The Many Faces of Mathematics

An Integrated Service Project by:
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Introduction

Two summers ago, I was preparing for my last year of college. I was finishing a B.S. in mathematics and a minor in music. I had done well in school, worked as an engineering technician, and had participated in essentially every aspect of student life. I knew-- or at least I thought I knew-- that I wanted to go to graduate school and pursue a PhD in applied mathematics. But after a lot of thought (and a failed GRE Math Subject Test), I realized that an advanced degree in math wasn't what I wanted. So I panicked-- what was it that I wanted to do?

To answer this question, I turned to my network of coworkers, professors, and older friends and asked this simple question: How did you get to where you are today? Everyone's answer was utterly different, but there were common threads that ran through each story: spending time doing things they enjoyed, pursuing subjects that they could excel at, and taking advantage of diverse opportunities when they arose.

This exercise was useful in allowing me to understand how the professionals I know got to where they are. But, I thought, these people graduated with a multitude of undergraduate degrees. I have a *math* degree, and *what* am I going to do with that?

So I turned to a much smaller network-- acquaintances who started their careers with a degree in mathematics. What was so surprising to me is that these people ended up in completely different fields: actuarial work, medical school, law, teaching, and so on. It became abundantly clear that a math degree opens unexpectedly diverse opportunities, especially if an individual pursues something that he or she likes and is good at. A math degree, as you will see from many of my interviewee's stories, builds a logical way of thinking and has an aura of difficulty-- qualities which are attractive to possible employers.

While I connected to all of these amazing, brilliant people, I also started searching again for what it was that I really wanted to do. I took classes in a variety of subjects and pursued the ones that I enjoyed. In May, I will be graduating with degrees in both mathematics and biology, and I hope to follow that with advanced study in biology. I know that my math background has helped me get to where I am today.

So now I present to you a compilation of stories from incredible individuals of many (but of course not all) of the careers possible with a math degree. They are organized by occupation, although you will notice that many of these people changed their occupations throughout their careers. Each story has "boxes" which have quotes from the interviews which were not included in the story itself. Scattered throughout the book are also some extra pages with special spotlights from the interviews-- tangents which became their own stories. I hope that the stories and information in this book will serve as an inspiration to you as you create your own career path.

-Yasmeen Hussain

Chapter 1: Law

Law may not be the most well-known path stemming from a math degree, but, as we will soon see, it's a very good fit for many math majors who enjoy the humanities. We begin our journey with Ruth Lee, who graduated from college just last year. Next, a law school admissions officer answers our questions about what a math major needs to do to get into law school. For those who don't want to be a practicing attorney after law school, we then take a look at James Bjorkman, who works for the government instead of a private firm.

Ruth Lee: Law Student

Ruth Lee describes herself as someone who is "ridiculously tenacious" about her goals. So when she decided at the age of five that she wanted to be a lawyer, she did everything possible to see that dream through. Also very academically driven, Ruth spent every summer after her freshman year in high school in classes or participating in research. She skipped two grades of high school, enrolled at the University of Washington at the age of 16, and asked her academic advisor what classes she should take in order to practice law. In preparation for law school, Ruth chose to double major in political science and mathematics.

"Math is very dear to me. I brag about it like moms brag about their kids."

It may seem strange that someone so dedicated to a life in law would choose a major in mathematics. But Ruth has "always been good at, and loved, math." When Ruth's college calculus professor told her that law schools vie for math majors, she had no trouble making the decision to major in it. While at the University of Washington, Ruth participated in many extracurricular activities, including work as a calculus tutor, volunteer work for students with disabilities, and a position as the Vice President of the math club. She was also involved in research ranging from a VIGRE program designing a template for teaching elementary school students mathematics to a summer REU at Texas A&M, studying wavelet theory. The latter research resulted in classification of all the refinable functions and a subsequent presentation at a conference. Ruth also conducted extra research and used three different computer programs in the preparation of her senior thesis about geometric combinatorics on Gale diagrams.

"I would have studied a lot more at the beginning of those classes [Abstract Algebra and Real Analysis]. With math, foundation is important. You have to have a firm grasp of the lower-level math classes to do well in the upper. "

In addition to pursuing challenging academic goals, Ruth spent a large portion of her undergraduate career "running around the math department talking to people." She frequented the offices of graduate students and professors to talk about homework, but they would "usually end up just chatting about movies or something." Building relationships with graduate students led Ruth to attend colloquiums that she wouldn't have heard about otherwise and brought her an unexpectedly large audience at a talk she gave about her own research.

All of the extra hours spent getting help on homework paid off, too, as Ruth graduated magna cum laude. Ruth says, however, that she wishes she had known as a freshman that a degree in math would not be an easy path. She did well in math classes early on in college, but her "first quarter of Abstract Algebra and Real Analysis…was devastating." After getting over this obstacle, Ruth loved her Matrix Algebra, Ring Theory & Galois Theory, and especially her Complex Analysis class, which she calls "the best part of undergrad."

The Law School Admissions Test (LSAT):
3 sections
(1) Reading comprehension
(2) Logic reasoning (ex: can you find the flaw in the author's argument)
(3) Logic games
Where does math help?
Math and symbolic reasoning help with logic games.
Who does best on the LSAT? (www.lsac.org)
1. Physics/Math
2. Philosophy/Religion
18. Political Science

Ruth was not quite as enthralled with her experience in political science, where she "just memorized stuff and regurgitated it for the tests and did very well." She did, however, use that major to find academic recommendations for law school, saying that "it's a lot harder to get to know your math teachers because talking about the Weierstrauss M Test won't help you get to know his or her personality." She also added that a political science degree would be useful for aspiring law students who would like more practice in writing and public speaking.

Although she got a lot out of her undergraduate experience, Ruth wishes that she would have "spent more time studying law and...studying for the LSAT..., and less time on the internet." She attributes much of her success in the law school application process to a high GPA and LSAT score-- numbers which "trump everything in law school admissions." Also adding to Ruth's success was her work in mathematics. Statistics from the Law School Admissions Council show that math majors come second (right after physics majors) in LSAT scores. When Ruth was accepted to a number of prestigious law schools, including Georgetown and the University of Pennsylvania, the deans of those schools personally told her that they loved having math majors at their schools. They knew that the course load of a math student was both difficult and unique in a sea of applications dominated by undergrads in "soft sciences".

"A caveat: Don't major in math if you want to go to an elite law school and you know it will lower your GPA."

Ruth's high GPA, research experience, and volunteer work could have landed her in a good graduate program in mathematics, but she was dedicated to her dream of being a lawyer. Ruth explains: "I love math and will always love math. I strongly believe people should do it for fun. There are *some* who should make it into a career. One of my best professors, who also wrote numerous letters of reference for me, told me once that one should only pursue math professionally if one 'has a *soul* for it.' Although I love math, I don't have the endurance to do it all day. I have a few friends...who I can see going into math because it's their whole passion and being. While I love math, [I] cannot devote myself completely to it...I'm really into the humanities and social sciences, too...Math is a sort of a harsh mistress...you need to give it your all if you want to do it right."

Knowing this, Ruth accepted an admissions offer at the University of Chicago. She has enjoyed her first year of law school (known as 1L), which she describes as a more intense and competitive experience than undergrad. There is a lot of assigned reading and subsequent in-

class questions which cannot be answered by the reading alone. Law students must be "creative and quick on their feet," as well as dedicated to studying.

"Math has rules to abide by, and we don't question the rules and ask "Is it moral that 1+1=2?" On the other hand, law has rules but you have to think outside the elements and question whether the law should be what it is."

That's where Ruth contends that her math degree really helped her. While her compatriots from humanities backgrounds have creative training, they "lack the discipline and concreteness" necessary to do well on law school exams, which comprise 100% of the grade. Ruth says that her math training helped her to be "detailed, logical, and clear without going off on unnecessary tangents." Although law schools, especially prestigious ones like the University of Chicago, are known for their competitive learning environments, Ruth argues that math and science majors adjust easily to the pressure: "Partial differential equations are hard. Galois theory is hard. Advanced probability is hard...It's not like you're not used to doing really difficult stuff…Math majors are used to studying, are used to *homework*. That practiced discipline serves you well in law school."

Ruth thrives on the competition and pressure of law school, but she readily admits that it isn't for everyone. She has a whole host of stories about students going "kind of crazy" the week before exams- crying and yelling, sending enraged emails to the official email list of the entire law school, having silent dances in the library, and general chaos invading the student body.

These dreaded exams contain story problems, like: "A has a crush on B and then grabs her, throws her against the wall and kisses her. B responds by punching A in the face. A then retaliates by pouring water all over B's sister's homework. While C is coming into the room, she slips on the water, falls into D, who has a miscarriage. WHO CAN SUE WHOM?" The exam itself involves finding all of the issues and discussing them, which takes patience and a good eye for detail, as well as a solid understanding of the "black letter of the law". Unlike Ruth, "most students hate exams."

"I like making arguments-- starting with…premises and reaching conclusions. I also like the idea of working with something that binds society together. People want to live with each other…but they can't do it without the law."

After her first year at the University of Chicago, Ruth transferred to Harvard Law School. Transferring law schools is somewhat rare, as most schools only accept a few transfer students and only those with competitive grades, but Ruth had very good reasons to try for a transfer. As Ruth says, "I transferred to Harvard Law School because it has been my dream school since I was 5, because my mother went to Harvard, because I wanted to experience a larger school with more opportunities, and because…it lives up to its legend, it really does."

While Ruth chose a career in law, many of her peers went on to take industry jobs with Google, Amazon, Expedia, and Microsoft, into academia, and into graduate school for public health or economics- in short, everywhere. Asked if she recommends getting a math major, Ruth responds with a resounding "Yes."

Christina Arteaga: Law School Admissions Officer for University of Utah

"We have students from a variety of majors in law school, from theater to electrical engineering. We encourage students to take writing classes so they are prepared for law school…Grades are important to help us assess if you can do well in a program of our caliber, but [research, extracurriculars, breadth of classes, difficulty of coursework, and work experience] gives us an insight as to what you will contribute to the law school."

James Bjorkman: Budget Analyst

As far back as second grade, James Bjorkman had a natural aptitude for mathematics. He had always been interested in numbers and patterns, so his choice of a college major was easy. James says his philosophy was "to study what I was interested in and opportunities would present themselves from there," so he decided to pursue a B.A. in Mathematics and B.S. in Political Science, another area in which he had great interest. James also specialized in International Relations and eventually obtained a minor in International Studies.

Favorite math classes:
Foundations of Analysis
Chaos Theory
Number Theory

His love for numbers also drew James to his first job as a teller for Wells Fargo. He worked his way up through the company for 5 years, ending as a manager in their health benefits services department by the time he graduated from college in 2005. James had taken a little longer to graduate than some of his entering classmates, choosing to study part-time for a while as well as spend a bit more time considering law school. He already had an interest in political science and heard that math majors do well on the LSAT, so he decided to take the opportunity to apply.

So, in the fall of 2005, James started law school, specializing in public international law. He says that, in law school, despite being the only math major in his class, "math really did come in handy." A math background was useful for the number-crunching required for case analysis and more importantly for obtaining the logical and deductive and inductive reasoning skill required to study law. He graduated from law school in 2008 and was accepted to the Presidential Management Fellows program, where he was placed at the US Department of State.

Currently, James works in the Central Budget Office of the State, where he does "analysis of budget trends and impacts of Congressional and other high-level decisions" on the operations of his department. Although he works with numbers on a daily basis, there's "no real high-level math" in his job, which James says is a good thing for him. He struggled with the math classes in which he "couldn't visualize or see a practical application" of the problems, and did much better with his electives, where he was able to study the "practical applications of math."

"I remember quite a bit of calculus…and bits and pieces of upper-division math. The things I don't use much, I don't remember as well- but I do remember a lot of the overarching principles and ideas. I might not remember how to construct a whatever-it's-called matrix, but I know how to find out how to do it. I've retained from math the same thing I retained from law school: the analytical skills. Basically those two degrees gave me the tools for my professional toolbox."

It's difficult for James to describe a typical day at his work, since it's "very reactive" and "depends on what other people are doing." When Congress passed the FY2010 budget, James and his team were "responsible for reading the legislation and report language, then turning that into numbers, and then doing an analysis to show what those numbers meant" for funding. He then reported their objective analysis to his department's leadership.

James is also involved in work that requires non-objective data analysis, like developing budget requests. Of those, he says that his team is "trying to get enough funding to operate [the State Department] effectively" by "really selling [their] position and [their] ability to accomplish US goals and objectives." He also created a data collection and dissemination tool for the account analysts to easily understand what raw data means "on a micro-level." James summarizes his job as looking at numbers all day and applying his math skills to real-world budget situations.

James enjoys his job, especially the chance to see what's going on in the whole State Department, the opportunity to provide necessary information to US policymakers, and the ability to do "a wide range of different tasks as opposed to the same thing day-in and day-out." Soon, though, James will be resigning from his fellowship position to enter the Foreign Service. This new program will allow him to switch job functions every 2-3 years and be stationed overseas for about 80% of his career.

If he could start over again at high school, James may have stuck with a math minor instead of going for a major. He says that doing so would have allowed him to avoid the classes which were so difficult for him, thus eliminating the need to take lighter class loads and retake certain classes. This, he maintains, would have made his undergraduate career shorter than eight years.

Despite this, James still believes that his math degree was worthwhile, and suggests that math students wondering what to do next should "ask themselves what they want to accomplish with math skills. Do they want to go into the private sector and help companies be innovative, create stuff, and make money? Do they want to be theoretical and sit around a college campus thinking all day? Do they want to go into financial services and look at market trends and try to predict the future? They should look at what else they're interested in and find a way to apply math to that. A friend of mine liked tutoring and teaching, so he became a math professor. I was interested in international relations, so I found a way to use both of those interests." But James stresses that he still doesn't know exactly what he wants to do with his life, noting that "it wasn't until I got this Foreign Service gig that I think I finally found my last step." It's been a long journey along with "unbelievable amounts of student debt," but James says "it's all been worth it."

Chapter 2: Education

Education is one of the best-known opportunities for math majors. Our first story is from Mason Kjar, who now studies law but got his start as a teacher. Many people follow a straight path to their dream career, and some venture into their field after pursuing something else. Mason is one of those whose career path bridges the gap between multiple fields.

Not surprisingly, as a math major, he taught math. But people who study math often have other interests which play into their career paths. Following her passion for music, Jessica Napoles chose to teach music instead of math, showing us that math isn't the only subject that a math major can teach.

Math teachers often have to deal with students who hate the subject. The fear of mathematics, widely known as "math phobia," is a well-recognized issue in education. In "math: the love/hate relationship," a teacher and a student address this dichotomy.

Not everyone involved in education works directly in the classroom. We have a story from Joel Duffin, an individual who assists K-12 teachers with curriculum and software development.

J. Mason Kjar: Law Student

Mason Kjar was good at math in high school and liked the subject. In college, he tried a number of majors, "including but not limited to engineering, construction management, English, and art," and had several jobs, including a stint as an assistant plumber, a manager in a tutoring business, a teaching assistant position in a ceramics lab, and a research fellowship. Mason enjoyed tutoring and had some great teachers as a college freshman and high school senior, so he finally decided to study math and physics, with the intent of teaching after graduation.

But, as it turned out, it was much harder to be a great teacher than Mason had expected. After a professor told him of an opening at Rowland Hall, he applied and was hired to teach math, physics, and personal finance to 9^{th}-12^{th} grade students. Although Mason hadn't taken an education route in college, Rowland Hall, a private school, was able to hire him without licensure. In order to expand his future options, however, he still applied to the Utah State Office of Education ARL program and obtained an alternative teaching license after 2 years of teaching and some evening classes.

"I decided not to leave Utah, which limited my options. Also, I just had my second kid and my wife and I needed income, so I had to get a job. I was worried that an advanced math degree would be very time and energy-consuming, so I didn't think I had many options other than teaching."

Mason's "first real teaching experience was on-the-job," and as he says, "the first day was good, but the first year was HARD. I came in very idealized and thought I could be as cool as all the awesome teachers I had seen over the years. In some ways I was-- the work was not challenging in terms of mental capacity, but it was hard emotionally. I let some students get to me, I took the work home with me too much, and it was physically demanding to stand and talk all day long...But the years went by and I got really good at

compartmentalizing my personal life from my profession and was able to feel joy in my work and passion for the subject. Finally, by the sixth year I saw signs that I was becoming too jaded and sarcastic-- after teaching teenagers all day, you become infused with so much teenage angst that it starts to affect you in subtle ways."

This, as well as a number of other factors, set Mason looking for other options. He eventually decided to try law school, which he felt would leave the most doors open for the future, and applied to the University of Utah's law school. The school looked favorably upon Mason's non-traditional background, since "they like to see some experience before law school" and his science majors helped to set him apart from the English and political science majors who tend to go into law. His acceptance was also added by a good LSAT score and great reference letters.

"I like construction. This summer, I converted my single-car carport into a two-car garage. I thought hard about becoming an electrician or real estate estimator, but I know that you can't work in hard labor all your life- the body can only take so much."

Now a law student, Mason has been drawing from the skills he learned in college and as a teacher. The math degree, as he says, has helped "develop and strengthen" his analytical skills, while the teaching experience has honed his people skills, which are helpful in law school. Mason isn't quite sure what he wants to do with his law degree-- ideas include intellectual property law, non-profit and public interest work, and becoming a law professor-- but he is enjoying law school in the meantime.

The hardest part of law school, Mason says, is "working hard all day long, staying in the law school until 8pm every night, and not seeing my family" as much as he would like. He has four children with his wife, who was once a teacher, but they all have had to sacrifice a lot in order for him to "explore this career change." Mason's wife, as well as Dr. Bertram and other professors at the University of Utah, have served as inspirational and motivational figures through Mason's career. That support is getting him through law school with strength and motivation that he says "would have gotten a 4.0" in undergrad.

If he were to go back to his undergraduate career, Mason would pursue more research and fellowships and prepare himself for graduate school. He remains convinced that a higher degree offers many more options to use your math skills than an undergraduate degree alone, giving the example that "to teach in college you have to at least get a master's." He also recommends that those desiring to teach high school take the "regular" math degree as opposed to the math education track. While a student may choose an initial path, Mason's experience makes it clear that change is possible and success can follow even a track that is "a bit crooked."

Jessica Napoles: Professor of Choral Music Education

Jessica Napoles is passionate about math. Her mind works well with organization and order, so math has always made sense to her. She excelled in her high school math classes, so going to college to study mathematics was a clear choice for her. But there's a twist-- Jessica is also very passionate about music. With a love for both subjects, she chose to take courses for a dual degree in Music Education and Mathematics.

"It's also a good idea to shadow people…get a grasp for what each person does with their day and decide if this is something you can live with. Ultimately, that's what did it for me."

In college, Jessica enjoyed her calculus and statistics classes alongside sight-singing and musical ensembles. "I could take calculus a million more times and still enjoy it," she laughs. Jessica even remembers how much she enjoyed classes outside of her major: sociology, physics, and chemistry. Her love of learning spanned a myriad of subjects.

Jessica chose a teaching track partially because of teachers who inspired her. "All of my mentors have been teachers, and that's part of why I knew I wanted to be an educator," she says. "The teachers in my life were always the most influential. It seemed like a natural course for me." Jessica had one high school math teacher who was very influential in her life and kept in touch with her throughout her college career. Her middle school choir teacher sparked Jessica's love for music at an early age, and her college music professors were mentors who she still calls regularly. Knowing that she wanted to be a part of the educational process, Jessica took as many student teaching opportunities as possible; something which she says prepared her well for a job in education.

"Everyone knows what a teacher does, because we've all had teachers, but unless you've had experiences with family and friends in a profession or have done job shadowing, it's not really clear what professions are out there…I just assumed that there were accountants and teachers."

Although Jessica knew she wanted to teach, she had to decide which subject she would be happier teaching: math or music. Ultimately, she decided that the creative outlets and curricular flexibility of music education would be more fulfilling, and she started looking for a job as a middle school choir director. As it turned out, the same high school math teacher who was a great mentor throughout her educational journey was also good friends with the principal of a middle school with a job opening for a music teacher. Somewhat unexpectedly, the principal called Jessica and asked her in for an interview. Jessica says that "it was interesting that a math person found this connection to a music job. It's totally random, but that's the way life works sometimes."

Although Jessica could have used her auxiliary math degree to get a job teaching both subjects, she chose not to do so because she wanted to develop as a choir director and not as "a math teacher who also teaches choir." Jessica enjoyed teaching music to middle school students for seven years, but she missed having math in her life. She started taking evening classes in accounting while she was still teaching, but found that, although her courses taught practical skills, accounting didn't rouse her passion like upper-division math classes did. Jessica then considered becoming an actuary, where she could apply probability and statistics to real-world problems.

However, Jessica's original analysis of what would make her happy prevailed, and she obtained a Master's degree in Music Education and left her teaching job to pursue a Doctorate degree in the same subject. She was happily surprised to find that research analysis relied heavily

on advanced statistics, bringing math back into her life. Finishing her PhD, Jessica began looking for a job as a professor. She consulted her mentors and graduate school professors, and searched the Journal of Higher Education and College Music Society websites. Although her advisor was well-connected and able to give her insight into which universities would be a good fit, Jessica discovered that the process was stressful because "you have to open yourself up to the whole world." She had three interviews and received three job offers. Upon visiting Utah, she fell in love with the mountains, natural beauty, moderately large size, and variety of available cultural experiences available in Salt Lake City.

"There's part of me that wishes there were more math in my life…but I probably wouldn't have done anything differently."

In her current position as a professor in the University of Utah School of Music, Jessica has a variety of responsibilities. Her job has a performance component, in which she conducts choral ensembles, and an academic component, research in the field of music education. Jessica describes her typical day-- or lack thereof. "Some days I spend the whole day doing research and other days…all my energy goes to concerts…and other days it's all about preparing students to be better teachers and going out into schools and observing student teachers. It's perfect. There are so many different things I get to do-- I don't get bored." Jessica insists that each of these tasks is equally exciting, and that the variety in her job keeps it exciting.

"If you can teach middle school, everything else is a cakewalk."

Jessica conducts research in teacher effectiveness, how people evaluate music, and what affects people's perceptions of conductors. The data collected in this research is analyzed using advanced statistics, which Jessica loves. She says "it's been nice for me to keep math in my life even though my passion is still in music...I don't have to exclude one or the other." Although Jessica doesn't use the material from all of her college math classes, she remembers the general concepts and relies on old textbooks and other resources to fill in the details. As she says, "The things that you don't continuously use, you lose, but you know how to find them."

"It's our responsibility to make decisions armed with a lot of knowledge, or else we do ourselves a disservice."

Jessica also works to continuously improve education. She makes a point to attend several conferences and professional development workshops each year in order to stay in communication with colleagues and keep up to date with progress in her field. She also writes grants to bring visiting artists to the university to work with her students so that she can acquire new tools and techniques to help students learn better. Jessica finds inspiration in educators, who she calls "indicators of what I aspire to achieve," and in students when they reach a moment of clarity. Her experiences as a mentor and a mentee have led her to believe that education is a cycle of mentorship, where each individual is mentored and pays the experience forward to others.

As a beginning college student, Jessica Napoles knew that she loved music and loved math. She didn't know that her career path would lead her to become a college professor, but loves that it has. As she says, "there were so many directions I could have taken, and ultimately I found out why *this* job is really perfect for me."

Mathematics: The Love/Hate Relationship

Ruth Lee: Law Student

"Math is unique. It's the only field where everything is proven. In science, theories may be supported and disproven, but never proven. But mathematical theorems are proven, and once proven, proven forever. The Pythagorean Theorem holds for every single right triangle in the universe for all eternity. That is a colossal and grand statement.

You know that you're not studying something your professor--or a passel of white men--made up. Math is universal and timeless. If all the humans disappeared tomorrow, Shakespeare, history, and sociology would have no meaning. But 1+1 would still equal 2.

Plato said that numbers were the highest form of knowledge. I think he is right...numbers, and their manipulations, are untainted by human (therefore fallible) influences.

I also like how there **is** a right answer in math. You can't make up stuff, you either know the answer or you don't. Even open mathematical problems--that we don't know the proof to--we can at least say what we don't know.

I can argue with someone about whether capitalism is right until I'm blue in the face, but if I want to convince them that Liouville's theorem is true, all I have to do is prove it. "

Kelly MacArthur: College Instructor

"People have this really interesting attitude towards mathematics-- if they're good at it, they'll like it. What the regular public doesn't understand about mathematicians is they think we all have it easy, like "you were born with some gene that you just understand mathematics all the time." I'm thinking "are you kidding me? Do you know how many mistakes I make? How many struggles we have?"

With mathematicians, we don't have any illusions…we're humbled to the point that, as smart as I think I am, I really don't know that much. Mathematics is a huge challenge, but at least I'm smart enough to know that I'm not supposed to get it all immediately. It's about the struggle and about being persistent-- the fun part of mathematics is the challenge and trying to get through that difficulty.

People not liking or not enjoying mathematics, I think it comes down to their confidence level about it. Once their confidence level is boosted and they see that they can succeed-- even with the smallest arithmetic operations-- they tend to like it.

I didn't like skiing for a long time, because it took me a very, very long time to feel like I was confident enough to really enjoy it and look forward to it. It took years of forcing myself to go out and do it. There were small moments when I enjoyed it and the rest of the time was just struggle. I felt like if I could just keep struggling, those windows of enjoyment will get bigger and bigger. I think it's the same with math. People just don't give it the chance.

I like teaching those students [who don't like math] because I like seeing their eyes light up at some point. I like the extra challenge...of changing someone's attitude. For me, teaching is not all about the subject, teaching for me is much more about helping people transcend their own negative thinking."

Joel Duffin: President of Models for Learning, Inc.

Growing up, Joel Duffin's father, an electrical engineer, encouraged and challenged Joel in the subject of mathematics, Joel always enjoyed math. At age 12, he decided that he wanted to be a physicist. As a 16-year-old enrolled at the University of Utah, Joel realized that the physics degree required quite a bit of math and decided to get a double major, saying that "it was good to get the math reinforced from both physics and math classes." After two years of college, Joel went on a two-year mission for his church. This experience taught him, among other things, that he "really loved interacting with people," which sparked his interest in teaching and an education-based career. Although he had the impression that physicists don't have the opportunity for much interpersonal interaction, Joel also concluded that it would be difficult to support his family as a high school teacher, thus he continued his studies in physics and mathematics.

"I always felt I learned more mathematics in my physics classes than in my math classes."

After graduation, Joel worked at Folio, a software company which later became known as NextPage. His job involved testing, technical documentation, and training on how to use a full-text search engine software.

After a few years there, Joel decided to go to graduate school in Instructional Technology at Utah State University. There, he worked on a project in instructional design theory with a professor who had developed the Model Centered Instruction theory. Joel also explored intelligent tutoring systems. He eventually got involved with some math professors and built the National Library of Virtual Manipulatives (NLVM), an NSF-funded resource from which math teachers can draw to enrich their classroom. As part of this project, Joel spent time working with math teachers in high schools, conducting research with students, and showing the teachers how to use the NLVM materials. This became the basis for his dissertation, and "8 years and 6 children later" he graduated with a Master's degree and a PhD.

"If you're young, unmarried, and want to do academia, go through it quickly."

After being "taught at" for 12 years, spending the two years of his church mission teaching, studying learning theory in graduate school, and working with and observing many teachers in the process of his PhD project, Joel says he has developed a solid perspective on the teaching process. Cautioning that "teaching is hard," he notes that new teachers spend their first few years "just trying to survive," then finally developing a routine. He says that "good teachers have a passion for the subject and convey that to their students. Good teachers are always learning. Some teachers get locked into their ways, stop learning and trying new things, and stop connecting with their students."

"[To find your interests], talk to as many people who have experience who are willing to talk to you. Find people you respect to work and learn with. Take your best guess, try it, and see what happens. Keep a journal and be reflective about what you are doing."

Joel continued to pursue his interest in education after earning his PhD. He had worked full-time during most of his graduate work and, after graduating, remained employed at jobs connecting him to people and projects he had encountered at Utah State University. Now, he is the president of a company that develops educational software programs. Joel says that his math degree has "always impressed employers," noting that "math gives you a background with lots of options. Math is the language of science and engineering--many scientists and engineers respect mathematicians, and companies see people who get math

degrees as having good potential. An undergraduate degree gives you the background to get you started, but you learn the ropes of industry or academia on the job, so companies hire new graduates for their potential."

As far as finding a career path goes, Joel believes that "universities could do a lot better job of helping young folks figure out where they are going." He advises students of any major to find the things that interest them, pursue those things, and then surround themselves with people who share those passions. As he says, "survey what really interests you, and then try to do something with it."

Chapter 3: Computers

As we saw in Joel's story, computers play a huge role in any field these days. In fact, some math graduates have had successful careers in the computer industry itself. The first interview is with Ed Casmer, who integrates both teaching and software into his job. Next, we hear from Lisa Casmer, who uses her people skills to work with both clients and computer scientists. The following interview is with Pedro Coronel, who started his career path as an actuary and now applies programming to problems in business.

Ed Casmer: Software Technical Sales

Ed Casmer started his undergraduate career at North Carolina State University as an engineering major, but soon got the impression that engineering was boring. After a bit of time tutoring his peers in algebra and calculus, he decided to become a math major. As Ed says, "I figured I love math, so I'll do math- with no notion of what it would lead to."

The descriptions of math classes fascinated him. He found his mathematical modeling class, where he modeled flows and systems, most interesting because it was related to the real world. As he says, "Instead of being given a theorem or formula and being told to go do something with it or plug numbers into it, we came up with our own formulas. In the rest of my classes, I tried to find something similar as well." Ed also enjoyed the extracurricular aspects of college, as he played sports, was a Resident Advisor, was a teaching assistant, and "had fun."

"I was never a 'real' math person. I'm a person who loves math. There are real math people who sit there with no notes and no notebooks and argue with the professors because they already knew the stuff. That's not who I was. I just enjoyed using math."

During his senior year of college, Ed did a National Student Exchange to the University of Utah. Interviews with several companies he met at the university's career fair led to his first job. Ed says he wasn't picky about his first job, noting that "when you graduate, you're so nervous about finding someone who thinks you're valuable enough to pay for you." The company that hired Ed boasted as a team work environment with great benefits. This first job was with one of the "Big 5" consulting firms, where people from every major are thrown into the same task for two years before moving on to more specialized work. Their hiring standards required a GPA above a 3.0, but the major didn't matter, as long as they got the impression that the potential employee had a good handle on reasoning. Ed describes a workplace of shared cubicles, lots of 20-somethings, and crazy hours, but he felt prepared for the job and really enjoyed it, saying, "Consulting appeals to an analytical mind, and that's what math produces. At the end of [your degree], you're a thinker-- you can analyze a situation and you can respond to it. That's what I got out of math more than anything else."

"Programming and math aren't that far off from each other. A math problem is just like stepping through lines of code."

After three weeks of training at a local office and three weeks at one of the company's central "universities," Ed was thrown into a programming assignment. He worked with a team to write a rating system and billing system for a satellite phone company. Although Ed hadn't enjoyed programming in college, he says that "when they were actually paying me to do logical

steps and recursive loops, I liked it." Ed also recognizes that all of the hard work he put into his first job paid off. After being innovative and working "crazy hard" at his first two jobs, getting the next jobs were dependent on knowing a network of people who knew his work ethic and were willing to offer him a position with a much easier hiring process.

As usual in the software industry, Ed soon moved to a different company. A coworker told him about a job teaching a programming language with a startup out in Silicon Valley. He took the job during the dot-com boom, where "everyone was jumping around jobs and getting pay increases." Although he enjoyed the teaching aspect and the substantial pay increase, Ed says that the extensive travel required for the job was too much, and he moved back to Utah to join another startup.

"I think when you graduate with math, there's no direct line to what you should or could be doing. It's a generalist major that enables you to go in a lot of directions without confining you to one real track. "

Although Ed has worked in the software industry since graduation, he has had seven jobs in that time span. After the Utah startup went under, he found a job at another startup company. He then went to work at a large outsourcing company with a software division, using pre-built processes to tell customers how much money they could save by using his company's services. Soon afterwards, Ed was out to dinner with one of the "stellar people" in his professional network, who offered him a job. Ed jumped at the opportunity, saying, "he alone was enough to make me consider [the job offer], and he's been my boss for 3 years."

Ed's current job is what he calls "sales from a technical aspect." Instead of being involved in programming and software development, Ed is marketing the software. The opportunity to "convey a lot of information in simplified form" is part of what drew Ed to the job. The work is quite flexible, an aspect which also really appeals to him. When he's working from home, he sets his own schedule, getting on his computer to do presentations and demos, make technical videos, and install software. When he's traveling, about 100 days a year, he attends software conferences and gives presentations to potential users. Ed notes that his job involves a lot of presenting in front of large groups of people, a skill which he picked up from his college work as a teaching assistant. Through this experience, Ed had learned to overprepare, gain a solid understanding of the subject, and then tell a story to 'blow the audience away'. This, he asserts, is the mark of a great presenter.

"I use math in everyday life. Someone posted on Facebook that 'Men are like a deck of cards…Sometimes you pull a king but most of the time you pull a jack.' [Because of my math training], I know that's not actually correct."

If he wasn't working in software, Ed would love to be teaching. He took a few math education classes in college, but didn't find the courses interesting enough to pursue, even though he loved teaching at a local high school. As he puts it, "the pay's not good enough, but I'd like to retire and then go teach-- I would get the most joy out of that." For now, though, Ed is very happy in his current job, working with people who push him to perform in a job that involves both the math that he loves and the interpersonal interaction that he enjoys.

Lisa Casmer: Former Software Manager

Lisa Casmer enrolled at North Carolina State University with "almost no plans" in mind. She knew she liked math, so she started taking math classes, as well as business, computer science, chemistry, and biology courses. Lisa "moved towards graduation as a completion of college," eventually deciding to declare as a math major because she had more credits completed in math than in any other department. But when it came to figuring out what she wanted to do with that degree, Lisa felt a bit lost, saying that she "had no career counseling at all as an undergrad. There was no counselor and no workshops to tell me what my options were as a math major."

So as Lisa approached graduation, she began to look for a job. She didn't "want to be crazy" like her pre-med friends, she didn't see the appeal of a career in education, and although she went to a "big actuarial school," Lisa also knew she didn't want to work for insurance companies. Equipped with at least the knowledge of what she didn't enjoy, Lisa took a temporary summer position at a computer repair company in North Carolina. Lisa had a solid computer science background coming out of college, and this job, which involved computer hardware and "no math," cemented her desire to work with computers. Following this temporary position, Lisa moved to Utah, where most of her family lived, to start looking for a job.

> *"I wasn't a hardcore math person- I did okay in my classes, but I wasn't crazy about it. I took chemistry because I enjoyed it. I just wanted a degree in something I enjoyed."*

While interviewing for various jobs, Lisa knew she wanted to avoid "technical support" positions and was looking for more technical work that allowed her to do some management. A job opportunity to do entry-level programming came up, and Lisa was excited to try her hand in the software industry. She enjoyed basic programming because it provided her with "instant gratification." At first, the job required programming with the company's own language, which Lisa says involved "just logic skills." For general logic skills, she says her math degree was very helpful, but as she moved up in the company, the computer science classes she took in college began to pay off.

Lisa enjoyed "transitioning through a lot of positions" in the company, which ultimately took her to managing the software product. She says, "As I moved more towards managing people, I got farther away from the science of things. I had to know what was logical and would make sense to an end user, [as well as] tell my programmers what I wanted. Without the computer science background, I don't know if I would have fully understood what it takes to create a software product." As a manager, Lisa noticed that people who came into the entry-level programming job without a math or computer science background tended to struggle with the logic of programming. She administered a basic logic test to prospective candidates, which she says that almost all science majors were able to pass because "the schooling taught them critical thinking."

> *"I wonder if you go towards math because you're naturally logical or if you learn it through the process."*

Lisa also "realized that you can do almost anything if you have people skills," saying that being able to talk to clients as well as understand technical language has been a great benefit to her and others who do similar work. She notes that "when employers saw that I had a math degree, they cared about that, but nobody asked me what my GPA was, and they definitely never asked about research." As a hiring manager herself, she "cared more about [potential employees]

being able to relate to another human being" than their grades. Although she never took management classes in college, Lisa picked up some effective team leadership techniques from books and trainings. She made a conscious decision to pursue people-oriented work, as she enjoyed interacting with people and "had the confidence…and intellectual background" to relay technical information to "a human being who has no knowledge of it."

After nine years with that company, Lisa's job and commute were inducing a lot of stress, so she decided to leave work and pursue other aspects of her life. Of not being employed, she says, "I miss [work] sometimes, but it's nice not to be tied to it," also noting that "it's not hard to fill your day when you're motivated to do things." For five years, Lisa was the president a nonprofit group called Women Making a Difference, which was focused on assisting local women in need. She has also had real estate investments and is "constantly educating" herself about nutrition and fitness. If she were to pursue more education at this point in her life, Lisa says that she would likely do graduate work in nutrition, as her interests have deviated from mathematics. Of her current use of math, Lisa says she uses fractions and basic math in cooking and exercise, and uses logic "all the time," but doesn't spend a lot of time doing "actual computations" and doesn't necessarily remember everything she learned in classes, but has a basic understanding of the subject and knows how to "find a reputable source" to work out the details.

"Everyone always wonders- what do you do with a math degree? Well, I don't know. [I can tell you] what I did. [I can tell you] what my friends did."

Lisa enjoys challenging herself and partaking in the learning process. If she had the chance to go back to her original college career, she might have gone in knowing what she wanted to study, taken more computer science classes, or spent more time researching career options. That being said, however, Lisa acknowledges that everything worked out anyway, saying that she ended up with a job she loved. Her advice to students looking for jobs right now is not to rule out any opportunities, saying that "there are so many jobs that don't sound like what you're looking for, but then you get into an interview and talk about it more and it's much different from what you thought. Expand beyond what you think [your dream job] might be labeled. A lot of entry-level [positions] don't sound appealing, but later you can develop other aspects of your career."

Pedro Coronel: Mathematical Consultant

Pedro Coronel started college planning to major in economics. But, after taking an honors calculus class, he became fascinated with mathematics and, although he was unsure what to do with it, knew that he wanted to continue his studies in math. At first, Pedro thought he might want to go to graduate school, but after some consideration decided that a doctorate degree wasn't right for him and began to pursue an actuarial career. He says that he "did dither a lot" in college and "things didn't really take a solid shape until [his] last year and a half," but that he thinks that it's "good to be open to lots of things." In the end, Pedro graduated with a bachelor's in math with a statistics emphasis and a business minor. He also took two actuarial exams during his undergrad--exams which prepared him for his first job out of college. Pedro had first considered life as an actuary because he wanted a well-paying job without a graduate school requirement. But later, as he says, "I became really taken with it. It's very, very interesting stuff." Pedro was fortunate to work for a company that was flexible in its task assignments within the 9-to-5 structure. His initial work there was essentially just analysis, a daily routine with which many of his coworkers were very comfortable. But Pedro was really more interested in the business and strategy aspects of the company, and he began to add more variety to his schedule: meetings with product managers, implementation planning with IT, and consultations with the legal department. As Pedro says, "That's when I realized that I wasn't sure I wanted to be a full-fledged actuary because it kind of pigeonholes you into being an analytical support kind of person. I find the business stuff a lot more interesting, and having a math background while dedicating yourself to a business career is a really good mix."

The actuarial exams:

1: "You can get by with your 3000-level stats and 5000-level probability and a few weeks of practice. This one got me into an internship."

2:"Not terrible. You can get this one with some advanced finance classes and 2-3 weeks of practice. This one got me an offer for a full-time job."

3&4: "Harder than anything I ever did in school. The amount of material is just insane. I passed these tests with the support of my work."

A math major and a business career:
"The way I see it, a math degree teaches you how to think- how to think in a way that's creative but structured and rigorous at the same time. That's something that few other majors can say. And in business, all you do is see brand new, original problems every day: how to fix competitiveness issues given such and such marketing conditions, how to get around legal requirements without breaking the law, how to organize things so they run more efficiently...Most people who are in charge of these decisions are people with liberal arts backgrounds. [Although these backgrounds] are very valuable, having a math background gives you a certain edge. I think it makes it easier for you to think outside the box without getting caught up in useless flights of imagination."

After two years as an actuary, Pedro had saved up enough money to return to his home country of Chile. Although he had no job there, he was confident that the quantitative skills he had developed would help him find one- and he was right. Pedro began working full-time for LAN airlines, helping them use recent statistical software to make calculations based on "efficiency, demand, and profit" and inputs flight demand data to optimize routes. He says that this job was "very mathematical and statistical, even more so than [his work] as an actuary." He spent a lot of time on conference

calls with colleagues in the United States and their support team in Bangalore, trying to get the new software up and running. Although this was an analytical role, Pedro also worked in the business field, with an on-the-side job helping a consulting firm develop a quantitative model for the management of operational risks for banks-- a model which he also helped sell. This work involves "using a lot of…math skills but also doing a lot of customer presentations and demos." The direct math skills he learned in class have proven very useful for Pedro's analytical work in risk analysis, but the softer presentation, business, and interpersonal skills he has picked up have been very useful for preparing presentations and explaining the risk analysis model to software developers.

"All knowledge is fascinating."

Currently, Pedro works as a consultant full-time in his own company. His company is focused on data mining and analytics, as well as the development of text-mining software for the legal industry. In his off time, Pedro is working to start a yoga center. It keeps him busy, and he says that his math skills were actually useful in a real-life situation: choosing the best startup loan. As Pedro says, "You impress people, especially at the bank, if you can come up with an amortization table in less than 10 minutes in Excel. They treat you better after that." Although he admits that he doesn't remember most of what he learned in class, Pedro often refers to his old textbooks, saying "Why trust your memory if you can have it in a book? It's better to free up brain resources for more creative thinking."

Creative thinking is a thread that runs deep in Pedro's career and life. He truly believes that his job success is only partially related to his math skills, and that the remainder of his successes hinge on a well-rounded personality, which allows "your brain to make more connections and be more creative." In order to hone his creativity, Pedro reads novels and poetry, plays several musical instruments, and studies economics and sociology, among other subjects. He believes that college gives people the chance to expand the breadth of their knowledge, and says that, if he had the chance to go back to college, he would take more classes unrelated to his major, like theater, philosophy, music, and dance. Pedro also might have joined some speaking clubs or taken more writing classes, as he notes that "writing and speaking skills are more than essential" in today's job market. Most importantly, Pedro stresses that what someone chooses to study in college is in no way a barrier to their future opportunities. After all, his own life is a prime example of that philosophy.

"Do what you feel like, and what makes you happy. Don't just do something because that's what you 'should' do given your major. I think the most important thing in life is to always be where you want to be. If you studied math but you decide you want to be a musician, go for it. The math and your studies will never go to waste, even if you're not using them."

Chapter 4: Applications of Mathematics

So far, we've seen math degrees used in the fields of law, education, business, and computation. Some find, however, that mathematics can have applications in the work being done in subjects like finance, engineering, and public health.

First, we speak with Debra Radway, who started her career as a consultant and now works as a financial planner. Next, we see how Mark Simons applies his degree to a completely different field-- systems engineering. In yet another application of mathematics, Jeff Duncan uses his degree, especially his statistics background, to make a difference in the field of public health.

Debra Radway: Financial Planner

Debra Radway had several reasons to get a math degree: she already had some college credit earned in high school, the major would allow her to graduate with a liberal arts degree in less than four years, it was challenging, and she was good at math. Debra augmented her mathematical curriculum with a business minor, an operational resources class through the engineering department, as well as honors classes in psychology and humanities.

Getting ready to leave college and enter a difficult economy, Debra interviewed for every job with on-campus postings that was advertised as being open to math majors. She now realizes that math majors with interpersonal skills have nearly limitless career options. Math majors, as Debra says, "have a lot of the skills that it takes to be successful in any job: analytical thinking, attention to detail, persistence, and the ability to think creatively about solving problems. If you combine these with interpersonal skills, a person with a math degree is invaluable in the workplace."

"Find something that requires attention to detail and analytical thinking as part of the job. There are a host of jobs that can use the skills you learn as a math major, so I wouldn't limit myself to 'math jobs.' The key is to get your foot in the door and start working and learn more about the kinds of jobs that are out there and what you enjoy and are good at."

Armed with these skills and the ability to market them to potential employers, Debra was offered a job with Accenture, a global consulting and technology corporation. The company's standards were rigorous (they even had a GPA cutoff for interviews), but Debra's quantitative skills and her ability to support herself through college distinguished her from other candidates. Debra was pleased with the end result, finding the opportunity for upward mobility within the company, the variety of the work, and the high earning potential to be a perfect fit for her expectations.

The work at Accenture closely followed Debra's academic preparation; the math degree assisted in her analytical and computer work and the business classes allowed her to understand the basics of business. Debra only wishes that she had more writing and presentation experience before entering the workforce.

Choosing a large company with multiple locations was very useful for Debra, who has relocated often to follow her husband's career. Eventually, her family moved to Chicago, and she left Accenture after 10 years of service. Debra stayed home with her children and worked on a self-study Certified Financial Planning designation while she managed her and another family's finances. Five years later, she began as a full-time MBA student at the University of Chicago's Booth School of Business, a top-ten rated school. After graduating with a degree in Finance and Economics, Debra continued her private financial management work from home. Only when her kids were in middle school did Debra look for full-time work in the field of financial advisement, at which point she joined Harris Private Bank as a Wealth Advisor/Financial Planner.

"I don't remember a lot of the math I learned [in school], but I am able to get it back quickly by reading the descriptions in books…That being said, I have raised two children who have better math abilities than I do."

Debra's work at Harris Bank has allowed her to work for a large variety of clients, evaluating their finances and "identifying issues that will keep them from reaching their financial goals." Debra enjoys her job in what she calls "financial design," and notes that she loves "meeting successful and interesting people and building relationships with them and their families."

Debra attributes her success in financial management to the skills she picked up at Accenture and the fact that she enjoys what she does for a living. She stresses the importance of pursuing work that is enjoyable, saying that "even people my age don't know exactly what they would be best at." Although she has been incredibly successful in her chosen careers, Debra notes that her interests are broad and she would be interested in pursuing a PhD in a science research career or in math education, since she has enjoyed her recent experiences as a university-level teacher. Considering what she would do if she had to start all over again, Debra notes that she has been "well-suited for consulting and financial planning" and would "do exactly what I am doing" today. After experiencing various opportunities in different fields, Debra found a career that suits both her interests and her abilities.

"When it comes down to it, I have chosen careers that attracted me and were intellectually challenging."

Mark Simons: Lead Communications Engineer

Mark Simons started college as a physics major. He "enjoyed the pure sciences," and decided to do a dual physics-math major in his sophomore year. But during his senior year, Mark was burnt out from school and the "economy was beginning to sour." He took a computer science class, enjoyed it, and dropped the physics degree, eventually finishing his undergraduate career in mathematics and taking more computer science classes on the way. As a math major, Mark "struggled with finding a specialty," saying that "math is good at general concepts, logic, and sound reasoning skills," making it a generalist major as opposed to training that gives "specific skills."

"When you succeed, you can make the front page of the newspaper. But most of the time you struggle in [anonymity]."

As a senior preparing to graduate and enter a wide job market, Mark had to go with his instincts on what kind of work he was looking for. He had "always liked space," which got him started in his first job as a computer engineer at NASA. Mark was stationed at Goddard Space Flight Center, working on "ground data processing projects in support of a spacecraft mission," essentially doing computer programming and "not much math". Mark's high math GPA, demonstrated skill in programming, and fulfillment of all of the listed job qualifications made him a strong candidate for the job. He stresses the importance of persistence in a job search, as he "got a few [interviews] just by writing letters and sending resumes to everyone," saying that "[the job search is] a dice roll"- the more times you roll, the more chances you have.

"The function of systems engineering is to guide the engineering of complex systems."-Kossiakoff and Sweet

Mark enjoyed his job at NASA, especially when he was able to work on a small piece of a big project that makes the news, like his efforts on a Hubble Telescope servicing mission. While working for NASA, he went back to school for a master's degree. He began as a computer science candidate, but eventually switched to operations research, which he found more enjoyable. When the bureaucracy of government work started to bother Mark, he left NASA.

Mark's next job involved doing modeling and simulation with discrete events, a subject which was similar to some of his math coursework. Although he has been working for the same company for years now, Mark says that "the work has changed around [him]." He "got pulled" into system design, where his college work and NASA background helped him pick up new information in the fields of weather processing and service oriented architectures.

"As a student, I thought I was a real people person, but in the office you find yourself working with people from different backgrounds and different agendas. [It's also very important if you're a project manager, another field I would recommend for math majors]. Working with people is key. It's a life skill, a maturing process. School can help by creating interesting team projects that involve a lot of student interaction."

Nowadays, Mark works as a systems engineer, a job he says is much more "big picture" than his initial career path. His current work involves supporting the FAA in air traffic control, and he is still able to be a part of big news, like in his recent involvement in an FAA acquisition which "made the business page when it was awarded." Mark's typical day at the office is busy-- he writes or works on system architecture in the morning until an onslaught of meetings takes up the middle of the day. After meetings, which are either internal to the organization or around the city with customers, "things settle down" and he goes back to preparing papers and

presentations, among other things. Although he acknowledges that he essentially has a desk job, Mark emphasizes that he interacts with a lot of people, saying that he often has to "run the show to get people organized and doing the right thing."

Mark enjoys systems engineering because it is "intellectually stimulating" and can be learned on the job. He "would recommend systems engineering as a career for math graduates," but cautions that "there are never any closed form solutions," which may not appeal to all graduates, especially those who "think that life needs to be as elegant as our proofs." On the other hand, Mark thinks that his math background has prepared him well for dissecting complex systems, noting that "with math you learn how to think abstractly. It's a rare skill."

Jeff Duncan: Informatics Project Manager at Utah Department of Health

After high school, Jeff Duncan spent six years as an active member in the Navy. By the time he got to the University of Utah under the ROTC program, he wanted to finish college quickly, so he eschewed the idea of an engineering degree. Instead, he chose to study math because he had a strong interest in computers and wanted to work on the computational aspect of applied mathematics. With a deep interest in applied math, Jeff chose electives like numerical methods, statistics, and mathematical modeling instead of pure math classes like topology.

"My career path is not typical. You have no idea of where you will be or which direction your career will take you, so enjoy the ride."

While he was in college, Jeff did a clerical work-study job for the VA Hospital, as well as some work in a Sherwin Williams paint store. At the time when Jeff was getting ready to graduate, he searched for a job in the Salt Lake City area, but work was scarce, so he applied to graduate school in the biomedical informatics program at the University of Utah. This was a diverse program in the school of medicine, in which Jeff was able to take the "mathematical modeling of physiological systems" track. Through this track, he was able to use his interests in numerical analysis and computers to develop models for biomedical instruments.

After graduating with his Master's degree, Jeff served in the National Guard for several years. After completing his military service, he took a job as a study coordinator at the University Hospital in the gastroenterology division, where he "worked on clinical trials, built databases, and did a lot of statistical analysis." After two years there, he was hired as a statistician in the Utah Health Department's Office of Vital Records. After a few years of doing data analysis and statistics for that office, Jeff became the Director of Vital Records, where his main responsibility included developing new computer systems for the department. Currently, Jeff is an Informatics Project Manager in the UHD, working on public health informatics problems. He is also back at the University of Utah, working on a PhD in biomedical informatics.

"In a lot of respects, I got lucky and the right doors opened when I needed them to open. I didn't really know where a degree in math would lead."

Much of Jeff's day is spent either in front of a computer or in meetings. Jeff's favorite part of his job is "conceiving new IT projects and making them happen," especially "computer systems that really have an impact on people's lives." One example that he gives is an interface that his group developed that connects the birth certificate system to a database that tracks the hearing tests given to newborns. This interface is used to identify and notify parents whose children had not been screened for hearing problems.

Jeff's desire to help others has extended past his paid work experience. He volunteers through the VITA program, doing tax returns for low-income families, of which he says "all of

the people who are afraid of doing math are also afraid of tax returns." Jeff has also had other mathematical experiences interspersed with his Department of Health work. He was an adjunct professor of algebra and trigonometry at Weber State University for three years, and he has been teaching statistics for the University of Phoenix for seven years. His Master's degree made him a strong candidate to teach, but he mentions that you really only need a Bachelor's degree to teach many of the beginning college math classes.

"I was always interested in computers. See which classes interest you the most and pursue those."

Jeff notes that he still uses some of the math he learned in school for his job. His work involves reading complex journal articles, reviewing research protocols, and looking at analytical methods, so his statistics courses have come in handy in those tasks as well as for "being able to read a journal article and not be afraid of all those Greek letters." He also observes that a fear of mathematics is something that holds back a lot of students from achieving in college, saying that "you can't even begin to comprehend statistics if you don't have a foundation in algebra."

"I've been influenced at every stage by peers, professors, and colleagues. Also, [my] years in the Utah National Guard put me into association with a lot of people in other fields."

But for those who aren't afraid of math, Jeff recommends it as a major. "It's a challenging and very flexible degree. There are actuarial careers, computer programming, software development-- all those fields require strong math skills. It's a versatile degree for someone who wants to go to college and has a good math aptitude but maybe doesn't have a clear career in mind." Jeff says he "never anticipated a career in public health," but he is happy about where his experiences have led him.

Chapter 5: Healthcare

Jeff approaches public health from a statistical standpoint. Our next story is from Toby Enniss, a surgeon who appreciates statistics from a more clinical point of view. Next, we get a chance to talk to Ellen, a current medical student.

Toby Enniss: Acute Care Surgeon

Toby Enniss knew throughout college that he wanted to go into medicine. He met regularly with his pre-med advisor in order to plan out which classes to take and which extracurricular activities to participate in to enhance his medical school application. Toby knew that he needed something to distinguish himself from "the rest of the pre-med crowd." Math was his favorite subject in high school, and he was awarded the University of Utah's Math Departmental Scholarship, so "choosing mathematics as [a] major [was] an easy choice." As he says, "I knew that if medicine did not work out, having a math background would offer me many alternatives," as well.

"Math always came easy for me."

Throughout his undergraduate career, Toby became interested in applied mathematics, especially statistics. He enjoyed his mathematical models in biology class, which gave "an excellent insight into applied mathematics," and was introduced to the importance of statistics as a research assistant to a cancer epidemiologist in the Department of Oncological Sciences. This job also gave him a good perspective on "the research side of the medical field." Toby also minored in chemistry, worked in the financial aid department, and passed the Math Subject Test GRE with a score sufficient for graduation from the math department.

"I now recognize the importance of understanding statistics in interpreting medical research literature and in formulating clinical studies."

After being accepted to medical school, Toby wanted to "simultaneously pursue a Master's in Statistics, but was not allowed to do so by the medical school administration." He wishes that he had recognized his interest in statistics earlier in his undergraduate career, as he may have been able to include a Master's degree in his career path. That not being possible, however, Toby forged on with his original plan of obtaining an M.D. By the time his four years of medical school were over, he chose to pursue general surgery, and applied to 15 residency programs.

"It has been interesting how life comes full circle. Opportunities present themselves when and where I have least expected them."

Toby was matched with the Wake Forest University Hospital in North Carolina, where he completed a 5-year general surgery training program as well as a 2-year acute care surgery fellowship. The acute care fellowship included training in trauma surgery, something that has always interested Toby, as well as preparation in surgical critical care and emergency general surgery. Nearly finished with his fellowship training, Toby interviewed for faculty positions at medical schools and landed a job as an Assistant Clinical Professor of General Surgery at the University of Utah Hospital. After 16 years of post-high-school education, Dr. Enniss still wants to be a part of the education process.

Ellen Webb: Medical Student

Ellen Webb has always wanted to be a physician, saying that "much of my family is in medicine, and it's something that always really interested me." She entered college knowing that she wanted to be a doctor, but decided to pursue mathematics instead of following the traditional biology-based path to medical school. Ellen needed something to set her apart from other prospective medical students, and math was something she was always good at and knew she could excel in. Ellen also worked as a grader, served in a hospital as an EMT, worked as a patient educator for the surgery department, obtained a minor in Spanish, volunteered for Planned Parenthood, and started and ran an honor society on campus.

Additionally, Ellen spent some time doing undergraduate research. The professor for her lower-level statistics class was impressed with her academic performance and invited her to work with him on an applied math project. Ellen says she "worked with nearest neighbor trees in conjunction with a larger project using computer programs to help model earthquakes, drainage networks, and other such natural phenomena" and notes that "I was lucky enough to have the subject choose me...I was more into applied math than the more abstract stuff."

"I was pretty set on what I wanted to do. I personally would never have considered a math career above medicine."

Now that she's in medical school, Ellen wishes she had taken more time to travel and enjoy herself during her undergraduate career, saying that medical school is "5000 times harder" than undergrad. Ellen says she studied more for one medical school exam than she "had done in [her] whole life combined." It is very common that, for the week preceding an exam, she and other medical students will study for 15 or more hours a day. Aside from studying, Ellen "manages to enjoy life" and is on the board for a student-run clinic where uninsured patients are treated on Saturday mornings.

Ellen doesn't use her math degree much in medical school, but she affirms that there are certainly applications in biochemistry, pharmokinetics, and the biostatistics portion of the national board exam. She notes that, although getting a biochemistry degree might have made the first year of medical school easier, "having a diverse background is a plus in any field and [that] studying something [she enjoyed] was worth the extra effort."

First year medical school schedule at University of Nevada, Reno:

8am-12pm	Class
12pm-1pm	Lunch
1pm-4pm	Afternoon class (3/wk)
Rest of day	Study

Studying mathematics and pursuing a diverse set of interests was also worth the effort for medical school admissions. Ellen offers her advice to other students pursuing an M.D.: "There are thousands of biology and biochemistry kids going for a few hundred spots each year. Anything that helps you stick out in the crowd is beneficial. Almost everyone has that near 4.0 with a good MCAT- you need something different and something more to really be noticed by admissions committees."

Chapter 6: Research

Not everyone interested in public health works in a clinic. Amber Smith, the subject of our first story, studies the spread of disease using mathematical models. Amber's area of research is formally classified as mathematical biology, the application of mathematics to biological problems. Alla Borisyk, a professor of math biology, uses math to study the brain. Math biology is by no means the only research area, however, and the next interview is with Nick Korevaar, a professor in pure mathematics.

The last, and certainly not least, story is from Kelly MacArthur, who has had a myriad of jobs. She is now a college instructor and PhD student, but has traversed a whole host of opportunities in order to get to where she is today. In the midst of these stories, we also have the opportunity to speak with three professors about how they balance career and family.

Amber Smith: Postdoctoral Researcher

Amber Smith chose mathematics as an undergraduate major because it was a subject she excelled in and found to be thoroughly enjoyable. Although Amber wasn't sure exactly she would end up doing with her degree, she knew she "would find something interesting" at the Colorado School of Mines, a science-oriented college. During her undergraduate course of study, Amber took a few mathematical modeling classes, one of which was specifically focused on math biology. This class was a defining point in Amber's career-- she realized that math biology was the field she wanted to spend her life working in.

"There are a lot of things (courses, concepts, etc) that seem useless at points during your undergraduate life, but many of those will make sense and be useful later on."

Amber also enjoyed her differential equations courses immensely and was interested in biology, especially that of infectious diseases and the human body. This combination of skills and interests was directly applicable to math biology, an approach that Amber found to be both "unique and incredibly useful."

A former ER doctor who taught Amber's math biology class also taught Anatomy and Physiology. This course was the first and only biology class taught at her engineering-centered school, and one of Amber's favorite courses during her undergraduate career. Amber also enjoyed non-science classes like Public Affairs for Engineers, which taught her how to give presentations and write papers-- useful skills for graduate school.

During her undergraduate years, Amber also participated in research-- a Research Experience for Undergraduates (REU) concerning numerics. Although the topic didn't excite Amber, the experience "introduced [her] to

Applying to Graduate School:
"Grades mattered more than the GRE, but the two things that matter the most are your letters of recommendation and your academic activities and experience… I think you need letters that can show (1) your research experience, (2) your classroom ability and academic potential, and (3) your character/personality.
If you're having a hard time finding someone [to write your letters], it's worth getting to know a particular professor. Sit down and talk with them about everything…course work, grad school, etc."

the world of research and taught [her] that there was more to mathematics than what was taught in the classroom." Retrospectively, Amber recognizes that more research projects and lab work would have given her a head start on graduate school.

Thinking about graduation, Amber interviewed for jobs with engineering companies, but noted that "they all wanted to turn [her] into a computer scientist." Knowing that what she really wanted to do was mathematical modeling, Amber applied to all the graduate schools in the west that had math biology programs. Upon visiting the University of Utah, Amber "just had a good feeling about it." She noticed that the math biology students were clearly a community and got along, and that there were several professors working on the types of projects she was interested in. Amber knew that Utah was right for her and enrolled as a PhD student at the University of Utah right after college.

"I was SO ready to graduate and have a finished project. Now I wish I was back in graduate school…I really enjoyed learning so many different things"

Amber started graduate school with the intent to study infectious diseases. Her first summer at the University of Utah was spent working with a medical doctor on an epidemiological bacteria project. Although Amber enjoyed that research, she was even more interested in papers she had read about infectious disease within a host. From that, she pinpointed her research focus: viruses and their interaction with bacteria.

"My thesis project morphed a couple times and, in a way, just sort of fell into my lap," says Amber. Although she continued to study viruses and bacteria, she explains, "The type of math and the biological questions would slightly change. I don't think the full extent of my thesis was known until it was actually done." With all these changes and unexpected issues along the way, Amber was ready to graduate and move on in her career. Since she wanted research, not teaching, to be the focus, Amber knew that she would have to apply for a postdoctoral position.

Since Amber had left bits of unfinished thesis projects on her way to graduation, she wanted to go to a place where she could finish the work that she had started. Los Alamos National Laboratory was an obvious choice-- two of her previous collaborators were already working there, and a more senior scientist (who is now her advisor) specifically asked her to apply.

Now, Amber is working on research in immunology and infectious diseases at Los Alamos National Laboratory. Although she is far beyond her undergraduate degree, she says that her undergraduate education built a solid foundation that she is continually adding to. This foundation includes all the basic mathematical concepts that Amber uses in her current research, as well as ideas about teaching techniques that she borrowed and adapted from professors she liked in college. Amber notes that the concepts and ideas she learned back in college "just started to make sense" during her last year as a graduate student, when, as she says, "I really understood what it meant and how to be a good mathematician and researcher...You know that you've learned something when you can look back at what you've done and think it sucks."

"There are so many things that you don't have time to learn in grad school but need to know to be a researcher and/or professor…There is a different focus as a postdoc. I am actually supposed to know something."

Amber's advice to someone considering a math major is "do it if that's what [you're] passionate about." She stresses that "having a job you love is key. There are so many careers one can have being a math major, not just teaching, and so many ways a mathematics degree can be used. Many of these may require an advanced degree, but it's well worth it."

Alla Borisyuk: Professor of Mathematics

Alla Borisyuk "became a math major by accident." Alla was attracted to the field of psychology, but she grew up surrounded by scientists who looked down upon the humanities. She began to consider other subjects she knew well enough to pass the university entrance exams. Soon afterwards, Alla enrolled as an undergraduate studying mathematics at Moscow State University.

The university's five-year undergraduate math program was strict, with little choice in courses. Studies focused on classical mathematics courses like topology, algebra, and differential geometry. In this environment, Alla learned a lot about proving theorems. Like every other second-year student, Alla had to choose a project on which to write her "diploma thesis," much like an honors thesis or senior project. She wanted to do something with applied math, but again felt societal pressure that "good students were in pure math," so she instead chose a pure math project in probability theory.

"The only way to do math is if you really like it, otherwise you're going to be miserable."

Working on this project made Alla realize that pure math didn't excite her, and convinced her that she didn't want to go into pure mathematics as a career. This experience helped Alla realize that she needed to switch her focus to something she actually enjoyed, something more along the lines of applied math.

During this period of transition, Alla still had a lingering interest in psychology and had heard of a field called computational neuroscience, which related psychology and the brain with math. On a professor's suggestion, Alla applied for a summer conference in New Hampshire. Being "young and bold," Alla asked the "big shot" professors at the conference for suggestions about graduate schools in computational neuroscience. She took their advice and received several graduate school offers, eventually choosing to pursue graduate studies in applied mathematics at New York University. Alla explains: "I didn't know I was going to one of the best graduate schools in the country. I happened to have really good guidance. I was really lucky."

"I'm not lying when I tell students that there are lots of careers they can pursue with a math degree. I think it teaches them to think well, to work well, to learn well- it's really good preparation."

Alla wasn't sure what to expect upon entering graduate school in a foreign country. As she says, "I figured if I hated it, I would go back [to Moscow]." Alla didn't hate graduate school. Actually, everything seemed to fall into place. Alla had entered a great department and had a very good advisor. She spent a lot of time in the lounge, talking and drinking coffee with professors and other students, forming relationships that would later shape her future career.

With regards to academic preparation, Alla's pure math background didn't adversely affect her success in applied mathematics. Quite the contrary-- her main asset was "a broad and quite good mathematical education." She attributes this to the way that "a mathematical education teaches you to think in a certain way [and] approach the world in a certain way." Retrospectively, Alla admits that she could have made a greater effort to learn more biology and neuroscience before graduate school, but she also asserts that her math degree provided a sufficient background for her graduate studies.

Near the end of graduate school, Alla considered her post-graduation options-- staying in academia, working for a company, or teaching in an elementary school. Alla had enjoyed her previous teaching experience at a summer school for high school students and was convinced

that she wanted to stay involved in teaching. After considering her options, Alla chose to follow an academic track because it would allow her to teach part-time and she "didn't feel the need to leave academia… [and] didn't feel the need to change."

Now confident in what she wanted to do, Alla began to look for postdoctoral positions. By this time, she was married and experiencing the "two-body problem," in which she and her husband were both looking for jobs and were not willing to live apart. Fortunately, they received two dual offers. Alla acknowledges that separately she and her husband "probably could have found places that were more suitable or more prestigious, but finding a job together was really a priority."

Alla went straight from graduate school to a postdoctoral position at Ohio State University in the Mathematical Biosciences Institute, where she conducted research, attended workshops, and participated in conferences for three years. She and her husband again began the job search process. This time, however, they had been told that many universities would try to find two positions if they knew that job candidates were applying together. Alla and her husband wrote in their cover letters that their spouse was also applying for a job in the same department. This time, they had three joint offers for university jobs and chose to work at the University of Utah.

"You have to enjoy math to be good at it. If you're doing well, it's really worth it. It really gives you a good foundation to build on, wherever you go."

Now at the University of Utah, Alla has found a career that follows her interests and has a good work-life balance. She does research in mathematical neuroscience, teaches in the classroom, and finds time to mentor students. Unlike academics with non-traditional careers, Alla went "up the academic ladder" in a focused path. Alla attributes much of her success in this journey to mentors, including her graduate school thesis advisor, her parents, and her parent's colleagues, and to indomitable luck.

Career, Family, and the Two-Body Problem

Nicholas Korevaar: Professor

"It's tough in a 2-career family. There's not enough time, even if you have a strong family structure, to be intense about research, teaching, and your family. People manage it but it takes great organization and a communicative relationship.

I had a "delta function change" when my marriage ended and we had two young kids. I jettisoned my research and focused on my teaching and my kids, which is totally compatible because they're basically the same thing. With tenure, I had the option to do that. I made a real effort to contribute to the department's mission, but for a period of years, I could stop doing research-- that was huge.

For a young couple when at least one is academic and they both have full-time careers, there are real problems. The job demands of this career were set back in the 50s and 60s when the social morays were different, so I think it's a problem universally in academics."

Alla Borisyuk: Professor

"In retrospect, [academia] was a really wise decision in terms of career and family. I think my job is perfect in allowing me to have a family because it's very flexible- if I need to run out in the middle of the day or if my child is sick and I need to stay home, most of the time I can do it. My husband is also in academia and equally flexible, so between the two of us, we usually find a way to do it. In that regard, it's an excellent job which allows us to not send our kids to school all day. It's still hard- it's not 100% under control at home or at work, but if you have two kids and a job it's hard in general.

The hard thing, though, is that you can't just take a couple of years off and go back to the same position-- "you can't get off the train and then get back on"…you can do it before grad school, but if it's much more than a couple of years then people don't look at your application the same way. For example, here we have conditions for postdocs that it can't be more than a certain number of years since they got their PhD, so academia has a very unforgiving standard track.

My husband and I were looking for postdocs and not willing to live apart. We had to consider sacrifices in each other's careers for that. We had two dual offers…and we probably could have found places that were more suitable or more prestigious, but finding a job together was really a priority for us.

When we looked for jobs again, we were very open about it. We wrote in our cover letters that our spouses were also applying for jobs in the same department. Again, we were lucky- it was a good year and we were from a good grad school and did well in our postdocs. We had three joint offers, so we had a choice- that isn't always the case.

I've seen a lot of couples with this "two-body problem" and it's easier if the second body is easily transportable. If they're both academics, it's harder. Fortunately, universities are open to the idea of families and there are more dual possibilities. Here, there is money specially allocated to hire both spouses. This is good for the department because it's more stable."

Kelly MacArthur: College Instructor

"Every once in a while, my daughter would come to class with me, and she was around the department, but I was a crazy woman trying to get homework done.

I tried every schedule possible. I put her to bed and then stayed up and did homework for a few hours or I'd fall asleep with her and then set my alarm for midnight or 1 in the morning so I could get up and do homework till four and then go back to sleep for a couple hours or get up at 4 and do homework until she woke up. It was crazy.

I got straight A's but I didn't have the luxury of meeting and doing homework … or eating lunch [with other students], so I missed out on some of the social aspects. "

Nicholas Korevaar: Professor of Mathematics

Nick Korevaar liked math, was good at it, and his father was a mathematician. By high school, all signs were pointing to a career as an academic mathematician. Nick knew that math was his strongest point and he knew how to get into the career. As he says, "I was on the math track and never got off."

Nick was drawn to the beauty of pure mathematics and to the competitiveness of the field. His competitive nature led him to participate in a competitive math team in high school and apply to top universities. He was accepted to and attended Harvard University, a school with a reputation that Nick believes was merited by its "great teachers and great education."

The mathematics curriculum at Harvard was fairly unidirectional, and Nick didn't stray much from his chosen subject. He took a lot of math and physics classes and tried some computer science. At the time, Nick resented the University's general education requirements and got out of them by studying language, but now he realizes that "you go to college before you're really an adult, so it's a great place to learn all kinds of things. I wasn't as outward-looking as, looking back on it, I might have wanted to be."

"I wish I had been more exploratory. I wish I had looked for summer jobs that required mathematical ability."

Nick's lack of exploration in courses was offset by his extracurricular endeavors. He ran cross-country, worked as a janitor, took a job as a grader for the math department, and lived in a co-op with 30 other people. He also took a summer job at the Foundation for Ocean Research, poring through historical tornado data for evidence to support the hypothesis of "an eccentric scientist" that an increase in automobile traffic leads to the directional vorticity of tornadoes.

Nick had a well-laid path to where he wanted to go- a pure math academic career. He wondered for a moment if he should be doing something in more applied mathematics, but he "applied only to really good schools and figured that if [he] didn't get in, [he] would do something else. " But Nick was accepted to several graduate programs in pure mathematics and chose to continue his education at Stanford. He spent the first couple of years in the program being "moderately ambivalent" and wondering if he really wanted to do pure math. Nick had friends who left the academic path for computer science, where "all kinds of cool things were happening," so he explored applied math in the computer science department. But getting into a new subject was difficult and Nick did like pure math quite a bit, so he stuck with it.

What matters most in a postdoc application?

- Evidence of research capabilities
- Papers you've written
- Letters of recommendation

As someone who liked "shapes and surfaces," Nick chose geometry as the topic of his PhD thesis. He didn't connect well with his first thesis advisor but eventually found an advisor who was eager to have a student and who he worked well with. However, despite its reputation at the time, Stanford did not live up to Nick's expectations. In his five years at the university, Nick felt as though he learned less math than in his undergraduate work, and he graduated without the math background he had expected.

Nick applied to several jobs and was offered a tenure-track professorship at the University of Kentucky, which he deferred to do a postdoc at the University of Wisconsin. After his postdoctoral work in Wisconsin and several years as an assistant professor in Kentucky, Nick was accepted into another postdoctoral position at the University of California in San Diego, a

job which he says “led [him] to do [his] best research.” The geometry group at UCSD was vibrant and active, with “visitors from around the world coming in all the time.” Surrounded by great mathematicians and mentors, Nick learned more math than he had during his PhD studies.

Drawn by the research possibilities, the location, and the mountains, Nick moved to Utah, where he now teaches and does pure math research at the University of Utah. His favorite part of the job is getting to know students, watching them figure out what they want to do, and seeing them succeed-- even if they don’t end up as mathematicians. Nick says, “The math major is a great major. It’s a gateway to all kinds of things. I write letters for undergraduate students: for law school, electrical engineering, biomedical engineering departments, math departments, Peace Corps, international relations, medical school…my students are doing great—they’re math majors, but they’re not necessarily doing math”.

When asked if math has been helpful in his life, Nick says, “my life has been helpful to math.” He explains, “As I’ve gone through life, I went from a person who was shy and didn’t do anything about it to someone who’s more outgoing and really appreciates human contact. Life-- and raising my kids-- has fed into my mathematics. I don’t know what comes first there. I’ve always been interested in teaching, and teaching is kind of like parenting, parenting is kind of like teaching. There has been an intertwining between my life and the kind of mathematician I’ve turned into. I don’t do much research anymore, but when I do, it’s collaborative because I love working with other people almost as much as figuring out the research.”

"Going to graduate school is easy if you've done well as an undergraduate. You don't have to explore other options if you're sure about what you want to do. On the other hand, looking back, it's interesting to wonder how my life would have evolved if I'd tried a stint in the Peace Corps or a job in the embryonic computer industry, after my undergraduate degree."

Nicholas Korevaar followed the career path of an academic mathematician because it “involved the least change in inertia” and because he truly enjoyed pure math, but he recognizes that this straight track is not for everyone. “Look around. Think about what you want to do with the rest of your life, and explore the possibilities. If you can think mathematically, you can combine that with verbal and writing skills… there are so many things you can do, but they have to be things you like to do and want to do.”

Kelly MacArthur: College Instructor and Undergraduate Advisor

By the age of five, Kelly MacArthur knew that she wanted to do math. Her family didn't quite understand what mathematicians really did, and her mother suggested that she look at engineering instead. Kelly distinctly remembers sitting in the hallway of her childhood house with the Encyclopedia Britannica, reading about engineering. She read and subsequently cried, knowing that math was what she loved; math was what she wanted to do, not engineering.

"I love my degree and I don't have any reason to change it."

Kelly soon set her sights on becoming a math professor. In her contestant biography in a Junior Miss Pageant during her senior year in high school, Kelly said that she wanted to be a professor of mathematics. As a first-generation college student with "no advice or mentor or help picking colleges," Kelly says that she "never thought about anything but math as a major," and enrolled at the nearby Arizona State University.

At Arizona State, Kelly pursued a degree in applied math with a minor in physics. She enjoyed her physics theory classes, along with her ODEs and PDEs courses. She even got some early teaching experience as a lecturer and tutor for lower-level math classes at her university. This experience reinforced her love of teaching and her goal of becoming a professor.

There were few research opportunities available at ASU, so Kelly obtained industry experience on two summer internships with Aerojet Ordnance. The variety of tasks she was able to do there was limited by her lack of security clearance, but she enjoyed the math, physics, programming, and daily work at Aerojet. Kelly programmed statistical packages and a theoretical smart-delivered air-bomb trajectory using the Fortran programming language. Her workplace had a gym and cafeteria, and the job paid well, but Kelly didn't like what she was producing and didn't see herself working on similar projects in the long term. As she put it, "there was some philosophical discernment…do I want to have kids and explain to them that mommy makes bombs?" So although Kelly loved the people in the science industry and liked the work at Aerojet, her original plan of academia remained intact.

"How can math not *help you in doing critical thinking? Learning mathematics and challenging your brain to think that way through proof classes is probably one of the best things anyone can do for themselves."*

Kelly knew she wanted to stay in math and eventually get a PhD. She had started college early and was 21 when she graduated. During her senior year, she realized that "if you know your entire life what you want to do, it becomes a bit of a burden." She wondered, "Am I good at nothing else? This is it? I'm so narrow that this is all I can do in life?" Faced with these thoughts and a bit tired of school, Kelly decided to do something different for a few years, mostly to prove to herself that she could do something besides mathematics.

So, Kelly enlisted in the Army as a linguist. She had been raised in what she calls a "very conservative, military-focused family," so enlisting seemed very reasonable. She had already lived independently for 4 years, but she was young, undisciplined, and immature and looking for something to challenge her and give her some focus. Although she didn't use math directly in her work as a linguist, her math background helped her to learn the new sentence structure, new lingual direction, and new alphabet of Farsi. Kelly says that she got everything she wanted from her time in the military but was glad to return to math afterwards.

Kelly got married while she was in the Army and left the service when she became pregnant. She was working part-time at a department store and interviewing around for jobs, as

she planned to be a working mom. But, as she says, "When I had Jaclyn, there was no way wild dogs and a gun to my head would have gotten me to leave my kid." When Jaclyn was two years old, Kelly taught a couple of evening classes at a community college while Jaclyn stayed at home with her father. Since Kelly only had her bachelor's degree, she was restricted to teaching remedial math. This was a perfect fit; she loved teaching students who didn't love math. To this day, Kelly likes teaching those students because she likes the extra challenge and the gratification that comes from students who finally understand the subject and achieve "freedom from their own negative thinking."

"I like teaching and I love mathematics so for me it seemed natural to be a professor."

But Kelly wanted to go farther into teaching and she needed at least a Master's degree to do that. After she and her husband divorced, she applied to the PhD program in mathematics at the University of Utah. It had been 6 years since Kelly had taken any mathematics, so she was accepted to the program but wasn't funded. Kelly needed to find funding if she was going to be a full-time student and a single mother. She met with Dr. Klaus Schmitt, who was on the graduate committee, to find out how to get funding for the following year, and left with some good ideas. A few weeks later, she got a call from the department with fantastic news- Klaus had found funding.

Kelly moved into the student apartments and started school. The only thing wearing on her excitement was trying to get homework done with a young child around the house. Kelly wasn't willing to leave Jaclyn with a babysitter, so she worked out a schedule with Jaclyn's father so that the child was always with one of them. Still, Kelly had to pull "crazy" homework schedules in order to succeed at being both a student and a mother.

"My life just seems to fall into place-- I have all these grand ideas and they work out. It's amazing. If you're the idea person and you're confident, people are willing to jump on board."

The first couple of weeks of graduate school were tough for Kelly, who hadn't used her math skills for years. She says, "I cried because it had been so long, I couldn't even remember how to find a determinant!" Three years into school, Kelly had finished her Master's degree and had started on the preliminary research for her PhD thesis. She realized that a standard path through academia would require her to move quite a bit, and she didn't want to take her child away from her father, who was still in school at the University of Utah. That decision, coupled with a general lack of excitement about her research, led Kelly to resign from her PhD program.

As Kelly says, "I couldn't just resign and do nothing, so I started looking around and doing some legwork." Kelly knew that she wouldn't be happy if she had a job that didn't involve math, so she looked more closely into computer graphics, a field that was born in mathematics departments and moved over to computer science when it grew larger. Through her friends' networks and connections, Kelly obtained the contact information for a manager at a computer graphics software company called Parametric Technologies. Kelly called the manager to ask some questions about which computer science classes she should take in order to make it into the field. During this conversation, Kelly mentioned that she could work for free, as an intern, and the manager suggested that she start right away.

"If I had to boil mathematics down to two things, it would be pattern recognition and problem solving."

Kelly worked two days a week and learned C++ and LISP overnight. At the end of the for-credit internship, Kelly was hired as a paid summer intern for 3 days a week, and at the end of that stint, Parametric offered her a full-time salaried position. Kelly worked there for 7 years

with "an incredible group of…mathematicians and computer scientists." She made a name for herself by being the go-to person for problem-solving. Kelly enjoyed working for months at a time on a problem with "so many details, it was mind-boggling." She especially loved the flexible hours; since everyone respected their team members and pulled her own weight, she was able to come and go as she pleased.

Most of Kelly's crazy schedules were driven by her desire to spend time with her daughter. Jaclyn went to a parent co-op school, where Kelly volunteered in the classroom for 3 hours a week. Kelly would come in with a lesson plan and extra math for gifted students. Kelly continued to gain teaching experience through this volunteer work and as an adjunct faculty member at the University of Utah. Eventually, her effort to keep a foot in every open door paid off.

When Jaclyn was in 6th grade, Parametric was experiencing a bout of layoffs. Kelly figured that this was a perfect opportunity to move to Arizona, closer to the rest of her family, where she would have some help raising her child, who "was not low-maintenance." Kelly began looking for jobs in Arizona, "applying almost anywhere," but the only job offer she received was for a full-time teaching position at the University of Utah. Kelly declined the offer, put her house up for sale, and volunteered for a layoff at Parametric. Her boss just laughed and refused to accept her resignation. In the meantime, another teaching position opened up at the U and Kelly finally "read the writing on the wall." She accepted the job at the university with fortuitous timing, as her entire work group at Parametric was laid off soon afterwards. Although the teaching job came with much less pay than her work in computer graphics, Kelly enjoyed her new role in the math education group, "teaching people who wanted to become teachers."

"Mathematicians are well-trained to think well and to learn things and to challenge ourselves and be persistent in that challenge. We lose that illusion that it's going to be easy…We're okay with the fact that it's hard, that it's going to take months to solve… I don't think I'm dumb if I don't understand something right away. I just don't think I've put enough time into it…There's something about not letting the struggle of mathematics get to you, not letting it get you down- it builds your confidence and you can take that to all areas of your life."

Several years later, Jaclyn graduated from high school and Kelly decided that it would be a good time to finish her PhD. Since she was no longer actively involved in raising her child, Kelly had "the time and freedom to do whatever" she wanted to do. Kelly had recently realized that the idea of math anxiety was something she was interested in researching, so she went to the graduate advisor with a proposal to pick up where she had left off more than a decade ago. The advisor told Kelly to "get a committee together, and it can be done." With just a few classes, a preliminary exam, and her dissertation left to finish, Kelly was well on her way to fulfilling the dream she had been carrying for so long.

Now as a PhD student, teacher, and the undergraduate advisor for mathematics, Kelly maintains that her math degree helped her gain "the critical thinking skills…and the level of detail" that "directly translates into being an incredible worker in almost any field." Kelly says, "I believe that and it ekes out of every pore of my skin, and when I go into an interview, I sell that. If someone isn't convinced…and they go into an interview, it's not the math degree that isn't going to get them the job, it's their interviewing skills. Your interviewing and personality and how you present your skills is...important." Kelly echoes the advice that I have been hearing across the board: "Some students come in here and ask me what you can do with a math degree. Tell me something you *can't* do with a math degree."

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