A Creative Path towards becoming Female Engineer enabling the next Opportunities in Computing

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Abstract: This chapter shows my creative journey to becoming a female engineer working on the cutting edge of computation and neuromorphic techniques. This chapter shows my real-life journey from early childhood, early education, through my professional career as a faculty member at Georgia Tech. Through this timeframe, I have had the fortune to work on neurally-inspired topics, programmable and configurable analog areas, and helping to develop the future of computation. Through this timeframe I have walked through many non-technical paths resulting in experiences that are part of my larger story.

Keywords: Neuromorphic Engineering, Floating-Gate Circuits, Field Programmable Analog Arrays

"It is brave that you *choose* to become a *female engineer*" – Sunny Bains, 2011

Not the kind of email response one gets every day. I had known Sunny for several years, and we had worked on a couple engineering communications over the previous decade or so. The statement struck me in so many ways. Why would anyone want to be female and in engineering given how hard the road. One might try to become an engineer if you were female, but to become female if one was already trained in engineering seemed between foolish and terrifying. And yet, it is my journey.

My journey is different from the other amazing women in this book, several whom I know personally and can attest to their struggles and successes. I do not have a story of barriers overcome preventing me to study or practice engineering because of my gender. For me, if I just lived according to social norms and behaviors, I faced no apparent roadblocks other than my own abilities to master the material. And yet, that was not enough.

I was not the first engineer to transition female socially, as brave women like Lynn Conway did decades earlier, losing her career and reputation at IBM as well as her children. Other engineers who have taken a similar journey might not believe they have the right to stand with other women engineers, or speak for the journey of other women engineers. While I respect their viewpoints, my journey, as well as the journey of my spouse, daughters, colleagues, and students compels me to stand and take my place with other women engineers, weaving my own story into the larger fabric.

My path has been a creative one, walking through my journey through engineering education, my journey to becoming an engineer working on the cutting edge of computation and neuromorphic techniques, and then becoming a female engineer. Through this chapter, I wish to share with you one perspective walking through my journey. Often through this process, I remember the Robert Frost poem (The Road not Taken) with the lines

> "Two roads diverged in a wood, and I—
> I took the one less traveled by,
> And that has made all the difference"

I. A Creative Path through Traditional Engineering Education

Among my family, I was the first practicing engineer. I remember considering engineering after two UCF engineering students came into our middle-school gifted classroom to give an overview about engineering. As I already enjoyed math, science, and computer programming, the direction was fascinating. Only decades later did I realize the personal importance that both engineering students were female. At a young age, I knew I was different, and not only did I connect well to girls rather than boys, but I both wanted to be them and viewed myself through these lenses. I was the 8th grader in chorus who still sang first soprano even after my voice broke; my mind knew where I was supposed to sing.

I always enjoyed Math and Science, and yet, I really enjoyed creating new things. Math and Science areas just seemed like a natural place to be creative. I know having a creative child sometimes created stress for my parents, as a creative child might not have efficiently followed directions. I was always curious what else could be done. I took to having Legos from the time I was five years old, and would spend hours creating new things everywhere. Whether it was developing new Lego spaces, or creating music on the keyboard, creating a unique theological perspective, seeing history in a different way, or creating a video game, I enjoyed the creative process. I personally enjoy the creative aspect of cooking and attempting to create something better every time I tried. Engineering just seemed natural as a creative opportunity, an opportunity to paint with the canvas of transistors an array of supporting opportunities. Students who have studied with me likely see these aspects, whether or not they themselves personally relate. I have also always enjoyed teaching anyone who would listen, as my daughters can attest, often with eyes rolled.

My family was always supportive of my directions, although they did not know how to help me throughout my journey. My immediate family, as well as my extended family, was very close growing up, and always with high expectations. My family came closest to engineering with my great-grandfather starting an electrical contracting business in the early 1900s, a business that lasted until my grandfather and uncle sold it in the late 1950s. My great-grandfather had my grandfather start in the new area of electrical engineering in Cornell, but that only lasted a semester or two before eventually he took his place in the family business. My grandfather saw my graduation B.S.E. and M.S. from Arizona State University (ASU) in August 1991, two months before he passed away.

My passion for doing engineering pushed me to take a unique path through my education. My younger brother, who earned his B.S.E. in Biomedical Engineering at USC on his way to earning his medical degree (at USC) speaks of it as "manipulating the (educational) system". I maximized my high-school opportunities in math and science, and I was looking to do so more.

Both of the major universities in Arizona (Tempe and Tucson) had a program for high-school students to live on campus and take a college course during their five-week summer semester. One school locked down any opportunity to real engineering courses until all general education requirements were completed. The other school, while confused initially, was at least willing to discuss the opportunity. I remember the program coordinator saying she would give someone a call, and a meeting was set up with Dr. Kelly, an associate dean of the engineering college at ASU. I had the opportunity to take linear circuits (ECE 301), a junior-level engineering course, between my junior and senior high-school years. I took to the subject immediately. I had a colleague in the class over lunch *accuse* me of really enjoying the compressed 5-week course, as opposed to others just trying to survive. Although I denied it, she was absolutely correct. After taking this course, I had the opportunity to take other electrical engineering courses in fall semester, and I would continue in spring semester.

The opportunity that came in spring semester (1987) would be the first key pillar that would shape my research career. Part of my interest in electrical engineering was the opportunity to build better computer games and graphics. I studied designs and schematics for hardware, and learned assembly language by 9^{th} grade. If one could build more memory or add another processor, one could make a far better game. So what could be better than making new computer chips that one could make far better games?

I noticed that a graduate level course in digital VLSI design (ECE 525) was being offered that spring semester at a time I could manage with my high-school schedule. I had a lot of the background by that point, so inquired with the professor, Dr. Lex Akers, if taking such a course would be possible. Even given the uniqueness of the request, eventually it became possible, although through a blended course that included the VLSI design course and the senior-level digital design course (ECE 425) that I independently learned. I immediately took to the material, although I realized there were times I was missing some of the prerequiste language and material. I just pushed harder given the challenge. I finished my first graduate course a couple weeks before I graduated high-school.

The background in digital VLSI design prepared me for starting my research trajectory. One day on campus in late April as the digital VLSI course was nearly finished, a few Ph.D. and M.S. level graduate students and I were in Lex Akers' office. The discussions moved towards building custom circuits for the new hot field of Neural Networks (NN). I did not get everything in that first discussion, and yet, I could see there were opportunities for a range of architectures. I remember Lex Akers saying, "there will be a noble prize in this area someday". Figuring out how to make physical systems compute and learn like the human brain seemed like goal worth pursuing. *It still is a goal worth pursuing.*

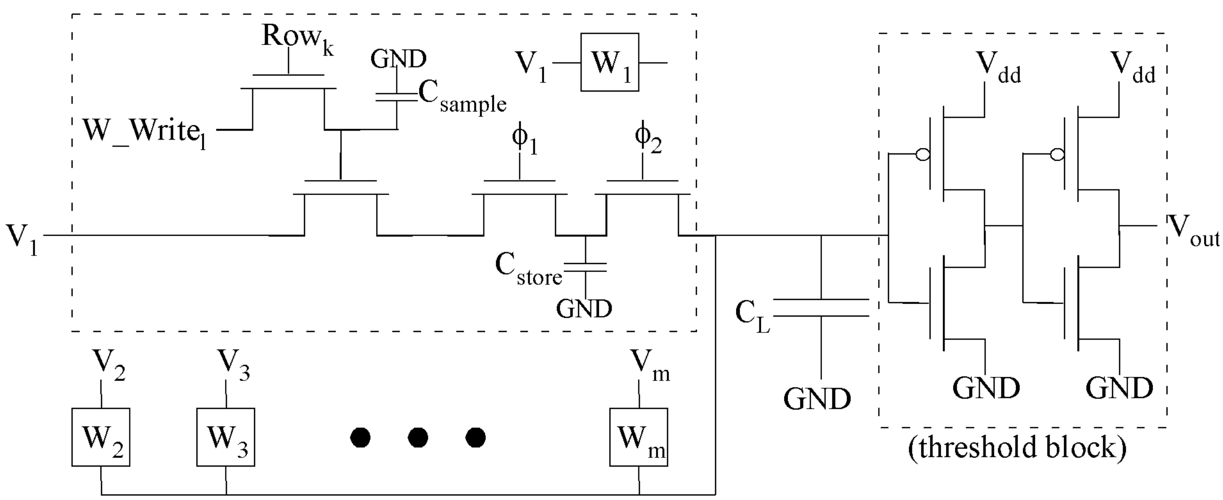

Figure 1: An initial charge-summing neuron and synapse implementation for a Neural Network (NN). The neuron had m inputs ($V_1 \ldots V_m$), and m dynamically stored weights ($W_1 \ldots W_m$) that were dynamically stored voltages on C_{store}. The charge was sampled into initial capacitors that would aggregate the resulting charge on a single node (C_L).

My first publishable results emerged that fall semester. Lex Akers made a challenge to try to figure out how to make as simple a circuit that could compute a NN. Realizing that the inputs and outputs of a NN typically are binary, where whole classes of NN at the time had binary input and output signals, a charge-summing based structure could implement this design (Fig. 1) with a few transistors when dynamically holding weighting voltages [1,2]. A couple of years later, I would learn that Yannis Tsividis published the first version of a charge-summing structure [3], but with some considerable differences where both approaches had their region of application. Individuals are still replicating these directions today (e.g. [4]).

A colleague of mine, Mark Walker, a Ph.D. student, mentioned he really liked the design, and then gently asked me "I don't see anything digital in this design. It looks analog to me." Although I know he was being encouraging, it felt insulting. It was not an analog design. I don't do *that* stuff. I eventually understood that analog design at its essence was efficiently using transistor devices for computation. And yes, I've taught analog design at Georgia Tech for the last two decades, and yes, I approach analog design differently.

II. A creative path towards Neuromorphic Engineering

Being at Caltech was magical, particularly getting to work with, and be mentored by, Carver Mead, for five years. Caltech was a place that marked its reputation on winning Nobel prizes rather than on football accomplishments (they stopped fielding a team in 1993) or basketball accomplishments [5]. There would be spontaneous celebration when a Nobel Prize winner from the campus was announced, such as Rudy Marcus in 1992, whose lectures on statistical mechanics I attended in 1994-1995. There would be frequent sightings of famous scientists, like Steven Hawkings, searching for books in the library. The informal meetings, several meetings over food, and discussions in the mountains north of Pasadena would have tales of individuals talking about the legends of science, individuals who were their personal friends. I made sure never to lose the sense of amazement and wonder of this special place, and yet, from the first day I stepped on the campus, I reminded myself never to act as if you don't belong.

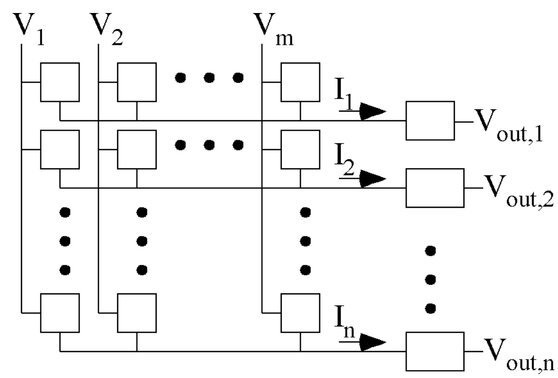

Figure 2: Physical NN implementations tend to be optimally implemented as a mesh architecture where synapse elements are the center of the mesh. The inputs ($V_1 \ldots V_m$) are locally input through global broadcast along columns, and the outputs ($I_1 \ldots I_m$) are summed along the row lines and go through neuron elements for the resulting output voltages ($V_{out,,1} \ldots V_{out,n}$). This structure effectively creates a crossbar architecture.

I started my Ph.D. degree at Caltech in Computation and Neural Systems (CNS) in the fall of 1992. During my time at ASU, I knew I had a strong passion for teaching and research and felt called to make a difference in the lives of graduate students working through the process. By the time I finished my joint B.S.E. and M.S. degree at ASU, I had been involved in multiple IC designs primarily focused at many different aspects of NN architectures (Fig. 2), circuit implementations, and analog memories (e.g. [6,7]). It took two application attempts to finally be accepted at Caltech, and I grew considerably because of the experience. And although I graduated from a much lower ranked school than my other Caltech colleagues, I never let those issues get in the way of contributing as an equal while at Caltech.

During one of his group meetings in March 1992, I met Carver Mead for the first time and immediately sensed his positive energy. I knew about his legendary career, as well as knowing how he created such a positive environment for everyone who worked with him. After having experienced a typical graduate school process, I was already passionate with a calling so that I could become faculty to make the graduate student perspective more positive. It was Carver's reputation that drew me to be part of his group. Until we had met, I was not certain if our technical areas would fully line up, but I was already willing to move my technical goals around. In many ways, things worked out better than I imagined. I'm thankful for the way that Tobi Delbruck, who defended his Ph.D. thesis just after I started in 1992, was a supportive mentor for me. Our group was an amazing group of people (Brad Minch, Chris Diorio, Kwabena "Buster" Boahen, Lena Peterson, Shih-Chii Liu, and Rahul Sarpeskhar) who mostly remained together throughout my entire time as a graduate student. I was always the most junior and youngest student in the group, even on the day I defended my dissertation in 1997.

Neuromorphic Engineering is a unique term, starting by the joint belief of John Hopfield, Richard Feynmann, and Carver Mead that one expected overlap between electrical engineering, computing, and neuroscience but having little idea how to build something in this area. In classic Caltech tradition, they started a class so they would understand the field. This year-long course in 1981 became several courses and eventually became a degree program, Computation and Neural Systems (CNS). By the time I started in 1992, this Caltech community had a decade of experience. I understood the wider community neuromorphic engineering community before I arrived at Caltech, having published and being at conferences for years, understanding the perspective within the family, as well as the outside perspective.

Neuromorphic Engineering looks to the computing opportunities in neural systems, implement those computations in synthetic systems, and in the process of building these computations, one asks new neuroscience questions. As Carver Mead said,

> "if you build it, you understand it. And if you understand it, you can build it"

and one can see Richard Feynman's influence. The computational advantages came from the great potential by physically based computation over digital computation:

> "taking all the beautiful physics that is built into...transistors, mashing it down to a 1 or 0, and then painfully building it back up with AND and OR gates to reinvent the multiply." – Carver Mead (1990)[8]

One major reason for studying the computation of the human brain (or other nervous systems) is the impressive amount of computation performed with minimal power. The human brain requires 20W average power, roughly 20% of the resting human body's energy consumption. Carver would hypothesize that physical (e.g. analog) computation would be at least x1000 lower energy compared to digital computation based on transistor counting arguments [8]. I would later be part of experimentally proving this hypothesis [9], and repeating that proof many times later (e.g. [10]).

When starting in Carver's lab, it was clear that that lack of a long-term memory device limited everything in the research community. By the early 1990s, everyone understood that the lack of an analog memory, particularly for storing network weights, was the primarily limitation for any analog implementation to move forward. The lack of a memory was *the struggle* that defined the field. Having both worked in this field for five years and published in these areas (e.g. [6,7]), I was painfully aware of the need.   The lack of an analog memory threatened to make this field practically irrelevant.

Carver saw the opportunity of a Floating-Gate (FG) device potentially being that solution, and yet, when I had started at Caltech, both academic and commercial attempts to make analog memory and computing devices in Si remained challenging.   Three of us, Brad Minch, Chris Diorio, and myself all looked at different and related aspects of these questions.   While many stories could be told of these days, all three of us benefited greatly from this collaboration decades later into our career. The presentation of The Single-Transistor Learning Synapse (Fig. 3) that I gate at EMBS (October) and NIPS (December) in 1994 [11], and at ISCAS in 1995 [12], demonstrated the first analog CMOS computation a long-term memory element that could be embedded into the computation and adaptation.   One could both adapt a crossbar of these elements, as well as measure or program a single device without affecting any of its neighbors.   These devices enabled a wide range of creative translinear circuits [13] as well as adaptive computing elements [14].

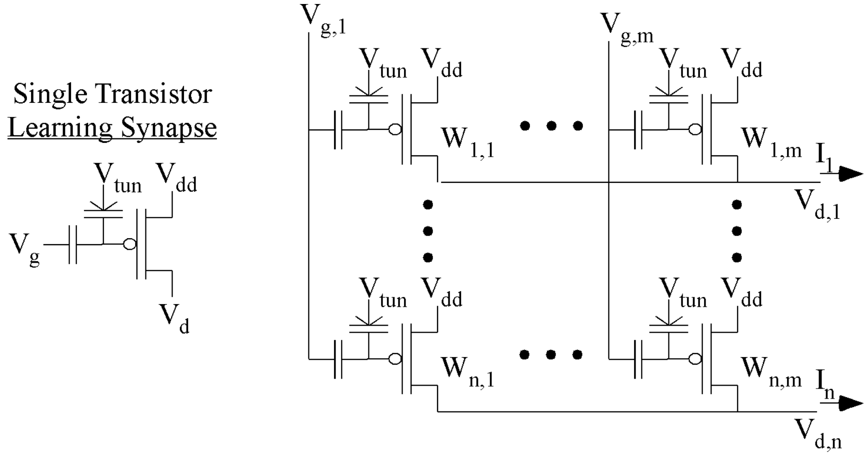

Figure 3: Single Floating-Gate (FG) element used as a single-transistor learning synapse element. This structure satisfies the architecture in Fig. 2, enabling long-term storage, computation, and adaptive capabilities in a single transistor element.

In 1997 I re-emerged into the traditional engineering areas starting as an assistant Professor at Georgia Institute of Technology (GT) after being immersed in the amazing Caltech culture for five years.   The potential of FG techniques for circuits and systems looked transformational.   And yet, as assistant professors sometimes find out, most were not so excited with these “new” concepts. May times in my first years at GT, I was told not to teach or do research in that “subthreshold stuff.”   Most did not even want to hear anything about FG or neuromorphic concepts, techniques that they thought would likely never become commercially relevant.   A few things changed over two decades.

In spite of these issues, I started building my research group, developing my teaching pedagogy, building bridges with other faculty, and staying centered to the opportunities I knew would materialize. After working with Carver for five years coupled with my ASU experiences, I knew how I wanted to build my research group and its resulting culture. The goal was to empower each individual as well as our collective community.   In my fifth year at GT, I remember looking around at my group meeting being amazed at this community of more than 20 graduate students, being thankful at how God brought everyone together, and somewhat wondering what would I do now with this community.

I had the opportunity to work with and co-teach with Phil Allen, one of the legends of traditional IC design, where we both developed a respect for each other’s perspective as well as became colleagues.   This collaboration gave me the perspective and language for designing FG techniques towards classical analog circuit approaches (e.g. [15,16]). Mismatch limits the performance of both classical commercial digital and analog designs. Having a programmable FG element in standard CMOS provided a method to minimize (or eliminate) circuit mismatches.

In the neuromorphic community, the question everyone feared and expected throughout the 1980s and 1990s was "Why not implement your neural algorithm in using DSP chips?". Even today similar forms of this question are feared by many people. I developed bridges with the DSP community, working with many of the founders in DSP, Ron Schafer, Jim McClellan and Russ Merseraeu, in a group that was the best DSP group anywhere in the world while I was an assistant professor. One of my proudest moments before earning tenure was Ron Schafer introducing me to his colleague and stating I belonged to their group, that I was one of them. The feared question no longer was ever asked as we directly addressed these questions as part of our research. I started mentoring other faculty starting my third year as a professor, an action that drew significant criticism by other faculty, and yet created additional collaborations and momentum. These efforts started an over 15 year research effort in large-scale Field Programmable Analog Arrays (FPAA) enabled through the programmable and configurable opportunities of FG devices [17]. The FPAA devices opened opportunities to understand the nature of analog computing [18], including foundational work on analog numerics [19], abstraction [20], and architectures [21].

Neuromorphic engineering did not appear as a primary focus of my research, as it had nearly zero interest in the academic and funding communities for my first decade at GT, and yet this research continued throughout this timeframe. The development of channel transistor models of biological channels and computational models of neural dendritic trees were two key neuromorphic developments that arose during these days. The result of this work showed a path towards building cortex while showing additional 100,000x energy efficient improvements over analog computing techniques [22,23]. A lower-bound estimate the computation of the human brain would be the equivalent of 10,000 IBM Sequoia supercomputers. Neural computation must be energy constrained, as any inefficiencies allowed requires a higher calorie intake.
Both opportunities started with my collaboration with Steve Baer (Math department at ASU), whom I took my first computational neuroscience class. When taking his course (Fall 1991), we started connecting transistors and biological channels, both in physics and in nonlinear dynamics. I would continue to work through this question over the following decade. Effectively, if we could have worked with Hodgkin and Huxley when they were doing their Nobel Prize winning work in the 1950s with current knowledge of transistor physics, what circuit model would we have developed? A decade later, we presented this transistor model on a Saturday 9am morning meeting at the Telluride Neuromorphic Engineering Workshop in 2002 (followed by later papers [24,25]), after Ethan Farquhar and I worked day and night on getting all of the nonlinear dynamics to match the original Nobel-prize winning data (Fig. 4). This model was the first serious rethinking of the Nobel Prize winning model, and has been predictive of biological physics when applied to synapses [26], dendrites [27], and networks [28].

John Lazzaro, an alumni of Carver Mead's group at Caltech, presented initial thoughts of building HMM classifiers at NIPS 1996 [29], effectively demystifying heavily guarded techniques used for speech recognition. And yet, listening to John's presentation, many opportunities for performing these computations were completely unaddressed. A few years later, I had discussions on the same day about Si implementations of dendrites based on the channel-model efforts, as well as discussions on an all-analog architecture for phoneme detection, which included Hidden Markov Model (HMM) classification. There was a moment realizing that the very circuits for variable-diameter active dendrites were very similar to the potential circuits for implementing HMM classifiers without some of the Lazzaro's earlier circuit concerns [29]. The work was initially published in 2004 [30], and Lazzaro's proposed yes/no wordspotting problem was solved using biologically modeled neurons utilizing dendritic coincidence detection [31]. Incorporating dendritic computation significantly increases the energy efficiency estimates of neuromorphic computing (x100,000), opening opportunities for even more energy efficient Si computing (e.g. [10]).

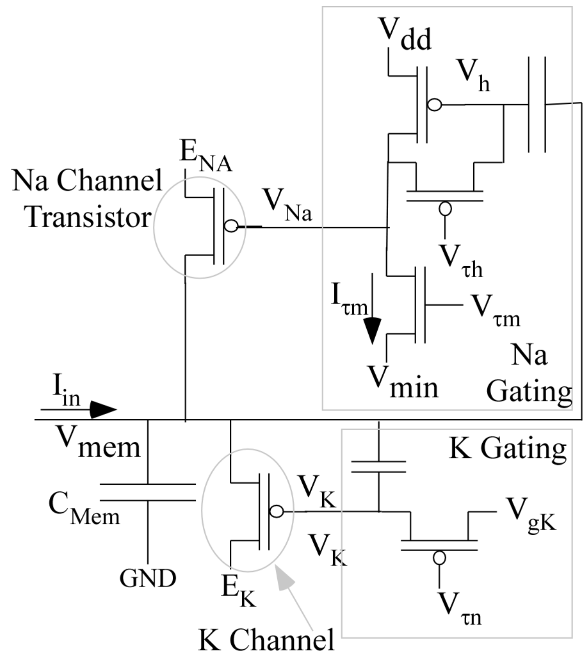

Figure 4: Classical Transistor Channel implementation of Hodgkin and Huxley's original neuron measurements.

III. A creative path towards becoming a Female Engineer

Between multiple faculty interviews at Caltech in the spring of 1997, a few unusual messages started appearing around the Internet about Lynn Conway's background. From my digital VLSI background and working with Carver Mead for nearly five years, I had a huge respect for her early work co-founding the field of digital VLSI design with Carver [32]. Investigations showed her contributions at IBM in the 1960s, including as an inventor of out-of-order instruction set execution. The reason it was hidden also became known: Lynn was fired from IBM in 1970 because a surgical gender change. I could do nothing else that day other than read everything available on this topic. Many cryptic comments over the previous four years made about Lynn started to be clear. Lynn believed no one knew, but apparently two decades later, many people eventually knew and yet had no issues with her history. The topic was personal for me, and more than the obvious technical connection and respect. As I had a faculty position starting soon, I tried to not think too hard about this news.

Ten years later, six of my Ph.D. students and I went to the annual Circuits and Systems conference in New Orleans. A couple of weeks earlier, I had obtained the book *She's not there* [33], and I could not put it down. In seeing the many parallels of a faculty member transitioning while preserving their family, I saw for the first time in my life, that my story might actually matter to someone else. And yet, how could I possibly disrupt everyone and everything that has been built? How could I survive if I did not do something? If I did something, what would be left?

The process for an assistant professor getting tenure is difficult. Years after faculty get tenure, they believe it was not that difficult, much like a few years after graduation all of the struggles of being a student have faded away. After submitting all of my final paperwork for tenure in Sept 2002, I could finally let my soul fly again. And she flew and cried out for authenticity. My faith moved from walking through the tenure building process to seeing the wider world. I was still as busy as before I got tenure in Spring 2003, now mentoring a group of over twenty graduate students while incubating a startup company, GTronix, that was co-founded with three of my first four Ph.D. students. And yet the heaviness of the process decreased.

The startup company did quite well, so well that it was the first company funded by the top-tier venture capitalists along Sand-Hill Road in Silicon valley. Being the first company, most of the company was moved to the Fremont, CA area of Silicon Valley during the summer of 2004. The Fremont to San Jose area was the center of the transgender community in the bay area, and Fremont, CA was effectively the center of a famous murder and trial of Gwen Araujo [34]. I would be traveling to Silicon Valley every month until GTronix would be eventually acquired by Texas Instruments in the summer of 2010.

As my soul became alive and my faith grew, I could feel a call towards authenticity. Many believed transition and faith were separate. In my case it was precisely because I felt God was calling me out towards authenticity that I needed to transition [35]. I know now that without transition, I would have experienced catastrophic health effects due to the stress of suppressing myself.

A key transition aspect was making sure my family would be intact through the process. Although such transitions with intact families are becoming more common today, a decade ago the number of examples were few, particularly when children were involved. My timing was not entirely my choosing, because in August 2010 my Department Chair (fortunately not at GT any longer) outed my transition to my entire department. I still postponed this process publically because I knew my family required more time to handle this transition. I officially transitioned in January 2012 at GT, even though I had practically transitioned significantly earlier. Today people often ask me how my family is doing. My response sometimes is "normal, and I am thankful for normal." I have personally walked with many individuals who transitioned and lost so much, and as a result, I am thankful for normal.

As part of my transition, I opened myself up to a few things I enjoyed doing. A few months after my official transition at GT (Jan 2012), a teaching and education group offered a book reading club (with afternoon snacks) on an educational topic. I would get an opportunity to know a different part of the GT campus, as this community was majority female in a technical school, and I was only one of a couple of engineers to ever participate. This first semester we would read a book, *My Freshman Year*, relating the story of an anthropology professor at Northern Arizona University (NAU) using her sabbatical year to immerse herself in the foreign culture of first-year undergraduate students [36]. She noticed that faculty and students walked and lived in different spaces, and would rarely interact. Most faculty have forgotten what it was like being a student, and more likely are somewhat terrified of their students. I could immediately see the appeal of such an adventure, and six years later I would do something similar for my first sabbatical semester (Fall 2018) in 21 years.

Fall 2014 I started a new adventure taking classes part-time at Emory, in a process that would lead to my pursuing a Masters of Divinity (MDiv). This journey was partially a journey to reconnect to a student perspective, as well as honor a promise I made to myself during my ASU days that I would take such classes. I graduated with my MDiv degree in May 2020. Along the way, I became very involved in campus ministry, including being the Faculty advisor for the Methodist community. My original trajectory to be faculty was a form of a calling. This journey has developed my call towards caring for the entire campus community, growing out of the original call towards graduate student mentoring. A call changes as we individually grow in authenticity. I am fortunate to have had multiple strong female role models, including a female pastor (Barbara Riddle) as part of our new church founding (Tuskawilla UMC founded in 1980). The multiple aspects of this seminary experience would be a book in itself.

These directions directly impact my current research directions. These directions have re-energized a passion for undergraduate teaching as well as ethical graduate student mentoring. And yet, with the potential successes in neuromorphic engineering and understanding the human brain, the resulting interdisciplinary questions bring in understanding from philosophy. The new opportunities in physical computing [18], which includes analog, neuromorphic, and quantum computing, bring new data and perspectives to address questions that philosophers and theologians raised for centuries and that they have only dreamed they could understand. When we build artificial or robotic systems, we effectively hard-code their purpose and function. And yet, if we build human cortex, embody it, and train it over years of data, will it act human, particularly as experienced by other humans? Will there be a soul to the machine? Over the next few decades, technical communities will directly have to address these questions, and I look forward to these opportunities. As we continue to augment our reality, as we already have smart phones attached to us, who do we become, and how do we connect to each other's humanity in these new spaces. Those who work with youth already struggle with these realities [37].

IV. Concluding Thoughts

April 30th, 2019, I woke up recovering from gender confirmation surgery. I realized I crossed my personal last threshold in this journey towards being a female engineer. I cannot help but remember Sunny's email, and my struggle that some might believe moves me towards a lesser status. And yet the journey has not concluded, where there is so much of the journey in front of me. One thing I learned from my mother, who passed away in October 2019 after a heroic fight against Parkinson's, is to continue moving towards all of these opportunities. Nothing seems to more honor her life than to live towards these new opportunities. I look forward to the next thirty years of my career, and look in amazement on technology's positive impact on all of humanity.

We live in amazing times as seen both in technology, as well as our understanding of the wide diversity of human expressions, where each accelerates each other. As the pace of innovation continues to increase, humanity already becomes challenged with a different mode of being, a mode of being where one expects huge changes in one's lifetime. In my grandparents lifetime there was significant change, but not so fast it could not be absorbed. My daughters, both likely engineers, will likely live in a world where we always expect significant improvements in technology within their generation. Every human endeavor will change as a result of technology's change, including areas such as religion, where the human struggle to reach for outer meaning in the world, will adapt with the changing technology. Things that don't change will become less relevant.

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