# Understanding the Acculturation of Women in Science

## The Interplay of Episteme, Techne, & Phronesis in Retaining Females in Undergraduate Science

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by

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Cornell University, 2013

## Abstract

Democracy is a fundamental ideal of our nation. Persistent gender imbalances throughout society indicate strongly, however, that our reality falls short of the ideal. Our institutional decisions, though arguably based on majority rule, do not ensure fairness because the decision-making discussions exclude categories of people and important modes of discourse or ways knowing. One such imbalance lies in the fields of science, technology, engineering and math (STEM) where women comprise only 13% of professors in the top 100 US universities. The challenge at present, then, is to find out why women leave the sciences in order to know what internal and external coercive forces affect their decisions. This dissertation employs Flyvbjerg's interpretation of Aristotle's three intellectual virtues *episteme*, *techne*, and *phronesis.* to help elucidate the attrition of women in computer science, physics and engineering. Each chapter represents each virtue and demonstrates the importance of integrating multiple ways of knowing. From an Aristotelian point of view, *phronesis* is the most important intellectual virtue that may ensure the ethical employment of science (*episteme*) and technology (*techne*). In the spirit of Flyvbjerg's research, I provide concrete examples through detailed narratives of the ways in which personality, power and values work together in choosing/leaving a major. Just as phronesis is marginalized in the intellectual scheme of things, so too are females as we learn from the attrition stories of two undergraduate females who have traversed the oppressive technocratic terrain of science and left. By incorporating Sandra Harding's Standpoint Theory the reader is able to pull out key lessons specific to their life experiences and struggles to

understand the acculturation of women in science. Ultimately, from my standpoint and understanding, I suggest curriculum oriented supports such as integrating personal values into science courses, having students earn grades that represent a more familiar mean (70-75% mastery instead of “a curve”), and frontloading the curriculum with more collaborative opportunities, to help retain more females in science.

# Biographical Sketch

Michele Whitecraft is a dynamic teacher, lecturer and researcher. She takes a holistic interdisciplinary approach to education and is actively involved in advancing women in science. She has been the recipient of the Presidential Award for Excellence in Secondary Science Education, the Tandy Scholar Teacher Award, and the Governor's Award for Excellence in Education. From her unique research and consulting experiences with the Department of Energy, National Science Foundation, National Institutes for Environmental Health Science, National Institutes of Health, and National Aeronautics Space Association, Michele has designed science curricula with real world experiments ranging from her work on the International Experimental Thermonuclear Reactor at Princeton to the artificial transmutation of the transuranium elements at UC Berkeley. With more than 26 years' experience in teaching high school and college chemistry, she has authored several monographs to enhance science education nation-wide and presented at several national conferences. She has publications in *BioScience*, *Journal of Nuclear Materials*, *Human Ecology* and the *Encyclopedia of Ethics*. Michele's experiences with these national organizations and research projects have inspired her desire to help advance women in all scientific endeavors in an effort to realize NSF's goal of 50-50 gender participation in science by 2020. Michele has been a member of the American Chemical Society, American Association for the Advancement of Science, Society of Women Engineers, American Association of University Women, Association for Supervision and Curriculum Development, and National Association of Research in Science Teaching.

*In Loving Memory of*
*Alfa Choice*

"There, but for you, go I"

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# Acknowledgements

Completing this degree has been the longest, most spiritual journey of my life thus far. It overwhelmed the substance of my present years, of course, but this journey has stretched back the length of my life story too. It really began in a gaping disconnect between the official American story of freedom and my own experiences. I have always felt haunted by the covert injustices I have lived and witnessed. Even in a country that boasts the greatest rights and freedoms in the world, I have not felt free, in part because the official story excludes our responsibilities to self and other.

Through this journey, I have been learning the freeing power of taking responsibility and sharing the story. Rosa Parks' story is my model. She pushed to be the best that she could be and shared it in a way that has served all of us. She did not stand on a 'safe' shore of sameness where career had lodged me. She stepped out. What she did is perfectly explained by a book that caught my attention, fortuitously misplaced in the science section.

> Security… what does this word mean in relation to life as we know it today?.. by this term, I mean a man who has settled for financial and personal security for his goal in life… His ideas and ideals are those of society in general and he is accepted as… respectable… A man is to be pitied who lacked the courage to accept the challenge of freedom and depart from the cushion of security…
>
> Turn back the pages of history and see the men who have shaped the destiny of the world. Security was never theirs, but they lived rather than existed. Where would the world be if all men had sought security and not taken risks or gambled with their lives on the chance that, if they won, life would be different and richer?... [W]ho is the happier man, he who has braved the storm of life and lived or he who has stayed securely on shore and merely existed. [Thompson, (1955), in Phillips', Socrates in Love (2007)]

Ah, precisely what I needed to hear right then, a coincidence, God's way of remaining anonymous! And so, here I would like to acknowledge all the people who were "coincidentally" placed in my life and thereby helped to "co-create" the person I am today. They are the people

who inspired, encouraged, supported and sang my song back to me. They are all my heroes and champions—they were the selfless ones who dared to believe in me.

First, I have to thank all 2500+ students whom I have had the honor to teach. I thank them for entrusting me with their lives and for pushing me to be all I can be. In particular, I would like to thank Shawnta Wiley, a vivacious African American student I had in my chemistry class at Tompkins Cortland Community College. Shawnta always held me accountable and turned my words back on to me. One day she brought me an application for the doctoral program at Cornell and said to me, "You are always telling us to follow our dreams; you need to follow yours too!" I honestly can't thank her enough. She shoved me off shore! It has been an honor to learn and grow with her. Truly, she has been a godsend. We have struggled together, and sung together, hoping to be heard by others. I am blessed to have her encouragement, support and friendship.

Additionally, I am grateful to my friends who never got frustrated with my endless typing, reading, and research. They got the irony that to make a difference in the world, I had to remove myself from it awhile, a lot. My dear friends Nancy Riddle, Christine King, and Chris Jolly were always there to cheer me on. Their kindness and grace were beyond my comprehension. Also, my heartfelt gratitude to my dear friend, Elaine Norris, whose critique and constructive criticisms allowed me to step back from my work and look at it with a critical eye. Her brilliance, kindness, patience and diplomacy made her a mentor beyond description. She truly is house-wife, academic, and teacher extraordinaire. And to Jennifer Orleans, Rosemary Hulslander and Bobbi Townsend whose smiles, love and encouraging words sustained and fortified me. Also to my dear friend and colleague, Bryan Duff, who "got me" the day I met him. Bryan's kindness, thoughtful words, encouragement and wisdom have been so inspiring.

Finally, to my friend Alfa Choice who was always looking out for me and still does. Her grace, style, love and wisdom I will always carry with me. I will always acknowledge and honor her presence in the empty seat in every class I teach. Her life will not be in vain. She will forever be my inspiration.

I also want to thank all the incredible professors I've had as mentors. Avery special thanks to Dennis Manos who knew how to build me up without tearing me down. To Scott Peters, David Pimentel, and Dawn Schrader, whose classes ran upon the amazing parallel energies of their own critical thinking processes and their abilities to engage their students'. Truly, I experienced what David Brooks calls "limerence" in each of their classes. I was attracted to each of them because of their practical wisdom and ethical approach to enlightenment. I did not know at the time what made them so special. Ironically, and unbeknownst to me, their beautiful pedagogies became the central theme of my dissertation. David Pimentel's selfless mentoring was my first experience with kindness at Cornell. He spent countless hours sharing his expertise with me and tucked me under his wing. He made me feel heard and that my story mattered. Scott Peters has been equally wonderful. The time he took in nurturing my intellectual growth and sharing his expertise could never be repaid. I will spend the rest of my life trying to "play it forward" with my students to reciprocate his grace. Dawn Schrader has also been an amazing role model. Her intelligence, charisma, and style liberated me from the fear of being a stodgy intellectual. She made me realize that you really can have it all.

Further, I need to thank those whose books changed my life. When you read the words of someone else and find yourself in those words, you feel like you are becoming more whole and true to yourself. Thank you to those whose writings have changed my life, to Paulo Freire, Bent Flyvbjerg, Robert Nash, Parker Palmer, Harry Boyte, Dave Matthews, Marianne

Williamson, David Brooks and Scott Peters for putting their wisdom down on paper. The courage and time they put into eloquently articulating what they felt in their hearts, gave me the courage to do the same.

In addition to books that changed my life, I need to thank the participants in my study whose stories changed my life. I wish all of life's greatest blessings to Kendra Bartell and Lucy Vela. Their selfless desire to make a difference for the next generation of physicists and engineers will never be forgotten. Their time, experiences, courage and passion have been so inspiring to me. In understanding their stories, I was able to understand my own.

Lastly, I'd like to thank my family. To my parents who forgot to tell me I was "just a girl" and for all the sacrifices they made for me to get an education. Their devotion and love for one another made me understand the "staying power" required to make a difference in this world. To my wonderful sister, Lisa Anderson, whose encouragement, strength and support I can never repay. Lisa was always sending me cards and rooting me on from four hours away. I spent countless hours on the phone with her crying about how I just felt like I couldn't go on. She always knew just the right thing to say to keep me going. And to her husband George Anderson for being her rock and whose love carried us all through some of my family's most painful trials. I also want to thank my nephews Leigh and Colt Metzler. When people acted like I was crazy to leave my $80,000 a year job to try to make a difference, Leigh was so supportive and encouraging. That twenty eight year old put it all into perspective when he said, "Some people invest in the stock market. You are investing in yourself and our country's future. Go for it!" And to my nephew Colt, whose beautiful gift for teaching makes me so proud to be a teacher. I treasure his enthusiasm for teaching and am honored to be his aunt. The trials he has had in his life are far greater than anything I could ever imagine at such a young age. I hope I

can inspire him as much as he has inspired me. I also need to thank my most beautiful English bulldog, Berkeley, who gave me the courage to leave my entire family behind and move to Ithaca to pursue my dreams. He made me feel like I was the greatest thing since bacon treats! I wanted to prove to him that I was. Finally, I need to thank my best friend, Bruce Huggins Jr., for his wisdom, patience, encouragement, support, humor and love. I don't believe there is a person on this planet that knows me better than he. He loves me in spite of myself. I actually don't know how he put up with me when half the time I couldn't even put up with myself. I was constantly testing my "theories" out on him and he painstakingly never faltered or complained. When I felt I could no longer go on, more than anyone, he graciously sang my song back to me and so beautifully lifted me back up. I can't thank him enough for showing me heaven on earth.

One last acknowledgement; I'd like to thank you, the reader, for sharing your valuable time with me. It is no coincidence why my dissertation is in your hands right now. In the pages that follow, I hope my writing helps you to see, feel and remember who you are. I also pray you walk away from it with that one intangible "something" that you can't exactly pinpoint, but know is there.

# Overview & Introduction

## The Big Picture

Democracy is a fundamental ideal of our nation. Persistent gender imbalances throughout society indicate strongly, however, that our reality falls short of the ideal. Our institutional decisions, though arguably based on majority rule, do not ensure fairness because the decision-making discussions exclude categories of people and important modes of discourse or ways knowing. One such imbalance lies in the fields of science, technology, engineering and math (STEM) where women comprise only 13% of professors in the top 100 US universities. The challenge at present, then, is to find out why women leave the sciences in order to know what internal and external coercive forces affect their decisions. This dissertation employs Flyvbjerg's interpretation of Aristotle's three intellectual virtues *episteme*, *techne*, and *phronesis*[1] to help elucidate the attrition of women in physics and engineering. From an Aristotelian point of view, *phronesis* is the most important intellectual virtue that may ensure the ethical employment of science (*episteme*) and technology (*techne*).

In the spirit of Flyvbjerg's research, I provide concrete examples through detailed narratives of the ways in which power and values work in US science education and the

[1] *Episteme:* Scientific knowledge. Universal, invariable, context-independent. Based on general analytical rationality. The original concept is known today from the terms "epistemology" and "epistemic."

*Techne:* Craft/art. Pragmatic, variable, context-dependent. Oriented toward production. Based on practical instrumental rationality governed by a conscious goal. The original concept appears today in terms such as "technique," technical," and "technology."

*Phronesis:* Ethics. Pragmatic, variable, context dependent. Oriented toward action. Based on practical value-rationality. Deliberation about values with reference to praxis. The original concept has no analogous contemporary term. [Terms that are similar are "applied ethics" or "policy studies."] (Flyvbjerg, p. 57).

consequences they have in inhibiting the democratization of higher education as a whole. Just as phronesis is marginalized in the intellectual scheme of things, so too are females as we learn from the attrition stories of two undergraduate females who have traversed the oppressive technocratic terrain of science and left. Scientific and technological development must take place with ethical checks and balances for a democracy to thrive. The ability to have deliberation representative of *all* our nation's constituency is essential to this process and to the growth and betterment of democracy as a whole. Ultimately I show how action research (my life and career as a teacher) can trigger a phronetic process that can re-align our democratic ideals where both science and technology are concerned.

## The More Focused Picture

I pursue what I pursue in life because of my identity. If I had a job that I couldn't identify with, I would still exude who I am and what I am about, through my actions in that job. I would always find ways to "Wow!" people, share my love of math and chemistry, fight for the underdog, help those who are unheard be heard, and help others realize their dreams, just as others have helped me. I would enjoy my job, regardless of what it was, because it allowed me to be me—because it allowed me to express who I am at my inner core. If, on the other hand, I was told I had to behave in a way that was contradictory to who I am I would be unhappy—I would look for another job. This dissertation asks, "What can we learn from how a female student rationalizes leaving a STEM field to reform science education in Higher Education?" More specifically, it explores how women who leave the STEM fields interpret their decisions *in the context of their identity* and answers the following questions:

- Why do female students with the intellect and drive to succeed in STEM fields, leave?
- How do they interpret their decisions in the broader context of their identity?
- What is the impact of the experience on these women?

- How can we retain them?

These questions can all be addressed through Aristotle's intellectual virtues of episteme, techne and phronesis; a balance of which is necessary, since episteme has not provided the tools or "know how" to create sufficient intellectual diversity within the science to which it belongs. As W. A. Wulf (1998), former president of the National Academy of Engineering, explicates, "Without diversity, we limit the set of life experiences that are applied, and as a result, we pay an opportunity cost—a cost in products not built, in designs not considered, in constraints not understood, and in processes not invented."

Today, much research has been done on why women do not pursue science. However little is known on the attrition experience and what we can do to help students who choose science, to stay in science. This dissertation fills that gap in an effort to build products, consider designs, understand constraints and invent processes that will advance humankind.

I have structured this dissertation to tell the story of my growth as an intellectual as well as to model knowledge integrating Aristotle's three intellectual virtues of *episteme, techne,* and *phronesis*. This is extremely important to me for two reasons. First, I want to show that the process of knowledge construction is just as important as the knowledge itself. Second, because I want to model how employing diverse intellectual virtues can provide a more objective understanding of the attrition of women in science. In other words, instead of just asking the bully (*episteme*) who hit whom, I am asking the recipient of the punch (*techne*), as well as the innocent by-standers (*phronesis*). I believe research incorporating each of Aristotle's intellectual virtues will provide a more accurate representation of why women leave science than just the use of knowledge created from controlled experiments via the scientific method (*episteme*). Getting diverse perspectives, in my view, is a much more thorough, holistic approach to knowledge

production which, in turn, may allow us to develop better solutions to retain women in science. Further, by implementing what Sandra Harding (1991) calls "strong objectivity" I have centered the core of the dissertation around those who have been subordinated—the female physics and engineering students in my study—because, as Harding points out, they offer a *stronger* objectivity due to their increased motivation to understand the perspectives of those in power. Strong objectivity allows the relations of power that are hidden in the traditional knowledge production process to surface. By acknowledging the role that power and social location play in the process of knowledge production I am modeling Harding's concept of *strong objectivity*.

Following the work of Kurt Lewin, the chapters of this dissertation adhere to the components of practical theory building suggested by Peters (2010). The first chapter (*episteme*) is a literature review situated in the empirical research on cognitive abilities, preferences and cultural biases of females pursuing STEM fields in general and computer science in particular ("*Why Aren't More Women in Computer Science?"*). This chapter gives the reader an understanding of the way things are and why and how they came to be the way they are. This chapter was published in Making Software: What Really Works and Why We Believe It (2010). Unfortunately, I believe we got it wrong. I knew the entire time we were writing it that there were several things that did not "sit right" with me. Because the person I was writing it with had more power than I, I had to "back down" from my arguments. Despite demonstrating that I have been true to my desire to have my work published in areas outside of science education in *diverse* sources (as the non-APA style indicates), I regret that this first chapter was published. The angst that I felt for succumbing to the allure of another publication, drove me to write the second chapter. Incidentally, I should mention that this second chapter better models integrity to my 'knowledge' than the first, and further models an ability to practice what I preach.

The second chapter (*"Attrition Profiles: In Their Own Words")* uses narrative inquiry to further elucidate female students' views of the way things are and their perception of the way things should be in the broader context of their identities. The 'forward' and Part II of this chapter are the parts of which I am most proud. The interpretive nature of this research methodology not only rounds out the imbalance of mere cause and effect research, but it offers a tool (*techne*) for introspection. This introspection is a practical way to help academics understand the importance of *phronesis* in educating diverse groups of students which is the ground work then for chapter three.

Finally, in chapter three I offer research and pedagogical strategies that will help us "move from the way things are to the way things should be" (Peters, 2010, p.13). This chapter is entitled, *"epiSTEMological Differences: The Interplay of Aristotle's Intellectual Virtues on Science and Science Education Reform in Higher Education."* Although this chapter offers strategies (humanistic *techne*) it is primarily about the importance of *phronesis* to enhance diversity in science. This paper was submitted to the highest journal in my field and after six months of deliberation (with a promised turn-around time of 30 days) they contacted me and said, "We apologize for the delay in response to your piece, as the editors had an extended discussion on the scope and character of position papers we wanted for the Journal." I knew that sending this paper to such a positivist journal was bold; however I am happy that it generated discussion. Indeed, I am making every effort to spark conversations that "move from the way things are to the way things should be" (Peters, 2010, p.13). The Journal went on to say, "While your paper represents some interesting theoretical challenges to educational philosophy, it does not match our current view of the scope of a position paper." Here the operative words are "current view". In time, I am confident that scientists will see the greater objectivity in deriving

knowledge from a variety of different sources and methodologies other than simplified cause and effect. This paper was then resubmitted to this journal's Canadian counter-part with a cover-letter that was much more detailed in why it "matches…the scope of a position paper" on October 31, 2012. I have not yet heard back from them.

Collectively, these chapters will further provide to the following stakeholders the foundation upon which the following questions may be answered:

- Professors: What can they do to keep this valuable talent in their fields? How can we differentiate instruction to reach all students?
- Parents: How can they shop around to help their students choose colleges that will nurture their contributions and unique abilities?
- Students: What schools are willing to see the value of their contributions and do something about it?
- Policy makers/Higher Education: How will they proactively promote diversity? How can we monitor our progress toward equity and equality in science and science education?
- Public: How will the "processes not invented" enhance the quality of their lives?
- Researchers: How can a balance of episteme, techne, and phronesis work in consort to uncover knowledge that has been constrained by the illusion and perceived superiority of episteme.

# Why are So Few Women in Computer Science?

By Michele A. Whitecraft & Wendy M. Williams[2]

## Abstract

The research on the causes of the gender imbalance in computer science professions has created many passionate debates that suggest a need for change. In this paper we review the literature in the areas of biological differences between males and females that are coupled with cognitive-ability differences, especially in gifted individuals; differences in career and lifestyle preferences; and the culture of the computer science milieu. Despite clear gaps in understanding the relationship between gender and participation in CS/IT and given the potential benefits to women and society, we conclude that it is advisable to consider steps to encourage women to enter the fields of CS/IT and offer cultural, curricular, and confidence-oriented interventions suggested by various authors (Margolis, Fisher, & Miller, 2000; McGrath & Aspray, 2006; American Association of University Women, 2000).

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Whitecraft, M., & Williams, W. (2010). Why Aren't There More Women in Computer Science? In A. Oram, & G. Wilson (Eds.), *Making Software: What Really Works and Why We Believe It* (pp. 221-238). Cambridge: O'reilly

# Why Are So Few Women in Computer Science?

By Michele A. Whitecraft & Wendy M. Williams[3]

Consider the following statistics.

Girls receive higher grades than do boys, from kindergarten through college, including grades in mathematics. In the latest year for which we have data, girls comprised 48% of all college math majors, took 56% of all Advanced Placement exams, and took 51% of AP calculus exams [College Board 2008]. Yet, only 17% of AP computer science test-takers in that year were female [College Board 2008]. Likewise, although 57% of all 2008 undergraduate degree recipients were female, women comprised only 18% of computer science (CS) and information (IT) degree recipients [National Center for Education Statistics 2008].

Curiously, 23 years earlier (in 1985), 37% of computer science bachelor's degrees were awarded to women [National Center for Education Statistics 2008]. Between 2001 and 2008 alone, there was a 79% decline in the number of incoming undergraduate women interested in majoring in computer science [Higher Education Research Institute 2008].

Why are so few women in computer science? Should we care? And, if we should, can anything be done to reverse these trends? Debates over these issues fall into three major categories. Some argue that women are less likely than men to possess cognitive abilities at the extreme right tail of the distribution, which are necessary to compete in computer science (see [Ceci and Williams 2007], [Ceci and Williams 2010], and [Halpernet al. 2007]). Others say that

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women are not as interested in computer science and simply prefer to study other subjects [Ferriman et al. 2009]; [Durndell and Lightbody 1993]; [Seymour and Hewitt 1994], and still others argue that women are directed out of the field by stereotypes, biases, and "male culture" [American Association of University Women 2000]; [Margolis et al. 2000]. This chapter reviews the research pertaining to each of these three positions and follows each argument through to its logical implications.

## Why So Few Women?

First, we'll review the common explanations given for this situation and the formal research that investigates them.

### Ability Deficits, Preferences, and Cultural Biases

Much research has been done on innate ability differences, preferences, and cultural biases as reasons for the underrepresentation of women in science, technology, engineering, and mathematics (STEM) fields. Ceci, Williams, and Barnett developed a framework to understand how these all interact [Ceci et al. 2009]. Next, we address the research on each factor and then work it through Ceci et al.'s more integrative framework. The picture that emerges (see Figure 1) gives the reader a feel for the complexity of the interactions between the contributing factors. Although there are certainly biologically rooted gender differences at work, the research suggests that there also may be some detrimental gender biases involved, which raises further questions.

#### Evidence for deficits in female mathematical-spatial abilities

Innate ability differences between males and females (as well as environmentally mediated differences traceable to experiences during childhood) have been explored as one possible reason for the declining number of women in computer-related fields. Substantial evidence supports the argument that women are not as capable at highly math-intensive pursuits

as are men. This sex asymmetry is found at the very upper end of the ability distribution. For example, the top 1% of scores on the mathematics SAT shows a 2-to-1 ratio of males to females, and the top .01% shows a ratio of 4-to-1 [Hyde and Lynn 2008]; [Lubinski et al. 2001]. Males also earn most of the very low scores, meaning that males' performance is simply more variable overall.

Ceci, Williams, and Barnett [Ceci et al. 2009] divide the evidence on cognitive sex differences into mean differences (at the midpoint of the distribution) and right-tail differences in proportions in the top 10%, 5%, and 1%, the latter being a better representation of those in the science, technology, engineering, and math (STEM) professions. Based on a national probability sampling of adolescents between 1960 and 1992, Hedges and Nowell found that the distribution of test scores for male and female test-takers differed substantially at the top and bottom 1%, 5%, and 10% [Hedges and Nowell 1995]. Males excelled in science, mathematics, spatial reasoning, social studies, and mechanical skills. Females excelled in verbal abilities, associative memory performance, and perceptual speed. These findings raise the possibility that biology accounts for some of the observed gender patterns of participation in related fields of STEM, CS, and IT.

Research on relative brain size, brain organization, and hormonal differences is also relevant. Ceci and Williams review the recent biological work on cognitive sex differences, investigating brain size, brain organization, and hormonal differences [Ceci and Williams 2010]. Discussing Deary et al.'s finding of a modest correlation (.33-.37) between intelligence and brain volume [Deary et al. 2007], in which men on average have slightly bigger brains, Ceci and Williams note that "in most of the research on biological correlates of sex differences, the focus is on means, whereas the focus on sex differences in the STEM fields is on the extreme right tail (the top 1% or even the top .1% or the top 0.01%)." In other words, many studies of average

brain differences are not pertinent to our question, because strong evidence of mathematical and spatial ability differences between men and women appear only at the very top (or bottom) of the range of ability scores.

Other research cited in Ceci and Williams' review suggests that males and females use different parts of their brains to complete the same tasks (Haier et al. 2005). Ceci and Williams conclude that "with additional independent replications and representative sampling, it can be concluded that men and women achieve the same general cognitive capability using somewhat different brain architectures."

Additionally, Ceci and Williams cite research that investigates the role of pre- and postnatal hormones in understanding cognitive sex differences. In one study, male rats were superior at figuring their way around a maze, compared with female rats. Once the male rats were castrated, their superiority disappeared. Ceci and Williams also review research in which biological females, given estrogen-suppressing drugs coupled with large doses of male hormones during sex-change operations, developed enhanced spatial abilities. The large body of research in this area suggests that hormonal factors might affect professional choices of women. However, it is unclear how much. Ceci and Williams conclude that the evidence is "not strong and consistent enough to justify claiming that hormones are the primary cause of sex differences in STEM careers."

Before we leave the subject of hormonal differences, however, we should consider the possibility that they underlie some behavioral differences that predispose women not to be as attracted as men to working in computer science.

Statistics show that women are committed to the professional work force. They hold 57% of all professional occupations in the U.S. in 2008 [Ashcraft and Blithe 2009]; [National Center

for Education Statistics 2008], and they are also successful in math (as measured by grades), a closely related academic discipline. Thus, it seems important to go beyond the explanation of ability deficits and to ask about women's choices. The statistics call for a gender-sensitive analysis of the factors influencing women's decisions to participate in the field of Computer Science—or not—and we also need to address the possibility that women find themselves disenfranchised by the male culture of CS. If, in fact, significant reasons for a gender imbalance lie here, then here, too, may exist an opportunity to reverse a portion of this trend.

**The role of preferences and lifestyle choices**

Accordingly, some researchers have addressed preferences and cultural forces. Some claim that culturally inscribed career and lifestyle choices are the major reason for the small number of women in computer science, and others claim more strongly that discouraging cultural forces are the most instrumental causes. Next, we review evidence for each of these positions. With respect to career choice, gender shifts within professions have occurred throughout history, notably within teaching, secretarial work, and medicine [Ceci and Williams 2010]. These shifts are easily explained by changes over time in these careers' prestige levels and financial remuneration, rather than by hormones or genes. Repeatedly, men have taken over whatever kind of work is considered more economically valuable, suggesting that gender workforce patterns are driven more by cultural and political forces rather than simple biological differences. In a recent longitudinal study of women's choices to work in health-related careers, we can find an interesting parallel case in which cultural values drive career choices. Jacqueline Eccles and colleagues at the University of Michigan found that even when mathematical ability was taken into consideration, young women were more attracted to health-related careers because they

placed a higher value on a people/society-oriented job than did their male peers [Eccles et al. 1999].

Margolis, Fisher, and Miller [Margolis et al. 2000] provide further evidence of a "female" inclination—or values choice—to serve people and society in their 2000 study involving 51 male and 46 female computer science majors at Carnegie Mellon University (comprising a total of 210 interviews). A representative quote from a female computer science interviewee resonates with Eccles's research:

> The idea is that you can save lives, and that's not detaching yourself from society. That's actually being a part of it. That's actually helping. Because I have this thing in me that wants to help. I felt the only problem I had in computer science was that I would be detaching myself from society a lot, that I wouldn't be helping; that there would be people in third-world countries that I couldn't do anything about. I would like to find a way that I could help—that's where I would like to go with computer science.

Margolis, Fisher, and Miller found that women's quest for people-oriented purposes for computers was in concordance with other research in the field of computer science [Honey 1994]; [Martin 1992]; [Schofield 1995]. They report that 44% of the female students in their study (as compared to 9% of the male students) emphasized the importance of integrating computing with people through projects with a more human appeal. Overall, women preferred computing for medical purposes (e.g., pacemakers, renal dialysis machines, and figuring out diseases), communication, and solving community problems over computing for the sake of computing, developing better computers, or programming for games.

Tagging some similar values issues, Ferriman, Lubinski, and Benbow point to gender differences in lifestyle preferences and orientation toward life as the main reason for women's underrepresentation in high-intensity STEM careers [Ferriman et al. 2009]. Their research is unique in that they were able to hold ability constant and narrow the population down to only those who excel in STEM careers. By following mathematically precocious youth over 20 years,

they found that "following the completion of their terminal graduate degrees, men seem to be more career-focused and agentic, whereas women appear to be more holistic and communal in their orientation toward life and more attendant to family, friends, and the social well-being of themselves and others more generally." By this argument, then, there are few women in CS simply because women are more interested in and prefer other disciplines and areas.

**Biases, Stereotypes, and the Role of Male Computer-Science Culture**

Some researchers reject the notion that any inherently female quality (whether ability or interest) causes women's underrepresentation in CS and IT careers. They argue instead that the culture of CS and IT discourages women. In "The Anatomy of Interest: Women in Undergraduate Computer Science," Margolis, Fisher, and Miller focus on how women students who enter CS with high enthusiasm and interest in computing quickly lose their ability and interest in the subject [Margolis et al. 2000]. They looked at factors beyond intellectual preference that influenced interest in an abstract body of knowledge. For example, they explored how gender-biased norms eroded confidence, and also how a masculinized standard for success shaded women's interest and ability in computing. The authors suggest that there may be some "pernicious ways in which male behavior and interest become the standards for 'the right fit' and success," and this, in turn, contributes to women's waning enthusiasm in the subject. In other words, as their interviews showed, women who refused to conform to the image of the myopically focused "computer geek" who "hacks for hacking's sake" might feel out of place.

For those who perceive the culture of computing as one in which the "boy wonder" icon is up all night programming feverishly in isolation, Margolis, Fisher, and Miller offer this insight from a female computer science teacher:

> My point is that staying up all night doing something is a sign of single-mindedness and possibly immaturity as well as love for the subject. The girls may show their love for

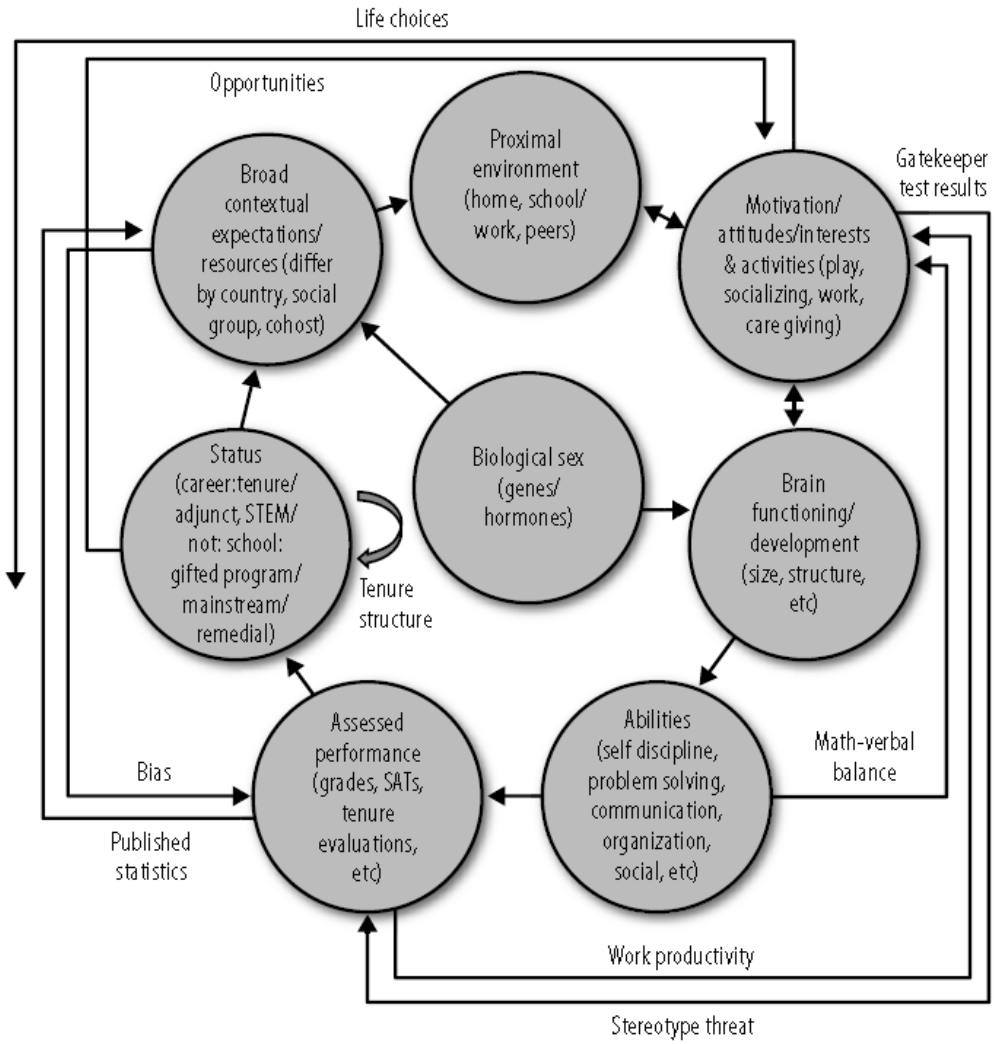
> computers and computer science very differently. If you are looking for this type of obsessive behavior, then you are looking for a typically young, male behavior. While some girls will exhibit it, most won't. But it doesn't mean that they don't love computer science!

Shortcomings of the Margolis, Fisher, and Miller case study include the fact that it examines just one small subset of the general population of students pursuing computer science, and thus, we should be wary of extrapolating these personal accounts to the broader population. We should not make broad assumptions based on this small sample. Furthermore, even though their interview questions were designed to elicit students' own experiences rather than their abstract thoughts, the authors admit that this interviewing technique was not conducive to assigning relative weight to different detachment factors, as "factors frequently shifted and appeared enmeshed with one another" [Margolis et al. 2000].

At the same time, these findings resonate with other studies of computer culture, such as one by the Educational Foundation of the American Association of University Women (AAUW), which combines input from its 14 commissioners (researchers, educators, journalists, and entrepreneurs) in cyberculture and education. Their report covers the Foundation's online survey of 900 teachers, qualitative focus research on more than 70 girls, and reviews of existing research, in order to provide insight into perspectives on computer culture, teacher perspectives and classroom dynamics, educational software and games, computer science classrooms, and home community and work [AAUW 2000]. Like Margolis, Fisher, and Miller, the AAUW found cultural deterrents to female participation in computer science. They found that girls are concerned about the passivity of their interactions with the computer as a "tool." Additionally, they found that girls rejected the violence, redundancy, and tedium of computer games and expressed dislike for narrowly and technically focused programming classes. Furthermore, the

AAUW contends that these concerns are dismissed as symptoms of anxiety or incompetence that will diminish once girls "catch up" with the technology.

Finally, in a comprehensive compilation of research in IT, CS, and CE, McGrath Cohoon and Aspray integrated research from over 34 key researchers in the field [McGrath Cohoon and Aspray 2006]. Their potential explanations for the underrepresentation of women include experience, barriers to entry, role models, mentoring, student-faculty interaction, peer support, curricula, and pedagogy, as well as student characteristics such as academic fitness, values, confidence, and response to competition, plus the culture of computing. In light of these culturally based concerns, we might ask what, exactly, high-ability women who opt out of disciplines such as CS do choose to do with their intellectual lives? Ceci, Williams, and Barnett remind us that women with high math competence are disproportionately more likely than men to also have high verbal competence, allowing them greater choice of professions [Ceci et al. 2009]. Hence, issues of culture and choice likely dovetail, directing capable women out of the computer field, thus revealing that more than biology, and factors other than solely raw ability, are at play. Figure 1 (next page) depicts the interplay of all these factors, both biological and cultural.




With so many confounding factors, it is no surprise that we have no clear solution to the barriers that some women may face in CS and related fields. On the other hand, we do have an emerging picture of multiple and interacting forces potentially acting against women's full participation, which raises implications to which we now turn.

**Should We Care?**

To the extent that women do not choose CS because of troubling aspects of culture that could be changed, we must ask ourselves whether we ought to push for more women in CS, for instance, through educational policy. Since CS is a desirable professional field, women might benefit by enhanced opportunities to take part. Furthermore, insofar as CS is a key area for

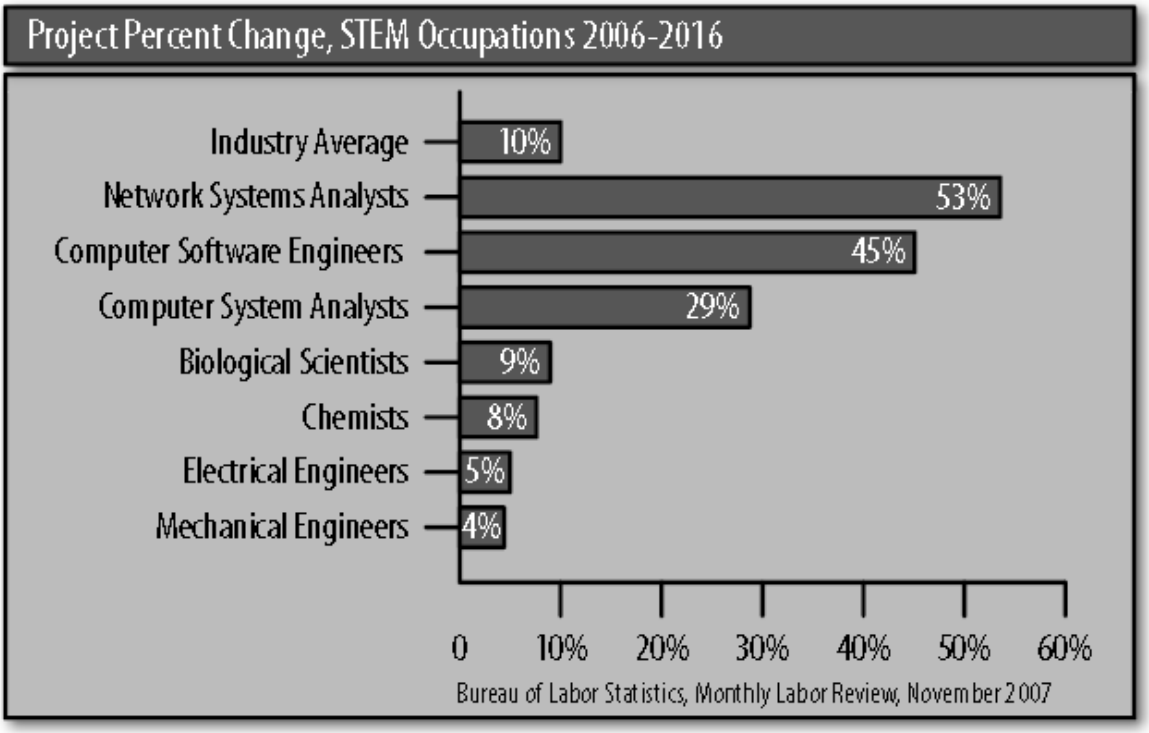
global competition, it may be beneficial for CS to become more gender-inclusive. Diversity may improve the products of computer and software teams.

Ultimately, however, the issue might go beyond any immediately measurable benefit. The inadequacies of the research at hand might actually suggest that we need to think within a different frame of mind: one that recognizes possible biological differences *and* a broad range of culturally determined qualities as key elements of a complex equation. First, let us address the potential benefits to women of participating in CS. First, IT jobs pay considerably more than most female-dominated occupations [Bureau of Labor Statistics 2004]; [National Center for Education Statistics 2008]. According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer science averaged $61,407 in July 2009 [Bureau of Labor Statistics 2010]. For computer systems software engineers, the median annual wages in the industries employing the largest numbers in May 2008 were: scientific research and development services, $102,090; computer and peripheral equipment manufacturing, $101,270; software publishers, $93,5790; and computer systems design and related services, $91,610.

The Bureau of Labor Statistics classifies computer software engineers' prospects of landing a job as *excellent.* Projecting ahead from 2008 to 2018, the percentage change projections as indicated on the Bureau of Labor Statistics website are: computer software engineers and computer programmers show an increase of 283,000 jobs, representing a 21% increase; computer software engineers show an increase in 295,000 jobs, representing a 32% increase; and computer software engineers show an increase of 34%. The only decline in projected jobs occurs in computer programming, at 3%. Thus, CS is a burgeoning field, with

good pay and good job prospects. Compared to other STEM occupations, the computer industry will see the greatest percentage of growth and demand, projected to 2016 (Figure 2).

*FIGURE 2. Projected percent change, STEM occupations 2006–2016*




Technology job opportunities are predicted to grow at a faster rate than jobs in all other professional sectors, up to 25% over the next decade [Ashcraft and Blithe 2009]. Considering the huge demand and projected employment to 2018, it might not be optimal that a possibly male-focused work culture may prevent some women from reaping the benefits of a career in CS.

The financial benefits to women of greater participation in CS are clear, but beyond these are the benefits that might accrue across the board when women are enabled to participate in all professional fields, including CS. The United States needs competent people to fill computer related jobs and do them well. The United States Department of Labor estimates that by 2016 there will be more than 1.5 million computer-related jobs available [Bureau of Labor Statistics

2004]. Despite the technology industry being one of the fastest growing industries in the U.S., if current trends continue, by 2016 the technology industry will be able to fill only half of its available jobs with candidates holding computer science bachelor's degrees from U.S. universities [Bureau of Labor Statistics, 2004]. In other words, we will benefit from participation by all people who show promise and capability, of both sexes.

Beyond this, gender balance might provide some benefits that some people have attributed to diversity. Indeed, some scholars have advanced the notion that diversity—including gender diversity—improves team performance, though not all scholars agree with this assertion, which frequently is made more on sociopolitical grounds than on scholarly ones. Research oriented around self-categorization/social identity and similarity-attraction tends to result in a pessimistic view of diversity, whereas the information-processing approach tends to give rise to more optimistic outcomes. As Mannix and Neale explain [Mannix and Neale 2005]:

> The self-categorization/social-identity and similarity-attraction approaches both tend to lead to the pessimistic view of diversity in teams. In these paradigms, individuals will be more attracted to similar others and will experience more cohesion and social integration in homogeneous groups. The information-processing approach, by contrast, offers a more optimistic view: that diversity creates an atmosphere for enhancing group performance. The information-processing approach argues that individuals in diverse groups have access to other individuals with different backgrounds, networks, information, and skills. This added information should improve the group outcome even though it might create coordination problems for the group.

Page, an advocate of diversity, says that under the right conditions, teams comprising diverse members consistently outperform teams comprising "highest-ability" member [Page 2007]. From his extensive work in complex systems, economics, and political science, Page asserts that progress depends as much on our collective differences as it does our individual IQ scores. The research on the benefits of diversity in the IT workplace suggests that teams with equal numbers of women and men are more likely (than teams of any other composition) to experiment, be

creative, share knowledge, and fulfill tasks [London Business School 2007], and that teams comprising women and men produce IT patents that are cited 26–42% more often than the norm for similar types of patents [Ashcraft and Breitzman 2007].

Research on this topic often credits diversity with a myriad of positive outcomes for team performance, yet it must be acknowledged that 50 years of research by social scientists has shown that performance advantages are not so clear-cut. As Mannix and Neale (2005) point out, whereas tenure diversity (diversity in employee length of service) has particularly negative effects on performance, diversity based on social-category variables such as age, sex, and race seems to produce mixed effects, and the effect particularly depends on proportions (ratios of minority to majority members). In a large-scale, four-study project in which the authors measured the effects of racial and gender diversity on team process and performance, Kochan and colleagues found that gender diversity had either no effect or positive effects on team process, whereas racial diversity tended to have negative effects [Kochan et al. 2003]. Although Kochan and colleagues reported few direct effects for either type of diversity on team performance, they did indicate that contextual conditions (such as high competition among teams) exacerbated racial diversity's negative effects on performance.

Interestingly, Sackett and colleagues pose the question of how, exactly, performance is being assessed throughout the literature evaluating the benefits of diversity [Sackett et al. 1991]. That is, the authors note that performance ratings are tricky. After controlling for differences in male-female cognitive ability, psychomotor ability, education, and experience, when the proportion of women was small, women received lower performance ratings. Sackett and colleagues found that when women formed less than 20% of a group, they received lower performance ratings than did men, but when their proportion was greater than 50%, they were

rated higher than the men. The authors did not find any parallel effects of proportion of representation on the performance ratings of men. Because the sex of the rater was not recorded, other potentially plausible explanations, including fear of class-action lawsuits or claims of discrimination, are difficult to evaluate.

In other words, researchers may lack credible measures for valuing gender diversity, at least with respect to performance. Does proportion truly enhance performance, or is there some other underlying factor giving the perception of enhanced performance? How can overt diversity (male/female, Black/White) be studied while also appropriately assessing values and attitudes for similarities and differences? Would a gender- or ethnically-diverse work group whose members share similar attitudes and values be considered homogeneous or heterogeneous? Clearly, parameters need to be defined, and creating valid measures is part of the difficulty for research in this area.

Amidst these confusions, the fact that potential benefits of a diverse workforce may also include financial rewards is worth noting. A 2006 Catalyst study found higher average financial performance for companies with a higher representation of female board members. The study claims that for return on equity, sales, and invested capital, companies with the highest percentages of women board members outperformed those with the least by 53, 42, and 66%, respectively [Joy and Carter 2007]. Previously, a 2004 Catalyst study indicated that companies with the highest percentage of women leaders experienced a 35.1% higher return on equity and a 34% higher total return to shareholders. However, it could be argued that these results stem from progressive attitudes, not gender per se. Furthermore, Adams and Ferreira found that the average effect of gender diversity on both market valuation and operating performance was negative [Adams and Ferreira 2008]. This negative effect, they explain, may be driven by companies with

greater shareholder rights. In firms with weaker shareholder rights, gender diversity has positive effects. Therefore, given the Catalyst researchers' inability to control for variables such as business attitudes and shareholder involvement, we need to question their "face-value" conclusions.

Of additional concern should be politically forced and mandated measures creating gender diversity on boards. In 2003, the Norwegian Parliament passed a law requiring all public limited firms to have at least 40% women on their boards. Since then, researchers from the University of Michigan have investigated the consequences of this law. Ahern and Dittmar found negative impacts on firm value; however, they are quick to point out that the value loss was not caused by the sex of the new board members, but rather by their younger age and lack of high-level work experience [Ahern and Dittmar 2009]. Forcing gender diversity on boards for the sake of social equity produces inexperienced boards that can be detrimental to the value of individual companies, at least for the short run. What remains to be seen are the long-term consequences of such mandates.

Finally, some have argued that a diverse workforce fosters innovation. Overall patenting in all IT subcategories grew substantially between 1980 and 2005, but U.S. female patenting grew even more dramatically. All U.S. IT patenting for both genders combined grew from 32,000-plus patents in the period from 1980–1985 to 176,000-plus patents—a five-fold increase [Ashcraft and Blithe 2009]. For the same period, U.S. female IT patenting grew from 707 patents to more than 10,000—a 14-fold increase. This is particularly noteworthy because the percentage of women employed in IT remained relatively flat [Ashcraft and Blithe 2009]. Also, because women influence 80% of consumer spending decisions, and yet 90% of technology products and services are designed by men, there is a potential untapped market representing women's product

needs [Harris and Raskino 2007]. Including women in the technological design process may mean more competitive products in the marketplace. W. A. Wulf, former president of the National Academy of Engineering, notes one perspective on diversity: "Without diversity, we limit the set of life experiences that are applied, and as a result, we pay an opportunity cost—a cost in products not built, in designs not considered, in constraints not understood, and in processes not invented." On the other hand, concerning the research on diversity, Thomas A. Kochan, MIT Professor of Management and Engineering Systems, has said: "The diversity industry is built on sand. The business case rhetoric for diversity is simply naïve and overdone. There are no strong positive or negative effects of gender or racial diversity on business performance." Kochan does, however, acknowledge, "there is a strong social case for why we should be promoting diversity in all our organizations and over time as the labor market becomes more diverse, organizations will absolutely need to build these capabilities to stay effective" (personal communication, March 16, 2010). The most parsimonious current summary is that there may be some benefits of gender diversity, but that there may be costs as well.

**What Can Society Do to Reverse the Trend?**

The research on the causes of the gender imbalance in CS professions has created many passionate debates that suggest a need for change. Some argue that women are choosing what they wish to do—and it is medicine (where women are 50% of new MDs), veterinary medicine (where women are 76% of new DVMs), and fields such as biology (where women are also at parity with men; see [Ceci and Williams 2010]). But if our society were to wish to explore options for encouraging more women to enter CS, what might we do? Can the trend toward an overwhelmingly male CS field be reversed? Fortunately, research has looked beyond why

so few women are in CS; studies have also examined potential interventions dealing with culture, curriculum, confidence, and policy.

Research and initiatives at Carnegie Mellon serve as an excellent paradigm for evidence-based intervention in CS instruction at the post-secondary level. Some of these approaches include interdisciplinary courses that bring students of diverse backgrounds together to work on multifaceted problems, an undergraduate concentration on human-computer interaction, and a course that engages students with nonprofit groups in the local community, applying their skills to community issues [Margolis et al. 2000]. Additionally, Carnegie Mellon has found that directly recruiting women has a strong effect on increasing women's participation in computer science. Through their recruitment program and the programs previously outlined, they raised their proportion of women undergraduate CS majors from 7% in 1995 to 40% in 2000. Despite an overall decrease in enrollments in computer science across the country, in 2007, Carnegie Mellon represents a positive outlier, with 23% female enrollment.

**Implications of Cross-National Data**

In 2004, Charles and Bradley analyzed data from the Organization for Economic Cooperation and Development (OECD), focusing on higher-education degrees awarded in 21 industrialized countries. As expected, women predominated in traditionally female-typed fields such as health and education, and lagged behind in stereotypically masculine fields [Charles and Bradley 2006]. In all 21 countries, women were underrepresented in computer science (Table 13-1). What was surprising, however, were the results as far as egalitarian versus nonegalitarian countries are concerned. One might expect the underrepresentation of females (or the overrepresentation of males) to be greatest in nonegalitarian countries. However, Turkey and

Korea, countries not known for equality of the sexes, have *smaller* male overrepresentation factors (see Table 13-1, below). This could, in part, be due to policy issues mandating both

*TABLE 13-1. Male "overrepresentation factor" in computer science programs, 2001*[a]

| Country | Factor of overrepresentation |
|---|---|
| Australia | 2.86 |
| Austria | 5.37 |
| Belgium | 5.58 |
| Czech Republic | 6.42 |
| Denmark | 5.47 |
| Finland | 2.29 |
| France | 4.57 |
| Germany | 5.58 |
| Hungary | 4.66 |
| Ireland | 1.84 |
| Korea, Republic | 1.92 |
| Netherlands | 4.39 |
| New Zealand | 2.92 |
| Norway | 2.75 |
| Slovak Republic | 6.36 |
| Spain | 3.67 |
| Sweden | 1.95 |
| Switzerland | 4.66 |
| Turkey | 1.79 |
| United Kingdom | 3.10 |
| United States | 2.10 |
| *Notes*: Values give the factor by which men are overrepresented in computer science programs in the respective country. They are calculated by taking inverse values of the "computer science" parameters from previous calculations (see McGrath Cahoon and Aspray, 2006, Chapter 6) and converting the resultant positive values into exponential form. | |

[a] Values give the factor by which men are overrepresented in computer science programs in the respective country. They are calculated by taking inverse values of the "computer science" parameters from previous calculations (see [Charles and Bradley 2006]) and converting the resultant positive values into exponential form.

genders' participation in computer science experiences. Note that the overrepresentation values show the factor by which men are overrepresented in computer science programs in each respective country (see [Charles and Bradley 2006] for a complete discussion on how these values were calculated).

Charles and Bradley's research does not support standard arguments of social evolution theory, since the most economically developed countries are not producing greater numbers of women in computer science. Likewise, the authors show that there is not a strong correlation between the number of women in the workforce or in high-status jobs and the number going into computer science. These findings again suggest that the reasons for women's under-representation in computer professions are more likely found in the realm of culture than biology, the realm in which change is possible. But it is critically important to note that this research also provides little evidence that women's representation in computer science programs is stronger in the most economically developed countries, or that it is stronger in countries in which women participate at higher rates in the labor market, higher education, or high-status professional occupations [Charles and Bradley 2006]. Thus, the role of women's preferences emerges as the most likely explanation for where women end up, as opposed to explanations implicating biases as preventing women from entering CS.

The underrepresentation of women in computer science in all 21 countries studied indicates that there is a deep, shared belief in a given culture that women and men are better suited for different jobs. What makes the work of Charles and Bradley so interesting is that, with so much cross-national variability, there is a lot of room for social and cultural influences to play out. In the United States, we emphasize free choice and self-realization as societal goals that education seeks to nurture; yet the prevailing stereotypes may secretly stifle students' "free"

choice as they pursue fields that are in line with the conventional identity of being male or female in our culture. Charles and Bradley observed that the governments exerting strong controls over curricular trajectories, such as Korea and Ireland, had less female under-representation in computer science. This suggests that we may want to defer adolescents' career choices to a time when gender stereotypes do not have such a stronghold on them, and implement policies in which students explore math and science, including computer science, from kindergarten to 12th grade and beyond.

**Conclusion**

In this chapter we have provided recent evidence to help the reader navigate and explore the question of why so few women pursue CS careers, why we should care, and what, if anything, should be done about it. We have looked at areas of biological differences between males and females that are coupled with cognitive-ability differences, especially in gifted individuals; differences in career and lifestyle preferences; and the culture of the computer science milieu. Despite clear gaps in understanding about the relationship between gender and participation in CS/IT, it is worth debating the costs of acting versus not acting to encourage more women to participate in CS, within the context of the empirical literature on women in science.

In short, some in industry and business argue that the paucity of women in CS/IT-related fields is a detriment to the economic advancement of women and the economic development of our nation—and some have argued the opposite. Although some transnational comparisons of women's underrepresentation in CS [Charles and Bradley 2006] call into question the value of interventions, on the whole it does seem wiser for policy-makers to work toward broadening both genders' exposure to computers at an early age, when students are not so entrenched in

gender identity roles. Given potential benefits to women and society, it seems advisable to consider steps that may encourage women to enter the fields of Information Technology, Computer Science, and Computer Engineering. Cultural, curricular, and confidence-oriented interventions have been suggested by various authors [Margolis et al. 2000]; [AAUW 2000]; [McGrath Cohoon and Aspray 2006], and should continually be assessed regarding whether they are effective in the first place, whether they advance or hinder female participation in the field of computer science, and whether these changes in fact enhance the field. The ultimate goal should be the quality, effectiveness, and advancement of the CS profession, regardless of whether this means that the futuristic view of CS is largely male, largely female, or somewhat more gender balanced.

**References** [4]


[Adams and Ferreira 2009] Adams, R. and D. Ferreira. 2009. Women in the boardroom and their impact on governance and performance. *Journal of Financial Economics* 94(2):291–309.

[Ahern and Dittmar 2009] Ahern, K. and K. Dittmar. 2009. The changing of the boards: The value effect of a massive exogenous shock. Under review.

[AAUW 2000] American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, DC: American Association of University Women Educational Foundation. Retrieved from *http://www.aauw.org/research/upload/TechSavvy.pdf*.

[Ashcraft and Blithe 2009] Ashcraft, C. and S. Blithe. 2009. *Women in IT: The Facts*. Boulder, CO: National Center for Women & Information Technology.

[Ashcraft and Breitzman 2007] Ashcraft, C. and A. Breitzman. 2007. Who invents IT? An analysis of women's participation in information technology patenting. National Center for Women & Information Technology. Retrieved from *http://www.ncwit.org/pdf/PatentExecSumm .pdf*.

[Bureau of Labor Statistics 2004] Bureau of Labor Statistics. 2004. *Occupational Outlook Handbook*, 2004-05 Edition. Washington, DC: Labor Department, Labor Statistics Bureau. Retrieved from *http://www.bls.gov/oco/ocos267.htm*.

[Bureau of Labor Statistics 2010] Bureau of Labor Statistics. 2010. *Occupational Outlook Handbook*, 2010-11 Edition. Washington, DC: Labor Department, Labor Statistics Bureau. Available at *http://www.umsl.edu/services/govdocs/ooh20042005/www.bls.gov/OCO/index.html*.

[Ceci and Williams 2010] Ceci, S. J. and W. M. Williams. 2010. *The mathematics of sex: How biology and society conspire to limit talented women and girls.* New York, NY: Oxford University Press.

[Ceci and Williams 2007] Ceci, S. J. and W. M. Williams, ed. 2007. *Why aren't more women in science? Top researchers debate the evidence*. Washington, DC: American Psychological Association Books.

[Ceci et al. 2009] Ceci, S. J., W. M. Williams, and S. M. Barnett. 2009. Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin* 135(2):218–261.

[Charles and Bradley 2006] Charles, M. and K. Bradley. 2006. A matter of degrees—female underrepresentation in computer science programs cross-nationally. In *Women and Information Technology: Research on Underrepresentation*, ed. J. McGrath Cohoon and W. Aspray, 183–204.Cambridge, MA: MIT Press.


[4] **(the non-APA format models my commitment to interdisciplinary publications)**

[College Board 2008] College Board. 2008. *AP summary report (calculus AB, computer science A and AB).* Princeton, N.J.: College Board. Retrieved from *http://professionals.collegeboard .com/data -reports-research/ap/archived/2008*.

[Deary et al. 2007] Deary, I., K. Ferguson, M. Bastin, G. Barrow, L. Reid, J. Seckl, J. Wardlaw, and A. MacLullich. 2007. Skull size and intelligence and King Robert Bruce's IQ. *Intelligence* 31:519–525.

[Durndell and Lightbody 1993] Durndell, A., and P. Lightbody 1993. Gender and computing: change over time? *Computers and Education* 21(4):331–336.

[Eccles et al. 1999] Eccles, J., Barber, B., and Jozfowicz, D. (1999). Linking gender to educational, occupational and recreational choices: Applying the Eccles et al. related model of achievement related choices. In *Sexism and stereotypes in modern society: The gender science of Janet Taylor Spence*, ed. W. Swan, J. Langlois, and L. Gilbert, 153–192. Washington, DC: American Psychological Association Books.

[Ferriman et al. 2009] Ferriman, K., D. Lubinski, and C. Benbow. 2009. Work preferences, life values, and personal views of top math/science graduate students and the profoundly gifted: Developmental changes and gender differences during emerging adulthood and parenthood. *Journal of Personality and Social Psychology* 97(3):517–532.

[Haier et al. 2005] Haier, R., R. Jung, R. Yeo, and M. Alkire. 2005. The neuroanatomy of general intelligence: Sex matters. *Neuroimage* 25(1):320–327.

[Halpern et al. 2007] Halpern, D., C. Benbow, D. C. Geary, R. Gur, J. Hyde, and M. A. Gernsbacher. 2007. The science of sex differences in science and mathematics. *Psychological Science in the Public Interest*, 8(1):1–52.

[Harris and Raskino 2007] Harris, K. and M. Raskino. 2007. *Women and men in IT: Breaking sexual stereotypes.* Stamford, CT: Gartner.

[Hedges and Nowell 1995] Hedges, L. and A. Nowell. 1995. Sex differences in mental test scores: variabliity and numbers of high-scoring individuals. *Science* 269:41–45.

[Higher Education Research Institute 2008] Higher Education Research Institute. 2008. *Freshman: Forty year trends, 1966–2006*. Los Angeles, CA: Higher Education Research Institute.

[Honey 1994] Honey, M. 1994. The maternal voice in the technological universe. In *Representations of Motherhood*, ed. D. Bassin, M. Honey, and M. M. Kaplan, 220–239. New Haven:Yale University Press.

[Hyde and Lynn 2008] Hyde, J. and M. Lynn. 2008. Gender similarities in mathematics and science. *Science* 321:599–600.

[Joy and Carter 2007] Joy, L. and N. Carter. 2007. The bottom line: Corporate performance and women's representation on boards. *Catalyst Research Reports*. Retrieved January 29, 2009, from *http://www.catalyst.org/publication/200/the-bottom-line-corporate-performance-and-womens-representation-on-boards*.

[Kochan et al. 2003] Kochan, T., K. Bezrukova, R. Ely, S. Jackson, A. Joshi, K. Jehn, J. Leonard,D. Levine, and D. Thomas. 2003. The effects of diversity on business performance: Report of the diversity research network. *Human Resource Management* 42:3–21.

[London Business School 2007] London Business School. 2007. Innovative potential: Men and women in teams. Available at *http://www.london.edu/newsandevents/news/2007/11/Women_in_Business_Conference_725.html*.

[Lubinski et al. 2001] Lubinski, D., C. Benbow, D. Shea, H. Eftekhari-Sanjani, and B. Halvorson. 2001. Men and women at promise for scientific excellence: Similarity not dissimilarity. *Psychological Science* 12:309–317.

[Mannix and Neale 2005] Mannix, E., and M. Neale 2005. What differences make a difference? The promise and reality of diverse teams in organizations. *Psychological Science in the Public Interest* 6(4):31–55.

[Margolis et al. 2000] Margolis, J., A. Fisher, and F. Miller. 2000. The anatomy of interest. *Women's Studies Quarterly* 28(1/2):104.

[Martin 1992] Martin, C., ed. 1992. *In search of gender-free paradigms for computer science education*. Eugene, OR: International Society for Technology in Education.

[McGrath Cohoon and Aspray 2006] McGrath Cohoon, J. and W. Aspray, ed. 2006. *Women and Information Technology: Research on Underrepresentation*. Cambridge, MA: MIT Press.

[National Center for Education Statistics 2008] National Center for Education Statistics. 2008. *Classification of Instructional Program 11*. Washington, DC: U.S. Department of Education Institute of Education Sciences.

[Page 2007] Page, S. 2007. *The Difference: How the power of diversity helps create better groups, firms,schools, and societies.* Princeton, NJ: Princeton University Press.

[Sackett et al. 1991] Sackett, P., C. Dubois, and A. Noe. 1991. Tokenism in performance evaluation: The effects of work group representation on male-female and White-Black differences in performance ratings. *Journal of Applied Psychology* 76(2):263–267.

[Schofield 1995] Schofield, J. 1995. *Computers and classroom culture*. New York: Cambridge University Press.

[Seymour and Hewitt 1994] Seymour, E. and N. Hewitt. 1994. *Talking About Leaving: Factors Contributing to High Attrition Rates Among Science, Mathematics, and Engineering Undergraduate Majors.* Boulder, CO: University of Colorado, Bureau of Sociological Research.

# Attrition Profiles: In Their Own Words


## Abstract

Although we have made great strides in advancing women in biology, chemistry, and math (undergraduate degrees earned by women are at approximately 50% in each area), physics and engineering still lag far behind with undergraduate degrees conferred to women in these math intensive fields, at less than 20%. What are the stories that surround this statistic? Why do females who have the intellect and drive to choose to major in physics or engineering, leave? In this chapter I look at how two female students—one in physics and one in engineering—interpret their decisions to change majors in a broader context of their identity and accordingly, what we can learn from their stories to reform science education in Higher Education. Much of the research on the underrepresentation of women in science has been from "outside looking in" without regard to the personal standpoint, values, and meaning-making of the individual females pursuing undergraduate degrees in science. This chapter takes an "inside-out" approach using narrative inquiry based on the epistemological assumption that human beings make sense of experience through narrative, which therefore becomes the relevant space of research. In both profiles, neither young woman is taking part in the overarching discourse of what being a physicist or an engineer should look like, nor does their part seem to matter. Yet, here their stories are important for that very reason. They are the stories that go unheard in the public discussion about the culture of science. The attrition profiles, herein, teach us lessons about how different females' identities, contribute to their decision to leave the sciences and offer insight as to what we in higher education, can do to prevent it.

**"The truth that matters is not empirical truth but… The *narrative* truth."**
*—Jerome Bruner*

## Forward

Narrative inquiry is a fascinating form of research and tool for introspection. Though it has been used for testing hypotheses within the frame of conventional research, narrative has otherwise been held with some suspicion. In raw form, it is less controlled, too richly generative perhaps. Many find it too wild to nail down into what gatekeepers of our field consider legitimate knowledge. Precisely so! That's why I like it. Narrative inquiry pulls 'liminal' out from under the subliminal, frees the conscious from the 'un-' and 'sub-', and adds so much extra to the ordinary. Narrative inquiry has the power to make all those things of which you are intuitively aware made manifest in the spoken words of another. In fact, I have found that its most thrilling aspects are in the little epiphanies of everyday life. Narrative contains the real substance of who we are and what we do. The narrative inquiry process presented herein offers a model through which valid research can be done and further provides some new answers accordingly to the sticky questions that STEM fields still face about reaching and retaining diverse student bodies.

Traditional, positivist paradigms claim superior integrity and validity based on the production of generalizable knowledge. That claim is a little bit of an illusion, as we all know, and tremendously imbalanced. Narrative inquiry, alternatively, offers both particular (offering value for the storyteller) and universalizable (offering value for others) knowledge. To be clear importantly, "universalizable" is not the same as universal. I use the term universal here to mean the external made internal (from the outside-in) and universalizable to mean the internal made external (from the inside-out).

This distinction was my own little epiphany from proximal readings of the student profiles herein and of former director of Yale University's Intelligence lab's Albert Schank's book, Tell Me a Story (1990):

> Stories illustrate points better than simply stating the points themselves because, if the story is good enough, you usually don't have to state your point at all; the hearer thinks about what you said and figures out the point independently. The more work the hearer does, the more he or she will get out of your story.

Because I had to do more work—because I had to distinguish for myself, why overlapping stories of how a "Grand Unified Theory" was different from the supposedly "universal" appeal of poetry described by one of my participants—my imagination allowed me to create a new knowledge framework that would explain the confusion. Unbeknownst to me at the time, this term differentiation would be key in knowing how to better encourage, support, and graduate a more diverse student body in STEM fields. This idea "universalizability" came from the process of understanding my participants' stories and was a solution within itself.

This experience points to another important kind of research integrity too. I love whereby another key idea about what we can do with narrative as researchers (beyond the testing of a hypothesis) emerges from the study of narratives. I would argue that the use of one's imagination to create new knowledge is more intimate than receiving knowledge via the direct, expressed thoughts of others and/or combing data for obvious, "logical" trends. The magic in the generation of knowledge from research, for me, has been from the epiphanies of the "il"logical, which makes me question "whose" definition of logic are we using anyway? As a graduate student I was told to include in a paper to be published research based on "brain size and intelligence". Keeping the expletives inside, I couldn't believe what a phallic reasoning process this body of research actually was. I tactfully shared my views, and explained the flawed

reasoning with examples of where "bigger isn't better". I gave examples of the tremendous amount of energy that resides in a small nucleus of an atom and more, how much smaller and more powerful the computers of today are compared to the computers of the early seventies, yet I was still told to keep this information in the paper (which was later published). Because we have allowed the "logic" of the "gatekeepers" of knowledge to proliferate unquestioned, we have overlooked the diverse ways of knowing and generating knowledge that transcends the traditional boundaries of what is logical and what is knowledge.

The intimacy of narrative is valuable to research, truly gratifying in fact, because it occupies a space that cause-effect research methodology leaves wanting—the space beyond the literal dependability of exposition. It's a space created by the very nature of language, which always impinges on what we call meaning. Norris (Personal Correspondence, October 15, 2012) further explains it this way:

> Exposition has certain standards and structures that only admit certain kinds of statements, and gets backed into 'yes or no' kinds of structures, or gets pushed into the wrong argument altogether! Formal research methodology pulls whatever meaning it can out of the dependability of language (that is, the extent to which language can be dependable, the extent to which that 8:30 bus comes about then). As we know, though, there really is so much more to know, so much more to experience. The bus that comes, might come very early or late. It might be broken down, brand new, full, empty, with a nice driver or the mean one. An odiferous lady might be in our 'usual' spot, a pregnant man might be blocking the passage.

Her point is that literal language has a hard time capturing all that our senses can and has a hard time processing all that our brains do. That's why a story can often say more than expository speech.

People who can do more than echo dominant the culture – children, neophytes, people on the edges, the unsatisfied and the curious – can help the rest of us ask new questions. Certainly such a perspective can be distorted, but at least it's a different distortion than that of the main

stream. People who haven't been imbued by a dominant culture's ways of knowing, doing and/or being can see things differently and offer perspectives that make us question things we may take for granted because we continually, blindly, do things a certain way to follow the norms of the culture. I am reminded of a story Al Roker shared on the Today Show. He said that after his daughter saw the Wizard of Oz for the first time she asked, "Daddy, when did the world turn color?" I find the thinking process here, given the data presented, to be profound despite its inaccuracy (or not?). This telling misreading jolted me into thinking about the impossibility of full integrity in any representation given the assumptions, right or wrong, scientists and the general public alike, make as they engage in any language act. When we talk about logic and reasoning, I ask, "Whose logic and reasoning (to paraphrase Sandra Harding)?" Science is not logical and good reasoning processes do not always lead to correct answers. Follow the thinking process here: a former student of mine reasoned that because you can eat sodium chloride, the elements of which it is comprised could be safely ingested. This is absolutely not the case. Chlorine is a toxic greenish yellow gas and sodium is explosive when added to water. Certainly two elements you would not want to ingest! But, alas you say, "Well this is just a kid who is deficient in understanding chemical properties… if he were a *true* scientist he would not have logically thought this." Well, *true* scientists (and physicians) get it wrong too, because our assumptions fill so nicely the missing parts of the skeleton, so to speak.

The common conflation of the idea of 'natural' and 'safe' provides endless further examples. I can't tell you the number of educated people I have met that think if it is natural it is good for you. I tell them that uranium is natural, but I am not going to build my house on it (at least not without radon mitigation) and that poison ivy is natural, but I'm not going to go rolling around in it. Scientific discourse is packed with such fallacy. To say that aspartame is "safe"

*because* it comes from two natural amino acids, is an outrageous statement to make. It's been made.

Remember, too, the phlogiston theory: It made sense and was *logical* that when a vessel filled up with this smoke (phlogiston) the candle would go out, because we could *see* the smoke. We could not grasp, at the time, that it was due to the depletion of oxygen, because we did not know that oxygen existed. "If you can't see it, it's not there," is certainly a crazy statement for a scientist to make today in light of all the new tools we have to detect various invisible forms of matter and electromagnetic radiation, but then, given their tools, it was logical. It is the ability to step outside normal logic and reasoning that innovative ideas are born—not from conforming to rules and regulations. To see ordinary things in extraordinary ways makes a great scientist and scholar. Bernard Baruch said it eloquently, "Millions saw the apple fall, but Newton was the one who asked why. "

Not so long ago, I'm not sure I even saw falling apples. As a budding scientist and undergraduate, I was frustrated with having to take art, music and theater—after all, I'm science, damn it! I had no time for these "trivial things". As time unfolded, however, I became keenly aware as to how the "powers that be" knew better than I. I was at the "interface of competing logics that created a gap," and in that gap "was opportunity to move outside either system and to develop new thinking" (E. Norris, personal correspondence, October 15, 2012). It was art, after all, that gave me the answer to a scientific problem. Here's what happened: Because I could not draw for beans, I chose a photography project to fulfill my art requirement as an undergraduate. At the same time, as a research fellow studying acid rain for Pennsylvania, Power and Light, I could not figure out why my acid levels in my stream were increasing so dramatically—even in the absence of rain. After putting a portfolio of the photographs of my

stream together for art class, the answer hit me like a ton of bricks—and I didn't even know my brain was still working on it! The photographs showed beautiful autumnal leaves on the trees on one day, and then the next… completely gone! Well, not *completely* gone. They had been blown off the trees from tremendous winds and had been lying stagnate, decomposing in my stream for days. Was it logical that art would give me the answer to a scientific problem—not at the time. I do know now that it is the richness in the diversity of my experiences that allow me to be a better problem solver than most by looking at connections others might not see-- being new to research, did not constrain me to the cultural norms of my discipline. Instead of an artificial "integrity" that comes from an impossible purity of logic, I yearn for 'integration' that comes from many ways of knowing/seeing the world.

As you—and I do mean you, because the study of narrative recognizes both the narrator and the audience as active participants in the study – progress through this paper in angst over my incorporation of "non"-scholarly resources (yes, I referenced Al Roker, David Brooks, a house-wife and even a college chemistry text), remember that my interdisciplinary approach, among other things, earned me several different honors and opportunities. In addition to being the recipient of the Presidential Award in Science Education for the state of Pennsylvania, I have a patent for the inside wall of the International Thermonuclear Experimental Reactor at Princeton; numerous NSF, DOE, NIH, NIEHS, grants and fellowships; and publications in *The Journal of Nuclear Materials, BioScience, Human Ecology, The Encyclopedia of Applied Ethics* (to name a few), positivist evidence for the value of my approach. I certainly am not alone then in thinking that what we have been doing in the past could become unhealthy for our discipline, as it stifles innovation. We have been committing the equivalent of academic incest, by continually citing only each other within our own field and not branching out to share and

exchange knowledge with those in other disciplines. It's time for new stories, what might be called the inside stories… stories that will move us forward.

# Attrition Profiles: In Their Own Words Part I

**Introduction**.

Girls receive higher grades than do boys, from kindergarten through college, including grades in mathematics. In the latest year for which we have data, girls comprised 48% of all college math majors, took 56% of all Advanced Placement exams, and took 51% of AP calculus exams (College Board, 2008). In 2008, women earned 43% of the bachelor degrees conferred in statistics and math. Despite these statistics, women are seriously underrepresented in the math intensive fields of engineering, computer science and physics in which they comprise only 17, 18 and 19 percent of the bachelor degrees conferred respectively (IPEDS, 2009).

In 2010 the four, five and six year graduation rates reported for all bachelor's degrees conferred to females at all US institutions was 40.6, 55.4 and 59.5 percent respectively. For males the graduation rates were noticeably lower at 31.9, 49.6 and 54.8 percent. These data suggest that females persist more than males as similar trends have been seen since Congress passed the Student Right-to-Know Act in 1990. Paradoxically, recent studies of scientists, engineers, and technologists in business and the high-tech industry have found that women in these fields have higher attrition rates than do both their male peers and women in other occupations (Simard, Henderson, Gilmartin, Schiebinger, & Whitney, 2008; Hewlett, et al., 2008). Although researchers have explored the attrition rates of underrepresented racial minorities (URM) majoring in STEM fields (Seymour & Hewitt, 1994), little has been done to determine actual attrition rates of females within individual universities, let alone nationally.

To date, little work has been done to understand the attrition experiences of undergraduate females pursuing STEM fields. This paper explores, through narrative inquiry,

how women who leave STEM majors interpret their decisions in a broader context of their identity. The attrition profiles herein depict the complex and multilayered relationship between individual experience and cultural context of learning science from individual females' perspectives. As educators, we need this information to understand and improve our practice – after all, differentiated instruction is all about an "n" of 1. As researchers, we recognize that 500 people reporting that they had seen a magician cut a person in half, is not as reliable as that of the lone stagehand who has witnessed the event from behind the curtain (Scriven, 1972). These attrition profiles are of the "lone" female "stagehands" who have "witnessed the event from behind the curtain".

In this paper I first share my research problem and my personal, practical and intellectual goals for doing this study. Next, I situate the study in the literature to provide the reader with an understanding of how my conceptual framework and my experiences led me to the formulation of my hypothesis. I then show how the epistemological assumptions of narrative inquiry make it a great choice in methodologies to achieve my personal, practical and intellectual goals underpinning this study. In the same section, I review the ethical considerations of the study. Finally, I assess the validity of my research design in terms of trustworthiness and limitations in the last section.

**Research Problem, Questions, and Goals**

You can tell what a nation values from the policies it enacts; you can tell how committed the nation is to these values by how they are enforced. In the United States Title IX of the Education Amendments Act says of 1972 says, "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance...

(United States Code Section 20)." With great strides being made in the STEM areas of biology, math, and chemistry (undergraduate degrees earned by women are at approximately 50% in each area- IPEDS 2009 data), I yearn to understand why the areas of engineering and physics lag so far behind (degrees conferred to women are only 17 and 19 % respectively- IPEDS, 2009).

A good starting point here, is to understand why a female who has the intellect and drive to choose to major in physics or engineering, leaves. How does she interpret her decision in the broader context of her identity? How does she rationalize her choice and what does that say about how her identity is affected (or not)? Is she running *to* something or *from* something? How does she experience the cultural climate of learning science? Is it emotionally sensitive and responsive? Does she feel like an "insider" or an "outsider"? How does her identity shape the presumptions she had about learning science at the college level? Is there a disconnect between how she learned science at the high school level compared to college? In short, does she interpret her decision to leave as a consequence of her way of knowing, being and/or learning in the world? In other words, are discriminatory practices evident in the stories of females leaving physics/engineering?

This research will illuminate the human condition of two female physics/engineering students who are "confined and shaped by forces and barriers which are not accidental or occasional and hence avoidable, but are systematically related to each other in such a way as to catch one between and among them and restrict or penalize motion in any direction" (Frye, 1983, p. 4). Consequently, an additional benefit of this narrative research is that it will unveil the values, cultures and traditions of higher education (as seen through the eyes of female students) that are rarely articulated and exposed to critical scrutiny (Turner & Robson, 2008; Trahar, 2008). Likewise, Trahar (2009) indicates that subjecting events inside and outside of the higher

education "classroom" to intense and sustained critical reflection through narrative inquiry can produce "insightful accounts of processes which go beyond the particular story itself" (Pring, 1999, p. 6), [and] can contribute much to effective intercultural communication and to the internationalization of the academic Self (Sanderson, 2007). To borrow further the words of Yale historian William Cronon, "we tell stories ***with*** each other and ***against*** each other in order to speak ***to*** each other" (Cronon, 1992, p. 1374). Accordingly, this research will allow the otherwise marginalized student to be heard; to speak ***to*** the values, cultures and traditions of higher education—and more importantly, to the people that hold them.

**Goals: Personal, Practical, and Intellectual**

In accordance with Maxwell (2005), in this section I discuss my personal, practical and intellectual goals that inspired the need and design for this study.

As a high school chemistry teacher for 20 years and a college chemistry instructor for 11 I have come to realize that I have always been an informal practitioner and researcher using narrative inquiry. Instead of writing up the stories on paper, however, I have held them in my heart and brain and used them to become a better teacher. As I shared my stories with my students, and they with me, a bond of trust was formed. I was proud of the endless number of females I sent out into the world to become scientists and engineers. That is, until they would return to tell me that "they don't teach it the way you did," or that "my professor doesn't even know I exist". With further probing I came to realize that "they don't teach it the way you did" really meant that her professor didn't share the joy of discovery with her and "my professor doesn't even know I exist" meant that in an auditorium of 150 students the professor was not able to witness first hand her enthusiasm for the subject or compliment her on and nurture the growth of her excellent problem solving strategies.

As an informal practitioner of narrative inquiry I have taken their words seriously. Visible in their painful personal stories are signs of broader structural function. I see specifically the disjunction between my pedagogy and the more hostile pedagogy of lecture classes, and I wonder if to some extent I set these students up for failure.

Perhaps as an academic, I can now atone for sending them out into what they perceive as a hostile environment; one that has been passed down from an antiquated, male dominated system of higher education that favors competition over collaboration, lecture over cooperative learning—a world I hoped no longer existed since my undergraduate days of "look to your right, look to your left…". Because my work is my life, I hope to use narrative inquiry to do what in C. Wright Mills views as deliberately intervening in the politics of time and space to connect my private matter of "personal troubles" with the "public issues of social structure" (Mills, in Peters, 2010, p.33). I perform this research not only to give voice to what I personally find troubling, but I do it in memory of a dear friend who struggled with the repression of "the system" and whose life has tragically ended.

Finally, as far as my personal goals are concerned, I hope that using narrative inquiry as my research methodology will expand the reciprocal relations between students and professors to democratize higher education. Mary Parker Follett (in Matthews, 2002, p.41) argues that our instinct for democracy is rooted in a desire for wholeness and mutual support:

> We have an instinct for democracy because we have an instinct for wholeness; we get wholeness only through reciprocal relations, through infinitely expanding reciprocal relations.

It is my personal goal to change science education from a gatekeeper mentality to one of a door opener, "bent on widening participation" (Mathews, 2002, p. 41).

As for my practical goals, I want to hold higher education accountable to Title IX, not through law suits, but by creating tools to deter discriminatory practices *(in point, the development of my Index of Inequality; Coefficient of male advantage (CoMA) values formulated during my internship—see final overall conclusion page 200*). Through narrative inquiry, I believe I will be able to hold a mirror up to higher education in the sciences to initiate educational reform and to motivate professors to be proactive in their attempt to make science education inclusive by differentiating instruction. This will support my personal goal of creating a more democratic, emotionally sensitive and responsive system of higher education.

My intellectual goals are diverse and many. As it pertains to this study, I seek to understand how the change in context—from high school to college—affects the decisions a female makes concerning her career and identity. Additionally, I want to experience the process through which she navigates the cultural climate of higher education to better understand why she would relinquish (or change?) her dreams and, from a practical point of view, know how to support future students in this situation so that they reap the rewards of "staying the course".

**Conceptual Framework and Review of the Literature**

Research in the underrepresentation of women in science previously fell into three camps: ability deficits, preferences and cultural biases (see Whitecraft & Williams, 2010, for the full review). It has not been entirely sufficient. Recently (2011) Ceci and Williams concluded that the greatest impact is that of the "free and constrained" choices (preferences) women make:

> Although the reasons for this attrition are not well understood, it appears to have less to do with discrimination or ability than with fertility decisions and lifestyle choices, both freely made and constrained. The tenure structure in academe demands that women having children make their greatest intellectual contributions contemporaneously with their greatest physical and emotional achievements, a feat not expected of men. When women opt out of full-time careers to have and rear children, this is a choice—constrained by biology—that men are not required to make (Ceci & Williams, 2010, p. 275).

Unfortunately their research only looks at women at the professorial level and not those aspiring to become scientists and engineers. Additionally, that they would find "free and constrained" choices of greatest significance seems like a feeble evasion to squarely address the difficulty and complexity of the problem. After all, is a choice really a choice if it is not freely made? Further, Forester (Policy Analysis as Critical Listening, 2006) cautions against Whitecraft and Williams' use of the term "preferences":

> But preferences are just one form of subjective orientations that we might wish to explore. What about 'values'? We say typically that we 'hold' preferences, but we 'cherish' values. We take values to make up part of who we are, what we stand for, what makes us distinctive—in ways that mere preferences do not. When we cannot have one preference, we typically try to substitute another satisfaction in its place (p. 130).

Extending the point further, Forester cites Nussbaum (1986), "But when we cannot honor a value or lose the valued object, we don't simply look for other satisfactions but we grieve, we feel a deep loss for the intrinsic good that we've lost." Despite being rich with empirical evidence and a thorough literature review, a major shortfall of the Whitecraft and Williams (2010) paper is that it mainly includes explanatory research of a positivist nature (via survey and experiments) taken out of context. A more complete understanding of why women leave science needs to address the issue of "values" and identity which Whitecraft and Williams (2010) paper provides evidence of but never directly addresses due to the underlying explanatory paradigm. A more interpretive approach can mitigate some of the shortcomings of that analysis.

Forester reminds us that, " Asking about values, probing for what can be deeply meaningful in a person's life, accordingly, involves an intimacy and requires a degree of respect that asking about preferences typically does not—and so treating another's cherished values as merely strategic preferences can get interviewers in a good deal of trouble." The "trouble" that

Forester mentions could mean both undermining a person's identity as well as not fully understanding the identity of a person *in context*. For this reason, I conclude that most of what we know about the underrepresentation of women in science is incomplete as it mostly stems from an explanatory approach and not an interpretive approach. This research aims to fill that gap.

Precisely because of this lacuna, researchers are turning more frequently to Sandra Harding's Standpoint Theory to address the complexity and the importance of the interpretive nature of the research in an attempt to make it more whole. According to Standpoint Theory the perspective from the lives of the less powerful can provide a more objective view than the perspective from the lives of the more powerful (Bowel, 2011). Since the empirical research addressed above was done from a position of the more powerful, the meaning constructed can be very different from that of the participant/researcher, co-constructed, interpretive knowledge generated from the design of this study. That is, most of the research in this area has been from the outside looking in; with Standpoint Theory, research focused on power relations should begin with the lives of the marginalized.

Beginning with the lives of the marginalized brings us yet to another theoretical model this study will employ, Berry's Model. Indeed, the hypothesis of this study, for the most part, is based on Berry's Model of Acculturation as it explains experiences of cultural encounter. Female students who feel marginalized or separated will tell stories about feeling like outsiders, being misunderstood, or being discriminated against [or experiencing discrimination] and describe their choice to change majors as a consequence of their way of knowing, being, or learning—as a consequence of who they are. On the other hand, students who feel valued and

whose ways of knowing, being or learning is perceived as being integrated or assimilated may change majors for other more positive reasons.

Clearly, what they are saying in their stories of fitting in, or not, can be made sense of through Berry's Model of Acculturation. Acculturation can be described as, "a complex process that includes those phenomena that result when groups of individuals having different cultures come into continuous firsthand contact, with subsequent changes in the original cultural patterns of either or both groups" ( Encyclopedia of Educational Psychology, 2008, p.8). Most of the current literature uses Berry's model of acculturation to distinguish between the four models (separation, marginalization, assimilation, and integration) of acculturation. A comparison of the different models is in order. The first table describes the characteristics of acculturation in which I believe a participant in my study would describe reasons for changing majors (feeling separated or marginalized) in a negative light:

| Separation | Marginalization |
|---|---|
| • In the separation model of acculturation, also referred to as *cultural resistance*, an individual will maintain a strong identification with the culture of origin and does not accept the behaviors, attitudes, beliefs, or values of the dominant or host culture.<br><br>▪ Although an individual may be presented with opportunities to acculturate, the individual consciously chooses to maintain an allegiance with the culture of origin. In this model the | • The marginalization model is described as a rejection or nonacceptance of the behaviors, attitudes, beliefs, and values of both the culture of origin and the new dominant or host culture.<br><br>▪ It is important to keep in mind that a marginalized individual can maintain cultural competence with both groups and have marginal traits as well. Additionally, a degree of acculturation or identification with both cultures |

| | |
|---|---|
| individual only displays the behaviors, attitudes, beliefs, and values of the culture of origin. | must occur before marginalization takes place. |

Source: (Cano, 2008, p. 9)

The second table depicts the modes of acculturation that a participant in my study could interpret changing majors in a more positive light (feeling assimilated or integrated):

| Assimilation | Integration |
|---|---|
| ▪ Assimilated individuals strongly identify with the dominant or host culture, resulting in the loss of the original cultural identity.<br>▪ The assimilation model of acculturation has come to be known as *cultural shift*. Assimilated individuals that no longer identify with their culture of origin may behave in a manner that no longer reflects the behaviors of the original culture.<br>▪ For example, assimilated individuals may no longer speak the native language, listen to native music, take part in native dances, or follow the native culture's dating process.<br>▪ Along with behavioral changes, assimilated individuals shift their beliefs, values, and attitudes to match those of the dominant or host culture**.** | ▪ The integration model of acculturation, also referred to as *cultural incorporation and biculturalism*, is exactly what the term implies.<br>▪ The integration model is a merge and combination of two cultures: the culture of origin and the new dominant or host culture.<br>▪ Individuals in this model may successfully display behaviors, attitudes, beliefs, and values from both cultures. Individuals in this model identify with both cultures and have a level of comfort within both cultures. |

Source: (Cano, 2008, p. 9)

Although narrative inquiry may be used to test a hypothesis such as the one above, the most exciting aspects of this form of research, in my view, come from the little epiphanies emanating from the particulars of the participants stories (more on this in Part II).

As mentioned previously, little is known about the reasons women leave science as most of the research of the underrepresentation of women in science addresses why women don't go into the sciences in the first place. Additional reasons for the dearth of knowledge in the area of attrition may simply be because we do not want to know, we are content with looking the other way, or we would actually have to **do** something if we found out how high the numbers are and how traumatic the experience may be. This study attempts to round out the literature and uses the theoretical argument that "narrative reconstruction is an attempt to reconstitute and repair ruptures between body, self, and world" and that individuals confront the assault (in their biographies) by "linking up in interpreting different aspects of biography in order to realign present and past and self and society" (Williams, in Riessman 2008, p.57). In turn, the knowledge garnered from this study will be the very mirror upon which higher education is forced to reflect on higher education's educational practices in general, and in science education in particular—even with an n of 2!

**Methodology/Epistemology/Ethics**

In recent years there has been a dramatic shift away from positivist, explanatory methodologies in the social sciences, towards a more interpretive approach. Ospina and Dodge (2005), refer to this as the "narrative turn" (p. 144). Accordingly, the narrative turn suggests that social phenomena are not universal, that people in different contexts construct the world in

different ways (Ospina & Dodge, 2005). How just one person perceives and interprets the world *is* significant; especially when some of our national policies begin with, "No *person* shall…".

In this section I define narrative inquiry, explain how and why it makes sense to take a narrative orientation to my research, and discuss the strengths and weakness of this methodology. Then I review the production, collection and analysis of the data followed by a section detailing ethical considerations specific to this methodology.

Chase (1995) uses the word narrative to describe "something broad and deep: the entire linguistic event through which a woman constructs her self-understanding and makes her experiences meaningful" (p.24). Taking it further, Lieblich (1998) and her colleagues offer the following definition for *narrative inquiry*:

> Narrative research…refers to any study that uses or analyses narrative materials. The data can be collected as a story (a life story provided in an interview or a literary work) or in a different manner (field notes of an anthropologist who writes up his or her observations as a narrative or in personal letters). It can be the object of the research or a means for the study of another question. It may be used for comparison among groups, to learn about a social phenomenon or historical period, or to explore a personality. (p. 2)

Ospina and Dodge (2005) argue that with this mode of research, meaning can be better unveiled and understood in experience and through practice, and that it is always mediated through language and narrative, thus giving preference to interpretation. Further, the same researchers outline the five essential characteristics of a narrative as:

- accounts of characters and selective events occurring over time, with a beginning, a middle, and an end.
- retrospective interpretations of sequential events from a certain point of view.
- a focus on human intention and action—those of the narrator and others.
- part of the process of constructing identity (the self in relation to others).
- coauthored by narrator and audience. (p.145)

Narrative inquiry is a way of understanding experience and can be as diverse as reconstructing social events from the perspective of the informants; learning about human experience by focusing on the meaning making of social actors; or identifying and interpreting underlying general story lines (narratives) that describe, explain, or legitimate particular social practices, institutions, or structures (Ospina & Dodge, 2005). In this research we learn about human experience of two female physics/engineering students and how they interpret their decisions to leave in the broader context of their identity. At the same time, these "attrition profiles" will illuminate the complex and multilayered relationship between individual experience and the cultural context of learning science.

I turn now to the reasons narrative inquiry makes the greatest sense for the knowledge claims I seek. First, the core of the insights I want to uncover from their two experiences cannot be garnered from a questionnaire or survey. Most of the students who leave science may not have even reflected on how their decisions affected their identity and what if anything was pushing or pulling them into an unanticipated direction. How do they rationalize their choices and what does that say about how their identities were affected? Do they look at their choice as failure or do they spin their identity to interpret their decisions as a success? Do they feel that their decision was freely made or constrained? These insights and rationalization processes cannot be unveiled by a mere survey or questionnaire because they fail to honor what Rabinow and Sullivan (1979) might call "human agency (as opposed to determinism), a theme of human complexity and variety (as opposed to simplicity) and an emphasis on the role of context and world in human activity and especially in the human interpretation of such activity" (p. 12). Unlike explanatory, paradigmatic researchers who "predict events and behavior using laws of

statistical probability to generalize causal relationships" I, as an interpretive researcher aim to "understand intention and action rather than just explaining behavior" (Ospina & Dodge, 2005, p. 146). A compelling story connects personal experience to public narratives, allowing society and the culture of science to "speak itself" to each individual (Berger & Quinney, 2005, p. 10). A survey, crafted from the researchers point of view, could not elicit this authentic response.

A second reason this methodology is the best choice for the knowledge I seek is well articulated in Scott Peters' book, Democracy and Higher Education: Traditions and Stories of Civic Engagement (2010):

> [R]ichly told stories have a great and vastly underutilized power as resources for learning. They are open to multiple- even irreconcilable- interpretations. Rather than being a problem, this is one of the reasons why they are valuable. Not only can they teach us things we wouldn't and couldn't otherwise know; they can also provoke, inspire, and move us to think and act in new ways. (p. xiii)

It is my sincere hope that using this research methodology will be the catalyst that "provoke(s), inspire(s), and move(s) us to think and act in new ways" in the academy.

Finally, because narrative researchers and participants are viewed as being in a collaborative relationship with one another with the understanding that "both parties will learn and change in the encounter" (Pinnegar & Daynes, 2007, p. 9) this method is an excellent model of the interdependence of students and professors and researchers in the academy. It softens the power hierarchy in saying "I want to learn from you," "what you have to say is important," and "I care about how you perceive the world." Forester (2006) says that, "opening the door to interdependence is like opening a treasure chest" (p. 582), in this case narrative inquiry is the key to opening that chest.

In short, lived and told stories and the talk about the stories are one of the ways that we fill our world with meaning and enlist one another's assistance in building lives and communities

(Clandinin & Rosiek, 2007, p. 35). The process of narrative inquiry will help us build better lives and better communities.

Much of the above speaks to the strengths of narrative inquiry—the richness of the stories told, the natural process of telling and re-telling stories to make sense of our lives, the ability of a story to "provoke, inspire, and move us," the co-construction of knowledge, the ability to understand the complex, multilayered problems in context,… and the list goes on. The literature does cite some of the weaknesses of this methodology, however some do so by falsely by trying to jam interpretive research into the traditional, scientific method paradigm whose nature is prescriptive, predictive, generalizable, and (seemingly) definite (see Flyvbjerg, 2001, for an excellent critique). I look at these issues further in the final section entitled, "Trustworthiness and Limitations."

Next, I review the structure of the narrative process in terms of what Reissman (1993) calls the "Telling," "Transcribing," and "Analyzing."

**Telling**

I used purposive sampling to select 2 participants who excelled in math and science in high school. I allowed students to choose where they would like to be interviewed and neither had a preference, so we used an empty conference room in my building. The interview questions I prepared in advance were as follows:

1. Tell me about (student's name? or "yourself"?).
2. Who are your heroes/heroines and why?
3. What are your hobbies and what do you like to do in your spare time?
4. How were you raised and what are you most proud of as an adult?
5. Tell me about a significant episode or a memory from:
   a) elementary school
   b) middle school
   c) high school
   d) college
5. What kind of a person were you during each stage?
6. Who were significant people for you during this stage, and

why?

7. Tell me about your overall college experience.
8. As a freshman I see you majored in physics/engineering. Can you tell me how you were inspired to major in this area?
9. How did your pre-college experience nurture this desire?
10. I see you changed your major to _____. Can you talk to me about the events that led you to change your major? (Further probing questions: How did you handle X? How did you respond to Y? What did you do about Z? (Forester, Exploring Urban Practice in a Democratizing Society: Opportunities, Techniques and Challenges, 2006)
11. What would you say was the single most important reason why you changed your major?
12. Who are you today, as a result of your college experiences and how have you changed since high school.
13. What, if anything, could have kept you moving toward your original goal of becoming a physicist/engineer?
14. If you could change one thing about the college experience what would that be and why?
15. What kind of legacy do you want to leave behind for other students who have had similar experiences?

<u>Telling—(After Transcription)</u>

16. What lessons can we learn from your story?
17. What else might you have done, if you had it all to do over again?
18. Is this you?

Questions 1-4 were "ice-breaker" questions to make the student feel comfortable and to set the tone that there are no "right or wrong" answers in the interview. Questions 5-7 were modified from Lieblich et al. (1998), while questions 7 to 12 were intended to illicit a cultural perception in the broader context of the students' identity. Questions 13- 17 move us from the way things are to how they should be through the students' eyes [specifically, questions 16 and 17 are taken from Forester (Exploring Urban Practice in a Democratizing Society: Opportunities, Techniques and Challenges, 2006, p. 576)]. Finally, after time for reflection and transcription, questions 16 and17 give us additional reflective insight in our phenomenon of interest, while question 18 is a validity check, " did I get this right?" suggested by Reissman (Reissman, 2008, p. 140).

Through this sampling and interviewing strategy, I sought to understand how my participants make their contradictory experiences of achievement and struggles intelligible and meaningful. I asked students to elaborate on different aspects of the interview by using what and how questions to highlight the relationship between culture and experience (Chase, 1995, p. 31). Further, I believe the questions and design of the interview above adhere to Forester's eight guidelines:

- Choose actors, not spectators, intimately engaged with a problem that you find crucial, fascinating, and compelling.
- Ask those actors to tell the stories of instructive cases revealing both challenges and opportunities.
- Do not ask the actors, 'What did you think about X?' Ask 'How did you handle X?'
- Get the actor's story with a trajectory.
- Help the actors help us: ask for relevant details, not good intentions; ask for examples, not abstractions.
- Ask for practical implications.
- Allow time for reflections and 'lessons learned'.
- Give 'reflection' content by mining the riches of surprise (Forester, 2006, p. 576)

After soliciting the stories of the two female students, I transcribed the interviews to create "attrition profiles" in accordance with the suggestions of Reissman (1987) (see below) and Peters (2010) (see page 73).

**Transcribing**

I used two digital tape recorders (one as a backup and for clarity in case of "muffled words") had them professionally transcribed and listened to them over and over again to experience the full essence, intonations and complexity of the conversation. I adhered to what Reissman (1987) calls a "fully formed" narrative by including six common elements:

- abstract (summary of the substance of the narrative),
- orientation (time, place, situation, participants),
- action (sequence of events),

- evaluation (significance and meaning of the action, attitude of the narrator),
- resolution (what finally happened), and
- coda (returns the perspective to the present). (p.19)

According to the same source, it is through these structures that a teller constructs a story from a primary experience and interprets the significance of events in clauses and embedded evaluation. Most importantly, the student had multiple opportunities to change and add comments to the final story in accordance with Peters' model outlined in Democracy and Higher Education: Traditions and Stories in Civic Engagement (2010) (see "How the Stories were Constructed" p. for more detail).

**Analyzing**

In an analysis of over 200 life story interviews, McAdams (1985, 1987, 1993) proposed the following features for the understanding of life stories:

1. *Narrative tone.* The overall tone of the life story may range from "hopeless pessimism" to "boundless optimism." In Western literary tradition, the more optimistic narratives have been termed "comedy" or "romance," while the more pessimistic end of the scale have been called "tragedy" or "irony" (Frye, 1957).
2. *Imagery.* The word pictures and sensory expressions that the *I* chooses to convey the unique quality of the person's experience—an individual's favorite metaphors and symbols—create an important feature of the person's identity.
3. *Theme*. "Themes are the goal-directed sequences that characters pursue in narrative"(McAdams, 1996, p. 308). McAdams, Mansfield, and Day (1996) have studied life stories predicated on a comparison and contrast of the themes of agency (autonomy) and communion (affiliation). Hermans (1993), likewise, has conducted several studies using what he calls Valuation Theory. Life story themes of "S" ("self-enhancement motive") and "O" ("the longing for contact and union with the other") form the basis for comparison and contrast in his work.
4. *Ideological setting.* This "backdrop of fundamental belief and value that situates the plot in an ethico-religious location" (McAdams,1996, p. 308) also generally includes an early incident that tells the story of how these values came to be.
5. *Nuclear episodes.* These are particular scenes that stand out in bold print in the life story…. Of most importance are high points, low points, beginning points, ending points, and turning points in the story. These constructed themes typically affirm self-perceived

continuity or change in the Me over time (McAdams, 1996).

6. *Imagoes.* McAdams (1996) defines these as idealized personifications of the self that function as main characters in narrative. Often stock characters like the "good friend," "the intellectual," "the clown," etc, they personify aspects of the *Me*. Research suggests that between about two and five main imagoes can often be identified in an adult's life story (McAdams, Mansfield & Day, 1996).
7. *Endings.* Through what he calls the "generativity script,"McAdams (1996) suggests that the ending of the life story is not necessarily death, but that we gain a sort of immortality through the generativity, creation, nurturance, or development of a possible legacy of the self for future generations. "The generativity script provides a narrative mechanism whereby the *I* can create a *Me* that 'outlives the self'" (p. 309).

Although a majority of the analysis dealt with the latter six (thematic analysis) in the context of the learning culture in science and the students' identities, tone was important to ascertain the canvas upon which the story was painted. As articulated in the "Discussion and Analysis" section, other aspects of performance and structural analysis did pique my interest and influenced my overall analysis, however my main emphasis was on thematic narrative analysis.

Finally, the inherent risks in social science research have been described by some as being in no way comparable to the participants in for example, biomedical research. I disagree. I believe that I should be a guardian of my students' futures (their lives) and was prepared to encourage them to use a pseudonym if I felt one was warranted. Others say IRB process is more to protect the institution and not the participant (see Seidman, 2006, p.77). Regardless, I recognize the value of a complete consent form that made clear my purpose, research design, methods, and relationship with my participants. Seidman (2006) believes that the process of making an informed consent form clear, can lead to a more equitable relationship with the participants and to "the increased effectiveness that almost always flows from equity" (p.77). Consequently, although I do not believe either of my participants needed to use a pseudonym, one did choose to use the pseudonym of "Lucy Vela".

**Trustworthiness (Validity) and Limitations**

Paradigmatic knowledge associated with laws and principles, used to predict and control, and the implied "objectivity" associated with the traditional, scientific method is inadequate in penetrating the complexities and multiple layers of lived human experience (see Flyvbjerg, 2001, for an in depth critique). Therefore, in exploring the "subjective truths" of our participants or the process of narrative inquiry as a whole, we look instead, to the "trustworthiness" of the data. Consider the description by The Personal Narrative Group (1989):

> When talking about their lives, people lie sometimes, forget a lot, exaggerate, become confused, and get things wrong. Yet they *are* revealing truths. These truths don't reveal the past "as it actually was," aspiring to a standard of objectivity. They give us instead the truths of our experiences….Unlike the truth of the scientific ideal, the truths of personal narratives are neither open to proof nor self-evident. We come to understand them only through interpretation, paying careful attention to the contexts that shape their creation and to the worldviews, that inform them. Sometimes the truths we see in personal narratives jar us from our complacent security as interpreters "outside" the story and make us aware that our own place in the world plays a part in our interpretation and shapes the meanings we derive from them. (p. 261)

Further, narratives must be seen as interpretive, and the researcher as interpreting those interpretations. Therefore, narrative research does not aim at certitude, prediction, and control; it is about interpretation that is trustworthy and valid ("well grounded; having such force as to compel acceptance") (Personal Narrative Group , 1989, p. 261).

As Polkinghorne (1988) explains, concepts such as "cause," "validity," "justification," and "explanation" were redefined as part of the effort to limit knowledge to whatever could pass the test of certainty. The same author asserts that if investigative criteria are to be effective for

research aimed at understanding aspects of the realm of meaning and its linguistic structures, the basic definitions of the concepts concerning the generation of knowledge must be reclaimed. Polkinghorne argues that human science can be made more inclusive by pointing out how these reclaimed concepts apply in a more open research model. "Human science can no longer only seek mathematical and logical certainty. Instead, it should also aim at producing results that are believable and verisimilar" (Polkinghorne, 1988, p. 160).

The quality of the meaningfulness of the attrition profile stories gathered from my research, rather than the factual truthfulness, give my participants' stories credibility (Giovannoli, 2001). According to Doan (1994), "The hearers of the story believed that it was true because it was meaningful, rather than it was meaningful because it was true" (p.2). Similarly, Giovannoli (2001) characterizes the narrative mode of thought: " … good stories that gain credence through their lifelikeness; … concerned with the particulars of experience; it chronicles events over time. The proper venue of the narrative mode is within the subjective world of meaning" (p. 11). Conversely, the paradigmatic world is concerned with abstract and general theories in the empirical world of universal truths (Giovannoli, 2001). Concerning credibility further, McAdams (1996) offers this perspective:

> As imaginative stories of one's real life, functioning to give life a meaningful ordering, life stories may be judged by such aesthetic standards as coherence and richness and by such pragmatic standards as credibility. Lying somewhere between pure fantasy and slavish chronicle, life stories are psychosocial constructions that aim to spell out personal truths—narrative explanations for life-in-time that are believable, followable, even compelling. (p. 307)

To establish the "trustworthiness" and validity of my research, I have been mindful of Lieblich (1998) evaluation criteria for narrative studies [for alternatives see also Reissman (2008),

Flybjerg, (2001)]. The table below describes Lieblich's (1998) this criteria and the actions I took to adhere to the criteria:

| **Criteria and Description** | **My Action** (To assure this criteria was met…) |
|---|---|
| ***Width: The Comprehensiveness of Evidence*** This refers to the amount of evidence that is provided to allow the reader to make an informed judgment on the evidence and its interpretation. | My interviews were comprehensive and in excess of 150 minutes each. I was continually asking my participants to give me instructive examples of challenges and opportunities, specifics of how they dealt with different experiences and their feelings about the outcomes of the incidents they provided. |
| ***Coherence: The Way Different Parts of the Interpretation Create a Complete and Meaningful Picture*** Lieblich and her colleagues distinguish between internal coherence (how the parts fit together) and external coherence (how the research compares to existing theories and previous research). | In the analysis, I show how the different parts of the interview fit together as I cite multiple excerpts from different parts of each interview. I tie in Berry's Model of Acculturation (specifically marginalization and separation) and Standpoint Theory to show how this research compares to and connects with existing research. See page 74 for the external coherence to existing empirical research themes. |
| ***Insightfulness: The Sense of Innovation or Originality in the Presentation of the Story and Its Analysis*** Does this research move the reader to greater insight into his or her own life? | In the section on "How to Read the Profiles" (p. 74) I specifically ask the reader to interact with the profiles to provide insight into his or her own life. I then proceed to share my insights and personal stories throughout to model how this is done. Additionally, I spend a considerable amount of space showing the advantages of the "universalizability" of narrative inquiry and how understanding someone else's story helps us to understand our own. |
| ***Parsimony*: *The Ability to Provide an Analysis Based on a Small Number of Concepts, and Elegance or Aesthetic Appeal*** This refers to the literary merits of oral or written presentation of the story. | Although I do agree that there is elegance in simplicity, I do not necessarily see additional validity or trustworthiness in *the ability* to tame the messiness of life. For me, this hints of a positivist approach and does interpretive research a disservice to imply that this is necessary. Organizing my participants' interviews into a coherent, storied profile allowed me to select a small number of themes for analysis. |

Lastly, an ongoing process of consensual validation by which the "sharing of one's views and conclusions and making sense in the eyes of a community of researchers and interested, informed individuals" advocated by both Riessman (1993) and Lieblich et al. (1998) (in Giovannoli, 2001, p.43) will continue to promote discussion and validate aspects of my study for years to come. This, in conjunction with "clearly identifying and telling stories of my own background, intentions and purposes throughout the process" (Clandinin & Connelly, 2000, p. 93), and mentioned previously, will help to safeguard the integrity of my study.

As for limitations of this study, a positivist would argue about the inability to generalize with an n of 2. The purpose of this interpretive research is not to generalize, but to provide pivotal case studies through the understanding of intention and action, rather than just explaining behavior. Riessman (1993) also helps clarify perceived limitations of using narrative stating that, "personal narrative is not meant to be read as an exact record of everything or even what actually happened in the person's life" (p. 64). Further, Heron (1981) suggested, "Where the human condition is concerned it is better to be vaguely right than precisely wrong, better to own a fruitful confusion than mask it with irrelevant precision" (p. 165).

**Conclusion (Part I)**

> "There is *only* a perspective seeing, *only* a perspective 'knowing;' and the *more* affects we allow to speak about one thing, the *more* eyes, different eyes, we can use to observe one thing, the more complete our 'concept of this thing, our 'objectivity', be (emphasis in original)."
>
> *Friedrich Nietzsche in Flyvbjerg, 2001*

In short, I believe the oversimplified relationship of cause and effect is at the root of the "mechanistic metaphor" (Giovannoli, 2001, p. 21) of what "good science" looks like. The "scientific" method is "insufficient to account for the multiplicity of events (referring to the past,

present, and future and to the relationships with other actors) that together form an interconnected totality" (Giovannoli, 2001, p. 21). "Attrition Profiles: In Their Own Words," honors the wholeness and complexity of life in context. It is my hope that this research provides pivotal case studies of the "subjective truths" of women to reform higher education, help retain women pursuing science degrees and enhance the quality of science as a whole—for *both* women and men.

## References


Berger, R., & Quinney, R. (2005). *Story telling sociology: Narrative as social inquiry.* Boulder, CO: Lynne Reinner Publishers.

Bowel, T. (2011, March). *Feminist standpoint theory*. Retrieved January 12, 2012, from Internet Encyclopedia of Philosophy: http://www.iep.utm.edu/fem-stan/

Cano, M. (2008). Acculturation. In N. Salkind, *Encyclopedia of Educational Psychology* (pp. 8-9). Thousand Oaks: Sage.

Ceci, S., & Williams, W. (2010). Sex differences in math-intensive fields. *Curriculum Directions in Psychological Sciences, 19*, 275-279.

Chase, S. (1995). *Ambiguous empowerment: The work narratives of women school superintendents.* Amherst: University of Massachusetts Press.

Connelly, F., & Clandinin, D. (1990, June-July). Stories of experience and narrative inquiry. 9, no. 5 (June–July 1990): 2–14. *Educational Researcher, 9*(5), 2-14.

Clandinin, D., & Rosiek, J. (2007). Mapping a landscape of narrative inquiry: Borderland spaces and tensions. In D. Clandinin (Ed.), *Handbook of Narrative* (pp. 35-75). Thousand Oaks, CA: Sage.

College Board. (2008). *AP Summary report (calculus AB, computer science A & AB).* Retrieved from http://professionals.collegeboard.com/data-reports-research/ap/archived/2008

Cronon, W. (1992, March). A place for stories: Nature, history, and narrative. *Journal of American History, 78*(4), 1347-1376.

*Encyclopedia of Educational Psychology*. (2008). (Sage Publications) Retrieved September 19, 2009, from <http://www.sage-ereference.com/educationalpsychology/Article_n3.html>

Flyvbjerg. (2001). *Making social science matter: Why social inquiry fails and how it can succeed again.* Cambridge: Cambridge University Press.

Forester, J. (2006, December). Exploring urban practice in a democratizing society: opportunities, techniques and challenges. *Development Southern Africa , 23*(5).

Forester, J. (2006). Policy analysis as critical listening. In *The Oxford Handbook of Public Policy* (pp. 122-149). Oxford: Moran.

Frye, M. (1983). *The politics of reality: Essays in feminist theory.* Trumansburg, NY: Crossing Press.

Giovannoli, R. (2001, July 28). *The narrative method of inquiry.* Retrieved January 6, 2012, from Participative Design for a Participative Democracy: http://web.nmsu.edu/~dboje/TDemerys.html

Heron, J. (1981). Experiential research methodology. In P. Reason, & R. Rowan (Eds.), *Human Inquiry* (pp. 153-166). Chicester, England: John Wiley & Sons.

Hewlett, S. A., Buck Luce, C., Servon, L. J., Sherbin, L., Shiller, P., Sosnovich, E., et al. (2008). *The athena factor: Reversing the brain drain in science, engineering and techology.* Boston: Harvard Business Review Research Report .

Lieblich, A., Tuval-Mashiach, R., & Zilber, T. (1998). *Narrative research: Reading, analysis, and interpretation* (Vol. Vol. 47). Thousand Oaks, CA: Sage Publications.

Mathews, D. (2002). *For communities to work.* Kettering Foundation.

Maxwell, J. (2005). *Qualtitative research design: An interpretive approach* (2nd ed., Vol. 41). Thousand Oaks: Sage Publications.

May, G. S., & Chubin, D. E. (2003). A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education, 92*(1), 27–40.

McAdams, D. P. (1985). *Power, intimacy, and the life story: personological inquiries into identity*. New York: Guilford.

McAdams, D. P. (1987). A life story model of identity. In R. Hogan & W. Jones (Eds.), *Perspectives in personality* (Vol. 2, pp.15-50). Greenwich, CT: JAI.

McAdams, D. P. (1993). *Stories we live by: Personal myths and the making of the self*. New York: Morrow.

McAdams, D. P. (1996). Personality, modernity, and the storied self: A contemporary framework for studying persons. *Jounal of Personality, 7*(4), 295-321.

McAdams, D. P., Hoffman, B.J., Mansfield, E.D., & Day, R.(1996). Themes of agency and communion in significant autobiographical scenes. *Jounal of Personality, 64*(2), 339-377.

Nussbaum, M. 1. (1986). *The fragility of goodness.* Cambridge: Cambridge University.

Ospina, S., & Dodge, J. (2005, March/April ). It's about time: Catching method up to meaning. *Public Administration Review, 65*(2), 143-157.

Personal Narrative Group . (1989). Interpreting womens' lives: Feminist theory and personal narratives. In P. N. Group, *Truths* (pp. 261-264). Indianapolis: Indiana University Press.

Peters, S. (2010). *Democracy and higher education: Traditions and stories of civic engagement.* East Lansing: Michigan State University Press.

Polkinghorne, D. (. (1988). *Narrative knowing and the human sciences.* Albany: State University of New York Press.

Pinnegar, S., & Daynes, J. (2007). Locating narrative inquiry historically: Thematics in the turn to narrative. In J. Clandinin (Ed.), Handbook of narrative inquiry: Mapping a methodology. (3-34.). Thousand Oaks, CA: Sage Publications

Pring, R. (1999). The reflective Spin: Case studies of teachers in higher education transforming action. In A.-Y. Chen, & J. van Maanen. Singapore: World Scientific.

Rabinow, P., & Sullivan, W. (1979). *Interpretive social science: A reader.* Berkeley: University of California Press.

Reissman, C. (2008). *Narrative methods for the human sciences.* Los Angeles: Sage Publications.

Riessman, C. (1993). *Qualitative research methods: Narrative Analysis* (Vol. 30). Newberry Park, CA: Sage.

Sanderson, G. (2007). (Education, Producer) Retrieved September 15, 2008, from A Foundation for the Internationalization of the Academic Self: http://jsi.sagepub.com/cgi/rapidpdf/1028315307299420v1

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the Social Sciences* (3rd Edition ed.). New York: Columbia Teachers College.

Seymour, E. & Hewitt, N. (1994) *Talking about leaving: Factors contributing to high attrition rates among science, mathematics & engineering undergraduate majors. Final report to the Alfred P.Sloan Foundation on an ethnographic inquiry at seven institutions*. Boulder, CO:Ethnography and Assessment Research Bureau of Sociological Research, University of Colorado.xi, 544.

Simard, C., Henderson, A. D., Gilmartin, S. K., Schiebinger, L., & Whitney, T. (2008). *Climbing the technical ladder: Obstacles and Solutions for Mid-level Women in Technology.* Stanford, CA: Michelle R. Clayman Institute for Gender Research.

Trahar, S. (2008, Spring). *Teaching and learning: The international higher education landscape - some theories and working practices*. Retrieved January 6, 2012, from The Higher Education Academy: http://escalate.ac.uk/3559

Trahar, S. (2009, January). Beyond the story itself: Narrative inquiry and autoethnography in intercultural research in higher education. *Sozialforschung, 10*(1).

Turner, Y., & Robson, S. (2008). *Internationalizing the university.* London: Continuum.

U.S. Department of Education, National Center for Education Statistics, 1998–99 and 2008–09 Integrated Postsecondary Education Data System, *Completions survey* (IPEDS-C:99) and Fall 2009.

Whitecraft, M., & Williams, W. (2010). Why aren't there more women in computer science? In A. Oram, & G. Wilson (Eds.), *Making Software: What Really Works and Why We Believe It* (pp. 221-238). Cambridge: O'reilly.

# Attrition Profiles: In Their Own Words Part II

**"The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift."**
*—Albert Einstein*

## Introduction

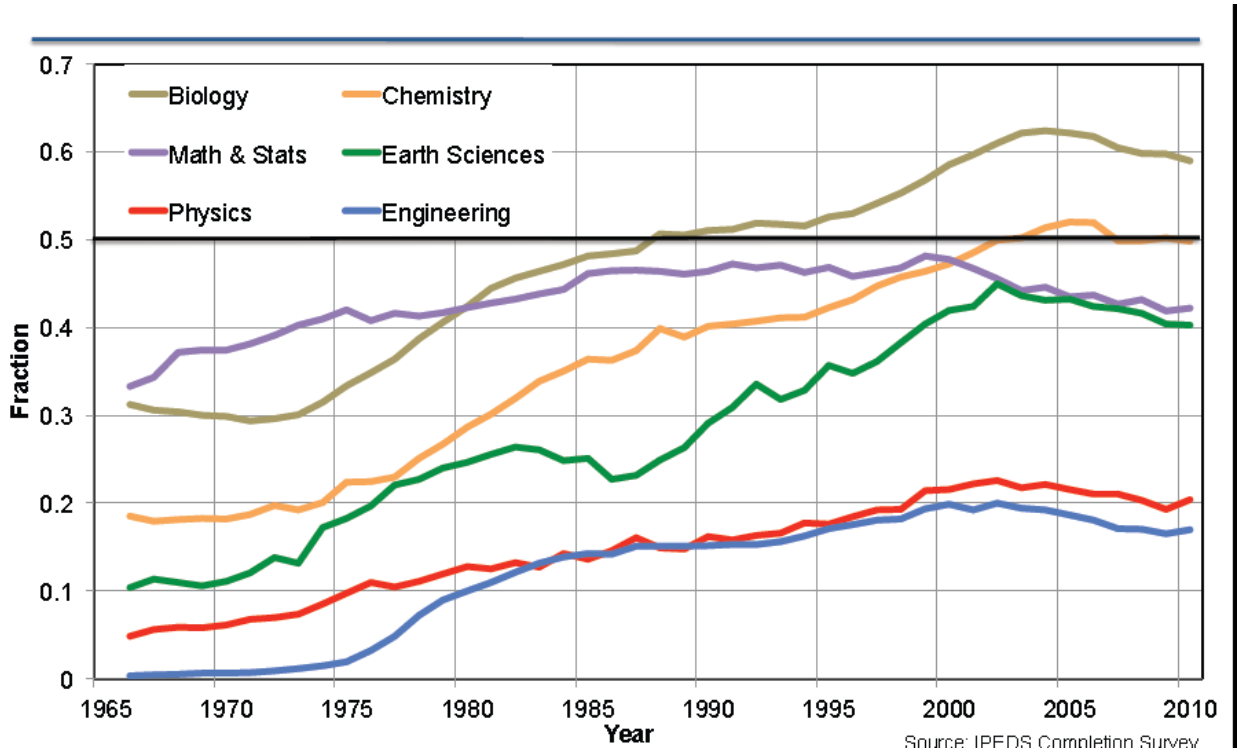
No amount of scientific experimentation is required to confirm what a reflective, veteran educator already tacitly knows: tell your students a story and magically, students give you their undivided attention. As education scholar Robert Nash (2004 ) recalls from befriending "mere journalists": "Tell a story and you've got their attention. Tell your own story and you've got them hypnotized. Get them to tell *their* own stories and you've made friends for life" (p.44). As a veteran, reflective educator for over 27 years, I attribute my success teaching chemistry to the sharing of stories and "informal" data collection garnered through the responsive listening to students' stories. In what follows, I show how caring enough to elicit a story directly from our students (as opposed to combing the literature for "statistically significant data" to improve education policy and practice), can help reflective educators and practitioners to retain underrepresented minorities via academic introspection—by discipline and by individual. Through the power of a story, in both telling and evoking, we academics can re-examine our own complicated truth stories and life struggles (Nash, 2004 ), become more self-aware, and thereby help to create the seismic change that will allow us to better understand ourselves and each other. Importantly, however, it's not about us per se; it is about the students and our relationships with them. This understanding can further help meet the needs of our ever-growing diverse population of students entering the physical sciences (and all disciplines, for that matter).

Narrative is a key source for the kind of information that we need in order to encourage, support and graduate women in STEM fields. With disparate logic systems and diverse experiences comes the creativity and imagination that bridges the interstitial gaps to foster scientific innovation.

Our nations' elementary and secondary schools are making headway in fostering diversity at the college level. In 2011, females took 46 and 47% of all AP calculus and chemistry exams, respectively (National AP Exam Summary Report, 2011). Accordingly, bachelor's degrees conferred to women in math (and statistics) and chemistry were 41 and 50% (2010), up from 1966 statistic of 33 and 19%respectively (Fraction of Bachelor's Degrees Earned by Women, by Major, 2012). A quick look at the National Science Foundation's WebCASPAR database shows the following trends over time:

**Fraction of Bachelor's Degrees Earned by Women, by Major (1966-2010)**

Credit: APS/Source: IPEDS Completion Survey



Conversely, in 2011 females took 31 % of all AP physics exams and yet only 17 and 20% of the bachelor's degrees conferred in engineering and physics respectively, were female (2010 statistic). Although it would be interesting to see if there is a correlation between the number of female students who take AP exams and percentage of degrees conferred to females four years later, these statistics are simply to illustrate the successes and challenges we have working toward parity in the physical sciences. Certainly, not all students who major in the physical sciences and math take an AP exam, nor do all students who take AP exams major in physical science or math. The point here is that increasing numbers of women are taking some of the most challenging courses and comprised 56% of all AP exams given in 2011 and 57% all of the bachelor's degrees conferred in 2010.

Most of the research on women in STEM fields is from the outside looking in. What makes my approach so different, and *logical*, is that I go directly to the source—to those females who have experienced the inside, have decided it is not for them and left. Ironically, it seems that the reasons they give for their decisions to leave are based on what they feel from deep within—from their values, not their preferences. For clarity, Forester puts it this way: "What about 'values'? We say typically that we 'hold' preferences, but we 'cherish' values. We take values to make up part of who we are, what we stand for, what makes us distinctive—in ways that mere preferences do not." The two participants herein, refuse to change who they are for a field that will not honor their contributions and abilities, let alone acknowledge them.

**"The hearers of the story believed that it was true because it was meaningful, rather than it was meaningful because it was true."**
*—Doan*

## How the profiles were constructed

The profiles herein, were constructed from the edited transcripts of narrative interviews of two female Cornell students—one majoring in physics, the other in engineering. The basic format was modeled from Scott J. Peters' approach in his 2010 book entitled, Democracy and Higher Education: Traditions and Stories of Civic Engagement. I paralleled Peters' five step process which can be simplified as follows (see Peters, 2010, p.65 for full description):

1) *Begin by assessing your interests and purposes. Ask yourself what the main issues, problems, puzzles, and questions are that you are interested in exploring through storied accounts of practitioners' experiences.*
   In my case, it was to understand:

   - Why do female students with the intellect and ambition to succeed in STEM fields, leave?
   - How do they interpret their decisions in the broader context of their identity?
   - What is the impact of the experience on these women?

   Peters also tells us to ask how we intend to use the profiles we construct, and what we hope they will help us to accomplish. I have detailed this in the general introduction, however a quick re-cap is to simply understand the attrition experience of women in science in an effort to retain, encourage and support them.

2) *Select and approach potential interviewees.*
   I sent emails out to "featured" women engineers from Cornell's website and they posted my project on their list serve. I also contacted the Director of Undergraduate Studies in the physics Department, Erich Mueller, and he sent my project description to one of the participants in this study, Kendra Bartell. I only had two students respond and they are both in this study.

3) *Conduct and record the interviews.*
   Both participants contacted me via email and I arranged the interviews for both during May of 2012. Although each participant had the option of choosing their interview site, they both met me in a small conference room in my building--Kennedy Hall. Students filled out an informed consent form after I described the study to them. Both interviews lasted approximately 2.5 hrs.

4) *Transcribe and edit the recorded interviews.*

This I did exactly as Peters' describes:

> …[B]egin by transcribing the exact words that were spoken, adding only basic punctuation (e.g., periods, commas, colons, semi-colons, exclamation points, question marks, dashes and perhaps italics or bold or all capital letters to signal changes in tone of voice. We save a copy of this first draft as the original unedited text. We then make a duplicate copy and begin a fairly long and difficult process of editing. During this step of the process we remove all of our words from the transcript, correct grammar, and shape what is left into paragraphs that make sense and flow well from beginning to end. The editing process usually involves removing some parts of the text, and moving other parts around. It involves listening to the recording of the interview several times in order to catch changes in tone of voice, laughter, pauses and other verbal cues that we may want to capture in the profile. It also involves checking back with our interviewees. We ask our interviewees to fix mistakes and fill in missing details, and we give them an opportunity to rephrase or remove passages or words they are not comfortable with. We also secure their approval of the final edited drafts, and their permission to use them. (p. 65)

With my participants, Kendra was able to make clarifications to her profile through email and Lucy and I met again for about 90 minutes to go over the clarifications of her profile. Both approved the final edited drafts and gave me permission to use them.

5) *Work with completed files as "data" for studies, articles and books, or as resources in classes we teach and collective reflection sessions we facilitate with practitioners.*

   I envision these profiles to be used as resources to enhance science education in physics and engineering. I would like to have current and prospective teachers of these courses write "Dear Kendra," and "Dear Lucy," letters detailing what they will do to support them. The solutions that are generated from this process may help to retain future generations of underrepresented minorities.

## How to read the profiles

Beyond corroborating the meta-lessons about what influences female students' decisions supported by traditional research paradigm — having a personal connection with a mentor, not liking the competitive environment, getting equal grades or better than their male counterparts and leaving, understanding math as a gift and not just a product of hard work— these stories are full of little epiphanies, some subtle some blatant. Not only can these singular stories provide rich ideas for educational reform, but they can also be used as a personal and disciplinary

diagnostic for inclusion. Each person who reads the profiles has the potential to find at least one significant lesson. Although your lessons and interpretations may be different from mine, we can all learn, grow, and improve science education by discussing these differences.

I suggest that you read these profiles as I do in order to understand what narrative can provide the researcher. Accordingly, read the student profiles before anything else, and interact with them in such a way that you are mapping your stories on to the teller's story. Do not even read the abstract. Go directly to the profile. Ask yourself, how can I relate to her from where she is? What have I experienced that I would share with her at this moment? Jot your notes down in the margin. Chances are you will see things in her message, that she may not see herself. What emotion does her experience bring to you? She is explaining to you who she is. Who do you think she is and what does this all say about who you are? How could you have helped her be happy with her decision to major in physics/engineering? And, if you are a(n) physics/engineering person, how can you help her "love" what you love? How can you bring the diversity of her experience into your world to enhance innovation and the understanding of science? How can you help her identify more with physics/engineering? Do you think it is through what you teach or how you interact with her? Or both? What are the universalizable possibilities in what you read?

Once you have formed your own opinions, continue on to read the abstract. Then read the discussion and analysis written from my perspective. You will see how I, a woman with different experiences than you, have interpreted her experience and identity. Perhaps you agree with my analysis. Perhaps you don't. Regardless, -- and this is key to the value of any one reading experience to education more broadly -- what will you take away with you from this process to enhance the face of science? This type of research, you see, has not only particular

value (for the story teller) but also universalizable possibilities that offer value beyond the individual (Nash, 2004)). Can you recognize in her experience anything that could be brought into your world of science, which could enhance our understanding and teaching of science?

These are not easy questions to address sincerely. They are especially hard for scientists who have been trained to delete themselves as much as possible from the process. Here, alternatively, the research requires one to enter another's mind and learn what they have to offer. It is self- effacement of a different order. Will you give yourself the chance to get lost in another's story and "fall into the rhythm of those around you" (to use David Brooks words) for something bigger than us all? Do you have the capacity to "derive the gist from complex systems and see patterns" (what Brooks calls *Metis*) in not just the physical world but the human one as well (Brooks, 2011)? Will you care not because you want to, but because you must (see Noddings, 1984, p.83)?

Further, keep in mind that the goal of this paper is to understand why intellectually capable female students leave physics and engineering within the context of their identity in an effort to increase retention. This question deeply precedes and, hence, precludes the distracting disclaimers that some might make, such as, "They just 'liked' English more," or "Their high school grades were inflated," or better yet, "The very prestigious AP exam is flawed," or even "Their parents were pushing them into something they really did not want to do." All of these miss the point, which is to find out how these females come to endow their experience with meaning and what can be learned about the culture of teaching and learning in physics/engineering—that alone, must be the focus. In other words, we need to think, "If Kendra were Cornell's star hockey player and wanted to move to another school, how would we convince her to stay? If Lucy were the top wrestler in her weight class, what would we do to

keep her?" The goal is to know how to keep qualified students in STEM programs, a broad goal achieved at the person by person level.

Objectivity, nonetheless, is still a standard for this approach to knowledge, but at such a personal level, I think we need to shift our understanding of it slightly. The reader/researcher is involved in the research in a new way and so we need Nietzsche's (1969) kind of objectivity whereby we "employ a variety of perspectives and affective interpretations in the service of knowledge (p. 287)". Moreover, as you read the abstract, discussion and analysis from my perspective, keep in mind that objectivity is not neutrality. To paraphrase Dante: The hottest place in hell is reserved for those who remain neutral in a time of crisis. Certainly US physics and engineering are in crisis mode and I am not neutral. As well, although I yearn to be objective, I want my honesty and the honesty of my participants (in both text and subtext) to provide the avenue to objectivity because the more traditional approach to objectivity is problematic, at least for the narrative researcher.

For example, by Haskill's (1998) definition, objectivity is not something entirely distinct from detachment, fairness, and honesty, but is the product of extending and elaborating these priceless and fundamentally ascetic virtues; and to this point, I do aim to work toward objectivity while contributing to the conversation on the underrepresentation of females in physics and engineering. My discomfort with the conventions of objectivity begins, however, as Haskill clarifies what is objective and what is not, with this example:

> Consider an extreme case: A person who, although capable of detachments, suspends his or her own perceptions of the world not in the expectation of gaining a broader perspective, but only in order to learn how opponents think so as to demolish their arguments more effectively-who is, in short, a polemicist, deeply and fixedly committed as a lifelong project to a particular political or cultural or moral program. Anyone choosing such a life obviously risks being thought boorish or provincial, but insofar as such a person successfully enters into the thinking of his or her rivals and produces arguments potentially compelling, not only to those who already share the same views,

> but to outsiders as well, I see no reason to withhold the laurel of objectivity. There is nothing objective about hurling imprecations at apostates or catechizing the faithful. But as long as the polemicist truly engages the thinking of the enemy, he or she is being as objective as anyone. In contrast, the person too enamored of his or her own interpretation of things seriously and sympathetically to entertain alternatives, even for the sake of learning how best to defeat them, fails my test of objectivity, no matter how serene and even-tempered. (p.151)

Haskill's examples well make his point, and more. I find his word choice—treating knowledge construction almost as a war—very disturbing. Not only does he use terms and phrases like "demolish", "rival", "laurel of objectivity", "enemy" and "defeat" in this example, but he later continues to intimate the communal construction of knowledge to be one of a rivalry instead of a cooperative venture in pursuit of truth in advancing the potential of all human-kind.

Here is another occurrence found outside the hypothetical case:

> Nothing is rhetorically more powerful than this, and nothing, not even capitulation to the rival, could acknowledge any more vividly the force and respectability of the rival's perspective. To mount a telling attack on a position, one must first inhabit it. (p. 152)

No wonder there is such angst amongst so many to welcome interpretive forms of research with open arms. If "war" is the position from which we are asking why qualified women leave physics and engineering programs, what will we learn if we pose each other as rivals, and if outright attack is the only way to be objective? And further, what will we look like to the very students about whom we are concerned, especially if their perception of this masculinist version of success is part of their hesitancy to take part? Women in our country are not allowed to take part in combat (nor do I want to), and it is no stretch to say they're also not 'allowed' to be in all sciences (where I want to be).

Ultimately, what bothers me is the tactical dishonesty implied in the language, to inhabit another's mind in order to attack it, to "demolish their arguments more effectively" as Haskill puts it. With all this deception going on among researchers, how can we know anything valid,

how can we claim integrity? The evidence I see (for the last fifty years girls have been excelling in biology, chemistry and math and NOT in physics and engineering), does not support the contention that the fields of physics and engineering are making an effort to increase their numbers let alone welcome diversity.

The profiles in my study come from a sincere place. We need to approach them with sincerity and honesty, or we will miss important ways to help. We can't be that vulnerable if we are at war. Haskill, in fact, lays out where we end up if we do not allow ourselves to interact honestly in our approach to objectivity:

> When the ascetic effort at detachment fails, as it often does, we talk past one another, producing nothing but discordant soliloquies, each fancying itself the voice of reason. The kind of thinking I would call objective leads only a fugitive existence outside of communities that enjoy a high degree of independence from the state and other external powers, and that are dedicated internally not only to detachment but also to intense mutual criticism and to the protection of dissenting positions against the perpetual threat of majority tyranny. (p.151)

As researchers, our independence is admittedly qualified insofar as our funding comes from federal and state government and special interest groups (external powers); and yes, we have been talking past one another, both "fancying ourselves [and our methodologies] the voice of reason." I am confident that it is not too late to redirect the "tyranny" of the cause-effect, traditional research paradigm to come together, understand, and embrace Nietzsche's (1969) point:

> There is *only* a perspective seeing, *only* a perspective 'knowing'; and the *more* affects we allow to speak about one thing, the *more* eyes, different eyes, we can use to observe one thing, the more complete will our 'concept' of this thing, our 'objectivity,' be (emphasis in original). (p. 119)

Therefore, in the spirit of approaching objectivity I call on the physics and engineering community to make the time to lay out why their rhetoric does not match their practice. More on this, as you read the profiles of the participants herein.

Finally, one additional word of caution is warranted before the reader continues on. In assessing the reasons these young women changed majors, it is inappropriate to assign weight to the number of times the participant describes something as a major reason for changing majors—one key defining emotional moment (rational or irrational) may outweigh many smaller happier or frustrating instances. Josselson (2007) describes it this way:

> There are, for all of us, moments that we can remember where a comment from someone else changed our lives—for better or worse—shattering a nascent dream or opening a new path. But we were not the passive recipients of these forces. It was our construction of the other that gave them the power to change our construction of ourselves. (p.20)

In the profiles that follow, we see the role of the "power of the other".

# “It’s Not You, It’s Me”
## Profile of Kendra Bartell

**Abstract**

In this profile, Kendra Bartell recounts how and why she became a physic’s major as well as how and why she decided to leave. In telling her story, we see how deeply personal the choice of a major can be from her use of anthropomorphic language. She says that she liked math, but didn’t “love it” and seems to be employing the “it’s not you, it’s me” break-up line to not *hurt* or “incriminate” the physics to which she had originally committed. Lacking any sense of entitlement, she automatically assumes the qualities portrayed by her high school teacher in the teaching and nature of physics were inaccurate compared to the “real qualities” physics possessed as defined by an ivy-league institution. Described by her friends as caring, loyal and creative, we experience her journey together as she describes her trials and tribulations of a physics whose rules, concepts, “objectivity” and people constrain her while being drawn into the communicative reciprocity, self-affirming, validating and universalizeable nature in the world and people of poetry.

## Student Profile of Kendra Bartell

I was born in Texas and I lived there until I was 5, and then we moved to Connecticut and we lived in a duplex with my aunt. Part of the reason we moved was actually education. My grandmother was a teacher in Texas and she was a second grade teacher and she told my mom flat out that I was smarter at 5 than the kids in her class. A lot of it had to do with ESL learning, because a lot of the kids were immigrants. She told us, "You need to move," and so because my aunt had that duplex we moved to Connecticut. So we lived with her for five years, and then she moved to another town in Connecticut and we moved within the same town. So I lived in Connecticut from the time I was 6 until I came to college. I had changed elementary schools because we moved when I was in third grade, within the same town. And so then by the time I was in high school I was back with some of the people I had known at the first school.

I really liked school. I was really lucky because I had a lot of good teachers. It's odd, though, a lot of my favorite teachers fell on the odd school years, like first grade, third grade and fifth grade were my favorite teachers.

When I moved from one elementary school to another, I was nervous because I was always a really shy kid. I had my set of friends in my first elementary school and then I was really nervous that I wouldn't be able to make friends. I didn't really meet the people I stayed friends with until fifth grade. So, like the first year I moved-- I switched schools in fourth grade-- and so the first year was kind of hard because I didn't really have good friends. But luckily our town wasn't that small, so I still got to see some of my older friends. So it ended up being okay, and then in fifth grade I met people that I stayed friends with.

In elementary school, I really liked animals; I really wanted to be a vet, and I really liked reading, which I mean, I still do. I just really liked animals. We had two dogs and I was in the gifted program, and one of the years I did a whole project about the day the in the life of a veterinarian; I shadowed our vet for like three days. Then, I think I wanted to become a marine biologist in like sixth grade. And then in seventh and eighth grade I really got into reading *Seventeen* magazine and I really wanted to be a magazine editor. That was my dream job— to be the magazine editor of *Seventeen*. That was what I wanted to do in seventh and eighth grade.

In eighth grade I really liked math; that was pre-calc. And then when I went to high school in ninth grade we did geometry and the same thing kind of happened every year. I didn't really love math, but I liked it. Every year, I would start off getting really bad grades because the subject was so different than what we had studied the year before and so I couldn't really make the transition; but then I just like worked really hard at it and teaching myself and going to see the teacher.

Math never came easily to me, but once I started really working at it, I always did fine in the class. Then tenth grade was another version of pre-calculus, and then eleventh grade was trig and then in twelfth grade I was in the higher – the BC calc. So that was like the highest AP level class.

Every year I started off the school year failing math and then I just, I brought my grade up, I think I got an A- in the class (BC Calculus). I never loved math, it was never my favorite. There are some people that are just better at math – they can just innately get it. But I think that the converse is also true, like, I was definitely one of the people where if I work hard enough I can do fine.

I took AP physics in high school in my senior year. My teacher was really inspiring. First of all, she was a woman and she had worked at a nuclear power plant before getting her teaching degree. She had firsthand experience with applying physics to her job. She was just really great, and she was always really open to meeting with everyone. The thing is, though, the idea of physics that I got in high school was not what it is actually is like. I was taking AP physics and AP calc at the same time. We were learning physics without any calculus, which isn't really how physics works. You need the calculus to do physics in such a way that it will actually prepare you for what college physics is like. So I kind of had this distorted image of it. I was really good at physics in high school but that's because it was kind of dumbed down. Even if the concepts weren't necessarily, the actual math and mechanics of doing physics problems and really understanding the math behind the concepts was off.

During my senior year of high school my two favorite teachers were my AP English and my AP physics teachers. My physics teacher – she was funny and she made the material understandable for everyone, and she was just really nice. And then I really liked my English teacher because I really admired her. She went to Harvard for her undergrad and got an English degree and then Brown for her education degree, and then she was teaching at our high school. And so she was just so smart and so well read. I really liked the books that she picked for us to read and the way she had us go through class. She had a better balance of like teaching the AP test stuff versus teaching the other stuff, and so I really appreciated that, because my eleventh grade English teacher was not as good it. For her it was more only about the test, which was boring. But I really liked the way that my AP teacher ran the class, it was a good balance between creative writing things, AP test preparation and actual literature discussions and essays. That was so nice; plus we read really good books! Looking back, part of me wanted to do the

CERN thing because I had an idealized version of physics. I had no idea what it actually meant to do physics. I just knew that it was, you know, this new technology and it was really exciting and so I wanted to be in that, but I had no idea of what – like, day to day, of what I would be doing. And then the other part of me wanted to be a teacher and I didn't know what kind of teacher because I just wanted to be a combination of my two favorite teachers, if that makes any sense.

It's not that physics was less appealing in college; it was just, I could see that I wasn't good at it; maybe part of it was less appealing, because I didn't love it enough to keep working at it. There were people in my class that it didn't come as easily to them as some of the other people, but they did love it enough to stick with it. They knew that was what they wanted to do with their future and I just started to see that that wasn't the case for me.

The way the physics track works at Cornell, you're supposed to take multivariable calculus before you get to electricity and magnetism, but they'll let you take them at the same time. Half the class had already taken multivariable calculus, and so they already knew all the math that went along with the physics, and they could get more involved with the actual concepts. But for me, I was taking them at the same time, so I was learning the math and the concepts at the same time. And so, because I had to work so hard at the math, I couldn't really get into the concepts as much, because I was playing catch-up with the math leading up to the concepts.

When I was in high school they were building the collider in Switzerland and so I had this grand plan that I would learn physics, go get my major and then I would go work in Switzerland. But I didn't have a real understanding of how intense it is to actually get all the training-- there are just so many different topics that you have to master before you can get to

that level. But then once I learned what you would actually be doing I didn't like it that much. I actually even had the opportunity to go to Switzerland to do research at CERN, but at that point I knew I didn't want to stay with physics, and so I felt too guilty because they would have been paying for us…and I just felt too guilty.

I've always loved English more than math and science, it was just I was good at both of them in high school. And so my parents were trying to encourage me to go with physics, but I've always loved English, I've always been a really big reader. I went through my whole magazine phase and wanting to be a Seventeen editor and when I came here, my second writing seminar was with Alice Fulton, who is a really famous poet, and so I started getting into poetry and so then I took creative writing.

In my sophomore year, I took my second class with Alice and it was this class where we read a book of poetry a week. We read contemporary poets and we would write poems in response. I started meeting with Alice and I really loved writing poetry (that's what I'm going to grad school for now). And it was pretty much meeting her I think, that really allowed me to acknowledge that that was what I really wanted to do. She was very encouraging and supportive. In physics the support wasn't to the same extent. I mean all the professors I had were very nice, and my teaching assistants were all very helpful (I used to be in the office hours every day), it's just, I feel like they weren't as invested. I don't mean it like an incrimination or anything.

Alice enjoyed my work and encouraged me further. And I feel like that just kind of goes along with the nature of the work, because writing is personal and subjective and creative, so there's a lot more to give feedback on; more things to discuss. But with physics and the assignments we were doing, the problems you either got it wrong or you didn't. And so there was much less to discuss and receive encouragement about, if that makes any sense. I did fine by

getting Bs and B-s but I would think to myself, "If this is what I'm gonna do for the rest of my life I shouldn't be getting Bs in the classes, I should be getting As!" That's how I thought about it. If this is something I am going to make a living off of it should be something that I'm excellent at.

Jim Alexander was the one of the professors I started doing research under. It was nicer because there were only twelve of us and a higher proportion of girls compared to the beginning classes where there were like 60 students, and there were less than 10 girls in the whole class. And so then going from a big class to a small physics research group where there were 3 girls in the class of 12 allowed me to become really good friends with those two girls and I'm still friends with them. We would meet with Jim one on one all the time, and he made an effort to get to know our lives-- where we came from and what we wanted to do and things like that.

We stayed over the summer my freshman year to really start getting into this, and so we were all basically working full-time, and you would have lunch with him. And then at the end of the semester, he threw us this party at his house and he cooked for us and that was really nice. So I felt connected with him, and I was going to ask him to be my advisor and he knew that, and so he was really supportive when I told him about changing majors and stuff. I think his son went through something similar, and like now his son is teaching at a private school, and so he was very encouraging about my future prospects in school like a social sciences or humanities major.

Thinking back, it was just hard in the big lecture classes. The professors have their own research going on and they do make an effort to meet with you (all of my professors had office hours). They were all very receptive, but it's different when there's like a line of ten people waiting to get into the professor's room to talk about the homework versus meeting one on one

to talk about a book. And I feel like part of it is the class size, like English classes are just tiny. So I was in honors introduction to mechanics, I think it started off with like 70 people and then after the first test it was like 50 because people dropped. And I think it was about 50, and the next two classes were also around 50 people. Yet, when you start professional writing seminars they are capped at like 15 people, and then same with creative writing, I think the cap is 18.

In my first professional writing seminar the teacher was actually a Ph.D. student, and he gave us a lot of feedback, and also through email-- he would talk with us about things. In physics, there's not a lot of feedback. I mean the TAs, they were very helpful. My first TA, he would just let me sit in his office and ask him about concepts. And so we'd always talk about general concepts in the course, too, as well as the specific problems, but it's just a different scope of learning, a different way of talking about things. It's like when you're talking about a book, it's so much easier to merge, or to go from talking about a book to talking about like life experiences and like what has influenced your life to lead you to the reading of the book, but with physics, there's nothing that can really do that, at least not in my experience with my interaction with the professors. It's like even with Jim, we would be talking about a physics concept and it wouldn't just like subtly change into talking about real life. If it ever did, it was like a distinct shift in the conversation. I guess it's a personal thing because I think there are people who physics comes naturally to. For example my ex-boyfriend, he is a physics major, it just comes naturally to him. He just gets it, and he can talk about it for days but I don't and I couldn't, and that was part of the problem. I think I felt that because I didn't feel that way about physics, I felt like something was wrong and so it wasn't for me. I think in choosing your major is definitely personal, because I think there are certain people that they couldn't do that about English like they couldn't do that about a book but I can and so that's why I turned to that. I

definitely think it's personal. I definitely feel when I talk about books with people I feel a connection with them, and I really like learning about why people have certain favorite books and I really like learning what people's favorite books are and then reading them.

I'm probably going to sound really pretentious, but my favorite book is Ulysses. I have only read it through once but I'm going to read it again this summer. I love it! I really admire his writing style, because each chapter focuses on a different element of writing and then they're kind of like constructed differently. For example, there's one chapter that's constructed as a play and then another one is completely stream of consciousness, and there's only like seven sentences in the whole 30-page chapter. Other chapters play with certain aspects of language, like figures of repetition and stuff like that. It's just so amazing to me that he could have come up with that and put it on paper and made it still so cohesive. Despite the fact that each chapter is really disjointed from the next, it's still a book!

As far as physics goes, I couldn't even tell you what aspects I found amazing. I don't know any more-- high school was a long time ago. I guess special relativity was the thing that came the closest to that, because the idea that we could figure that out, I think that time can seem different from two different observers is probably the coolest thing, but we didn't spend that much time on it and I never got to the level when you learned about that in detail. In physics I always like the lectures because I just liked the experience of being in a lecture, and I liked the days when we talked about the concepts more. I less liked the days when we would do like practice problems. So days when we would be going over like special relativity or the concepts behind magnetism, which I don't remember anymore, were good. There would also be days when it would be like all math, and those were the days that I didn't like as much, because I

couldn't really follow along as much, because like I said, I was learning the math at the same time. So with multivariable calculus, I actually learned it in physics before I learned it in math.

I was on the honors track here at Cornell because I had gotten like an A+ in AP physics. I got a 5 on physics and a 4 on BC calc. I'm really good at studying, which is what I think it was. The material was just easier in high school than it was here. But I don't know, when I was dating that guy who's a physics major, he would say sometimes, "You know, if you would come in on the non-majors – or non-honors track, maybe you would still like it". I don't think that's true, because I feel – at one point they do merge, like quantum mechanics, which is the spring of sophomore year, both the honors and non-honors people take the same quantum class, and that was the class that I knew once I got there, like this is not for me. I could not even understand the concepts, which had been the only thing that I really could get a firm hold on in other classes. Like the words aspect of the concepts that led to the math, but with quantum it was just like I didn't get either, I couldn't follow the math, I couldn't do the homework. And so, that would have still happened even if I hadn't been on the honors track, I still would have gotten to that same class and had that same experience, I think. I don't think that being in a non-honors track would have changed my feeling toward the material, because like I said, there was nothing that really made me excited the same way that my English classes made me excited. I think it was more like me, to be honest. I felt more connected to English and to writing and reading and it made me happier and more excited. When I would look at the course catalogues to see what I would be taking, the physics classes felt like things that I had to take, whereas all the English classes, they were courses I wanted to take. I want to take this.. I want to take this…and you're like, I should be taking physics instead of this. I had never even written poetry until I got here; I read it but I mostly read novels. I didn't really read poetry. And so then part of it was my creative

writing professor, she was the first one that was like, "you know, you are a poet, you could do this!" And then I kept going into that class with Alice and I really enjoyed talking about the books that we were reading. The way her class worked, it wasn't a workshop where we talked about each other's poetry, because we read a book a week and in class we would discuss the book and what we could take away from it as writers. And then we would write a poem in response and Alice was the only one that saw it. At the end of the class we shared with everyone but she was the only one giving us feedback about our writing. But like just talking about the books and feeling competent about what I was talking about made me excited. Talking about physics I never felt competent. So even if people in physics told me I was really good at and I still got the same grades as I did in real life, I doubt it would have changed anything. But I can't really say, because if they had said that and it made me – it could have also made me more invigorated in a way, but I don't know because the math was really hard for me and I could not really get my mind around it and the language wasn't working in my head. So I don't know. Even if they had said that something, I don't think it would have changed in that aspect.

In the first couple weeks of class I really didn't feel welcomed, but that was also because I had a really hard time adjusting to college. I had never done like sleepover camp or anything. So college was my first time being away from home. But eventually I met the two girls I stayed friends with, Amrita and Haley. Amrita decided to get a double major in English and now she's going to do "Teach for India" and then figure out what she wants to do. Haley stayed in physics but she concentrated in something outside of physics, and so it's less intense. They're both still physics majors, but they also did other things. We became friends because one day after our section, we all realized that we all had a crush on a TA, and so that's how we like started bonding. And so, the reason we all liked him was because he kind of didn't look like a physics

guy. He was really hip and he seemed artsier than all of the other guys that we had ever seen in physics. And so that's kind of what we liked about him-- he wasn't all that great at physics. No, there was this guy in our section that was like better at it than him. Nonetheless, I think he worked at CERN for like two years. But I don't know, he could have just not been a great teacher too, like people are – I found him to do better one on one. It was less clear when he was teaching all of us, but when I would go it his office, I would – I could ask him all the questions I wanted. So that was – he was more effective that way.

But yeah, so I made friends with those two girls, and then I also – I became friends with a lot of the guys in physics but it was partly because I would ask them for help. And then I became friends with them because I had crushes on them. So it was – I mean it was true, I had a crush on this one kid and he was really good at physics and so he used to help me with my homework. And then I realized that nothing was ever going happen with him, so we just became friends, and we would sit together in class, I liked sitting with him. And that's how I met a couple of the other guys who I became friends with. And we would just start – mostly it would be like we would be doing the homework together and then we'd start going out to Indian food every week, and so that was nice.

In physics it wasn't like – I don't know, it wasn't like I felt alienated because I had a lot of friends. I had my set group of people, and once we got to the third class, you know, I had my friends and we'd do our homework together, and I had people I could call to help me with stuff. But it was more so that I felt like I was the last in the pack. Everyone else got it so much easier than me and they had such an easier time understanding the same stuff. I felt bad asking for them to help me all the time. I know they didn't really feel bad but – or they didn't feel like I was

annoying, stuff like that-- I know they didn't feel that way but that's how I felt about it and so it wasn't good.

And then I started dating my ex-boyfriend when we were in quantum. But because we were starting to date, I didn't want to ask him for help all the time because I didn't want him to think I was stupid. Once I told him I was going to switch majors and stuff, he was like, you should have asked me for help and I would have done all the homework together. I was just like, no, I couldn't have done that, personally, like I couldn't do that. I mean I did ask for help, but I kind of – you felt like you were asking for help a lot. And I felt like that wasn't something that should be happening, if it was what I was supposed to be doing. Because like all the people I was asking for help, they didn't need to do that, you know, they could do the homework themselves and get through it and understand the concepts.

Even though I know I could ask my female friends for help, to be honest, they weren't as helpful as the guys. Like, me and my friend Amrita would do our homework together, but we would both have the same problems. We both wouldn't understand certain things but then the guys would. It was really competitive, really competitive. But I never felt like my friends were withholding information, they just wouldn't do that because they were my friends. I'm still friends with them, well some of them. Take my friend Scott, for example. He is one of the most competitive people I know in the class but he was also one of the people that I always knew I could ask for help. I don't know why – I don't even know how we became friends because we're so different, but he was always so nice about helping me. I knew he would – he wouldn't ever like say, "No, I'm not gonna tell you how to do that problem because I don't want you to get it right." He did always want me to understand. He was probably the person that I got help from the most, which is funny because he is like the most competitive person in the world. I had

friends and I knew they were my friends. I know Scott's my friend, but I didn't feel connected to physics, as a whole. I didn't feel a connection to the physics department and the physics professors, even though my friends were from my physics classes. It's a really weird thing, because I don't know how to explain it clearly really, because I know they're my friends and I know that I could count on them to help me if I really needed it, if I asked for it, but I just didn't feel like it was like whole, if that makes any sense. Whereas, with the English department, I feel like I'm so interested in everything that they do and am interested in going to all the graduate student readings and stuff like that. I got involved with the English Club and I'm doing poetry readings and things like that. I don't know really why it's so different. It's not like the professors weren't nice, it's just I never felt connected with them-- the same way I did with my English professors that I had. I think it probably has a lot to do with learning styles, because the physics classes are so competitive. In physics everyone is concerned with getting the best grade or getting two standard deviations above the mean. Whereas, with English, it's not competitive at all. I mean I guess it's slightly competitive in the creative writing classes because it's a lot easier to be judgmental about people's actual writing, but it's not competitive in the same way. In all the literature classes it's not competitive because you're just describing books, like, there's not a way to be competitive in the same way about that as there is in physics

If I had to rank my high school experience on a scale of 1-10 (10 being the best), I would probably give it a "7" because I had really good class experiences. I really liked the majority of my classes. Even though I started off hating the math classes and just not being good at it, at the end of the semester, or the end of the year, I did like the class usually.

My Cornell experience I would rate as a 5. No, 4-1/2; I wasn't happy. The classes were really hard and I didn't know how to study the right way really. The only classes I liked were

my English classes. It's just the material is so much harder here because the AP physics test, we didn't have any calculus on it, and the AP calc test I only got a 4 on. I was good at multivariable calculus, I liked that class. I actually really liked multi, but then translating the actual math onto the concept of physics and applying it-- knowing what the question is asking and how you should go about answering the questions-- that was just on such a completely different level than high school and it was just so much harder. I was just not good at making those connections and translating the techniques I had learned from my math courses onto the concepts of the physics classes.

I did much better in my multivariable calculus class than in my physics classes that use multivariable calculus. And so I feel like a lot of it is the translation from the pure math ideas, knowing how to do an integral to applying that to the physical situation, like the physics problem was the hard part. It's like I had a handle on multivariable calculus, it's formulas, it's follow-up procedures, but knowing how that translates to physics and answering the right question is different. Nonetheless, if I would have stayed in physics it would have been more like lying to myself than giving up my identity (my friends tell me I am caring, loyal and creative). Because I feel like that's kind of what I was doing for those first two years-- telling myself this is what I want to do, even though I knew it wasn't. I had picked it in high school and I if I picked it I have to stay with it! And so, I wasn't loving the concept of the physics that I was learning and once I started doing the physics research and seeing what an actual career in physics would look like, I didn't like it, it wasn't exciting, it wasn't really interesting to me. And then on top of that, I had started taking the English classes I really loved. And so I feel like it was both, being repelled by what the actuality of being a physics major and what having a career in physics would look like and being attracted to how much I liked English and writing.

If I had to describe a time where I felt really frustrated it would probably be my entire quantum mechanics class. I couldn't do the homework by myself, and then when we had the exams, it was just that feeling where you look at the paper and you're just like, I don't even know what the question is asking me, and that was just so distressing and so upsetting. That was my second semester sophomore year and that was the class that everyone built up because it's on the forefront of what's actually going on in physics research. Once you learn quantum mechanics, you can go forward into this day and age of physics. Because it wasn't interesting to me and I couldn't get any sort of hold on it, I just knew that I couldn't go forward. I feel like I was part of the problem because I really wasn't interested in physics once I actually learned what it was.

I just had this really different idea of what studying physics actually meant coming from high school because we weren't really learning it in high school. I enjoyed the dumbed down concepts-- like the ideas of like black holes and stuff like that, but actually learning what goes into those concepts so that you actually understand the concept fully, that's not interesting to me. It wasn't like I loved physics with all my heart but I still gave it up, so I don't really know how to make the experience better for someone else either.

There have been times when I have cried in front of my professors and that was never fun. Yeah, that was always embarrassing. In my quantum class I met with the professor after the first exam to go over the questions with him and having to admit to him that I didn't even know what the question was asking made me cry because that was really upsetting. So that was really bad.

In my electricity and magnetism lab, I remember being really embarrassed about not understanding circuits and so like one of the labs I just basically I didn't do anything and my lab

partner did everything. But he was my friend so it didn't bother me as much, looking back, as it did at the time. I was embarrassed when the TA came over and asked us about the lab and I couldn't answer any of the questions and my lab partner did all the talking.

Another embarrassing time was over the summer when we were doing the physics research. We had to give presentations and my professor asked me a question and I had no idea what the answer was and everyone in the class was obviously listening to the presentation and that was pretty embarrassing. Maybe people thought I didn't belong there--that's how I felt but I don't know if that's actually how they felt. My friends wouldn't have felt like that but the other people in the class may have.

In English, I cried in front of my professor this past semester but it wasn't really to do with discouragement in anything. It was because I had gotten into University of Washington and I knew that meant that me and my boyfriend were going to break up, and so that's what I was crying about. So I wanted to go tell my professor the news about Washington, and I was so excited because that's where she had gotten her Ph.D. She was the one who actually told me about their program, and so she was really invested and I know she was part of the reason I actually got in. But I went to go tell her and I tried to be happy about it but I immediately started crying because I knew –. And so it wasn't really about English, it was more about my personal life.

Even though this professor, Joanie Mckowski, wasn't my advisor, I met with her so much to go over my writing and stuff, and she really helped me in the application process. We would meet all the time and so she knew so much about my personal life. She knew everything about what happened – what was going on with my boyfriend-- and she would tell me things about her experience. We had a fairly strong relationship and so it wasn't awkward crying in front of her.

I would feel awkward if I cried in front of my one male professor in English but that's because he's a very formal person, and so that would just make me feel weird, too. One time I cried in front of Jim Alexander because I had set up this meeting with him to ask him to be my physics advisor but I set it up like three weeks in advance because I knew he was really busy, and in those three weeks I decided that I was going to switch to be an English major. I still met with him and I started crying because I felt like – I felt embarrassed that, he had invested his time with me in all the research stuff. He was very encouraging and he wasn't awkward. Also it was not as much crying, if that. It wasn't intense. I really didn't love physics, so there is really nothing anyone could do to keep me there. I didn't like what it actually was and so I think it was mostly me realizing that I didn't like it enough to work at it. I don't think there is anything that they could have said that would have made me like it more.

One thing I really do value about English and writing and reading is that you can make something universal for everyone. The idea that people from such different backgrounds could take something similar away from one book is just like really amazing to me. I also love how there are so many different things that you can take away from a piece of literature and that you can learn from or disagree with or incorporate it into your own writing. I also value knowing how to write competently.

Even though there is the "Grand Unified Theory" in physics, I don't care about it enough to try and figure it out myself. In general, the typical physics person values logic and rules. There were some that weren't like that but in some ways they still were. Like, even Scott, he's like a frat bro but he's also very serious about his studies and, he sets aside his time to study. He's really disciplined when he is studying, but then he still has that other side that's not the stereotypical physics nerd, but in some ways, like how he studies, he is very much still nerdy.

An English-person on the other hand is much more freewheeling. I think of them as outgoing. I'm trying to think about when I went to Seattle and I met the MFA students there, I was very nervous to try and hang out with them but they were just so like welcoming. I sat in on their poetry workshop. They were just so much more welcoming and willing to take me along and willing to talk about more things. They had just met me and they like took me out to the bars with them because that's just what they did after class. They were like, oh, you have to come with us, like, blah, blah, blah, and just like took me around and made sure that I got back to my hotel safe. I just feel like that wouldn't happen in the physics department. In physics, they have things like physics colloquium but you know, nobody really made an effort to talk to other people, it was like you talked with the person you went with and you talked about physics and what the colloquium was going to be about, but not so much like other things. I think that sounds really bad but – it was just my experience in the department.

Thinking about my own life in general, probably the single most defining moment I would have to say, I think it's when my creative writing teacher, the Ph.D. student, she said that, I was a poet! That was the first time that I really felt like yeah, she was right! And then it was reinforced throughout my class with her.

My mom and my best friend are really the two most significant people in my life. My mom because I get to talk to her about anything, and my best friend named Yan, because we have like – we are pretty much the same person. I'd say my heroes were my two English professors, Alice and Joanie. And not because Alice was famous, I actually had no idea she was as famous as she was. I was already in her class and on the first day (there were only six people in that first class) one of the girls said, "I can't believe I got into this class with her!" I was like, "Oh, is she famous?" and she said, "Oh my God, yes!" and I was like, "Oh, okay." And I went

and found a couple of her poems and was just blown away by her skill. In high school my stepdad and my twelfth grade English teacher were my heroes. My English teacher, because I couldn't believe that she had gone to Harvard and then Brown and then was teaching at my high school. And before that the editor of *Seventeen* magazine because I just wanted to be her.

If I could change one thing about coming to Cornell: I wish I could have met the friends I have now earlier. I didn't meet them until the very end of my freshman year and I wish I had known them at the beginning of freshman year because I really didn't have a set group for the first three-quarters of the year, and so I felt really like disconnected. I wish I could have met them earlier.

Based on my experiences, the advice I would give to a new student: Make a study group as fast as you can and be outgoing with the people in your classes, because once I found my friends it was easier for a while, until it got really hard and then I knew I didn't like it actually. I'd also tell them not to be afraid to actually talk to the professors because they are really nice and they will help you but you have to ask because if you don't ask then they won't know that you're struggling. I would say try to find one professor that you can really have a personal connection with on top of having them as an academic resource, because they can help you even with other classes and finding other resources or connections and stuff like that.

As a physics student, I may have felt like an outcast a time or two, but I think that was more internal than it actually being the case. With my friends, I felt so far behind that sometimes they would be talking about physics and stuff in the class and I would just be like completely restricted from the conversation because I couldn't get what they were talking about.

I did feel like some of my physics professors cared about me. They were the ones that I was more comfortable with asking for help from, and so they were more invested, but some of

the professors were too intimidating so I didn't ask them for help and they didn't really care. I thought their personalities and the way they taught the class made them intimidating. It is difficult to describe. It wasn't condescending because I know what condescending sounds like. It wasn't condescending but it was done in a way that if you didn't understand what they were talking about it was your fault, if that makes sense. In a way that's different than condescending. And so then I felt inadequate asking questions to them, and so I would ask the TAs and my friends instead. It was more in the way that they conduct the lecture.

It was like that in English too. I did have one English professor that was actually pretty condescending-- only sometimes, but not all the time. It was one of the bigger English classes. They do have some that are called gateway classes and it's like the big survey classes where you go through the first half of English literature. Those were big classes-- there were like 50 people. So two days you had a lecture and then one day was discussion with the TA and the professor was fairly condescending. She would ask a question like, what was one of the themes of this work and nobody would get it. The way she would say the answer was in a way that was like, "I'm so disappointed in you guys and how could you not know this?" And sometimes she just uses these vocab words that were clearly meant to make us feel stupid. But it also might have been me. I just really didn't like her, and she was not as like welcoming in one-on-one meetings as my other professors. But I think part of it had to do with that class, like the structure of the class. To be honest, I've heard really good things about her when you take her seminar classes. So I think part of it is because it was a big class and you have to cover so much material-- we really do have to get through it fast. If we don't get something it is kind of bad because the same thing – I've heard the same thing about one of my favorite professors in the English department, because he also teaches one of those gateway classes, and the people that take the gateway class

with him really don't like him and they don't think he's a good teacher. But I've taken two smaller seminar classes with him and he is one of my favorite professors! He wrote one of my recommendation letters. So I think part of the reason I didn't like that one instructor was because of the form of the class. I mean I obviously stopped taking physics classes before they got to be smaller, but I was dating my ex-boyfriend and he was going through the upper level classes and he seemed to really enjoy the smaller classes. So it's like you do get a more personal relationship with the physics professors once you get past the big intro lecture classes.

I don't know how they could fix the size of the big gateway classes because there are so many people that are interested in physics classes at the introductory level that they do kind of have to be that big. Or they have to hire more people, which, you know, they can't afford.

If I had to do things all over again, I don't really think I'd change anything. I feel like going through physics made me appreciate English more and made me feel more comfortable acknowledging that it is actually what I want to do with my life. I do like a lot of people that I met and some of them are still my really good friends. I definitely think my poetry professor calling me a "poet" made me feel great, but I don't think that if someone had said something like that to me about physics it would have changed anything to be honest. I just didn't love it. But, if there was a girl that was struggling but she still really loved it and a professor said something like that to her, I'm sure it would affect her similarly-- and make her keep going. I think part of me knows it's because it honestly wasn't for me, the material and what a career path in physics would lead to. That's not what I wanted. I mean I guess there are some ways that you can be creative, but it's still limited by the actual rules of the physical world and the rules of mass. I mean there are people searching for the Grand Unified theory but you're still working with a set number of tools and a set number of mathematical concepts and constraints. So it's not the same

as English. For my female friends that stayed in physics, I think that they just like the material more. They liked learning about the math behind the concepts and why the concepts exist, whereas I don't. It doesn't interest me as much as I thought it did when I was in high school.

One of the happiest times I had in physics, was probably when I had that dinner at my professor's house. It didn't have that much to do with doing physics. It was just doing something with people I liked and I thought that was really nice.

In English one of my happiest times was saddest the saddest, too. It was my last class with my advisor, Alice two Wednesdays ago. We were having poetry readings where we all read from our chapbook (a collection of 10-20 poems) that we made, and she had made a big deal about telling everyone in the class about me going to Washington and like how proud she was of me. And she read us this poem, it's called Ithaka, but Ithaka spelled with a K, by a Greek poet, and he is Constantine Cavafy, if I remember correctly. I had read the poem two years ago in the class with her, but she read it out loud to us this year for all the graduating seniors. We were all bawling because it's like the saddest poem when you're about to leave Ithaca.

At the end of the class I went up to her to see if she was going to be at the English graduation ceremony but she wasn't which was a bummer, because I wanted my parents to meet her. That day she told me that when she was reading through my chapbook, that I was going to have a book soon! I was just like, "Oh my God!" because she was the person that inspired me to actually become a poet and allow myself to do that. Her saying that is just the biggest compliment that anyone could ever give me, and so that was really amazing!

Who am I today? I don't know, that's such a hard question. I don't know, I mean I love reading, I love writing and I love talking about books, and I'm really excited to be teaching next

year, because I'm going to be a teaching assistant. I'm going be teaching freshmen so that's going to be really exciting.

Learning about English and literature is what I want to do! I applied to grad schools and was rejected from all the top places that funded you when you got in. Then I got into three schools and none of them were giving me any money at first, and so I had no idea what I was going to do. I had gotten in and so I would feel really guilty giving one up, but at the same time, I couldn't afford it-- I would have to take out like so many loans. But then what happened was with Washington. They only have three TA positions for the incoming class, and if you get one, you're funded completely, and so I didn't get it originally but I was on the list if one of the original three people declined. And so that's what happened. And so then I got offered the TA position and my parents were so excited and they're so happy. They also didn't want me to follow my ex-boyfriend around.

Overall, changing my major was such a personal thing and less so to do with the structure of the physics department. It's just I didn't feel as much of a connection with the majority of the people that I met in physics. Despite that, I do think that people were accepting of who I am. I had genuine friends, and the professors that I went to and got help from and were genuinely interested in helping me understand the material. It was just me – I don't know how it's possible for someone to stay with it if you don't love it.

# “I’m Not Accredited; I’m Independent!”
## Profile of Lucy Vela

**Abstract**

In this profile, Lucy Vela recounts why and how she became an engineering major and the circumstances surrounding her decision to change majors. She describes seeing her high school engineering teachers “all in one room together and talking about engineering and working together,” and” being among them” “enjoy[ing] that interaction.” In her story, she tells us how her pre-college teachers and community supported her to “get her out of the system,” and how that same type of support and encouragement was withheld at Cornell. We later hear how Cornell’s vision and curriculum greatly differed from her vision of “doing engineering” and how she came to re-define what success looks like. With her competitive, feisty spirit we see how she “sacrifices” accreditation and navigates a world of mixed messages—co-opting at times, and “break[ing] free” at others—all in an attempt to hold true to her values and “do” independence.

## Student Profile of Lucy Vela

I'm a junior in the College of Engineering. I'm doing an independent major, where my primary focus is in ORE, which is Operations Research and Engineering. My secondary focus is in product/facility development. Basically, I've co-create a department with two departments--ORE and another one with my advisor, Professor Klausner. We were able to create a schedule for me to finish the last sixteen credits in my major. So the independent major isn't accredited, but it's one of the other majors in engineering that a lot of people don't usually elect.

So the way I usually like to give my spiel, especially to interviewers for jobs and such, is that my program gives students within engineering a chance to really honor the credits that they took the first two years of their time here at Cornell, which were basic engineering courses that everyone took. And for those engineering courses, I enjoyed the material. They were informative; math, sciences and such. But then once you went into my major past the sophomore year, it's a little too late to leave. And my interests changed, and they weren't completely in ORE. So I enjoyed some of the courses. The sixteen credits allowed me to take it in any college, as long as it's some cohesive program that an advisor will foster and approve and continue to guide you.

As far as job prospects are concerned, the easiest one I could see was a consultant. In consulting there's often a need to really serve as a liaison between the engineers who think technical, and then the consumers who don't necessarily need to know and are paying not to know these technical things. That was what I wanted to do.

Through my course-work I discovered my dream job would be in product management. And it does have some sense of engineering. A lot of the professions and the job descriptions

that I see prefer engineers, but it would basically entail managing the evolution of a product, be it in a firm or on your own.

To give you a little background, I attended the School for Math, Science, and Engineering at City College in New York City. That's down in Harlem. And it's not – at the time, it wasn't known as a feeder school, but it's a feeder school to engineering schools. I first decided to go to that high school because it's one of the specialized high schools in New York City, and of my choices, that was the one that my dad and I agreed because I had more interest in math than I did other options. Styvesant was just too large, so I really wanted a small school, and that fit the bill. It was an easy commute from my home, and so that's why I really liked it. And when I was in the school, the only really tough engineering part of it was that they had a college level, add-on class where they showed you all different types of engineering. So I took civil engineering, principles of engineering, and mechanical engineering. In my final year, you're able to specialize in something, which is what I did and found engineering colleges really like that.

At first I thought civil engineering was my favorite because it was really fun to produce something online. We were taught REVIT, which I'm coming here to Cornell, and that's just new. So I'm just shocked that I had learned something in high school that they were actually using at Cornell. And it was really nice to hear that the little programs that I was making were actually awesome and I am sad I didn't save many of them. So yeah, I just found it fun for the creative part.

Although I couldn't say that I had any one particular inspirational teacher in high school, I did have a lot of teachers that were really good at what they were doing and many of them were past engineers who came to teach and were wanting to continue the craft. There were a lot of

opportunities to see them all in one room together and talking about engineering and working together. I saw that type of interaction, and I really liked that. In a club that I joined, I was a student representative for the school and that was nice because I was able to sit amongst them and hear what their thoughts were and see why they made decisions. I really liked that. And I thought, "You know, if they are engineers and they're awesome, then I might as well just see what engineering is doing. And I really like math. And what better way to start than with an engineering track." Also, I was really good at physics and I thought that would help me out so much when I got to Cornell. It kept me motivated because the courses were so much more tough than I expected them to be. And so, I chose advanced physics for my focus, which was one of the eligible engineering ones. And so that was great. In high school you could receive college credits for the classes I was taking from the City College of New York, but coming to Cornell, I didn't elect to keep them or transfer them over.

During my pre-freshman summer program at Cornell my advisors suggested that I take chemistry first and then physics just because of the seat capacity, and that it would really keep my courses going swell in terms of the availability of other courses. And so I took chem first and I got a "C". I was just devastated. For it to be your first semester and to do poorly, it really just set me off horribly and that was so tough that going into physics, I kind of was like down.
I didn't do as well in physics as I had hoped. I got a B, which a lot of people were just like, "why are you complaining?" I was in office hours all the time and it was one of those, "I'm-not-going- to-fail-again, I-just-can't-do-this, this-is-in-a-subject-that-I-love, this-is-unacceptable," deals. So I made friends like with the professor and I said, "Listen, I really need to pass. I don't want to just pass; I want to excel in this class." I worked through it and for the final I got a really good grade.

My chemistry class was in Baker Lab and was huge-- about 200, if not more. All the students were engineering majors which meant steep curve…steep everything. The professor was new and I guess it was better compared to the professor before because everyone just complained about him not being considerate of everyone's time and not really knowing how to teach students. He would keep students over or say, "This is *my* class!" I remember times just being in Rockefeller Hall, which is so much closer to the engineering quad than Baker, and I would just have to run, and literally like run my butt off, in order to make it to my math class on time and get a good seat because they're so large.

I think Cornell's engineering school (or whoever did decide to make the program) is awesome because I made most of my friends the summer before coming here. We took a couple of the introductory courses like Math 1910 and were able to get about nine credits ahead of other students. That really helped us out and at the same time they could see how we did in the courses. So those are the friends that I really went in and like huddled with when times were tough. But I guess even having that friendship, it didn't help much. It's sad to say, because it's just embarrassing for you to say, "Oh, my gosh, I'm failing my tests! Like, I don't even want to show you my test grades. I'm not gonna be able to tell you that although – even though you're doing okay and you understood the material- I, sitting in front of the teacher for the entire semester, I still don't understand." And I always knew chem wasn't like one of my greatest things, so that made it all the more difficult to tell them.

Physics has always been easier for me than chemistry. I learned over time (this was after even going to the Students Ability Office and getting checked out to see if I had an issue. Not an issue, but, a setback), that I am a visual learner. In chemistry, in both college and high school, they couldn't do much to be that visual about the subject matter. In high school we had toy

models and that helped me get by, but not in college here. In high school physics, it was really easy for my teacher to just draw out exactly what he wanted and it was great. We had high-scale cars that would just zoom down tracks where we could clearly see what was going on. Here, the physics department has great demonstrations right in front of the lectures. In Rockefeller Hall the auditorium has so much space up front, my professor could do exactly what I would be doing in high school, except demonstrating it for the entire class. So I guess it is a big thing, but I recognized that there are limitations in chemistry that you can't do stuff with. So I think, especially with my high school, they tried to do as much as they could in chemistry. It would take far too long to literally show you what the equation was doing in tangible form-- it would be just too much! My professor here in physics would make it fun because he would show you exactly how the concepts related to what you would be doing outside. He would say things like, "I know a lot of you are engineers. Imagine if you're using a gyroscope, and look at this beautiful phone that you have, and you might want to work on and design software for."

I always parade around like how great the Physics Department is. And I guess it's just they are really intent on having set office hour times with your section TA. They really make sure that your TA is great because they were always in class observing them and helping out. So I think they were great. It wasn't the same in chemistry. In chemistry I felt like my TA (I don't even remember who my TA for the section was) was like, "Pay attention; please don't break any beakers; go in an orderly fashion…" It felt very stereotypical high school (not my own high school), like they were just moving cattle around. Physics lab, especially in freshman year, was nice because it wasn't graded. It was just like if you participated and if you were able to follow along the guides, then you were able to get it done. I also liked that they had a pre-test, which means before lab, you should read this, and you should prepare and answer these questions and

just bring in as much as information from the lectures as you knew. So it made lab go fast, and you understood it.

In high school I enjoyed calculus. I was the salutatorian and got like 95s in math. My calculus teacher was new and he had received so many awards. He was just *really* good at teaching. Calculus here was not such a good experience. I guess I really like math, it's just I found coming to Cornell; it doesn't like me at all! Here, it doesn't matter how many times you sit with a textbook, it's completely different from what the professor is saying. I took my first math course in the summer where they had a PhD student come in, and it was the first time I encountered difficulties with understanding his language or English and I felt embarrassed to say something—even his handwriting was poor!

He was always on the board, and he would come in and be done and then leave. Not really hospitable for me asking questions or feeling comfortable enough to say, "Oh, I actually know that or I'm just a little unsure of what you're even talking about." When I did ask a question he wouldn't exactly understand what my question was. That was a big turnoff for me because it's hard not to like even know what you're trying to ask, especially in math when it doesn't matter how many times you've read the material beforehand. And so if I came up with a question and he said, "Oh, I guess you're talking about this," and he would go off on a tangent and talk about it for five minutes. I'd say to myself, "you know what? The class is about to end in five minutes. He's not gonna get it. Yeah, that's what I was asking." Here (and at least I appreciate Cornell for doing this), they go so much into detail with just one subject that you barely have time to really transition and show how you connect it to the other one; whereas we had a year in high school to cover material and had time to make connections. In high school we would meet more often than we do here. So I don't really fault Cornell. I mean, I guess I could

have better professors or have had a better experience while taking it, but I think it was just that they were trying to cram so much information in so little time.

I've always loved school. I used to go to school in the Bronx where they were one year ahead in the reading book that carries over, at least into Manhattan. And so when my parents moved to Manhattan, I was one year ahead. It was nice to feel like, "Oh, wow, I'm advanced. I'm surprised we're even so talking still about multiplication. What is this?" *[Laughter]*.

Yeah, so it was nice. And my teachers, they were all really supportive. I was the teacher's pet at the time, and I really was proud of that; feeling like I was going above and beyond. And that continued until the very end of the elementary school. I remember loving math. And it was great because you needed to – there were only a few students that they would really give time to and make sure that they got to a better middle school than others. Most students went to their zone school. And so they spent so much time with me trying to get me ahead, to pass exams and to try going for different middle schools and high schools and really trying to get me out of the system. They would always say, "Let's get you out of the system. You've got to get out."

My friends, at the time, they were the ones that would go straight to the zone school. We just played together, we never talked about school. I can't even fathom like a relationship with them as a student. We just looked – like we would just happen to be in the same class. So we would play, and we would hang out after school. We would go to each other's houses and that type of fun. And we would meet at lunchtime, but when it came to class time, other than like oh, did you understand that or something (it was weird), I didn't really talk to them. I guess my dad was really like stringent with me and just saying you have to focus on your studies. So whenever we did have fun, it was outside of school

So the magnet school I went to was good at reading. It wasn't specifically for math. At the time, they were so big on technology and I was just this like this old-fashioned, I-don't-like-computers kind of person and my friends would make fun of me. I guess socially, I had one really good friend who ended up coming to Cornell as well. We were just like two peas in a pod. We'd be together all the time. And that went on from sixth grade to eighth grade. So a lot of my success I really give to her.

In elementary school there was one teacher for science. His name was Mr. Fernandez. He was great because he would have these things called wuzzles. A wuzzle was a brain teaser you would do for the first 5 minutes before class. Sometimes at the end of class he would end it with a quote. He just was great because he treated us like adults at the time. Even though we were just like come on, like let us out (other teachers would have just let us out of class) but he expected more from us. He knew we were smart He was nice. He would really make sure that we knew why we wanted an education, why we're doing the things we did. He made us ask all of the big, life questions.

I guess the reason why I got into the magnet school, was that when they interviewed you, I said that I wanted to be a judge. And I knew that I had only said that because I wanted to be in. And that always like played in my head like I want to be a judge. And I would go on saying I want to be a lawyer. But then he would say no, why do you want an education? I'm not asking you why you want to study law. Why do you want an education? And it was really – because my parents just like forced me on it. It just turned out to be something that I really like. But it's sad because most people want to go against the norm, but even after trying, I found I really like school. I like studying. I like being able to be in control of my education. For my parents I think they realize it's just easier with an education. They did go to school, but they went to school like

part time because my mom had me. And she just said, "Just go this route. I'm not saying that you can't go the other route where you go take school part time and you work. It's just so much easier for you; and it'll be just so much less stressful. So don't like put yourself on the tired path. We're here to help you, so there's no excuse for why you need to work." When I was growing up it was just like do you want to be a doctor or a lawyer? That was what most people just asked you. So I said, "No, I don't want to be a doctor (I'm squeamish). But I can debate, and I can argue, and I will continue arguing so I will be a lawyer." And so that's why I thought sure, I'll be a lawyer, and I'll be great.

That was in elementary school. In middle school, I think I wanted to go into teaching because I really liked seeing how the teachers were with us. And so I thought oh, I might one-up you, and I'll be a professor then.

Then in high school it was just what would be more fruitful, profitable-- you know, what'll pay you more? That only occurred to me because other people were thinking about it like oh, I don't want to be that because I want to make $70,000.00 coming out. And I thought $70,000.00? Well, the teachers, they only make $60,000.00, I'm sure, if you like get a good contract or something or if you find a good location. So I just thought oh, scrap that.

My high school was a Math/Science magnet school and for the engineering track, the first year you did like principles of engineering where we used Autodesk Inventor and designed an alarm clock. Even though I didn't physically take things apart as a kid, I was proud of the fact that I was great at reading instructions. My dad was really good at making kit radios, and I was like, "You don't know how to do this. I'll get it done perfectly! Done!"

Growing up, I guess you could say there was like a little rivalry between my mom and my dad. My mom is in sociology, and she's a social worker. And so she always thought,

psychology and talking about things are great. Whereas, my dad's just like, "No, science is what's gonna get it!" He just wanted to be ahead of the curve. He knew I'd have a future in science! He said, "You can go and enjoy your English and stuff, but really just use them to create your argument for why you should be the mathematician."

I guess up until senior year, I felt, just like everyone else and good or better than everyone else in terms of my grades and stuff; that is, until the SATs came around. I really hit rock bottom because they were offering an SAT program in the school, and I automatically assumed it was free or that it would be paid for by the school. But I couldn't afford that and I was just like heartbroken. I thought well, wait, why haven't I been hearing about SATs? If I had known or if you'd just only told me sooner, I would have started to study a year ago, because I never really did well at standardized tests. I guess I really missed dropped the ball on that in high school. People would look at me and say, "But you're the best student here. Why are you getting such poor SATs?" I'm pretty sure I got like an 1880, which isn't bad. I know it is a good grade, but not good enough for the caliber that I was in my school.

I did better in the writing and the English part *[Laughter]* and I was so frustrated because I thought this is bogus. Like this test is rigged *[Laughter]*. I mean, this is not making sense. I can do calculus, but why can't I do this basic, you know – like I guess it was like time and the pressure, and I knew I just could not do standardized tests. But I guess it's always been that way. I can really perfect a problem where it takes me longer, but I can explain it to someone and show a diagram. And when I know something in math, I can go about it many different ways. But if you're asking me to just do this one simple thing among 100 other questions, I'm just like this is pointless.

The English Department in my school was just as great as the math department, but most people in my school tended to enjoy the math more. We would be like yes, we love math, like entertain us professor! So when I went and found out I was really good at writing, it was great. I expected to be good at writing. I didn't expect to be bad at math.

And if I like think of why the grades were so different, in writing, I wasn't nervous about doing well. I was just really nervous about showing my strength in math. I wish it just came with hard work, but no, I think it's a gift. I mean, I'm better at math than I say I am because you can visualize things. For a lot of people it's crazy for them to think they could visualize a derivative on a graph, they could picture a graph and then see well, what would that derivative look like, how would it like flatten out or transform.

In high school versus math, I did much better in English. In English, I think I would get like a 99 out of 100. And in math, I would do 95 out of 100 and so I guess my class grades were consistent with the SATs, but I liked the physics stuff more. Honestly, I think it was we – in the time, we were much like a mass of students. We were such a small school. We were so honest with each other. Like once a test would come out, you shouldn't like be hiding, you know, 'cause we would think oh, you have a bad grade then. You need to like step it up. We would be like what's your grade? Or why didn't you get that answer? Whereas here at Cornell, I am more like hiding. Here I've accepted that I'm like at least the mean. If I got the mean in the grade – in the test, oh, I would celebrate. So usually, I'm about a standard deviation below, which would be, you know, like a C. And so it's enough to pass me into the classes. And I enjoy it, and I still work hard for it, but I don't get good grades always.

In high school, they were just – I guess your grade meant how much did you study or how much – how prepared were you for the exam, and more how much of the material did you

grasp. Here the tests are just like how did you perform on that day, and not how much do you know? Because often times I've tutored other people in the exact same course. Or I would sit with them in office hours and show them that's not how you do the problem. This is how you do it. But it doesn't matter when you sit down and a lot of – most of your grade is held on test exams.

My high school and college experiences were the complete opposite. In high school – the class sizes were so much smaller. They were about 25 people. They used more technology that I enjoyed, and I'm surprised they don't use it here. So we would sit in classes, and we would have either a computer on our desk or even if it was in English, she would use a Smart Board or she would be physical. She would, you know, have these huge post-it notes, and she would just paste them everywhere around the room and so it was lively. And I would say that the teachers were so much more engaged in high school. They thought that they were teaching students who were going to be great. And they would remind us of it. They would say, "You know, you guys – like don't just – you need to stop me whenever you have any questions because you're literally why I'm sitting in this room. Otherwise, I could just, you know, go into the other room and talk to the teachers and just have lunch all day. So use me."

But when I came here, it was more like I was a part of a movie; that's honestly how it felt. I would just sit down in class, and there would just be like the front room, the front table, and they would show the slides of the PowerPoints. And that's as technological as they got. And sometimes they'd say "Oh, I can't deal with the power cord, I can't like plug it in. Forget it *[Laughter]*. We'll just scrap it." I'm just like well, there goes the visuals *[Laughter]*. Well, there it goes!

It's sad, but I didn't look up to my teachers in high school as much as I do the professors here. Despite that, I guess the professors here are great at what they do, but I always feel like there's just some disconnect between us. And I'm more – I tend to think that that's more because they're just so smart. And like sometimes it's hard to – I know it's hard to explain something as basic as multiplication when it's so easy for you to do nowadays. But I just think the professors do it all the time; they're so much more advanced in the course that they're teaching, that they just can't explain it. But that wasn't the way in high school. In high school, they really made it seem like they were learning among – with us, that they were just there to observe and tell us when we were doing something wrong and when we weren't, as a mass, coming to the right conclusion.

A frustrating time I've had here was during my freshman year. For your freshman year, you take a programming course from the engineering school. I took it during the summer. I took Java and I thought oh, great, like I don't know programming at all, but it's right up my alley. Like I did some meddling with programming in a different language in high school, but I loved it. And I thought, "Great!", but that was not the case. And I remember walking into that final and knowing that I had nothing, like nothing to offer. Nothing! Like I would just sit there and like cry my eyes out. But the professor, Bailey, he's great. And he would test each student based on what you knew coming in and how much you took coming out. And I was happy because there were some students going in who knew programs already like the back of their hand, but he didn't let them get away with it. He would really make them work for it. And he graded me based on how much I learned from coming in and leaving and not just like how I could perform compared to other students. But that really was like the worst because it fed into the other courses I had to take for programming where I dreaded 2110. And I still – like I'm

surprised that I was so afraid of one course. Like a course. Like I would – I changed my major so many times because of this one little course. And when I finally passed it, I was just like that still hands down the best day of Cornell. Yeah.

When you come here, you don't — declare until your sophomore year. So when I say I changed my major, it's more you change – you show what your major is by the courses you take because you need to meet certain requirements in order to graduate. Yeah. So I considered – when I first came here, I was ORE. And so I went through all the typical courses. And I made over – like I diverged already towards one major by taking Java instead of MATLAB, which is another programming language offered. And so by taking Java, it would help me do ORE, and it would help – like I guess you could take the next level. And so when I started with the programming course, I really didn't like it, and I thought, "Oh, my gosh, I got Ds!" Like I can't believe I just passed that class. Just like that was luck at this point. I can't do that again. I just can't.

That class was small and I took it over the summer. There were probably twelve students and there were probably three or four of the same students who were freshmen like I was, and we all lived together, we'd do the problems together. There weren't females in there, as I remember. And if there were, I'm forgetting *[Laughter]*. But no, I didn't know it that way, but that was the same thing in high school. There weren't a lot of females in my high school either, but that never posed a problem for me.

So I changed to civil engineering because it didn't require the second-level Java, the 2110 that I would have to take. And people thought I was crazy for doing that like over one course, but I said well, I enjoy civil engineering. I enjoyed it in high school. And you would still get to take math, the same math your – I guess your curriculum wouldn't change the next year. I guess

they could have paid more attention to – how do I say this? Let me think real quick. If programming were so important – and I would tell people if programming was so important that, at this point, I'm changing my major because of it, then in the previous course, in 1110, the course I took over the summer, you need to show me why and not just like rest on how much I learned or whether I was able to pass the class. Like if I'm about to change my major because of it, show me why I need this class to continue for the next four years, even if everything is telling me to get out. You know, I'm not in an area I'm comfortable with. I've tried learning it like time and time again, but nothing's working. So if they would have at least showed me or like been there to support why I need this course, I would push on. If I knew what I know now that most people who take 2110 dread it, and alumni, even now, they're still proud of their C-, for just needing it to pass a class, then I think I would have just stuck through it.

So with ORE, the most students, most students end up going into industrial engineering or they go into like – if they go into consulting, they build math models to solve their problems. And so now after taking many of the introductory courses, I see that those models are optimizing solutions. You could use – let's say you work for a beer company or in the consulting firm they want you to consult for a beer company, then you could optimize exactly what formula they would need, given the resources that they have. They'd say we have a problem. We have, you know, X amount of barrels of, you know, hops and this, and they would keep giving you exactly what they have. And they'd say we – it's not producing the amount of profit we want. We got to scale back. We have to, but we want to keep our standards. So how much leeway can you show us we can afford to lose with keeping with the recipe? And so they ask you to test and iterate over – well, if this happened, what would this be? Or present solutions to them. Yeah. So Java is helpful in being able to do a lot of the work for you. So let's say you produced – you

were able to do it by hand. Like there's a difference between doing a problem by hand and then letting the computer do most of the work. The small-scale problem that I showed you there, which you would do in consulting, you could do – you can use basic Excel for it to do statistics, but that's not the case if you are leading a company or you're working for Procter & Gamble, and they have their own systems. You need to show that you can contribute some ingenuity in creating a program to do a lot of the work for you 'cause it's just so large scale. So the reason why I ended up switching over to civi is because by not taking 2110 at that time, I would not qualify for ORE. So the only – the courses stay the same. That's why you really don't have to change your major that much, but – so I didn't take any civil engineering courses at the time.

For general education requirements you have to take two writing seminars. I like writing, but I just had really bad experiences with the topics of the course. You have a system like a ballot that you can request a certain course, and I never got it right. Like I got the ones I requested, but based on the description you get, it didn't tell me enough about the material, so I didn't find it interesting. I would just do the essays, and I just was like okay, fine. They definitely were more subjective. They would grade you based on a draft that you can produce, and then see how you transcend that draft into a final report. So they would give you a preliminary grade. They'd say, "For your work here, I would give you a "B." "And it's only a draft," they'd say. And they'd meet with you, and they'd tell you, "These are the parts you need to work on. You didn't exactly show why this person did this," or whatever. And then they'd say, "In order to get a better grade, you need to do this…" And so you would just go home, and you'd try it, and you'd work for about a week, and you'd go back to them and say okay, this is what I produced. And if it came to a B+ or an A-, you're like, "Great, I did what I had to do!"

I wasn't really part of the "English culture". And maybe coming into the engineering school and being a little pompous about like I'm in engineering, and this is not a technical course, I felt that it was – like the grades that the teacher gave me in writing were just like mashed together. I thought that yes, it was subjective, and it was based on a single essay, which, to me, was shocking. I'm just like you're not testing me in whether I can – it's not like testing me whether I can do math, you know. Seeing whether I can do a derivative and apply that to a job is completely different than me writing about a book. So I didn't appreciate it or anything, but in my math courses, I felt like they were testing me for how much of the material you are able to apply to a problem. Like can you solve this problem? Yes or no? If yes, you get the points. If not, let's see how much you did.

The only time I may have felt out of place at Cornell was probably after chem. I felt – I distanced myself. The chemistry people didn't make me feel different, but I distanced myself unknowingly because I thought oh, well, I'm just like – I see I'm going to be below the curve, and I can't do this. So I thought there were just things that were different about me. I thought that I was a visual learner compared to a lot of them who could just read the textbook for class and not take notes. There was a bit of angst, saying like, "Oh, I'm sitting in a room full of 150 people who have, one, either already taken this course and failed it last time, so they're breezing through, or two, they're just great at what they do-- they're majoring in this." And so I just – they didn't distance me. I distanced myself.

Honestly, I don't really feel connected to any college professors here. Well, I guess maybe I do now that I am a junior, but they're in courses that I just am taking for enjoyment. You have to take like six liberals. And so it tended to be in those courses that I enjoyed more, that I felt a connection to the professors. You take six liberals totaling eighteen credits. The first

liberal I took was in networks, which is cross-listed as Soc and CS and info science. And it was great because there were two professors, and I looked up to them so much. One is John Feinberg, and although I never got to talk to him, I was so nervous, I did talk to Professor Easly, and he was great. He's in the Department of Econ, and although I never went to him for help, I did ask him for career advice. I'd say, "I really like that work. What other way is there I can do something similar, even if it's just in my liberal?" And it was great because I thought, "Wow, I'm in a classroom, and I was so like students from sociology, and this is awesome!" I'm happy that they're learning just as technical stuff as I am and that I'm actually getting to do some of the lighter stuff-- talking about why it's important, how would this actually be, how would you go about solving this or implementing a solution about this or that. So it was really nice.

One of my defining moments in college happened in my sophomore year. I lived on west campus, and I was a student assistant. And so for the job, you get free housing and a free meal plan or a discounted meal plan. I was working as a student liaison between the students on my floors. That was really defining because I was able to see right in front of my face something tangible. I could touch a student and say, "It's okay. You're going through exactly the same thing I'm going through." I had to really accept that moment and those opportunities to connect with other students.

At the time, I thought it's just my job, you know. Like I'm really good at doing this because like at the time, I was good at peer mentoring, and I had taken like preliminary courses in it in high school and all that and such. But at this time, I was like wow, I'm one of you. Like I'm a student, and I'm not trying to – and I had to learn like I'm not trying to make myself more than you or that I know more. I'm just telling you my experience and hoping it lends some wisdom.

And so it was a good time for me to get that interaction. And my boss was a professor here. I don't know – I forgot what he does *[laughter]*, but he's a professor. And he would just be really honest with me. I never saw him in an academic setting, but it was nice to see a professor is human. It was great. He lived in Hans Bethe. I never had him in class, but we had great conversations. He said, "Well, do you know what – have you ever taken a course in anthropology?" And I said, "No, what is it? And I guess it's this..." and I gave a bogus example. He was like, "Well, how will you know? How do you know if you've never taken a course in it, you've never experienced it, that you wouldn't like it? You just don't know. And how do you know that that's not your perfect major?" And so I just thought, "Wow. You like actually stumped me here." And that's when I learned that I have to actually sit in on a course and try it out and not just like wait for the junior year to think oh, I think I like math, I'll enjoy that course. I'm done-- I scrapped that model. If I think I like something, I'll just do it; I have to try it, and I have to see it. And that was one of those life things I learned. I was transitioning and trying to see if I could move out of the college at the time. And just based on the credit – required credits and how much would transfer over, I could not transfer. I really liked that professor because we would always battle. He would ask, "Why do you like engineering?" And he would say, "How are you doing in your courses?" And I'd say, "Oh, I'm not doing that great."

I'd say the greatest compliment a professor has given me since I've been here was probably in 2930-- Differential Equations. I went to this professor's office hours, and I like – I cried, and I was just like crying my eyes out, and I said I know this is so weak for me to do, but I just like – I can't do this. I just can't do this assignment. I'm so stressed out. And he said, "Well, you're not super human. Nobody's expecting you to be. So just go home, forget this exam; forget it– just give it a break. I don't want to hear it. Just go home and sleep." And so he

was great. He was just like just go home and just go to sleep. I don't want to hear it. And if I hear that you did otherwise, which he was like, which you know I can't – like I'm not that into your business to know, but just like I'm giving you this break to go home and go to sleep. You look a little stressed. At the time I was so stressed, I was just relieved. I just thought, "Thank you!" He was compassionate, and that was a compliment. I took that as a compliment because he knew that I was trying so hard to get it done (I told him I've been going to my TA's office hours like crazy!) And he just said, "Scrap it! I know you – I know you're stressed. This problem is the least of my worries." And that was when I was just like oh, great.

I used to think having the strength to pursue engineering was just from within. I thought you had an engineering mindset and that's what led you. I think that is a big part of it. A lot of it is critical thinking. It's not about being an engineer; it is about the act of doing engineering. But as I would fail, it would be great to hear a professor like be honest with you and say, you know, I came to the same problems as you did. Or if it were a TA, especially for physics, she would say, "I really don't know how to do this either. I'm going to go ask the professor." So seeing those examples helped. A lot of times I would just observe, and I would just see how other people interact. And if they were positive and I saw that the engineers – the professors could work with each other-- that gave me a little bit of motivation to get through it. I thought, you know, this is what engineers do. They have to interact; they have to ask people for help. And a lot of that just developed over time. I sure did not know that at the beginning.

I made the decision to go "Independent" in the Advising Office in Engineering with Beth Holland. They have three advisers there and I would switch between the three, but I would always have to re-explain my situation. But then I sat with her, and I thought this isn't working for me. I just said I can't do this (the computer stuff). And so she was working with me to try

and figure out what it was that I wasn't getting, like whether it was I wanted to go in a different college or if it was within engineering. And at the time, I just thought I can't do this. I want to get out of the college. And so she set me up with meetings with internal transfer. I applied for internal transfer and I got it, but just based on the credits that I had I would have had to stay a summer and really throw my course off track. So I said okay, help me out. She suggested the independent major. It's great-- you can just like use sixteen credits to alleviate your other courses and make it pleasurable.

My boyfriend is going to engineering school here, too. We both went to the same high school, and we had such similar experiences. He did the summer program, so like amongst those friends that were there and with me, and I like was embarrassed to talk to (I was afraid to talk to new students because I didn't want them to judge me if I did not know something) I would always just be come on, I don't understand this. Oh, my God, I'm gonna fail. And I feel bad because I made a lot of my success bear on his shoulders *[Laughter]*. I guess he was the closest thing to home because I had met him from high school. My friend, Gloria, who also attended middle school with me, was a big source of support, too. They're like the closest thing I can bring from home and like keep strapped onto me and say no, I need to do this, I need to pass. So like whenever I start speaking crazy, like I'm not going to continue this or like I'm going to go back to New York City, they shut me right up. So my boyfriend and my friend Gloria – not many of the people from here, but people who would connect me back to why I'm doing this, have been the most significant people here for me.

I've had some embarrassing times here, too. I was going for a lot of studies and testing for why I would fall asleep suddenly, and I found out – or it's still not fully flushed out yet, but they – at the time, I was being diagnosed/studied for narcolepsy. And it's embarrassing because

I would just be so tired all the time. I felt so weak. I would purposely sit in front of the class because I knew I wasn't good at linear algebra-- And one time – I fell asleep right there and then. That was embarrassing! I was so out of it. And my boyfriend continued to wake me. And I was just like "Oh, I'm so tired" and I let it out like so loud. And I was so embarrassed because I thought no one understood… I'm trying to stay awake. And I was upset because at the end of the day, I was just so tired and embarrassed.

I can honestly say I have not had any professors who were condescending. I can like convince myself like yeah, they were, but that's me just reading what they were saying. If they couldn't meet with me and they'd say, "No, I'm sorry, you know, the deadline has passed, this cannot be done… this is not done." I more attribute it to being like well, then you don't think I can succeed, obviously. You don't understand. You're not being flexible. You're not helping me out. And this is stressful, and I can't – you know, how can I even survive within this school? If this is like the one thing that's keeping me from succeeding, why would you keep that from me?

But they weren't – like if I really was honest-- they were never condescending. They would just say something like, "Well, you need to tell me; I can't read minds. I can't like do things for you. So once you have a problem, you come to me, and you tell me, and I can help you out the best I can. But otherwise, I can't do it." I guess I blame them for that. I always felt like a lot of engineering professors were like that-- not condescending. I can't find a good word, but I just felt like the engineering professors were just different. In my writing seminar, my teacher could sense something was wrong, and she would come and tell me like, "Is everything okay? You haven't been sleeping. I could tell like maybe you're…" and I'd say, "Yeah, It could be that." But then again, I can't compare my writing seminar class to my engineering class

because there weren't smaller classes in engineering. I sat in front for most of my engineering classes and even though I know looking into a sea of people can be difficult, I still felt like that gave them some responsibility to say, maybe she's not falling asleep because she doesn't want to pay attention or she's slacking off in her work for other reasons. So a lot of times I would just be annoyed because I had to take so much initiative to go to them and explain my problem and risk crying in front of them, it was just so tiring.

I always like the sciences – or not science, but like what an engineer would call like soft science I haven't had English since my freshman year, so let's say like this year I take Human Development 1170, and I'm always just like – I like that professor because I think you know what? You do something that's so great. You ask so little of the students; you understand their time. And I just think once I label a class as nontechnical, I automatically like the profession that much more. And I'm happy because they respond; they live up to exactly what I think they're going to be. So like they're lively and they're happy and they're there for you and they're there after classes. Whereas with the engineering professors I would just feel like they were doing great things and can't be bothered *[Laughter]*. Can't be bothered-- like it's massive research, massive, you know – like you just can't begin to understand what they're doing!

One of the first things I tell people that if Cornell's done anything to me, it's made me self-aware and made me take charge of exactly what my path is. I am very self-aware, and I guess that's why I have a lot of opportunities– like I'm in the summer program-- and why it's leading to career success. So I'm self-aware. I also know that there's not one path. There's like jagged little paths. All the alumni come back and tell you it's going to be that way. And I had to learn the hard way, but I know it now. So I'm expecting a lot of little changes in careers. And

that's okay. I can always go back to school, if I need to. So yeah, that's who I am. I'm going to just piece what I'm going do after with what comes to it—just take one day at a time.

As for my friends, they'd say I'm dramatic *[Laughter]*. And they know – I'm a little cocky. Like when I'm good at something, even if my grades don't show it, I still say like I'm so much better than you at that. And if they go back to saying but I got a better grade in the class than you did, I say well, ha-ha, on one day you did great on that test *[Laughter]*. Well, let's see. Like try and explain this problem then. Can you do it? And they say well, I don't remember this and so that's why I can't do it.

Probably one of the happiest days of my life was passing 2110. It might seem weird for me to say that that's my defining moment in my life, but it's because I made so many tweaks to my major, and I reconsidered big life decisions about what I would be doing after college all based on this one course. I guess I really owned that that was just one course in my college career and I don't care if I failed it. I've failed other courses since then. Well, I really didn't fail them but after signing up for the course and going past the withdraw deadline, which is what I do. I would sign up for a course and then drop it, and sign up for the course, and then drop it. But once I actually said this is the last time I can take it, I need to pass this, this is not going to keep me from every little thing, that's insane, and I had to come to that conclusion. So it was great and really empowering.

And I guess the most negative memorable time I had at Cornell was when I sought counseling at Gannett in my sophomore year. There was a lot of change, a lot of big decisions going on, and so I really fell into a deep depression. And that was sad because I didn't think that I would ever succumb to that. I thought I was powerless. I couldn't control it. And I had to accept that it wasn't me that was letting depression come over me. It wasn't something I was

doing wrong, I just felt like everything wasn't going as I planned. And I don't think of my – at the time, I didn't think of myself as a perfectionist or inflexible planner or something or I didn't think things would be perfect, but I was just like why is everything going wrong? And I get I would have little days where things just go wrong, and I have to keep trying and persevering, but at that time, I was just so tired of it. And I just thought you know what? If I can't do this, then why make it so painful to get through these classes? Why did Cornell accept me in the first place if they were not going to support me!

A personal day in my life that I will never forget was my Sweet Sixteen birthday. I wrote about it in my application for Cornell. It's always like when I tell people about my Sweet Sixteen, they think I had a big party. No, that wasn't it. I'm an adventure junkie, and so I brought six of my friends – and that was great 'cause I was surprised my parents could afford it--six of my friends in a van, and we all went to Dorney Park in Pennsylvania. And so we all went there, and it was just so much fun. We had a cabana, so I felt special. And they would come ask, "What do you want for lunch?" And we would go play in the pool, and we would go hang out. And at the time, I was dating my boyfriend, so it was nice because I felt like my parents respected me and felt I could behave. It was just lovely because at the end of the day they surprised me. They blindfolded me and surprised me with a cake – and I usually know exactly what's going on—but they continued to surprise me. Even on my eighteenth birthday, I didn't even know that they were all coming together for a surprise party.

One thing that helped me get through it all was what Sarah Hernandez from the Diversity Programs Office said to me. She would always say, "I'm not telling you it's going to be easy, I'm telling you it's going to be worth it." They now post that on the billboards at Cornell Cinema. I'm so happy that it's getting recognition. I always respected her. She's so eloquent.

And she's just so classy and very inspirational. It was nice to look up to her and say oh, wow, she knows me, and she's supportive of me.

What lessons could other students learn from me? I would say that there are enough students in Cornell that feel that there's only a certain way to do things, and they go in and think well, if other people have done it, this must be the case for me that I can get through it. But it's not that they can't get through it. I know that I could go through all of my classes and just pass them and get C-minuses and move on, and I did that for the first two years of my degree. Although I tried to push to another college, I just felt like I wanted to honor those. I did do those classes. I don't feel like I should be here for another year because of it. I would want to like reach out to those students and say maybe you should look at why you're getting those grades. If it's not just because of a limitation of how the professor teaches the class, and you really enjoy it, don't let the grade reflect how much you like the subject. Don't just like sit in a sea of people and think oh, well, the class just sucks. If I had asked myself that constantly before, I might have switched to another college, but by that time, it was so late. In my classes I'm choosing now, I'm getting great grades. I'm getting As. And I'm shocked that I could get that. Don't get me wrong, I respect required courses because they're there for a reason. I appreciate my math courses; I couldn't do a lot of the econ that I'm expected to do and expected to do well in, if I didn't take calc. I just guess my mindset should have been different the entire time. I shouldn't have felt like you – I don't think any student should feel like you just have to get through it. That's not the case. You're paying money, and in my case, I was really lucky that I got Financial Aid. This is money. This is an investment, and so you need to consider whether you're getting a good return on that investment and if your experience is truly making out to what you had hoped it to be. A lot of students, especially me, come into Cornell and think oh, great, like even if it's a

hard class, we're going to get through it. But I would tell myself all the time everybody else is getting through it, not me. This is not the case. This is not the case. Something is wrong with me. Something is wrong. And I would never hold other people responsible. Or not other people, but like I would never expect much from the professor in that experience, but now if something's going wrong, in a little pompous way, but I'd say like what is it that *you're* not doing? I ask that of everyone that I interact with. Now I say what could the professor do better to make this experience enjoyable? What could my TA do better? Or what are the students doing around me? So I share some responsibility. I think other people need to do that more, especially in engineering. I think you go on out – you go in thinking if other people have done it, then you should be able to. And it's just a tough course.

I would say that the fun classes that I take are the English, or the sociology or the writing ones, if you could term it that way, the professors are really in tune with the students. And it makes it that much easier for us to respond to them. But with my engineering ones, I have to do a little bit more work, which, in my position, being the student, it's hard. It's like I'm telling a professor that he needs to do more or he needs to be more in tune with me. That's just really hard to do, especially as a freshman. You just think like you can't do that. But after realizing this is $1000 to $3000 for every single credit you're taking, then he needs to share some responsibility in my education too. So like in my soc class, I know that they're going to be more interactive with me and I just come to expect it and I'm glad when it happens. I've been right all the time. I haven't had one soc professor who's not been in tune with their students. But I have to make that my responsibility for my engineering professors. And so I find that a lot of the students who share the classes with me, they also learned that because I sat with them in chem, and they were never asking more of that of a professor. They never spoke out to the math

professor when we were taking our general engineering courses and now they're the ones who are saying I just don't understand this. The liberal arts courses are a lot more call and response. They have discussions to make sure you understand the material. They are interactive. In engineering courses there is no discussion *during* lecture (there are discussion sections with TAs, but not during the lecture). I like having discussions, it helps me to learn the material better and math and engineering courses just aren't taught that way here at Cornell, the way I would say grad students are, in the engineering courses.

And so I learned very early on that you need to interweave technical courses with nontechnical ones where you can actually have a say in your grade and have a say in the exam. (It's sad, but when you label like a course like technical and nontechnical-- it's really true here, especially for the engineering courses-- there are technical courses where four credits mean, you know, this is your big course, and you will probably fall below the curve). By interweaving technical and nontechnical courses you can boost your morale and manage your GPA.

Someone that I always go back to for inspiration, and was a professor in Carnegie Melon, his name was Randy Pausch. He has a famous "Last Lecture" series and he got me through everything. I got his book for a birthday present and I saw his struggle. My parents – or I guess the people around me-- didn't take as much from his message as I did. I wish they could take away from it what I did. Sometimes I'd say, "You're missing this part!" For me, I always felt like I took something more from everything he said. Definitely! I don't want to misquote it, but there was a part where he said the brick walls are not there to keep you away from what you want, they're there to show that you really want it or they're to keep others out. I always – like whenever I'm down, I reread the book or watch the video. He's my hero because he's so great in his field and for like his academics-- he recognized other people weren't as skilled in, let's

say, programming – he did virtual reality, and he made a program for students to really enjoy it, and made a story out of it. And so I didn't ever dive into the realm of what he did, but I'm just happy that he recognized that. At Cornell, I think we do a good job here. I just feel like we – when I talk about the classes and what we learn, just like when Randy Pausch talks about what he does and what he tries to teach others, we don't ever talk about grades. Sometimes your grade doesn't really reflect what you learn, and you spend so much time worrying about whether you should drop the course or not. On the other hand, Randy Pausch was a different grader. He would grade people on how you interacted with other students or how much you learned. And so he was different. It was still challenging because you have to do a lot in order to get a good grade, but it was just like on an entirely different scale, you know. It's not like here, it's not like 50% of your grade is an exam or 30-30-30 for a pre-lim and then a little bit of participation.

In the beginning of my undergraduate experience at Cornell I defined myself according to my grades, and now I just feel like well, you know what? They're not representative of what I know. And that I'm happy like when an interviewer brings it up, if they ever do. Not that they have, but I'm happy to nonetheless. If they ever do, I don't – I feel like I have to apologize a little bit for not being aware at the time that it was about more of my responsibility to improve them, but I still feel like giving the circumstances, I did far better than I thought I could have. Not knowing exactly what was going on at the time, I did face a lot of like mental stuff and health concerns that other people might not have been facing. And if they were, I hope that they got – you know, I hope that they're saying the exact same thing because it's not something I feel like apologizing for. My friends and I would always make fun of Cornell and say like Harvard has grade inflation. We should have gone there *[Laughter]*. Or I should have gone to a school like Brown where they're pass/fail. I don't think grades really mean much. They only mean

much when you're trying to apply to a business like JP Morgan. For ORE, they only mean so much when you're trying to apply for a job when you're competing amongst other Cornell juniors and I understand that. But I'm not applying for those jobs, and I don't find those jobs fruitful. And so when it comes to me applying for like a startup for the summer where it's in something I enjoy, I don't think that my grades should really – I don't think it's representative of what I can do. I think it is, honestly, when it's good at comparing you to other engineers, but it's not good for the job when you come out to say oh, I only got a 2.7 when other people from my high school are getting 2.7s easy in engineering.

There are some tests that we've taken here where the mean was a 33, which is crazy. You could only master 33 % of the material and still pass. Why not make the material achievable where 70% is the mean like they just don't understand that *[Laughter]*. That's fine. Like everyone else in the class is sitting there and thinking you're insane for giving that exam. But that's fine, you know. That's crazy. I once saw a student cry on an exam, and I was just like – come on. I said don't let it get to you. At the end of the class, I let her know you're not the only one. Everyone is going home thinking what was that? Like that better not ever happen again. And in the end, everyone's grades – like it just all ends up working out in the curve because if everyone else does bad, he has to make it seem like an average course, and so it's a B, fine.

I think a lot of my inner strength probably came from elementary school and high school, and from my ability to take the wisdom from stories like Randy Pausch while other people would just find stories like that as insignificant. I always felt it was a joy and probably a good gift of mine to take a lot of wisdom from stories like that. Whenever I would hear a professor say something to me or to another student, I would like absorb it and use it for energy and not let it get me down. So I would just keep that going. And I guess what really moves me is I am able to

tell other people about it, which is why when I heard about this study, I'm just like great, yes, you know, this is what fuels other people. And I hope that is does. So when freshmen come on campus – and I say even if you don't go to Cornell, just know that in your engineering classes, they will not define you. They will probably be the toughest classes you've ever taken, but don't let it define you. And if you do, then, you're going learn, in the end, that it shouldn't *[Laughter]*.

Five years from now I hope to have a job with the startup company that I will be working for this summer or have my own company. Either way I want to design products. The startup company I will be working for this summer is down in Chelsea, New York City. It's Quirky, Incorporated. They give everyday engineers a chance to submit invention ideas online. They choose the best ones of the group, and they produce it, manufacture it, sell it, and they do marketing for it. We have a Quirky line in the Cornell Store that anyone can buy. It's great because it brings everyone together. It's still engineering I guess the biggest one is women have it not easy, but women they're given a lot more slack than men are. And I think women should use that as best they can. Like I'm not saying like *[laughter]* men shouldn't get as much support because, trust me, they get enough of the advantage when it comes to jobs and even grades. There's just like all of the initial classes we take are geared more toward the way they learn—lecture, no interaction. Cornell should put an interactive, discussion class in the beginning of the program like Engineering 3350 and see how the guys do! But you can't take it until you are a junior or a senior. On top of that, I remember an example on a test and it was geared to the guys. You had to know how a steam engine or a piston on a car worked to get it right. When I asked the professor about it, he just gave us all the answer instead of explaining it. I think since engineering has been male dominated for so long, many of the practices used to teach it have not factored in women talents.

I really don't think the glass ceiling exists. I think even if it does exist, people recognize that, and they give women a bit more slack. Like to be honest, a lot of the times, when I would go running to a professor and cry, a lot of it was thinking oh, I'm such a weak person. But even if they saw it as oh, I'm sad because she's a woman and I want her to succeed, then use it. Like don't be afraid to use it. Like use the fact that you're a woman. I don't mean use it -- embrace it. I always try to separate myself and think oh, okay, it's not because I'm a woman. It's because I'm sad or it's because I'm not doing well. But if it happens to work out that I'm great at what I do and I happen to be a woman, then I'm like then use it, and show other people.

I'm really sensitive, and I'm really empathetic. But if you happen to be that way, let it be because you're sensitive and not because you're a woman. I know a lot of women, even professors, who are introverted and who even still don't have that need to like – not a need, but sometimes it's a need to cry *[Laughter]*. They don't have it, and so I just feel like if you are that type of person and you happen to be a woman, then don't be afraid to mesh the two. Don't be afraid to say yeah, I cry, and I'm a woman because it's going tell somebody else who thinks like –how do I say it? When I go back home and I tell them like I'm super sensitive and I cried in front of a professor, they'd say oh, gosh, Lucy, are you kidding? Like other guys won't do it. And I say you mean the other people won't do it. They're not just like guys, but if you want to go ahead and think that I'm a powerful woman because of it, then great. Then more power to you because now you know going on that you can do it and like people won't think differently.

The times that I'm most proud that I'm a woman are when I see Sarah Hernandez. She's great at what she does. And I just don't see enough women engineers doing engineering to know exactly what they're – like what setback we might feel just because we're women. I think the only setbacks that I've seen are because I can be highly sensitive or emotional. And while I

haven't seen men act sensitive or emotional even though they might be… I don't know, I just haven't seen them struggle with it to connect with them.

At first I felt like I had to suppress my femininity, especially in like the first two years, I suppressed it, and I would – like I remember not giving any time to like do my hair and things. And since I already had a boyfriend, I wasn't looking out for anyone *[laughter]*, you know. But then I realized like hey – as time would go on and as you would take more major-specific classes, the number of women would get smaller and smaller and smaller. And at that time, I realized I had to really like be proud of it and show the other men like, you know, you're going have women in your field, and don't let – like I don't ever want there to be a second where you don't think there won't be! So I would like dress up and like go in really professional. And I would – I guess especially with the other men, it gave them a bit more demand to do the same because I would go up to the professor well dressed, and I'd say hi. And I talk nothing about feminine things. I would be like womanly. I would say embrace your femininity because like it's the best way I know to show other people that I am happy with my identity because I can never be a man-- that's for sure. I didn't enjoy acting-- not manly, but like suppressing my femininity. I didn't do well. I wasn't happy at the time. And now even if it takes five more minutes, even if it takes me being late, I know that if being womanly makes me feel happy or – and just embracing it, like putting on makeup makes me feel happy or doing my hair, it just makes my - it just uplifts me, then I have to do it I know. And, I mean, I – even going back to – I went back to high school over winter break, and it's great because they all – all the teachers want to know what's going on with you, and like how are things going? And when I sit aside and I talk with them, I'm able to be honest and say like I had a really hard time, and this is where I am. And can you give me some advice? Let's get some feedback on it. And I don't have to be feminine, but I

made sure that I would walk in there like dressed up and nice; not for me, necessarily, but to show other girls who – exactly what I'm thinking and exactly that I'm put together and I'm not ashamed of it. I always like it because I feel like I look great and usually, if you are struggling, you are sloppy and not "put together". I can show them that in spite of having to struggle I am still put together. I think you are more approachable for young girls when you are put together.

I say "not ashamed of being put together" because I know a lot of engineers come in running with sweatpants, it means you were doing your homework like last minute — or you were like getting that last bit of testing done. And now I just think, no; I know the truth. You were doing it last minute, and you weren't studying all the time, and you were probably like on computer games and all that sort of stuff, and you don't care much for your appearance, which means you didn't do your stuff on time and you weren't managing things correctly.

And now that I can at least show and present myself in a way that makes me look put together. And for women, I don't think you need to do that—it's not mandatory. I feel like we're far beyond it and it shouldn't make a difference. Like, if you want to be in sweatpants all day and be amongst engineers, do it 'cause it's not gonna change much. I'm not telling people you have to dress up, but if you want to and if you feel like you want to be feminine like I did, then you're only going to get positive feedback.

I took a Human Ecology course and the professor would always come in dressed well. She seemed to enjoy being dressed well. And as a professor, I felt like maybe – like yeah, you go girl. Like you got that right *[laughter]* because you come in, and you know exactly that--you're comfortable in your subject you've chosen, you know you've gone this far, you feel, you look, you exude confidence! I felt like in engineering especially, when you're a girl or a woman, you don't stand out. And a lot of times that's because we don't do anything to stand out, we –

maybe it's just one more thing to think about that we don't want to—we don't want to invest the time by having to think about putting makeup on or putting on like a nice dress as well or seeing is this appropriate for this class? But in my classes, like I never knew– even if there were female students there. It's sad. It lends to how I didn't even know if there was a girl in my programming course. I just don't notice them. Like they just look among the masses, you know. I don't notice it. But then the minute one girl comes in pink and like with a bag, and I always take it like okay, tomorrow I'm going to wear this; tomorrow I'm going to use that bag that I just bought and I was so excited for. As I was further along in my courses, more people would do it. We just – like we laugh about it now. I'd say oh, my gosh, your scarf is so cute. But we wouldn't say that in front of a guy because they'd just be like, ugh. But then even if they do, I'm very quick to respond and say well, you know, maybe you should get out of your sweatpants and get into some slacks. You see how the professor will respond to you then. And they say well, what does that mean? I say because you don't look professional. And to be honest – and I've gotten into a lot of fights about that, but I say you don't look professional. And it's like I don't understand why you're going in pajamas to class. It's ridiculous!

Honestly, I just feel that if Cornell wanted to be ahead of the curve, if I had to redo college, I would have gone to Harvey Mudd or somewhere else with a general engineering degree because for those who just like engineering and critical thinking, it's great, but the minute I felt I had to major in a specific area in engineering, I felt like I was limiting myself, and I wasn't getting as much of the entire Cornell experience by not being amongst people of all different fields (for example I wanted to take courses with people in Human Ecology). That's when I had to break free. And I just thought no, I can't do this. I'm doing independent. I don't care that I'm not accredited!

**"Every life is a story, and every story has the potential to teach."**-- *Nash*

## Discussion & Analysis

In this section, I help myself (a recovering traditionalist) re-calibrate my instrument (in this case, my mind) to maximize analysis, by first reviewing the type of knowledge gained from narrative inquiry through Nash's (2004) eloquent comparison of the different paradigms of explanatory and interpretive research. I then dive straight in to my analysis and interpretation of the profile of Kendra Bartell, then to Lucy Vela's profile, followed by the conclusion.

In his 2004 book, Liberating Scholarly Writing: The Power of Personal Narrative, Nash makes the case for how scholarly personal narrative (SPN) is important in its own right and feels that part of its controversy is that it dares to redefine the idea of "rigor" to fit its own set of truth criteria. The examples of these criteria he cites are: trustworthiness, honesty, plausibility, situatedness, interpretive self-consciousness, introspectiveness/self reflection, and universalizability (p. 5). From his postmodern perspective, Nash argues that not all research needs to be replicable, validated, testable, and measurable in the same scientific ways in order to meet scholarly criteria. He explains:

> …difference in your research approach is good. It's especially good if it is pliable, fluid, and adaptable. It is good if it produces tangible benefits to others. It is good if it is personally honest and revealing, engaging, and probing. It is good if it is made accessible to everyone, particularly the nonspecialist. It is good if it is directed to the satisfaction of human needs, either for the near or far term. It can also be good for its own sake, particularly when it serves to enlighten, entertain, or inspire. Most important, I believe it is good if it is willing to continually examine and critique its own basic assumptions about what counts as defensible truth, knowledge, and value. (p. 6)

I believe the research approach herein, can be good in all the ways defined by Nash. I have not attempted to cloud my writing with what Nash calls the "fake idiom of academese and objectivity" as I am keenly aware that one's writing will always give one's personal story away. Peter Ives (in Nash, 2004) says it well: "We do not write about things as they are or were or will

be. We write about things as *we* are" (p. 8). "Who are we, then?" Nash asks. "We are storied selves who write our own realities based on (the storied world that each of us inhabits)" (p.8). To further elucidate how narrative inquiry can balance the currently lop-sided positivist approach of research in education reform and policy, Nash describes it this way:

> I tend to speculate, question, and philosophize in the scholarship. My colleagues, in contrast, test, verify, and extrapolate. I look for hidden subtexts and pretexts *inside* assigned readings inside colleagues and students assumptions about their lives and professions. My colleagues look for what is observable and verifiable in the world *outside* the text and beyond the individual psyche. I am more interested in what my students are able to narrate about their own lives in pursuit of the self-knowledge that often occurs from this type of intimate and honest, storytelling activity. My colleagues are more concerned with what students are able to demonstrate qualitatively or quantitatively by examining objective data. All of this is good, of course, if one or the other approach isn't pushed to the extreme, and if it doesn't crowd out those writers who might come at an understanding of research in an entirely different manner. (p.16)

The knowledge gained from the discussion and analysis that follows is an attempt to round out the traditional research paradigm that has been "pushed to the extreme".

*Kendra Bartell*

In our first profile of Kendra Bartell we see that personality and relationships are more important than aptitude in staying in the highly competitive field of physics at Cornell. Raised in a family that values education, this young woman excels in English, physics *and* math. Despite earning an "A+" in high school Advanced Placement physics and earning the highest possible grade on the physics AP exam (a "5" on a scale of 1-5), she decides to "break it off" with physics and turns to English where she feels welcomed, supported and validated. In the profile that preceded, we see how a young woman's constant thirst for reassurance in her competitive environment, shapes her perception of what success and physics should look like and how external data influences her internal perception of who she is and where she should be. Kendra's overarching desire to feel connected seems to be the foundation of her choice for leaving

physics. Described by her friends as caring, loyal and creative, these values stitch together her story. Diplomatic almost to a fault, we see the complete absence of any sense of entitlement and unlike most "It's not you it's me" break-ups, she really does think it is her.

## A Corrupted View of Physics & Success

Throughout her story we see Kendra dismiss her high school perception of what physics is as the "dumbed down," "idealized version," over the way the Cornell experience "says" it is. Despite having an inspiring female teacher and role model, and rating her high school educational experience greater than that of Cornell (she gave her high school a 7 and Cornell a 4 ½ on a scale of 1-10), she describes the Cornell version of physics through the following excerpts:

> *I took AP physics in high school in my senior year. My teacher was really inspiring. First of all, she was a woman and she had worked at a nuclear power plant before getting her teaching degree. She had firsthand experience with applying physics to her job. She was just really great, and she was always really open to meeting with everyone. The thing is, though, the idea of physics that I got in high school was not what 3it is actually is like. I was taking AP physics and AP calc at the same time. We were learning physics without any calculus, which isn't really how physics works. You need the calculus to do physics in such a way that it will actually prepare you for what college physics is like. So I kind of had this distorted image of it. I was really good at physics in high school but that's because it was kind of dumbed down. Even if the concepts weren't necessarily, the actual math and mechanics of doing physics problems and really understanding the math behind the concepts was off (p. 84).*
>
> *Looking back, part of me wanted to do the CERN thing because I had an idealized version of physics. I had no idea what it actually meant to do physics. I just knew that it was, you know, this new technology and it was really exciting and so I wanted to be in that, but I had no idea of what – like, day to day, of what I would be doing (p. 85).*
>
> *I just had this really different idea of what studying physics actually meant coming from high school because we weren't really learning it in high school. I enjoyed the dumbed down concepts-- like the ideas of like black holes and stuff like that, but actually learning what goes into those concepts so that you actually understand the concept fully, that's not interesting to me (p. 96).*

Having earned an A+ in Advanced Placement Physics and scoring a 4 on the highest calculus AP exam offered (BC calc as opposed to the lower AB calc), this young woman had the skill set to

do college physics. Perhaps the un-questioned superiority of an ivy-league institution to know "how things are" (with physics in particular) and the competitive nature of the program made her doubt her abilities, skew her interpretation of what success looked like and give undue weight to peer observations to the point where she no longer believed in herself. The following passages suggest a skewed understanding of what being successful looks like and how she was continually comparing herself to her peers to gauge that success:

> *(At Cornell) I did fine by getting Bs and B-s but I would think to myself, "If this is what I'm gonna do for the rest of my life I shouldn't be getting Bs in the classes, I should be getting As!" That's how I thought about it. If this is something I am going to make a living off of it should be something that I'm excellent at (p. 87).*
>
> *For example my ex-boyfriend, he is a physics major, it just comes naturally to him. He just gets it, and he can talk about it for days but I don't and I couldn't, and that was part of the problem. I think I felt that because I didn't feel that way about physics, I felt like something was wrong and so it wasn't for me (p. 88).*
>
> *And then I started dating my ex-boyfriend when we were in quantum. But because we were starting to date, I didn't want to ask him for help all the time because I didn't want him to think I was stupid. Once I told him I was going to switch majors and stuff, he was like, you should have asked me for help and I would have done all the homeworks together. I was just like, no, I couldn't have done that, personally, like I couldn't do that. I mean I did ask for help, but I kind of – you felt like you were asking for help a lot. And I felt like that wasn't something that should be happening, if it was what I was supposed to be doing. Because like all the people I was asking for help, they didn't need to do that, you know, they could do the homework themselves and get through it and understand the concepts (p. 93).*
>
> *We had to give presentations and my professor asked me a question and I had no idea what the answer was and everyone in the class was obviously listening to the presentation and that was pretty embarrassing. Maybe people thought I didn't belong there--that's how I felt but I don't know if that's actually how they felt (p. 97).*

## External Data/Internal Perceptions

As she formulates where she thinks she belongs, her negative interpretation of the above data, whether right or wrong, is being tempered by positive compliments and attention in her English and poetry classes. Paramount in her decision to leave physics is a noticeable absence of

examples of re-assurance from the people in physics and clear examples of re-assurance and connections to people in English and poetry:

> *In my sophomore year, I took my second class with Alice and it was this class where we read a book of poetry a week. We read contemporary poets and we would write poems in response. I started meeting with Alice and I really loved writing poetry (that's what I'm going to grad school for now). And it was pretty much meeting her I think, that really allowed me to acknowledge that that was what I really wanted to do. She was very encouraging and supportive. In physics the support wasn't to the same extent. I mean all the professors I had were very nice, and my teaching assistants were all very helpful (I used to be in the office hours every day), it's just, I feel like they weren't as invested. I don't mean it like an incrimination or anything (p. 86).*
>
> *The (physics) professors have their own research going on and they do make an effort to meet with you (all of my professors had office hours). They were all very receptive, but it's different when there's like a line of ten people waiting to get into the professor's room to talk about the homework versus meeting one on one to talk about a book. And I feel like part of it is the class size, like English classes are just tiny (p. 88).*
>
> *In my first professional writing seminar the teacher was actually a Ph.D. student, and he gave us a lot of feedback, and also through email-- he would talk with us about things. In physics, there's not a lot of feedback. I mean the TAs, they were very helpful. My first TA, he would just let me sit in his office and ask him about concepts. And so we'd always talk about general concepts in the course, too, as well as the specific problems, but it's just a different scope of learning, a different way of talking about things. It's like when you're talking about a book, it's so much easier to merge, or to go from talking about a book to talking about like life experiences and like what has influenced your life to lead you to the reading of the book, but with physics, there's nothing that can really do that, at least not in my experience with my interaction with the professors. It's like even with Jim, we would be talking about a physics concept and it wouldn't just like subtly change into talking about real life. If it ever did, it was like a distinct shift in the conversation (p. 88).*
>
> *I definitely feel when I talk about books with people I feel a connection with them, and I really like learning about why people have certain favorite books and I really like learning what people's favorite books are and then reading them (p. 89).*
>
> *I know Scott's my friend, but I didn't feel connected to physics, as a whole. I didn't feel a connection to the physics department and the physics professors, even though my friends were from my physics classes. It's a really weird thing, because I don't know how to explain it clearly really, because I know they're my friends and I know that I could count on them to help me if I really needed it, if I asked for it, but I just didn't feel like it was like whole, if that makes any sense. Whereas, with the English department, I feel like I'm so interested in everything that they do and am interested in going to all the graduate*

*student readings and stuff like that. I got involved with the English Club and I'm doing poetry readings and things like that. I don't know really why it's so different. It's not like the professors weren't nice, it's just I never felt connected with them-- the same way I did with my English professors that I had (p. 94).*

*In physics, they have things like physics colloquium but you know, nobody really made an effort to talk to other people, it was like you talked with the person you went with and you talked about physics and what the colloquium was going to be about, but not so much like other things. I think that sounds really bad but – it was just my experience in the department (p. 99).*

*Thinking about my own life in general, probably the single most defining moment I would have to say, I think it's when my creative writing teacher, the Ph.D. student, she said that, I was a poet! That was the first time that I really felt like yeah, she was right! And then it was reinforced throughout my class with her (p. 99).*

*In English one of my happiest times was saddest the saddest, too. It was my last class with my advisor, Alice two Wednesdays ago. We were having poetry readings where we all read from our chapbook (a collection of 10-20 poems) that we made, and she had made a big deal about telling everyone in the class about me going to Washington and like how proud she was of me (p. 103).*

Previously, she allowed peers to help her gauge her success in physics. Conversely, above we see people in authority—English professors and TAs—giving her direct, positive feedback. In contrast to the physics people who she inferred were not "as invested," this attention must have made her feel important, more intimately connected. Further corroborating the feeling of not being "as invested," is her word choice when she talks about Jim (her physics advisor): "We would meet with Jim one on one all the time, and he made an effort to get to know our lives--where we came from and what we wanted to do and things like that (p. 87)." Saying, "he made ***an effort*** to know our lives," seems to imply that it was more contrived and superficial. "Where we came from and what we wanted to do," seems less personal than: " Even though this (English) professor, Joanie Mckowski, wasn't my advisor, I met with her so much to go over my writing and stuff, and she really helped me in the application process. We would meet all the time and so she knew so much about my personal life. She knew everything about what

happened – what was going on with my boyfriend-- and she would tell me things about her experience (p. 97)." I believe this last statement is key to Kendra's view of the kind of "connection" she values. The reciprocity she experienced in having her professor share her own experience was crucial. Nash (2004) sheds light on why this reciprocity is so important:

> Good teaching, good helping, and good leadership are, in one sense, all about good storytelling and story-evoking. It is in the mutual exchange of stories that professionals and scholars are able to meet clients and students where they actually live their lives. It is the mutual sharing of our personal stories, particularly in the willingness of professionals to listen to the stories of others, that we make the deepest connections with those we are serving. Certainly, our students want competence, fairness, compassion, intellectual stimulation, enthusiasm from us as educators. In my opinion, though, they want something else equally as important. They want to be understood, and be heard, from the nucleus of the stories they are living. (p. 2)

Further, Schank (1990) contends that when someone tells us a story in response to one that we have told that captures an important generalization between the two, we believe that we have been "really understood," and we ascribe qualities of high intelligence and perception to our listener (p. 20). Joanie McKowski's ability to map her story to Kendra's story may have made her feel understood and connected. Similarly, Alice's moments of individual and public praise may have made Kendra feel important and honored to be accepted in to a group to which she may have "ascribed qualities of high intelligence"—at least to a group where her grades more accurately reflected this intelligence.

## The Language of (dis)Connection

Next I look at *how* Kendra tells her story and how her caring and loyal nature seems to make her diplomatic to a fault. I also look at how her diplomacy could possibly be due to her desire to have balance. Whether because she is a caring person or just loyal to the time her physics professors "invested" in her, Kendra is very careful not to blame anyone and holds herself completely accountable for not staying in physics. Her word choice seems to suggest that she treats the discipline of physics as a person (one constrained by logic and rules), and employs

the "It's not you, it's me" break up routine to be with someone who is "creative", "freewheeling" and "universal" (universalizable?)-- English:

> *It's not that physics was less appealing in college, it was just, I could see that I wasn't good at it; maybe part of it was less appealing, because I didn't love it enough to keep working at it (p. 85).*
>
> *I think it was more like me, to be honest. I felt more connected to English and to writing and reading and it made me happier and more excited (p. 90).*
>
> *I felt bad asking for them to help me all the time. I know they didn't really feel bad but – or they didn't feel like I was annoying, stuff like that-- I know they didn't feel that way but that's how I felt about it and so it wasn't good (p. 92).*
>
> *I feel like I was part of the problem because I really wasn't interested in physics once I actually learned what it was (p. 96).*
>
> *Maybe people thought I didn't belong there--that's how I felt but I don't know if that's actually how they felt. My friends wouldn't have felt like that but the other people in the class may have (p. 97).*
>
> *I really didn't love physics, so there is really nothing anyone could do to keep me there. I didn't like what it actually was and so I think it was mostly me realizing that I didn't like it enough to work at it. I don't think there is anything that they could have said that would have made me like it more (p. 98).*
>
> *As a physics student, I may have felt like an outcast a time or two, but I think that was more internal than it actually being the case (p. 100).*
>
> *It (the physics lecture) wasn't condescending because I know what condescending sounds like. It wasn't condescending but it was done in a way that if you didn't understand what they were talking about it was your fault, if that makes sense. In a way that's different than condescending… It was like that in English too (p. 101).*
>
> *It was just me – I don't know how it's possible for someone to stay with it if you don't love it (p. 104).*

The above are a few of the many examples in which her language choice speaks to her sensitivity. In a couple of other examples she describes "feeling guilty" about having the physics department pay for a research experience for her without her full commitment to the program and of being accepted to a graduate school, only to decline because she couldn't afford it.

Certainly she does not have an entitlement attitude and does not take lightly the privilege of an education.

Additionally, with reference to her language choice, Laberge and Sankoff (1979) tell us that a speaker generally uses the impersonal *you "*to assimilate herself to a much wider class of people downgrading her own experience to incidental status in the discourse, phrasing it as something that could or would be anybody" (p. 148). *I*, on the other hand, makes you the subject of your statements (Chase, 1995). Noticeable in her profile is how Kendra frequently changes the *I* to *you.* Here are a couple of examples:

> *I was just like, no, I couldn't have done that, personally, like I couldn't do that. I mean I did ask for help, but I kind of – **you** felt like you were asking for help a lot (p. 93).*
>
> *We stayed over the summer my freshman year to really start getting into this, and so we were all basically working full-time, and **you** would have lunch with him e87).*
>
> *I applied to grad schools and was rejected from all the top places that funded **you** when you got in. Then I got into three schools and none of them were giving me any money at first, and so I had no idea what I was going to do (p. 104).*

So why does she change from *I* to *you*? Or change *we* to *you*? In these instances it does sound as though she wants to downgrade her experience, and perhaps disconnect from (the pain of?) it. In the second case where she goes from *we* to *you*, almost makes it feel like it was a contrived, mechanistic, ritual instead of a fun, connecting, and relational experience.

So what can be gained from my interpretation (and my standpoint) of her language choice and style? Her diplomacy I have mentioned earlier, seems to be to a fault. The beauty of narrative inquiry is that it better helps you to understand your own story as well as the stories of others. In the words of Nash (2004), "… [I] write to explain myself to myself. I also write to explain myself to others." So, I believe her diplomacy to be to a fault, because I feel her sense of identity stems more from exogenous forces than from endogenous ones. Having a strong sense

of identity from within, I (a chemistry major in a time very few women majored in science) was able to separate the chemistry I loved from the banal delivery of many of my professors. I refused to let their view of how it was to be taught taint my enthusiasm for it. I had an "it's not me, it's you" attitude that I thought was healthy and kept me going. Instead of thinking that my poor grade in atomic and nuclear physics was due to my lack of ability, I attributed much of it to the banal delivery of my professor. Granted, I know today that that was an immature attitude to have at the time, but it was functional in preventing me from internalizing a grade of which was not a true measure of my abilities. Kendra, on the other hand, freely allowed Cornell's version of what physics looks like and how it is taught to be THE correct way—one that did not honor her love—that of the creative, conceptual side of physics.

Considering Kendra describes her best friend as "pretty much the same person," can we assume that she was looking for a "best friend" in her career choice? Perhaps some females equate the "persona" of the way physics presents itself (which is the extension of how this male dominated discipline wants to project itself) to be a contradiction of what they value and therefore not eligible for the status of "best friend" or worthy of a lifelong commitment (as many career choices are). Again, values here are much more deeply held than preferences. For myself, I used chemistry. Chemistry made me more interesting and helped me make people smile. I fed my internal identity—a person who fights for the underdog, helps those who are unheard be heard, helps others realize their dreams as others have done for me—through my love of chemistry and math. My identity at Kendra's age was already formed. Kendra, it seems, is trying to find hers and wants her career to be a reflection of who she really is inside. Instead of infusing who she is inside into a physics career where she knows she might be rejected-- the rule and logic governed world of physics-- she takes her intellect and creativity to the world of poetry

where she knows they are appreciated. She says, "Who am I today? I don't know. That's such a hard question (p. 103)." Why is it such a hard question? Is she stumped by the lack of universalizability of the story of physics? Or does she not understand how her values were not nurtured and/or appreciated by her initial career preference—physics? She *does* know who she is and says, "It's just I didn't feel as much of a connection with the majority of the people that I met in physics. Despite that, I do think that people were accepting of who I am. I had genuine friends, and the professors that I went to and got help from and were genuinely interested in helping me understand the material (p. 104)." A career choice is not just about "understand(ing) the material," I believe it is about the whole person exuding who they were created to be (and the ideal-- while helping others to do the same). We are no longer a generation that just subsists—we are one that has the ability to combine the diverse talents of all who enter our fields to maximize creativity and innovation to further knowledge— and *not* just knowledge of the universe, but of ourselves as well.

*Lucy Vela*

As with Kendra, Lucy liked school and grew up in a family that valued education. In Lucy's profile we see again that personality and relationships have more to do with staying in the highly competitive world of engineering than aptitude. Both Kendra and Lucy went into Cornell with the intellect and ambition to succeed in physics and engineering. If anyone could, these two young women could bridge the cultural gaps between the way things are and the way they ought to be. Instead, they both changed majors. Kendra had her armament of creativity, imagination and universalizability and Lucy her feistiness, resilience and confidence. Although positivist data would suggest that Kendra would be the more successful of the two (an A+ in AP physics, a "5" [the highest score] on the AP physics exam, and a "4" on the most advanced BC calculus AP exam) she did a complete 180 degrees and changed her major to English. Lucy on the other

hand, did very well in high school calculus but to her confusion, did better on the English part of the SAT test. Nonetheless, it was Lucy who refused to leave engineering (although, in theory she changed majors to "independent" with a concentration in engineering) and carved her own path to one day secure a position in engineering despite not being "accredited". Like Kendra the number of insights we get from reading her profile seems to be endless. Here, I chose to look at a few that stood out for me—cooptation, resilience, and disparate educational experiences.

## Cooptation

In the introduction I mentioned that narrative inquiry has the power to make all those things of which you are intuitively aware made manifest in the spoken words of another. Sometimes we don't even know what we really know until something someone says sparks that "aha!" moment. Case in point, after my interview with Lucy I walked around for days trying to wrap my mind around why I was so disturbed by the Randy Pausch example she gave me (p. 133). Granted she did preface it with I don't want to misquote him, but she said, "…but there was a part where he said the brick walls are not there to keep you away from what you want, they're there to show that you really want it or they're to keep others out (p. 133)." "There to keep others out?" Was that a Freudian slip? Does she really mean that? Has she "crossed to the other side"? Again, she did preface it as not wanting to misquote him. But, I wondered deep down, is this her co-opting? Even though I was a fan of Pausch's "The Last Lecture," I remembered in that instant how I hated that analogy of the brick wall. Yet, I was confounded by why. When I discussed this with a close friend, without hesitation he fed my own words back to me, "It's so obvious! You always tell me that 'education breaks down the barriers that prevent people from being all they can be'. The brick wall is man-made!" And he is right, I believe the purpose of education is to break down the barriers, not put them up! As Nikos Kazantzakis so eloquently puts it, "True teachers are those who use themselves as bridges over which they invite

their students to cross; then, having facilitated their crossing, joyfully collapse, encouraging them to create their own." The artificial, exclusive, and constraining structures that are in place (citing the journal just to get published in a journal, joining a popular professional organization just so *they* can hear a different perspective, having points deducted from a paper because you cited the NY Times for a automotive engineering example—one that could never be found in a peer-reviewed journal—to demonstrate the value of a female perspective in design, political hoops, resource hoops, and I could go on and on)-- the entire cacophony of the hoops[5] we must jump through just to have the opportunity to share knowledge with others-- feels more like a hazing (in the persecution and torture sense) and not a support for our future leaders. Marinating my brain in the conventional wisdom of the day will not help me to inspire and lead. I want more. Emerson (2009) so eloquently put it, "he who should inspire and lead his race must be defended from travelling with the souls of other men, from living, breathing, reading, and writing in the daily, time-worn yoke of their opinions"(p.541). The dissonance in Lucy's statement from what I wanted to hear, to what I actually heard created the perfect venue to have my heart's song—the song that academia was insidiously sucking out of me—sung *back* to me. In understanding her co-optation, I was able to understand my own.

Elsewhere in Lucy's profile we see other instances I would classify as being co-opted. On page 137 she says, "I really don't think the glass ceiling exists." Wiersma (1988) would argue that women use disavowal as protection against anticipated criticism for violating women's traditional roles. However Lucy qualifies her statement further and says:

[5] For clarity, the motivation behind the hoop is paramount. Hoops of ignoble origins that impede rather than support knowledge construction, are what I am referring to here. Motivations are really hard to nail down, but results aren't. If the outcome of a requirement is enabling and supports the construction of knowledge, then it's good. If it's merely exclusionary, then it's not. I liken it to a hobble which, according to Wikipedia (yes, I just cited Wikipedia), is a device that prevents or limits the locomotion of a human or an animal, by tethering one or more legs.

*I think even if it does exist, people recognize that, and they give women a bit more slack. Like to be honest, a lot of the times, when I would go running to a professor and cry, a lot of it was thinking oh, I'm such a weak person. But even if they saw it as oh, I'm sad because she's a woman and I want her to succeed, then use it. Like don't be afraid to use it. Like use the fact that you're a woman. I don't mean use it -- embrace it. I always try to separate myself and think oh, okay, it's not because I'm a woman. It's because I'm sad or it's because I'm not doing well. But if it happens to work out that I'm great at what I do and I happen to be a woman, then I'm like then use it, and show other people (p.137).*

Here it seems she is straddling two different worlds. It seems she is trying to spin a perceived weakness into a tool for acceptance of diversity by "separating myself". Although I found the above passage difficult to understand, in the context of this statement from page 119: "There weren't females in there, as I remember. And if there were, I'm forgetting *[Laughter]*. But no, I didn't know it that way, but that was the same thing in high school. There weren't a lot of females in my high school either, but that never posed a problem for me," it would seem that she has one foot in both worlds and if she 'slips up' and recognizes that she is in the minority, she doesn't have to worry because she will be given the benefit of the doubt, or in her words some "slack".

Later on page 124 she offers this instructive story:

*I'd say the greatest compliment a professor has given me since I've been here was probably in 2930-- Differential Equations. I went to this professor's office hours, and I like – I cried, and I was just like crying my eyes out, and I said I know this is so weak for me to do, but I just like – I can't do this. I just can't do this assignment. I'm so stressed out. And he said, "Well, you're not super human. Nobody's expecting you to be. So just go home, forget this exam; forget it– just give it a break. I don't want to hear it. Just go home and sleep." And so he was great. He was just like just go home and just go to sleep. I don't want to hear it. And if I hear that you did otherwise, which he was like, which you know I can't – like I'm not that into your business to know, but just like I'm giving you this break to go home and go to sleep. You look a little stressed. At the time I was so stressed, I was just relieved. I just thought, "Thank you!" He was compassionate, and that was a compliment. I took that as a compliment because he knew that I was trying so hard to get it done (I told him I've been going to my TA's office hours like crazy!) And he just said, "Scrap it! I know you – I know you're stressed. This problem is the least of my worries." And that was when I was just like oh, great.*

That Lucy would consider a professor who says, "this problem is the least of my worries," (meaning "her" problem was the "least of [his] worries") a compliment (let alone the "greatest compliment") and an example of compassion, says to me that she has either been so beaten up that she looks past the off-handed "compliment" or she feels so part of the male dominated culture that she is being treated like one of the guys (think back to elementary school, when a boy showed that he liked you by pushing or hitting you). Perhaps you disagree with my interpretation. Nonetheless, from years of teaching I have learned that my students don't feel heard or important when you minimize instead of acknowledge their problems. To say, "Scrap it!" seems more like it was a time inconvenience for the professor to help her with the assignment. "Come back in a couple of days when you don't feel so stressed, and then I'll help you," may have mitigated some of the stress and made her still feel like she, as well as the material, was important. I also think it is interesting to note that throughout her profile she describes not feeling connected (p. 122) to most of her "technical" professors and in the passage above she seems to correct herself from "I know you," to "I know you're stressed."

## Resilience

Next, I show how some of Lucy's co-optive experiences add to her resilience and allows her to stay focused on her goal of "doing engineering" (p. 125). Without a doubt, Lucy has her own unique formula for resilience. She is competitive, feisty, confident and flexible. She has a support system of friends and family that she "straps" (p. 126) on to her*self* when the going gets tough. Co-opting sometimes allows her to keep her "blinders" on so that she is not easily discouraged. Overall, she values being independent and "breaks free" (p. 140) from what Cornell says a good engineer looks like and carves her own path.

Clearly, her confidence *in herself* is building over her time at Cornell, despite her struggles. In the beginning she may have been caught up in a posturing, "head game" and comes

to realize that running to class in sweats does not necessarily mean that the students were getting every bit of studying in up to the last minute. She now has the local knowledge that allows her to rationalize through it and by her junior year she realizes what is really going on:

> *…I know a lot of engineers come in running with sweatpants, it means you were doing your homework like last minute — or you were like getting that last bit of testing done. And now I just think, no; I know the truth. You were doing it last minute, and you weren't studying all the time, and you were probably like on computer games and all that sort of stuff, and you don't care much for your appearance, which means you didn't do your stuff on time and you weren't managing things correctly*. (p.139)

Even with a strong confidence level (she even refers to herself as "pompous" at times) she is continually using "self-talk" to build herself up:

> *I've always loved school. I used to go to school in the Bronx where they were one year ahead in the reading book that carries over, at least into Manhattan. And so when my parents moved to Manhattan, I was one year ahead. It was nice to feel like, "Oh, wow, I'm advanced. I'm surprised we're even so talking still about multiplication. What is this?" [Laughter]. (p. 112)*

> *When I was growing up it was just like do you want to be a doctor or a lawyer? That was what most people just asked you. So I said, " No, I don't want to be a doctor (I'm squeamish). But I can debate, and I can argue, and I will continue arguing so I will be a lawyer." And so that's why I thought sure, I'll be a lawyer, and I'll be great. (p. 114)*

At times she even became "cocky confident" as we see in her feisty and jovial exchange with her dad:

> *My high school was a Math/Science magnet school and for the engineering track, the first year you did like principles of engineering where we used Autodesk Inventor and designed an alarm clock. Even though I didn't physically take things apart as a kid, I was proud of the fact that I was great at reading instructions. My dad was really good at making kit radios, and I was like, "You don't know how to do this. I'll get it done perfectly! Done!" (p.114)*

Later, she has a similar positive, argumentative exchange with a professor:

> *. ..And my boss was a professor here. I don't know – I forgot what he does [laughter], but he's a professor. And he would just be really honest with me. I never saw him in an academic setting, but it was nice to see a professor is human. It was great. He lived in Hans Bethe. I never had him in class, but we had great conversations. He said, "Well, do you know what – have you ever taken a course in anthropology?" And I said, "No, what is it? And I guess it's this..." and I gave a bogus example. He was like, "Well, how will*

> *you know? How do you know if you've never taken a course in it, you've never experienced it, that you wouldn't like it? You just don't know. And how do you know that that's not your perfect major?" And so I just thought, "Wow. You like actually stumped me here." And that's when I learned that I have to actually sit in on a course and try it out and not just like wait for the junior year to think oh, I think I like math, I'll enjoy that course. I'm done-- I scrapped that model. If I think I like something, I'll just do it; I have to try it, and I have to see it. And that was one of those life things I learned. I was transitioning and trying to see if I could move out of the college at the time. And just based on the credit – required credits and how much would transfer over, I could not transfer. I really liked that professor because we would always battle. He would ask, "Why do you like engineering?" And he would say, "How are you doing in your courses?" And I'd say, "Oh, I'm not doing that great."(p. 124)*

I believe that "battling" with her professor and telling her father, "You don't know how to do this," was her feisty way of "being known" and acknowledged. Nash (2004) says this about "the argument":

> Another category of responsive story is the argument. When you tell a story that implies something is wrong with yourself, you may hope for a story that disputes your point. Sometimes, you make an assertion, however, without intending to stir and argumentative response but do so anyway. Of course, not all arguments are unfriendly; mutual storytelling, even in the form of the argument, can make the storytellers feel closer to each other. (p. 52)

Her battles and quip to her father were not unfriendly. I believe they made her feel closer to both her professor and her father. I also believed this is something she craved with her professors that she was able to substitute through her friends through an exchange such as the one below:

> *… But in my classes, like I never knew– even if there were female students there. It's sad. It lends to how I didn't even know if there was a girl in my programming course. I just don't notice them. Like they just look among the masses, you know. I don't notice it. But then the minute one girl comes in pink and like with a bag, and I always take it like okay, tomorrow I'm going to wear this; tomorrow I'm going to use that bag that I just bought and I was so excited for. As I was further along in my courses, more people would do it. We just – like we laugh about it now. I'd say oh, my gosh, your scarf is so cute. But we wouldn't say that in front of a guy because they'd just be like, ugh. But then even if they do, I'm very quick to respond and say well, you know, maybe you should get out of your sweatpants and get into some slacks. You see how the professor will respond to you then. And they say well, what does that mean? I say because you don't look professional. And to be honest – and I've gotten into a lot of fights about that, but I say you don't look professional. And it's like I don't understand why you're going in pajamas to class. It's ridiculous! (p.140)*

Not only do we see her feistiness in action, we see she loves a challenge. We also see how the importance to conform makes females blend in, as well as how one young woman's choice to wear whatever she wants, at the risk of not conforming, liberates her to re-unite with the feminine things she values.

In an interesting aside, I too co-opted my dress. For the last twenty-five of my twenty-seven years in education I refused to wear pink. Then, out of the blue (no pun intended), I decided to "break free" and wear pink to cover a class for a colleague. I was so happy to have stepped out of my comfort zone and back into "me" when a female student walked up to me after my well-received lesson and said, "You make me want to wear pink." She needn't say another thing. I knew exactly what she meant!

Lucy had insight about dress and she also had the important ability, or flexibility, not to allow her grades and by extension Cornell, to define her is suggested in the following passages:

> *Here I've accepted that I'm like at least the mean. If I got the mean in the grade – in the test, oh, I would celebrate. So usually, I'm about a standard deviation below, which would be, you know, like a C. And so it's enough to pass me into the classes. And I enjoy it, and I still work hard for it, but I don't get good grades always. (p. 116)*

> *So when freshmen come on campus – and I say even if you don't go to Cornell, just know that in your engineering classes, they will not define you. They will probably be the toughest classes you've ever taken, but don't let it define you. And if you do, then, you're going learn, in the end, that it shouldn't [Laughter]. (p.136)*

In her closing remarks, she, not Cornell, is going to have the last say in what an engineer looks like, even at the expense of not being "accredited":

> *Honestly, I just feel that if Cornell wanted to be ahead of the curve, if I had to redo college, I would have gone to Harvey Mudd or somewhere else with a general engineering degree because for those who just like engineering and critical thinking, it's great, but the minute I felt I had to major in a specific area in engineering, I felt like I was limiting myself, and I wasn't getting as much of the entire Cornell experience by not*

> *being amongst people of all different fields (for example I wanted to take courses with people in Human Ecology). That's when I had to break free. And I just thought no, I can't do this. I'm doing independent. I don't care that I'm not accredited! (p.140)*

On that note, if I were a prospective employer, I would want to hire this young woman. If being "accredited" means conforming to a culture unwelcoming of diversity, then I'm glad she "broke free" and chose independence over accreditation in more ways than one. A high GPA does not mean the person will be a great or even good engineer. Engineering is about inventing, imagining and creating—qualities that are truly enhanced and made successful through tenacity. Lucy has tenacious qualities that can further the process of doing engineering. The teamwork that had endeared Lucy to the process of engineering in the first place, could be better served by her successful "subjective" qualities to a greater degree than the "objective" ones, in my view. Productive teamwork is the process through which team members freely bring their best attributes to the table to work on a common goal. While one person may offer their computer programming savvy, another may have the interpersonal skills to derive the gist of the customer's challenges and needs as well as the technical and communication skills to articulate them.

## Disparate Educational Experiences & Mixed Messages

Finally Lucy's profile was a sobering reminder of the multitude of mixed messages we send in education that can have a negative effect on our students. Having taught at the high school level for more than 15 years, at a community college, a state university, and two ivy-league universities I've seen where students get derailed. At the high school level I have always witnessed so much more encouragement and support from teachers to students than I have witnessed at the college level (at the college level I have been fortunate to always have under 50 students in my class and they are continually telling me that in the big freshman lectures, the professors don't even know their names). Then "swooosh!" when students get to college, we

pull the rug out from underneath them and sit back and say, "Aha! Let's see what you can do now without all that 'touchy-feely,' support and encouragement crap! Let's see what you are really made of! Welcome to the real world where we have regressed into the animalistic, 'survival of the fittest' mode. A world where your test of fitness comes from masculine conceptions of what worthiness looks like," so to speak. Is there any evidence of this cynicism in Lucy's profile? Let's see.

Lucy's profile is full of mixed messages we in higher education continue to proliferate and enable. Mixed messages that deal with the rhetoric of valuing diversity are found throughout her profile. In several instances, I see evidence that suggests Lucy was well-schooled in the official stories to help her "get out" (p. 112). She knew what stories to tuck away and which ones to pull out. Schank (1990) elaborates:

> But which stories do we choose to tell which do we carefully tuck away untold or even uncomposed? … One problem is that the stories we tell as children often are shaped for us. When the college interviewer asks a 17-year-old why he or she wants to go to college, there is, unfortunately, a right answer. The issue for the teenager is to learn the right answers, to learn the official stories that qualify one to be accepted into various subcultures. (p. 208)

Lucy knew at a very young age what stories to tell, "I guess the reason why I got into the magnet school, was that when they interviewed you, I said that I wanted to be a judge. And I knew that I had only said that because I wanted to be in (p. 113)."

Despite knowing what official stories to use to get somewhere in life, Lucy chose to write her college essay on her sweet sixteen party. This, with my *scholar* hat strongly secured to my head, is the kiss of death! Isn't the "official" college essay about saving the world, searching for a cure for cancer, or spending a good portion of your life in the Peace Corp? Hmmm… I would have thought that the admissions committee would have thought this was shallow and pedestrian, lacking a vision for the future of mankind. Could it be that selection committees appreciate the

authenticity of everyday experience? Or, did they simply reject the essay and say, "Ah what the heck, let's give her a shot." Nonetheless, it would be interesting to know. After all, Lucy has a right to be angry if she was accepted as one person and expected to be another once she arrived. This is what she says, "I was just so tired of it. And I just thought, you know what? If I can't do this, then why make it so painful to get through these classes? Why did Cornell accept me in the first place if they were not going to support me (p. 130)?!" Why did they? Is it a game where you bring women and minorities on board, make them relinquish who they are, strip them of all support and say, "Well, we tried, they just couldn't hack it." Again, mixed messages.

Other mixed-messages found in Lucy's profile continue to deal with disparate educational experiences in the areas of support and encouragement. Support and encouragement are not the same as "coddling". I, personally, have seen academia confound the two at times. In Lucy's profile, we see what might be considered evidence of her high school teachers' support and encouragement in the following passages:

> *And so they spent so much time with me trying to get me ahead, to pass exams and to try going for different middle schools and high schools and really trying to get me out of the system. They would always say, "Let's get you out of the system. You've got to get out." (p.112)*

> *And I would say that the teachers were so much more engaged in high school. They thought that they were teaching students who were going to be great. And they would remind us of it. (p.117)*

Despite the support and encouragement from her high school teachers, the prestige and mystique of being an ivy-league professor garners greater respect in her eyes:

> *It's sad, but I didn't look up to my teachers in high school as much as I do the professors here. Despite that, I guess the professors here are great at what they do, but I always feel like there's just some disconnect between us. And I'm more – I tend to think that that's more because they're just so smart. And like sometimes it's hard to – I know it's hard to explain something as basic as multiplication when it's so easy for you to do nowadays. But I just think the professors do it all the time; they're so much more advanced in the course that they're teaching, that they just can't explain it. But that wasn't the way in*

> *high school. In high school, they really made it seem like they were learning among – with us, that they were just there to observe and tell us when we were doing something wrong and when we weren't, as a mass, coming to the right conclusion. (p.118)*

Unfortunately, the inability to teach is falsely being connected to "brilliance" or "genius" and is being used as an acceptable excuse. This is reminiscent of a broader societal value. The underlying myth here is that high school teachers (who are certified to teach) aren't as smart as college professors (who generally aren't certified to teach). And, although, the converse could be true as well, it seems reasonable that a person who has had more formal training in pedagogy would be a better teacher. Or is it? It is also interesting to note that states typically will not allow someone uncertified in a particular area to teach a course in that area, whereas in academia there aren't those types of regulations in place. Case in point, my polymer chemistry professor (at an ivy-league institution), a biology PhD, explained that he himself had never had a course in polymer chemistry. Likewise, many graduate students are having their first "go" at teaching our undergraduate students. Mixed messages and myths such as these pervade education and can be dangerous in devaluing the importance of teachers in the co-construction of knowledge.

Another mixed-message between the high school and college educational experience I found in her hilarious account of professors struggling to use technology. As a graduate student, I cannot tell you the number of times my professors had to "scrap" their lessons because of difficulty with technology. As a former high school chemistry teacher, I would not dream of not testing my equipment before I used it! Furthermore, I would have a back-up plan just in case. Here is her description:

> *But when I came here, it was more like I was a part of a movie; that's honestly how it felt. I would just sit down in class, and there would just be like the front room, the front table, and they would show the slides of the PowerPoints. And that's as technological as they got. And sometimes they'd say "Oh, I can't deal with the power cord, I can't like plug it in. Forget it [Laughter]. We'll just scrap it." I'm just like well, there goes the visuals [Laughter]. Well, there it goes! (p.117)*

I just loved this example! At an ivy-league institution the assumption is that all the latest, greatest things are going on with technology. Although this might be true of the research, it is not necessarily true in the classroom. Contrast the above example with her high school experience and we see tools of learning being withdrawn at the expense of different learning styles:

> *... In high school we had toy models and that helped me get by, but not in college here. In high school physics, it was really easy for my teacher to just draw out exactly what he wanted and it was great. We had high-scale cars that would just zoom down tracks where we could clearly see what was going on. Here, the physics department has great demonstrations right in front of the lectures. In Rockefeller Hall the auditorium has so much space up front, my professor could do exactly what I would be doing in high school, except demonstrating it for the entire class. (p.110)*

Although she uses this as a positive example of a teaching strategy that is helpful to her—demonstrating—it still is not the same as handling the toy models on your own to "clearly see/experience what is going on".

In another example we see how mixed messages are not just between the educational experiences of high school and higher education, but within higher education, across disciplines. In this example Lucy simply wants the support that comes from acknowledgement initiated by the professor. Whether it is deliberate or unintentional, she sees the disconnect in responsiveness to her actions in two different classes:

> *But they weren't – like if I really was honest-- they were never condescending. They would just say something like, "Well, you need to tell me; I can't read minds. I can't like do things for you. So once you have a problem, you come to me, and you tell me, and I can help you out the best I can. But otherwise, I can't do it." I guess I blame them for that. I always felt like a lot of engineering professors were like that-- not condescending. I can't find a good word, but I just felt like the engineering professors were just different. In my writing seminar, my teacher could sense something was wrong, and she would come and tell me like, "Is everything okay? You haven't been sleeping. I could tell like maybe you're…" and I'd say, "Yeah, It could be that." But then again, I can't compare*

> *my writing seminar class to my engineering class because there weren't smaller classes in engineering. I sat in front for most of my engineering classes and even though I know looking into a sea of people can be difficult, I still felt like that gave them some responsibility to say, maybe she's not falling asleep because she doesn't want to pay attention or she's slacking off in her work for other reasons. So a lot of times I would just be annoyed because I had to take so much initiative to go to them and explain my problem and risk crying in front of them, it was just so tiring. (pp.127-128)*

She then goes on to excuse such behavior because, "…the engineering professors, I would just feel like they were doing great things and can't be bothered *[Laughter]*. Can't be bothered-- like it's massive research, massive, you know – like you just can't begin to understand what they're doing (p.128)!" Here I interpreted her laughter after they "can't be bothered" to indicate that she knew their indifference was wrong but that it is "the sacrifice one must make" for the sake of knowledge. I also found that she was very serious with her tone afterward, and was not saying this in a sarcastic way. This was disturbing to me as I feel she is beginning to equate intellect with lack of caring abilities and thinking this is superior.

Although this last example could be placed in the disparate educational experiences between high school and college, I feel that the point is more broadly how the general population views "average". As a high school chemistry teacher and college chemistry instructor, tests were not just to see how well my students understood the concepts, but they were used to see how well I taught the material. For a student whose conception of average is 70-75 percent of something, it must be quite shocking, and even demoralizing, to get a 33 percent on a college test *even* knowing that you are the mean. Here is Lucy's description of her experience:

> *There are some tests that we've taken here where the mean was a 33, which is crazy. You could only master 33 % of the material and still pass. Why not make the material achievable where 70% is the mean like they just don't understand that [Laughter]. That's fine. Like everyone else in the class is sitting there and thinking you're insane for giving that exam. But that's fine, you know. That's crazy. I once saw a student cry on an exam, and I was just like – come on. I said don't let it get to you. At the end of the class, I let her know you're not the only one. Everyone is going home thinking what was*

> *that? Like that better not ever happen again. And in the end, everyone's grades – like it just all ends up working out in the curve because if everyone else does bad, he has to make it seem like an average course, and so it's a B, fine (p. 135).*

I have to ask. What is the purpose of not making the material achievable? As a teacher, I would be embarrassed that a test I designed did not test what I taught. A test is an instrument for both the student and the teacher to reflect on the mastery, delivery, and construction of the material taught. You can design a test that challenges everyone-- even the genius in the class-- and have a mean of 75. For heaven's sake you could even put "bonus" questions on the exam to further challenge the outliers. In my view, this 33 mean is a demoralization tactic, designed to break students down, not build them up. Again, this is another example of mixed messages that complicate the learning process, not just for females, but for males as well.

So, with most of these mixed messages common knowledge, why don't we fix them? Could it be that they serve a purpose? Maybe some of the more covert mixed messages are deliberately in place and no one copied me on the memo. Perhaps the deliberate inducement of the struggling and the suffering has become the pedagogy of the enlightened. Perhaps, our quest for universal 'T'ruths, must start with those which are universalizable 't'ruths—from the spot of pain and suffering in us all that accords universalizable 'T'ruths with universal 't'ruths; similar to seeing the structure of the atom in the structure of the periodic table, only knowing it is true. In other words, so that we are not like "lambs to the slaughter," the infrastructure of some institutions of higher learning could be without metaphorical supports (and encouragement) because the "sturdiest temples" are those that develop their own supports *from within.* Could it be that the feeling of being broke and the demoralizing games are not to break us of our spirit, but to put us back in touch with it? And, most importantly, that we have to figure this out ourselves?

I don't think so. On the basis of one life experience, I can confidently say that you don't have to break someone down to build them up. You don't have to make someone suffer to help them realize their full potential. I believe that it comes from grace. For those of you who were worried and thought that to be kind and caring, you would have to be all "touchy-feely," you are wrong. You can exude kindness and caring by conferring dignity, respect and honor on those around you.

So what was that one life experience that opened doors for me, both personally and professionally? Here is the story: One of my greatest teachers of all time was a physics professor named Dennis Manos at Princeton University. In 1991, I was the only female on an all male research team developing an erosion diagnostic for the International Thermonuclear Experimental Reactor. I was the token woman and under-lettered at that. It was awkward. I felt alone and no one asked my opinion; even when I gave it. Never uttering a word about the strange dynamic within our research group during our first week together, Dennis and I would have our regular meetings. In those one-on-one meetings, Dennis would ask my opinion about things and put me in charge of deciding what materials (elements) to use. I'll never forget, he once asked me what the bond energy of nitrogen was. I looked it up in the nerdy handbook I carried around and told him (to this day I will never forget that value-- 940 kj/mole). The next day, at a meeting filled with PhD physicists and engineers, he posed the same questions to them that he had already posed to me the day before. As these prestigious researchers pondered his question, I had already formulated my response from the previous day's conversations and confidently described what I felt our course of action should be. The next thing I remembered was how some of their unruly eyebrows began to rise as if to say, "This kid knows her stuff!" From that day on, I was one of the team. Researchers shared their knowledge with me and I with

them. We had a great time working together and our efforts led to a patent for a plasma erosion diagnostic for the tokamak fusion reactor (the elements of which were chosen by yours truly). To this day, Dennis and I have never talked about what he did. But, I know in my heart of hearts that was his way of showing me how much he believed in me.

To this day, I use the same strategy with my students who are struggling or need to have their confidence uplifted. I talk to them on the side, have them think and talk through the answer when there is no stress, then, later I will throw the question up to the class and call on them. It is honestly magical what happens next! Once the student knows you believe in them and support them, they often reciprocate by wanting to "wow" you! All they needed was that one push to get them going. Truly, there is an indescribable synergistic effect that occurs when people believe in each other.

***"We see what we believe: we observe what we narrate; we transform what we reframe."***
***—Robert Nash***

***"To know as we are known."—Parker Palmer***

***"Imagination is more important than knowledge."—Albert Einstein***

## Conclusion

In this paper, I sought to reframe our approach to understanding why women are under-represented in physics and engineering and moreover, why those female students with the intelligence and drive to succeed in physics and engineering, leave. Instead of designing an empirical study looking from the outside in, I chose to go directly to the young women who have experienced the change, in context, to understand the experience from the inside-out. I chose this approach because I understand that in designing experiments, the types of questions asked are conditioned by the types of answers expected and that "facts" may be distorted by our

expectations or totally overlooked because they were not anticipated (Brown & Lemay, 1981). Narrative inquiry, as an interpretive form of research, can help transform this body of research by allowing those unanticipated experiences to surface and round out the exaggerated benefit placed on the traditional explanatory paradigm. Umemoto (2001) and Forester (2006) further remind us that simplistic views of objectivity can blind rather than empower us.

If I have done my job, it may seem as though I have been finger painting all over a scholarly paper—blurring the lines with the personal and operationalizing opinion. I have also claimed that I am a successful teacher, chemist and great problem solver (or did I downplay my abilities with just "good"), without providing empirical evidence related to these claims. However, you may have reasoned that the latter is a silly request and you just granted me the same courtesy I give every other academic every time I pick up a journal – respect for the opportunity to learn from another's story—sterile as it may be because, perhaps, *your* story is "hidden" behind the security of the traditional "objective" research paradigm, the "official" research paradigm that generates "scientific" knowledge, THE story of choice. Again, these "official" stories as explained by Schank (1990) "are the ones that have been carefully constructed by one or more people to tell a version of events that is sanitized and presumed to be less likely to get anyone in trouble, where the overall intention of the official story is to make complex issues seem clearer than they otherwise might appear" (p. 31). Not only is this applicable to the participants in this study, who don't want to get anyone "in trouble," but this is also applicable to our choice in research methodologies. Here I use parentheses in Schank's quote to make the parallel and to drive the point home, further:

> … which stories *(research methodologies)* do we choose to tell *(use*) which do we carefully tuck away untold or even uncomposed? The act of creating stories to tell *(knowledge)* has a great deal to do with how we see ourselves. One problem is that the stories we tell as children *(academics)* often are shaped for us *(by the 'gatekeepers' of*

> *knowledge)*. When the college interviewer asks a 17-year-old why he or she wants to go to college, there is, unfortunately, a right answer. The issue for the teenager *(academics)* is to learn the right answers, to learn the official stories *(the scientific method)* that qualify one to be accepted into various subcultures *(academia)* (p. 208).

How do we see *ourselves*? Nash describes this inner turmoil eloquently:

> Constructivists tend to ask: what meaning lies *inside* of you and how can you best narrate it? Objectivists ask: what meaning lies *outside* of you, and how can you best prove it? In reaction to this overly facile dichotomy, though, I would offer that, at some level, we are all constructivists *and* objectivists.
>
> Scratch an empirical researcher, or a no-nonsense, just the facts teacher, or positivist scientist deeply enough, you will find a closeted constructivist, just waiting for permission (and legitimacy) to go public with some pretty fascinating personal stories and learnings. I would quickly add, however, that, at some level we are all objectivists as well. Scratch a phenomenologist, or memoirist, or postmodernist deeply enough, and you will find a closeted objectivist, just waiting for the decisive empirical research that will ground and validate all of the insights gained from narrating fascinating, personal stories and learnings. (p. 19)

For me, I have yearned for the opportunity "to go public." I have been a closeted-constructivist for the last 27 years in chemistry and in education. In essence "I sold my soul" to be accepted into a scientific community to have what I do matter. I have been living a double life-- an objectivist, when my colleagues were looking, a constructivist when they weren't. The older I got and the more constrained I felt, the more my true self fought back. But it is because of my students, professors like Dennis Manos, small acts of civil disobedience (of which this paper is a part), and the support of people who believe in me (my committee members in particular), will we inspire and retain a more diverse population of scientists who will know, without a doubt, their contributions and perspectives matter. In the words of Marianne Williamson, (1996), "As we are liberated from our own fear, our presence automatically liberates others" (p. 47).

Further, how do my participants see *themselves*? "Self," according to Bruner is nothing more than a narrator's creative construction, not some incontrovertible essence that makes each

one of us truly unique and special (in Nash, 2004 , p. 19). "Self," he says is whatever story we construct about who we are, depending on who we are with, and who we would like to be, at any given time. It is clear from both profiles what Kendra and Lucy do not want to be-- victims. They tell stories that reflect the view they have of themselves combined with the view that they want others to have of them (Schank, 1990, p. 138). The conclusions they draw from their experiences are rooted in their minds' conception of reality and the official stories they have been told. As time progresses and they look back and interpret their past experiences in light of present ones, perhaps their stories will change. I know mine has. Schank tells us:

> Normally, after much retelling, we are left with exactly the details of the story that we have chosen to remember. In short, story creation is a memory process. As we tell a story, we are formulating the gist of the experience which we can recall whenever we create a story describing that experience. We need to tell someone else a story that describes our experience because the process of creating the story also creates the memory structure that will contain the gist of the story for the rest of our lives. Talking is remembering. (p.115)

Earlier we saw Kendra give an example of a physics professor being condescending to her, but she immediately said he wasn't (p. 110). Then to make us understand that it is a ubiquitous practice, not just in physics, she gives an example of an English professor being condescending so as not to "incriminate" any one field. By demonstrating the ubiquitous nature of behavior that could be construed as inappropriate or discriminatory, perhaps she is creating the story that will also create the memory structure that will forever remind her that she was not a victim. Will her story change? Only time will tell.

So how do we reconcile all of this? Chase (1995) says that in contemporary American culture, "the story of successful women's co-optation – of women acting like men, of caring only for their own success, of denying subjection shared with others—is more fully articulated and more frequently heard than the story that women (in her case, superintendents) struggle to tell

about their professional commitments and individual solutions to inequality" (p.183). Judy Marshall (1986) calls it muted awareness: "There are potential disadvantages in being a woman, but when you acknowledge it you increase the likelihood of such disadvantages becoming significant (in Chase, 1995, p.185)." A co- optation story, according to Chase, conveys this message:

> As a successful professional, I have certain competencies and expertise, and I have access to professional power that I use to make a significant contribution in the field. I chose professional work because I wanted to make those contributions, not because I wanted to prove anything about women in general or advance a so-called feminist cause. I am aware that some women may experience sexism or racism. However, I have avoided such treatment by fitting in and winning acceptance from my male colleagues. My success is due to my competence, my impeccable professional manner, and my refusal to participate in inflammatory talk about women's issues, inequality, racism or sexism. (p. 186)

When professional women, like Kendra and Lucy, tell co-optation stories, Rosenwald (1992) says they "display the scars" of the inequitable conditions in which they work. In both cases, it would seem that the denial of discrimination represents the wounding experience of marginality, described by Chase (1995, p.186). Women tell this type of story when they feel that their success-- their ability to do their work well—is contingent upon fitting themselves into the established patterns of professional discourse (Chase, 1995, p.93). Power, according to Heilbrun (1989), is "the ability to take one's place in whatever discourse is essential to action and the right to have one's part matter" (p.18). In both profiles, neither young woman is taking part in the overarching discourse of what being a physicist or an engineer should look like, nor does their part seem to matter. Yet, here their stories are important for that very reason. They are the stories that go unheard in the public discussion about the culture of science.

What would it look like for these women "to have their part matter"? In my view, it has everything to do with their values. Preferences don't define you, values do. That Kendra now

*prefers* English over physics was a choice she made because her values weren't integrated into her physics program the extent to which they were in English. The outward manifestation of choosing a career comes from an inner desire to be true to oneself—to be true to one's values. In other words, the truth behind a career choice is "contained within" the values of the individual. To have Kendra's part matter would have meant that her love of the conceptual, creative, universalizable world of physics would have been honored and nurtured in the physics curriculum-- a curriculum that would honor the value of creativity and imagination required to advance knowledge in physics. Interestingly, in Bruner (1986), Quine (a world renown physicist himself) asserts that physics is 99 percent speculation and 1 percent observation—a characteristic of physics that would seem to warrant a need and desire for creativity and imagination. Perhaps, if she had the opportunity to succeed at what she enjoyed the most from high school physics, she would have gained more confidence while becoming more resilient in the process. Lucy on the other hand, would have benefited from a more collaborative approach to her class work—one that enticed her into engineering in the first place (see her profile p. 117). Frontloading a curriculum with diverse course work (not just the rule-following, close-ended problem solving, lecture format variety) and using diverse pedagogical strategies could help build confidence and honor her talents and gifts.

Finally, understanding other people's stories will help us to understand our own. Physics, made no attempt to understand Kendra's story, nor engineering Lucy's. Further, understanding other research methodologies can help us to understand and question the predominant explanatory paradigm, to balance "objective" knowledge claims. Elsewhere, I have named what is happening here "epistemological fractalization" whereby, in this case, we have embodied the power of "objectivity" and subordinated "subjectivity" in the manifestations of how we do

science. These profiles demonstrate that "the language of our questions, and the language in which we might presume a conversation to unfold, can discourage, intimidate, humiliate, or otherwise silence many people with important experiences and knowledge to share" (Forester & Weiser, 1995, p. 138). Ironically, the solution to Kendra and Lucy's stories must come through stories presented in as much their own language as is possible, recognizing that all language is messy. Conversation is no more than responsive storytelling (Schank, 1990). "Responsive" here is key. It would seem that physics and engineering are doing all the talking because the rules and laws of physics have "gone to its head," forgetting all the while, that imagination and creativity are what gave it its unearned power anyway (imagination and creativity being the very virtues valued by both Kendra and Lucy). To paraphrase Schank (1990), to the extent that intelligence is bound up with our ability to tell the right story at the right time, understanding the story means being able to correlate the story we're hearing with one that we already know. Our physicists and engineers need to broaden the circle of experiences to foster more affiliative relationships (and become more intelligent in the process) instead of allowing the tradition that guides their actions in the physical realm morph into the human realm. In my view, it would be wise to make physicists and engineers (and all academics for that matter) take a class outside their comfort zone! Not only will they experience the vulnerability and hopefully become more empathetic and reflective in the process, but they will come to realize that you do not have to immerse yourself in your lab to have extraordinary epiphanies in their areas of expertise to come to them. In fact, maybe the converse is true… we won't know until we try. Further, I would argue that this ability to map one's stories onto another's is the basis of what Aristotle would call the highest intellectual virtue—phronesis. Only when we come to realize that relationships are

the key to reality, not facts and reasons (to paraphrase Palmer, 1993), will we experience the maximum potential for innovation in science. Only then, "will we know as we are known."

Finally, that hypothesis I said I was testing in the "Conceptual Framework and Review of the Literature" Section—turns out I was right. Both Kendra and Lucy told me their overall experience at Cornell was highly negative—no surprise there! Kendra described her acculturation process as one of separation and in typical Kendra fashion she said, "I'd have to go with separation, but like with a less negative connotation? I felt separated but it wasn't something that the other students and professors were actively doing." Lucy felt marginalized—again, no surprise there!

## Recommendations for future study

Look again at the graph on page 71. It too, has a story to tell! Doesn't it seem strange that in 1966 more women earned undergraduate degrees in math more than in any other science listed? If physics and math are so inextricably tied, why don't their points hover together? Why is it that in 2012 the arcane ideas that females are less capable than males in math, still exist? Why haven't we been telling people that females can't do biology, chemistry or earth science—areas with much lower starting points in 1966 than math? Sure there are more male outliers at the right tail than females, but there are also more males at the left tail than females in math. Why hasn't the stereotype been enabled that there are more unintelligent males in math than females? Could it be that the story that "girls can't do math" has acted as dropped popcorn? Allow me to clarify with this excerpt from Schank (1990):

> Part of being intelligent is figuring out where the actions of others fit. Dumb animals perceive everything unknown as a potential threat. Perhaps not so brilliant, but as the guy said who dropped popcorn around him to keep the elephants away, "See? It works." (p. 227)

We need to be intelligent. We need to figure out where the research stories fit in and understand that research is always done in a social and political context. As an illustration, Clinchy (2002) cites Harvard psychologist G. Stanley Hall (1917) who worried that higher education might shrink women's wombs, rendering them infertile or "functionally castrated; we worried that it might shrink their minds, or at least fail to expand them to their full potential" ( p.634). I'm sure a study, if it hasn't already been done, correlating the research questions to the prevailing oppression of the time, would further elucidate the plethora of 'il'logical antecedents and biases described in the forward.

Additionally, and speaking to a similar point, the CollegBoard website quotes a UC Berkeley study that finds, "The subject-specific, curriculum-intensive AP Exams are the epitome of 'achievement tests,' and their validity in predicting college performance should not be surprising (Geiser & Santelices, 2004)." Females, overall, graduate from college at higher rates than males. Why don't they publish a correlation between success on the AP exam, sex and retention in the major? That, for me, would be extremely telling and indicative of potential discriminatory practices in curriculum and pedagogy.

Finally, it would be interesting to see if some of the mavericks and people who carved their own paths in life felt marginalized. Are there more "outside of the box" thinkers amongst those who have been marginalized? When you feel you do not fit in and refuse to take on the dominant culture's values and norms, does that correlate to greater innovation (both with and without support and encouragement)? Does the phrase "necessity is the mother of invention," take precedence over grade point average? All great questions—for future study!

## References


Brooks, D. (2011, March 7). The new humanism. *New York Times*. Retrieved March 10, 2011, from http://www.nytimes.com/2011/03/08/opinion/08brooks.html?_r=0

Chase, S. (1995). *Ambiguous empowerment: The work narratives of women school superintendents.* Amherst: University of Massachusetts Press.

Clinchy, B. (2002). Revisiting women's ways of knowing. In B. Hofer, & P. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. pp. 63-87). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Emerson, R. (2009). *Essays and lectures: (Nature: Addresses and lectures, Essays: First and second series, representative men, English traits and the conduct of life.* Digireads.com publishing.

Forester, J. (2006). Policy analysis as critical listening. In *The Oxford Handbook of Public Policy* (pp. 122-149). Oxford: Moran.

Forester, J., & Weiser, I. (Eds.). (1995). *Profiles of environmental/community mediators: Transcripts* . Transcript, City Regional and Planning Department, Cornell University.

*Fraction of Bachelor's Degrees Earned by Women, by Major.* (2012, September 15). Retrieved from American Physics Society: http://www.aps.org/programs/education/statistics/womenmajors.cfm

Geiser, S., & Santelices, V. (2004). *The role of advanced placement and honors courses in college admissions.* Berkeley: Center for Studies in Higher Education, University of California. Retrieved from http://press.collegeboard.org/releases/2005/advanced-placement-proves-gateway-college-successAdvanced Placement Proves Gateway to College Success

Haskill, T. (1998). *Objectivity is not neutrality: Explanatory schemes in history.* Baltimore: The Johns Hopkins University Press.

Heilbrun, C. (1989). *Writing a woman's life.* New York: Ballantine Books.

*Hobble (device).* (2012, October 29). Retrieved from Wikipedia: http://en.wikipedia.org/wiki/Hobble_%28device%29

Ives, P. (2002). The whole truth. In R. Root, & M. Steinber (Eds.), *The Fourth Genre: Contemporary Writers of/on Nonfiction* (2nd ed.). New York: Longman.

Josselson, R. (2007). *Playing pygmalian: How people create one another.* Lantham, MD: Roman and Littlefield Publishing.

Leberge, S., & Sankoff, G. (1979). Anything YOU can do. In T. Givon (Ed.), *Discourse and Syntax, Syntax and Semantics* (Vol. 12, p. 429). New York: Academic Press.

Nash, R. (2004 ). *Liberating scholarly writing: The power of personal narrative.* New York: Teachers College Press.

*National AP Exam Summary Report.* (2011). Retrieved August 15, 2012, from http://research.collegeboard.org/programs/ap/data

Nietzsche, F. (1969). *On the genealogy of morals.* New York: Vintage Books.

Noddings, N. (1984). *Caring: A feminine approach to ethics and moral education.* Berkeley: University of California Press.

Norris, E. (2012, October 15). Personal Correspondence. (M. Whitecraft, Interviewer)

Palmer, P. (1993). *To know as we are known.* New York: HarperCollins Publishers.

Pausch, R. (2007, September 18). *Really achieving your childhood dreams.* (R. Pausch, Performer) Carnegie Mellon University. Retrieved from http://www.thelastlecture.com/

Peters, S. (2010). *Democracy and higher education: Traditions and stories of civic engagement.* East Lansing: Michigan State University Press.

Rosenwald, G. (1992). Conclusion: Reflections on self-narrative understanding. In R. G., & R. Ochberg (Eds.), *Storied Lives.* Yale University Press.

Schank, R. (1990). *Tell me a story: A new look at real and artificial memory.* New York: Macmillan Publishing.

Umemeto, K. (2001). Walking in another's shoes. *Journal of Planning Education and Research, 21*, 17-31.

Wiersma, J. (1988, March ). Tho press release: Symbolic communication in life history interviewing. *Journal of Personality, 56*(1), 205–238.

Williamson, M. (1996). *Return to love: Reflections on the principles of "A Course in Miracles".* New York: Harper Perennial.

# epiSTEMological Differences: The Interplay of Aristotle's Intellectual Virtues in Science and Science Education Reform in Higher Education


## Abstract

Higher Education is serving a more diverse student population than ever, and for reasons of social fairness and in the interests of good science on the whole, we must meet their needs. In particular, a greater number of females are entering the natural sciences than ever before. If we intend to experience the richness that diversity can bring in scientific progress and innovation, then we need to know how to best educate and retain these students. In this paper, I argue that the natural sciences have confounded Aristotle's three distinct intellectual virtues of episteme, techne, and phronesis – roughly understandable as the theoretical 'know why' of science, the technical 'know how', and the practical knowledge and ethics (Flyvbjerg, 2001)--- to the detriment of effectively fair pedagogy and what we might call generally 'good science'. This happens through a process I name as *epistemological fractalization*, wherein the fractal supplies a good metaphor for what happens in our labs and classrooms to Arsitotle's careful parsing of what gives a scientific claim 'virtue.' Feminist approaches to knowledge help me tease out the current muddle, and, with my fractal model, I offer up a solution for science education to be proactive and refractive in its reform. Finally, I cite pioneers whose methods create the space for *phronetic* opportunity thereby enabling advancement toward *equal* opportunity – the opportunity to experience the richness of diversity in scientific progress and innovation.

# epiSTEMological Differences: The Interplay of Aristotle's Intellectual Virtues in Science Education Reform in Higher Education

Higher Education is serving a more diverse student population than ever, and for reasons of social fairness and in the interests of good science on the whole, we must meet their needs. In particular, a greater number of females are entering the natural sciences, than ever before. If we intend to experience the richness that diversity can bring in scientific progress and innovation, then we need to know how to best educate and retain these students. W. A. Wulf, former president of the National Academy of Engineering, further reiterates the importance of diversity: "without diversity, we limit the set of life experiences that are applied, and as a result, we pay an opportunity cost- a cost in products not built, in designs not considered, in constraints not understood, and in processes not invented."

The practice of science education (herein referring only to the natural sciences) in the US, some could say, mimics the process of science and is complicit in perpetuating and enabling oppressive ideologies. It could be said that Higher Education's systematic misrepresentation of equality in access by the dominant class (white male) gives a false sense of equality in opportunity of the subordinate class (female and non-white students). Whether or not there is deliberate obfuscation, the work that must be done for true equal opportunity remains undone.

The broader problem seems to be this: the practice of education in the natural sciences in the U.S. mimics the gender-programmed process of science and thereby is complicit in perpetuating and enabling oppressive ideologies which eventually, squeeze out women. In this aspect at least, Higher Education is in desperate need of reform.

Here specifically, I argue that the natural sciences have confounded Aristotle's three distinct intellectual virtues of episteme, techne, and phronesis – roughly understandable as the theoretical 'know why' of science, the technical 'know how', and the practical knowledge and ethics (Flyvbjerg, 2001)--- to the detriment of effectively fair pedagogy and what we might call generally 'good science'. This happens through a process I name as *epistemological fractalization*, wherein the fractal supplies a good metaphor for what happens in our labs and classrooms to Arsitotle's careful parsing of what gives a scientific claim 'virtue.' Feminist approaches to knowledge help me tease out the current muddle, and, with my fractal model, I offer up a solution for science education to be proactive and refractive (defined later) in its reform.

The Aristotelian framing of this problem comes from Flyvbjerg's Making Social Science Matter (2001) where he elaborates on the writings of Aristotle's intellectual virtues outlined in The Nicomachean Ethics. He summarizes the three virtues as follows:

> *Episteme:* Scientific knowledge. Universal, invariable, context-independent. Based on general analytical rationality. The original concept is known today from the terms "epistemology" and "epistemic."
>
> *Techne:* Craft/art. Pragmatic, variable, context-dependent. Oriented toward production. Based on practical instrumental rationality governed by a conscious goal. The original concept appears today in terms such as "technique," technical," and "technology."
>
> *Phronesis:* Ethics. Pragmatic, variable, context dependent. Oriented toward action. Based on practical value- rationality. Deliberation about values with reference to praxis. The original concept has no analogous contemporary term. [Terms

that are similar are "applied ethics" or "policy studies."] (p. 57).

These distinctions are very useful for thinking through pedagogy in the natural sciences. At the university level, theoretical *know why* may help in your research, but it does nothing for your ability to teach. As Aristotle noted, working with people is not the same as manipulating experimental apparatuses; choosing practical actions for the human realm requires a different kind of thinking than one employed for making such choices in the natural realm. *Techne* is the proper rationality for developing knowledge to determine actions that deal with the physical realm; phronesis is the proper rationality for developing knowledge to determine actions (praxis) that deal with people (Polkinghorne, 2004, p. 126). Science is about techne for sure. Science teaching is about people, hence phronesis.

A pedagogy class or two can give only a shallow understanding of what a teacher really needs to know. In order to teach you must be continually judging the human experience with a people-centered kind of know-how. As Benner et al. (2008) describes it this way "… [the] practice [of science education] falls outside means-ends rationality (*techne*) and must be governed by concern for doing good or what is best for the [student] in particular circumstances, where being in a relationship and discerning particular human concerns at stake guide action" (p.5). Pedagogy's essential grounding in phronesis has been lost in a greater epistemical confusion. It is my belief that science, and by extension science education, mistakenly frames its knowledge as independent of human context. Here I say "by extension", because it would appear that the training to be a scientist begins with being educated *in* science where, under the reign of 'objectivity,' not much has been said about context. Further, the same assumption that science is universal, invariable and context-independent seems to have bled over into science education pedagogy, where a "one size fits all" lecture format prevails. And yet, we know – the

history of science fully demonstrates – that all scientific investigation is conceptualized from a social, political and economic context. So too, then, science education is even more-so experienced within the overlapping social, political and economic constructs of the institutions of education and of science itself.

Before exploring what this all means, let me discuss some confusion residing in the very foundation of Aristotle's concept of *episteme* in light of Flyvbjerg's concept of 'context independence. It is a bit confusing, flawed even, at least when coopted to frame 'scientific knowledge.' A fundamental flaw in Aristotle's episteme—scientific knowledge being universal, invariable, and context- independent—is acknowledged by Albert Einstein when he said, " …no amount of experimentation can prove me right. One experiment can prove me wrong." Additionally, in the context of an electron in an atom, Newton's Laws are no longer applicable as they were applied to "ordinary" objects travelling at "ordinary" speeds. Here, science invokes Heisenberg whose "Uncertainty Principle" says that it is impossible to know the exact location and momentum of an electron (an extraordinary object travelling at extraordinary speeds) at the same time. Likewise, the Phlogiston Theory was the theory of burning that made greatest sense in a time when oxygen had not yet been discovered. Hence, it would seem that Aristotle was positing the 'ideal' of *episteme* and not the human vanity of pretending we can really achieve *episteme.*

Falk et al. (2009) provide an example of the common uncritical cooption of the *episteme* in their production of 'knowledge' in their review of Flyjbjerg's "context-independent" term:

> The early stages of learning depend upon following a set of prescribed, context-independent rules. Flyvbjerg uses the example of nurses-in-training. Given a procedure to follow for inspecting a hospital room full of infants, beginning nurses followed the procedures step-by-step for each baby. They never skipped a task, no matter how unimportant, even in a room full of crying babies. This contrasted with the experienced nurses who, when faced with a similar situation, were able to identify which tasks were

> key and which could be left out in order to tend to more babies faster. Calling on their many experiences and intuition, these nurses were able to better serve their patients by forgoing the prescribed routine (p.2).

Basically, they are saying that a novice blindly follows a set of rules without thinking about context (hence, context-independent), whereas an experienced nurse is able deliberate and prioritize in context (hence, context-dependent). Whether or not you agree that any human blindly follows rules (usually there is more politics to rule-following than just depth of background), you can see in this example an attempt to isolate the episteme, to locate *know-why*. Falk et al. patently disregard the human context wherein the *episteme* he is trying to isolate is formed and known. Regardless, it seems strange and unnatural to imagine a human being blindly following rules without deliberating on what is appropriate or inappropriate in a given circumstance; after all, isn't this what makes us human? Perhaps Falk et al. are confused themselves and are really commenting on manipulating the "stuff" or *know how* (*techne*) at a point when the novice grasp of 'why' (*episteme*) isn't yet so strong. I next turn to explore this concept of *techne* in the context of science education.

The "production" mentality of *techne* in to "produce" new scientists through science education, has resulted in an unfavorable cultural climate for many students (Margolis, Fisher, & Miller, 2000; American Association of University Women, 2000). Instead, a phronetic, ontological practice in which a professor 's morals, habits, and dispositions guide practice may be the resolution to creating a more intellectually stimulating, relatable, and favorable educational climate. According to Flaming (2002), simply applying generalizable and communal knowledge from education theory (which most science professors have never even had) to foster learning is inferior to employing ontological dispositions to guiding practice. *Techne*-ical

practice leads to competent educators, but only phronetic practice results in educational excellence (Flaming, 2002).

By holding on to this antiquated notion of science as universal, invariable, and context-independent, it seems that science education has functioned as an instrument "to facilitate integration of the younger generation into the logic of the present system and bring about conformity [instead of becoming] the practice of freedom, the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world (Richard Shaull in Freire, 1970, p. 34)."

In light of the recent financial collapse of Wall Street, it is fitting to infuse Freire's concept of "banking" education experienced in higher education, at this juncture. Education is traditionally framed as "an act of depositing, in which the students are the depositories and the teacher is the depositor" (Freire, 1970, p. 57). In this framework, the teacher lectures, and the students "receive, memorize, and repeat" (p. 58). Freire explains that banking education is generally characterized by the following oppressive attitudes and practices:

The teacher:

- teaches and the students are taught;
- knows everything and the students know nothing;
- thinks and the students are thought about;
- talks and the students listen-meekly;
- disciplines and the students are disciplined;
- chooses and enforces his choice, and the students comply;
- acts and the students have the illusion of acting through the action of the teacher;
- chooses the program content, and the students (who are not consulted) adapt to it;
- confuses the authority of knowledge with his own professional authority, which he sets in opposition to the freedom of the students;
- is the Subject of the learning process, while the pupils are mere objects. (p. 59)

Highly 'educated', if not *well* educated, Wall Street collapsed. To avert similar catastrophe in science education, we need to invoke Flyvbjerg's framework of phronetic social science, become refractive[6] practitioners and ask:

> (1) Where are we going?
>
> (2) Is this development desirable?
>
> (3) What, if anything, should we do about it? The 'we', here consists of those organization researchers asking the questions and those who share the concerns of the researchers, including people in the organization under study.
>
> (4) Who gains and who loses, and by which mechanisms of power? (p.374)

Although the sparse number of students pursuing physical science speaks volumes for "where are we going?" this paper adds to discussion of what should be done about it. Next, to better understand where we are going, I give the reader information on the context of how it may have "come to be" through history and feminine epistemology.

First, though the word "epistemology" is derived from *episteme*, it no longer means only one kind of knowing (i.e. a state of mind capable of demonstrating what is known through the scientific method). Today it is used in a broader sense for example, feminist epistemology and constructivist epistemology. Pressley (2005) describes feminist epistemology this way: Feminist epistemology is concerned with "whose knowledge" is being considered. Feminist epistemologists critique traditional epistemology and argue for ways of understanding knowledge that focus on context and situation. Feminist epistemologists do not suggest that empirical evidence is wrong, but rather that it is necessary to understand that most beliefs are as much a result of their social context as they are factually true. The particulars of knowledge

[6] I prefer the scientific term of refraction over reflection. Reflection simply means light hits something and bounces off at the same angle it entered. I want people to refract. I want them to take in all that they observe, mull it over, and send it back out into the world at an improved angle. "Reflective" implies status quo in my view and the inability to think critically.

construction are the main focus for feminist epistemologists, rather than universal circumstances for justifying knowledge. These philosophers are often working on undertakings that are political in addition to intellectual.

"Empirical evidence" to a researcher is that which is directly observed with the senses in a systematic process of inquiry known as the scientific method. However, in a different context this word can simply mean "experience"; even experiences absent of "controls" and "treatments". Language as well as the symbols of our culture can mean different things to different people. Next I invoke the work of Thomas King, to see how stories we've been told can shape the process of knowing.

In the book, The Truth About Stories, King (2003) contrasts the Christian story of creation with the Native American story of creation:

> [t]he elements in Genesis create a particular universe governed by a series of hierarchies—God, man, animals, plants—that celebrate law, order and good government, while our Native story, the universe is governed by a series of co-operations—animals and humans celebrating equality and balance. ( pp. 23-24)

He then argues that the Genesis story creates a tone of competiveness, whereas with the Native story the world is at peace, and the pivotal concern is not with the ascendancy of good over evil but with the issue of balance. King (2003) continues:

> So here are the choices: a world in which creation is solitary, individual act or a world in which creation is a shared activity; world that begins in harmony and slides toward chaos or world that begins in chaos and moves toward harmony; a world marked by competition or a world determined by co-operation… You recognize this pairing is a dichotomy, the elemental structure of Western society. In cranky old Jacques Derrida notwithstanding, we do love our dichotomies. Rich/poor, white/black, strong/weak, right/wrong, culture/nature, male/female, written/oral, civilized/barbaric, success/failure, individual/communal. We trust easy oppositions. We are suspicious of complexities, distrustful of contradictions, fearful of the enigmas. (p.25)

Science is often portrayed as a solitary, individual act (Brotman & Moore, 2008). Pressley (2005) corroborates the King's argument and reveals the consequences of this dualistic thinking he mentions:

> Western philosophy is built around the idea of binary oppositions such as reason/emotion, mind/body, universal/particular, objective/subjective, and male/female. These are typically hierarchical with the first term given privilege. This dualistic thinking has led to the association of maleness with reason, mind, objectivity, and universals while femaleness is associated with emotion, body, subjectivity, and particulars. Feminist scholars often argue that these dichotomies create one type of knowledge that is masculine. These theorists argue that the period for singular methodology and theory has passed, and it is time to incorporate new standpoints into our way of understanding truth. (p.5)

Perhaps, ironically, the singular methodology and perceived superiority of ***the*** scientific method grew from the stories that have lived in our communal subconscious—stories that smothered our desire for connectedness and communion even as they enacted the social, human element of all our thinking. Let me call upon another language or story, that of fractals, to describe how this could happen.

**Epistemological Fractalization**

> "Great fleas have little fleas upon their backs to bite 'em,
> And little fleas have lesser fleas, and so *ad infinitum*."
> Augustus de Morgan, *A Budget of Paradoxes*, pub. 1872, p. 377

"Ad infinitum" means to continue forever without limit (Dictionary.com, 2011). Earlier King (2004) described the story of Genesis as conceivably playing a role in how we, as Westerners, see the world—a hierarchical world where creation is a singular, individual act; a competitive world; a world whose theme was set into motion with telling of Genesis; and so on, and so on. Conversely, if our original initiating theme stemmed from the telling of the Native story, perhaps a research paradigm today would be more accepting of a feminist epistemology; more balanced, cooperative, and equal. To move from "world" to "research paradigm", I am

suggesting that the stories that we have been told, and the stories we tell ourselves, can be manifested in who we are and what we do; oftentimes to the point where we have forgotten why it is we believe what we believe and continue our lives in an endless state of reflection instead of refracting. Josselson (2007), puts it a little differently:

> There are, for all of us, moments that we can remember where a comment from someone else changed our lives—for better or worse—shattering a nascent dream or opening a new path. But we were not the passive recipients of these forces. It was our construction of the other that gave them the power to change our construction of ourselves.

So, although I am saying that we are passive recipients of these forces, Josselson disagrees. I do believe that the Feminist Movement is opening our eyes to seeing how we gave others the power to change the construction of ourselves. However, I believe that *all* of our psyches may have been more subtly infiltrated. Fractals (a metaphor I have used elsewhere), can provide greater insight into how this can happen.

A fractal is an object or quantity that displays self-similarity on all scales (Krawczyk & Ibrahim, 2001). The *Dictionary of Math* (2008) defines a fractal as a geometric pattern repeated at smaller and smaller scales to form irregular shapes and surfaces that do not look like the original pattern. With these definitions we can assess the points of departure between a conventional, male-oriented science; being done in a linear, reductionist style where the primary approach is to study the parts in isolation in an attempt to understand the whole system; from a more feminine, holistic approach where we look at the interactions between the parts, rather than the parts themselves, to understand the whole system. Men seem to be more linear, independent, and have a great ability to analyze; whereas women seem to be more nonlinear, connected, and have a great ability to synthesize (Shepherd, 1993). Unfortunately, since science has been male dominated, we have not experienced the synergy of the marriage between analysis and synthesis

in scientific discovery. Fractals can help us to make sense of how we got to this point and allow us to see how things could be in understanding how cognitive structuring can lead to our epistemological differences.

Empirical evidence suggests that females have greater inter-hemisphere brain communication than males (Bitan, Lifshitz, Breznitz, & Booth, 2010; Kenji, Yamaura, & Kitazawa, 2000) in certain tasks. This finding seems to parallel the more holistic approach women take in constructing knowledge. Fractals can provide a model for a parallel basis of cognitive structuring and different epistemological approaches.

First, we can assume that both the initiator and generator structures of fractals are the same in both genders (see figure1, below). Baxter Magolda (2002) describes cognitive structures as "sets of assumptions we use to make meaning of our experience" (p. 90) and would be the generators in fractal science. All assimilation and accommodation (to use Piaget's terminology) will occur based on the initial fractal formed, yet the overall shape would vary depending upon one's innate evolutionary placement in the inclusion/autonomy continuum.

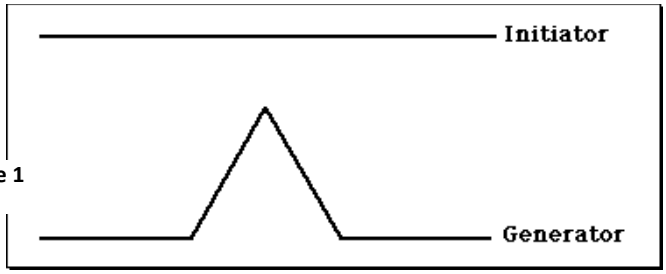
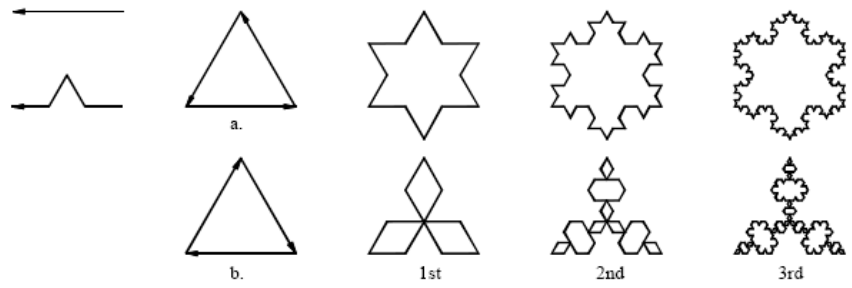



Figure 1

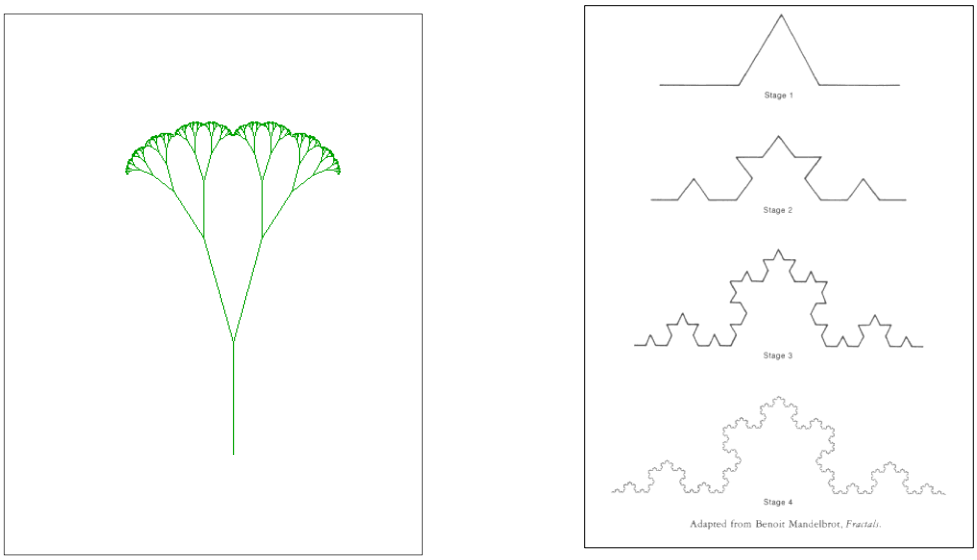
As explained by Kegan (1994), the two greatest yearnings in human experience are to be both included and autonomous or independent. Kegan points out that the evolutionary biologists would refer to periods of adaptation – of life organization- as involving a balance between differentiation and integration. He sees these terms as the biological way of speaking of the phenomena we experience as the yearnings for autonomy and inclusion (Kegan, 1982, p. 108)

However, a person's raison d'être, manifested outside of brain chemistry and neural networks (fractals), dictates what is done with exogenous stimuli and creates a point of differentiation whose iterations develop different forms (figure 2). Because males, for one reason or another and with respect to intellectual/professional pursuits, tend to be more autonomous and independent, every decision they make, every assimilation, every accommodation, has their best interest in the center and so their fractals are point-centered (see figure 2b, below). With females, on the other hand, their yearning generally is at the inclusionary end of the continuum where their fractals are developed to encircle; every decision, every assimilation; every accommodation contributes to this circular fractalization (see figure 2a, below).

**Figure 2(diagram source: Krawczyk & Ibrahim, 2001)**




Second, we could look at a fractal geometry where the initiators are different and thereby create different male/female patterns throughout where, nonetheless, the respective yearnings for independence and inclusion are still the structural foundations for cognitive development and, by extension, their epistemologies. Kegan states that infancy initiates themes that can be traced through the lifespan and inaugurates a disposition on the part of the person toward the activity of evolution. These themes I equate to the initiators in fractal mathematics; for males it is a bifurcation of the initiator (see diagram, next page), for females two angular initiators coming together from different directions to form a triangular iteration (see diagram, next page).




Male Fractalization Construct (left)
Female Fractalization Construct (right)
(diagram source: Krawczyk & Ibrahim, 2001)

In *The Evolving Self* (1982), Keegan describes the first two years of life as having "great salience." But it is not "salience *sui generis;* the distinctive features of infancy, it is suggested, are to be understood in the context of the same activity which is the person's fate throughout his or her life" (p. 77). The recurrence of these distinctive features (generator fractals repeating at every level) in new forms later on in development are not understood as later manifestations of infancy issues, but contemporary manifestations of meaning-making, just as the issues of infancy are, in their own time, contemporary manifestations of meaning-making (Kegan, 1982, pp. 77-78). These initiating chunks of information, I contend, are the basis upon which all information is organized and all knowledge 'given' meaning. The point here being, we can become so far removed from the initiating structure that we blindly keep following the pattern without questioning, "Where are we going?" and "Is this desirable?" So seems to be the case with science and science education.

To recap, King (2003) posits that it is the initial stories we are told and tell that may influence how knowledge is "created"—hierarchical, competitive, and done in isolation. The self-similarity, from the story of creation to ***the*** scientific method, is reminiscent of a broader, reoccurring fractal theme. Our failure in science and in Higher Education has been that we have been reflective practitioners (repeating patterns at every level) instead of refractive practitioners. In other words, we have inhibited our view of what "good science" looks like because of epistemological fractalization. The phronetic process of refraction, will allow us to reverse this trend, and supports why phronesis, in Aristotle's view, is the most important of the intellectual virtues. Phronesis (which interestingly, as mentioned earlier, has no parallel contemporary term) functions as the "checks and balances" to prevent a single-methodology, epistemological fractalization for "creating" knowledge, from happening. The witty turn of phrase in the second verse of Augustus de Morgan's poem, quoted earlier, catches this sense of reversal:

> *"And the great fleas themselves, in turn, have greater fleas to go on;*
> *While these again have greater still, and greater still, and so on."*
> Augustus de Morgan, *A Budget of Paradoxes*, pub. 1872, p. 377

This second verse from Augustus de Morgan's poem, I use to suggest that this thought process—one of episteme, in the Aristotelian sense, as a superior way of knowing —can be reversed (first verse: positivist-deductive; second verse: interpretive-inductive). Consider the following quote from Hughes (1995):

> All scientific investigation is conceptualized from a social, political and economic context. What is worthy of measure and analysis is that which has economic, political, social or aesthetic value to the dominant group — the people with economic, social and political power. What is measured is often important to the maintenance of the present structure and balance of power. (p.400)

In government the "powers that be" allocate monies toward the research problems they value. A lack of diversity at the top end of government allows the process of epistemological

fractalization to proliferate, thereby enabling "exclusivity" (as opposed to inclusivity) in science education. Phronetically infusing government with diversity, can be the catalyst that breaks the rhythm of the positivist paradigm, thereby creating the humanistic *techne* upon which epistemological plurality legitimates knowledge in the purist sense. Quoting Nietzsche, Flyvbjerg (2001,) says, "'objectivity' in phronetic organization research is not 'contemplation without interest' but employment of 'a *variety* of perspectives and affective interpretations in the service of knowledge'" (emphasis in original) (p.139). An awakening to this "variety of perspectives" is recently being witnessed in science education as some pioneers break away from an insidious epistemological fractalization and move toward a more inclusive model of teaching. M.I.T. is in the forefront of creating a more inclusive model of teaching by promoting a more collaborative environment. In the January 12, 2009 article in the New York Times it describes the standard lecture going by the wayside:

> M.I.T. is not alone. Other universities are changing their ways, among them Rensselaer Polytechnic Institute North Carolina State University, the University of Maryland, the University of Colorado at Boulder and Harvard. In these institutions, physicists have been pioneering teaching methods drawn from research showing that most students learn fundamental concepts more successfully, and are better able to apply them, through interactive, collaborative, student-centered learning. (Rime, 2009)

In fact, the American Association of the Advancement of Science (AAAS) has been citing studies like this for years. In 2001 they devoted a considerable amount of space to science education reform. Of the many empirical studies citing collaborative learning over lecturing, one out of Pennsylvania discussed how the entire physics department adopted a collaborative, inquiry based approach:

> Students perform even better in an intensive class that emphasizes active, inquiry based learning. Workshop Physics, a course designed by Priscilla Laws and colleagues at Dickinson College in Carlisle, Pennsylvania, features 6 hours a week of hands-on labs and no lectures. All three of the department's lab rooms were designed so that students face each other in small groups. (Stokstad, 2001, p. 1609)

Collaborative learning is a wonderful arena for knowledge development and should be implemented not only in the teaching of science, but as a phronetic process whereby the local knowledge of the stakeholders (the students) work in consort with professors to reform higher education. Inquiry based learning also moves away from the "banking methodology" into the realm of experience where students are apt to become better acquainted with the phronetic process.

The academic institutions noted above may have been jolted into a conscious awareness of the self-similarity of the fractalization process from an influx in diverse student populations, but this is only speculation. Nonetheless, it would seem what these universities have done would be what Schrader (2004) would classify as an "epistemic stretch":

> I propose that there may be a point of what I referred to as "epistemic stretch" created by professors who are willing to make themselves aware of their own and their students epistemological framework, take into account various aspects of the development of a moral climate in the classroom, and combine them together in designing educational experiences, context and demands that both challenge and support students' epistemologies in an affectively and intellectually safe context. (p.88)

The above would serve as an exemplar of *phronesis* in action from an expert, refractive practitioner. Schrader goes on to say, "Students may feel slight discomfort in their current knowing system but they feel safe enough to let go of it (p.88)." Likewise, with science educators reaching across the aisles to provide an inclusive environment for all students, they too "may feel a slight discomfort in their current knowing system" and need to "feel safe [and receptive] enough to let go of it." Case in point, the traditional, positivist paradigm for generating cause and effect, explanatory knowledge must be balanced by an interpretive,

phronetic approach which is becoming more widely accepted thanks to Flyvbjerg's (2001) pivotal exposé in Making Social Science Matter.

**Conclusion**

In this paper, I have attempted to show how Aristotle's intellectual virtues have been confounded at times, and lost at others, in the process and practice of doing science and in science education. Instead of taking a conspiracy approach, I use the cross-context (which also could be considered context-independent) idea of epistemological fractalization, to describe how we could lose sight of our true reason for being and how the stories we are told may play a role in suppressing our ability to question status quo. I offer evidence by way of the pioneering institutions that have questioned the banking concept of education, refracted on it, and made the value-rational decision to do something about it (phronesis). In light of this, Harry C. Boyte cautions us, "[t]hough it has been significantly discredited intellectually, positivism continues to structure our research, our disciplines, and our teaching, even amongst its sharpest critics. It is like a genie that academia let loose long ago, now lurking below the surface and threatening her destruction (Peters, 2010, p. xvii)." Through the Aristotelian intellectual virtue of phronesis, we have a mode of action that will counter this destruction, all we have to do is have the courage to implement it.

## References


American Association of University Women. (2000). Tech savvy. Retrieved from http://www.aauw.org/research/upload/TechSavvy.pdf

Baxter Magolda, M. (2002). Epistemological reflection: The evolution of epistemolgical assumptions from age 18-30. In B. Hofer, & P. Pintrich, Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 89-102). Mahwah, NJ: Lawrence Erlbaum Associates.

Benner, P., Ronda G. Hughes, R., & Sutphen, M. (2008). Clinical reasoning, decisionmaking, and action: Thinking critically and clinically. In R. Hughs (Ed.), Patient safety and quality: Evidence based handbook (pp. 1-23). Agency for Healthcare Research and Quality.

Bitan, T., Lifshitz, A., Breznitz, Z., & Booth, R. (2010). Bidirectional connectivity between hemispheres occurs at multiple Levels in language processing but depends on sex. The Journal of Neuroscience , 30 (35), 11576-11586.

Brotman, & Moore. (2008). Girls and science: A review of four themes in the science education literature. Journal of Research in Science Teaching , 45 (9), 971–1002.

Currie, J., & Newson, J. (1998). Universities and globalization: Critical perspectives. Thousand Oaks, CA: Sage Publications.

Dictionary of Math. (2008). Retrieved November 9, 2008, from http://www.msnucleus.org/membership/html/jh/physical/dictionary/math/definitions.htm

Duncan, A. (2010, November 4). The vision of education reform in the United States: Secretary Arne Duncan's Remarks to United Nations Educational, Scientific and Cultural Organization (UNESCO). Retrieved January 20, 2012, from Department of Education: http://www.ed.gov/news/speeches/vision-education-reform-united-states-secretary-arne-duncans-remarks-united-nations-ed

Falk, T., Rocha, S., & & Warnick, B. (2009). Social science and its discontents: An essay review of Bent Flyvjerg's Making Social Science Matter. Education Review , 12 (4).

Flaming, D. (2002). Using nursing science does not guarantee nursing excellence. Research and Theory for Nursing Practice , 16 (3), 147-159.

Flyvbjerg. (2001). Making social science Matter: Why social inquiry fails and how it can succeed again. Cambridge: Cambridge University Press.

Freire, P. (1970). Pedagogy of the oppressed. New York: Continuum.

Hughes, D. (1995). Significant differences: The construction of knowledge, objectivity and

dominance. Women's Studies International Forum, Vol. 18, No. 4, pp. 396-406, 1995.

Josselson, R. (2007). Playing pygmalion: How people create one another. New York: Rowman and Littlefield Publishers.

Kegan, R. (1994). In over our heads: The mental demands of modern life. Cambridge, MA: Harvard University Press.

Kegan, R. (1982). The evolving self: Problem and process in human development. Cambridge, MA: Harvard University Press.

Kenji, K., Yamaura, A., & Kitazawa, S. (2000). Sex differences in lateralization revealed in the posterior language areas. Cereb. Cortex (2000) 10 (9): 866-872. , 9, 866-872.

King, T. (2003). The truth about stories: A native narrative. Minneapolis: University of Minnesota Press.

Krawczyk, M., & Ibrahim, R. (2001). Exploring the effect of direction on vector-based Fractals. Chicago: College of Architecture, Illinois Institute of Technology.

Margolis, J., Fisher, A., & Miller, F. (2000). The anatomy of interest. Women's Studies Quarterly , 28 (1/2).

Mayo, P. (1999). Gramsci, Freire, and adult education: Possibilities for transformative action. Macmillan.

Peters, S. (2010). Democracy and higher education: Traditions and stories of civic engagement. East Lansing: Michigan State University Press.

Polkinghorne, D. (2004). Practice and the human sciences: The case for a judgment-based practice of care. Albany: State University of New York Press.

Pressley, L. (2005). Whose knowledge is it anyway? Feminist Epistemology and Science. Library, (December).

Rime, S. (2009, January 12). At M.I.T., large lectures are going the way of the blackboard Retrieved January 16, 2010, from New York Times: http://www.nytimes.com/2009/01/13/us/13physics.html?pagewanted=1&_r=1.

Schrader, D. (2004). Intellectual safety, moral atmosphere, and epistemology in college classrooms. Journal of Adult Development , 11 (2), 87-101.

Shepherd, J. (1993). Lifting the veil: The feminine face of science. Boston: Shambhala Publications.

Stokstad, E. (2001). Trends in undergraduate education: Reintroducing the intro course. Science (293), 1608-1610.

Sypnowich, C. (n.d.). Law and ideology. Retrieved from The Stanford Encyclopedia of Philosophy : http://plato.stanford.edu/archives/fall2010/entries/law-ideology/.

Vedder, R., & Denhart, M. (2011, March 10). Ten principles of higher education reform. Retrieved January 20, 2012, from The Heartland Institute: http://heartland.org/policy-documents/ten-principles-higher-education-reform

Zemsky, R. (2009). The case for transforming American higher education. New Brunswick, NJ: Rutgers University Press.

## Overall Conclusion

Although a greater number of females than males have been earning bachelor's degrees since 1982 (Institute of Education Sciences, 2009), they are still earning fewer in the physical sciences. If females have the intellect and drive to choose a STEM field for their college major, we need to be proactive in creating an environment that supports them. If as a nation we want to assure equal access, practically effective opportunity must exist. In the words of Vincent Tinto (2008), "access without support is not opportunity." Coercive and exclusionary learning environments do not foster the democratic ideals of our nation nor do they operationalize our belief in equality or our understanding of fairness.

Title IX of the Education Amendments Act says of 1972 says, "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance... (United States Code Section 1681)". Dismissing women's ways of knowing and learning is a covert form of exclusion. Women are being denied the benefits of science through discriminatory teaching methods and hostile environments that have been passed down from an antiquated, male dominated system of higher education that favors competition over collaboration, lecture over cooperative learning.

To date no one has taken the time to monitor retention rates of females in science, despite the urging of Shirley Malcom, Presidentof AAAS way back in 1996. Consider this excerpt from the NSF website:

> "Don't let perfection be the enemy of good," she said, encouraging women to press their institutions for specific goals. She urged them to be scientific in their pursuit of equity, to ask for data and to document women's situations.
>
> At times, she noted, more emphasis may be needed. "Stop being polite. Challenge people. Be prepared to ask the impolite questions."
>
> One question that many are asking is why do women who drop out of science have grades as good as the men who stay in. Malcom offered some likely explanations:

> discrimination, lack of support, and pressures associated with marriage, family, and child care. But nobody knows for sure.
>
> "We know the retention and graduation rates for college basketball players," she pointed out. "Why not for women studying science?
>
> She urged women to press university administrators to conduct exit interviews with women who drop science majors, then use that information to help bring about change (Working Toward 50-50 By 2020: Women in Science Take Stock, 1996).

One of the main purposes of this dissertation was to listen to and hear the particulars of two females' experiences in order to gain a better understanding of how female science students perceive the way things are and the way things should be. As Connelly and Clandinin (1990) suggest, "it is the particular and not the general that triggers emotion and moves people" (p.8). Sixteen years after Shirley Malcom's entreating we still do not know the attrition or retention rates of females in science; perhaps these attrition profiles will trigger the emotion that move people beyond the rhetoric of equal access into the realm of equity of opportunity. For instance, the Student Right-to-Know Act to could be expanded to include a CoMA[7] (Coefficient of Male Advantage) values. These CoMA values would be the tool to monitor the progress universities make toward fostering equitable learning environments—toward fostering the support required by diverse learning styles and ways of knowing. The profiles herein, gave us many ideas of what these supports look like. Many of them are curriculum oriented. For example integrating personal values into the science courses, earning grades that represent a more familiar mean (70% mastery of content instead of a 33%), frontloading the curriculum with diverse course

[7] I developed CoMA values from being immersed in 15 years worth of data during my administrative internship at SUNY Cortland in the Spring of 2011. These values can be easily computed from information that our government already mandates every US college and university to report as required by the "Right to Know" Act in Education. Basically the "coefficient of male advantage" is reporting the number of times males will graduate in a particular department compared to females using the average 6 year national graduation rate as a baseline. For example, let's suppose that 20 females and 20 males enroll in physics. If the "background" graduation rate of females is 60% and for males 50%, then if we assume equitable support of both males and females we would expect 12 females to graduate and 10 males. If for example, only 11 females graduated compared to 10 males this would show a "coefficient of male advantage" of approximately 1.1 [calculation: (10/50)/ (11/60)]. A CoMA value of 1 would mean it was equitable for both males and females. This is what each department should strive for. If a department has CoMA values greater than one it needs to provide greater support for females. If it is less than one, it needs to provide greater support for males.

work (not just the rule-following, close-ended problem solving, lecture format variety) that honors the collaborative approach to knowledge production in science, and so on.

## Further Implications

To recap the big picture: Democracy is a fundamental ideal of our nation. Persistent gender imbalances throughout society indicate strongly, however, that our reality falls short of the ideal. Our institutional decisions, though arguably based on majority rule, do not ensure fairness because the decision-making discussions exclude categories of people and important modes of discourse or ways knowing. As mentioned previously, one such imbalance lies in the STEM fields where women comprise only 13% of professors in the top 100 US universities. This figure is the result of a kind of unrefined majority rule of those in power, not the result of democracy as the highest standard of fairness that we know. Is this what we have boiled our democracy down to—"majority rule"? Or, as citizens, do we hold on to a more deliberative form of democracy? Dewey (1988[1927]), suggests a deliberative form of democracy where "mere majority" rule is "foolish" and irrational so long as "the conditions and methods of discussion and persuasion" remain as they are in society (p. 365).

Implementing a national policy of reporting a Coefficient of Male Advantage (an "*In*Equity Index") for each major as part of the "Right to Know" Act in Education, although not perfect, is at least an attempt to level the playing field and move toward equity in opportunity. Students and their parents can select schools that have the CoMA values closest to "one" for their major. This would suggest a culture of equitable treatment for both females *and* males. Ultimately, universities could use these CoMA values to attract female students to their schools in math and science, and for males in biology and health related fields. Our government could also support this endeavor by using these CoMA values as part of the NSF grant application

process. The bottom line, again, is best articulated by W. A. Wulf, former president of the National Academy of Engineering, with his perspective on diversity: "Without diversity, we limit the set of life experiences that are applied, and as a result, we pay an opportunity cost—a cost in products not built, in designs not considered, in constraints not understood, and in processes not invented." Further, more females with bachelor's degrees in STEM fields means more attaining higher degrees; ultimately leading to the democratization of higher education.

In other words, Frances Moore Lappe (2006) said, "To save the democracy we thought we had, we must take democracy to where it's never been" (p.11). We must go beyond the rhetoric of "access" and into the realm of creating real opportunities for women in science through our universities. We must develop tools that unveil the true internal and external coercive forces that undermine our democracy. If we can make epistemic improvements of Democracy by making it more egalitarian, cooperative and accountable as Bohman (2000) suggests, so too can we improve on the scientific discoveries and advancements in our country. As Dewey (1939) put it, "the future of democracy is allied with the spread of the scientific attitude" (p. 148). The quality of our democracy then, depends on pushing science to new places. Perhaps, in the light of these attrition profiles, we can now see how the "coefficient of male advantage" could act as an accountability tool since prudence, in the phronesis sense, seems to have been missing from many areas in our undergraduate science curriculum.

## References for Acknowledgements, Overview & Introduction, Overall Conclusion and Further Implications


Bohman, J. (2000). *Public deliberation: Pluralism, complexity and democracy.* M.I.T Press.

Connelly, F., & Clandinin, D. (1990, June-July). Stories of experience and narrative inquiry." 9, no. 5 (June–July 1990): 2–14. *Educational Researcher, 9*(5), 2-14.

Dewey, J. (1939). Freedom and culture. In *Science and free culture (1989)* (pp. 102-148). Buffalo, NY: Prometheus Books.

Dewey, J. (1988[1927]). The public and its problems. In *The later works,1925–1953: Volume 2: 1925–1927* (pp. 235-372). Carbondale, IL: Illinois University Press.

Flyvbjerg. (2001). *Making social science matter: Why social inquiry fails and how it can succeed again.* Cambridge: Cambridge University Press.

Harding, S. (1991). *Whose science? Whose knowledge?* Ithaca, NY: Cornell University Press.

Institute of Education Sciences. (2009). *The condition of education.* Retrieved from National Center for Education Statistics: http://nces.ed.gov/programs/coe/indicator_fsu.asp

Lappé, F. (2006). *Democracy's edge: Choosing to save our country by bringing democracy to life*. Jossey-Bass.

Phillips, C. (2007). *Socrates in love: Philosophy for the die-hard romantic.* New York: W.W. Norton & Company, Ltd.

Peters, S. (2010). *Democracy and higher education: Traditions and stories of civic engagement.* East Lansing: Michigan State University Press.

Roose, J., Santos, S., & Raposo, C. (2009). *Participatory budgeting: The case of Santa Leocádia de Geraz do Lima.* Retrieved November 1, 2012, from http://congreso.us.es/cesrea/OKpapers/Roose%20Participatory%20Budgeting%20Santa%20Leocadia-Portugal.pdf

Tinto, V. (2008, June 9). *Access without support is not opportunity.* Retrieved from Inside Higher Education: http://www.insidehighered.com/views/2008/06/09/tinto

United States Department of Labor. (1972). *Title IX, educacational ammendments of 1972.* Retrieved from http://www.dol.gov/oasam/regs/statutes/titleix.htm#.UK0EotWN_6M

Whitecraft, M., & Williams, W. (2010). Why aren't there more women in computer science? In A. Oram, & G. Wilson (Eds.), *Making Software: What Really Works and Why We Believe It* (pp. 221-238). Cambridge: O'reilly.

*Working Toward 50-50 By 2020: Women in Science Take Stock*. (1996, April). Retrieved February 2, 2011, from National Science Foundation: Frontiers: http://www.nsf.gov/news/frontiers_archive/4-96/4women.jsp

Wulf, W. (1998). *National academy of engineering meeting*. Retrieved January 12, 2010, from http://www.nsf.gov/news/speeches/bordogna/04/jb040308engsymp.jsp

*"There, but for the grace of God, go I"*