Through my high school and early undergraduate years the thought of a graduate education in mathematics, the bane of my young existence, was unthinkable. My grades poor, self-awareness minimal, and goals nonexistent, I ploughed through my first and second years of college without a thought toward the future, assuming I'd become a software developer. It was only when I had my first truly humbling mathematical experience that I realized math was for me — and the catalyst was politics.

On the precipice of the midterm Iowa Caucuses in spring 2018, I enrolled in an American politics course, hoping to finally fulfill my general education requirements. Being a small honors class, each student was tasked with writing an essay and designing a half-hour talk on a given topic. Mine was redistricting, the process of dividing states into electoral districts. My research led me to a series of papers discussing the math behind redistricting. At first, I thought I had just found an interesting tie-in to bulk up my project, but I soon realized I'd found something more: ideas that would sate my endless curiosity, be a source of insight for myself and others, have a material impact on those around me, and nourish my growing love for math.

Driven by my new passion, I applied for a NSF-supported REU sponsored by one of the papers' authors. That summer, I had the privilege of being named a Tisch Fellow at the Voting Rights Data Institute (VRDI). Supervised by Dr. Moon Duchin, Dr. Justin Solomon, and Dr. Daryl DeFord, I spent the next six weeks hopping between Harvard, MIT, and Tufts University, learning from and working alongside fifty other bright, passionate mathematics initiates. I collaborated with exceptional colleagues to develop GerryChain, a software package for sampling electoral districting plans using Markov chain Monte Carlo (MCMC), established new techniques for sampling balanced tree partitions, and posed novel questions about graph cuts. Over that time, I came to know what the phrase "math research" meant. We worked diligently, sought gaps in our knowledge, and approached our work with respect, humility, and self-awareness. Being immersed in such a non-judgmental, diverse workplace was my catalyst: I knew I wanted to become a mathematician.

I returned to the University of Iowa with a budding sense of purpose and direction, throwing myself into my academic work. I added a mathematics major, enrolled in graduate courses, tutored for the Mathematics and Computer Science Departments, and began an NSF-supported undergraduate research assistantship. As my principal research project, I co-authored a paper on optimally balancing tree partitions, and presented our work at the 2019 Texas MAA Section conference [4]. I tutored nearly 20 hours per week, ranging from undergraduate to introductory graduate courses, where I learned to make complex material accessible for other students while solidifying my own foundations. Outside the classroom, I co-founded the UI's Society for Industrial and Applied Mathematics (SIAM) chapter, serving as its inaugural Webmaster and, later, as Treasurer. In the summer of 2019, I returned to the VRDI to help instruct the next cohort of Tisch Fellows. I excelled academically during my final two undergraduate years, making the Dean's List twice; at the same time, I learned to be patient with myself, find joy in struggle, and recognize the value inherent to hard, dedicated work.

Just as I finished my undergraduate degrees, litigation following the 2020 redistricting cycle came into full swing. Motivated by the idea of service through mathematics, I took a political mapping analyst position at the National Democratic Redistricting Committee, followed by a data scientist position at the MGGG Redistricting Lab, the organization which sponsored the VRDI. At the Lab, I studied voting and civil rights through a mathematical lens, getting a great deal of experience in both applications and research. Our practical work supported numerous civil rights litigation and grassroots organization efforts across the country, and our research studied the effects of proposed ranked-choice voting (RCV) legislation and provided new ways to measure the impact of redistricting on individual communities [3, 1]. I realized I wanted to continue my education — not just to broaden and deepen my mathematical knowledge, but to address pressing social and political issues, build inclusive and equitable math communities, and make math more accessible to those traditionally excluded or underserved.

As I transitioned to graduate school at George Mason University in fall 2022, I brought all the lessons I'd learned — creating inclusive spaces, amplifying others' voices, the value of democratized knowledge — with me. Through my teaching responsibilities, I worked hard to be a better advocate for and communicator of mathematics, and in spring 2023 I was given the GMU College of Science Dean's Excellence in Graduate Teaching award. Additionally, I spent late July and early August as an instructor for GMU's LaunchPad program, a three-week algebra and analysis boot camp for incoming PhD students. Now, as a research assistant, I work diligently to buttress my math foundations, remain open to new and challenging ideas, and carve out my own space in the research world. As a co-manager and mentor at the Mason Experimental Geometry Lab (MEGL), I am lucky to occupy a unique position at the crossing of research and mentorship, helping to bring aspiring mathematicians into the fold. My teaching and research experiences have unequivocally shaped my steadfast aspirations to make meaningful contributions to the body of mathematics knowledge, while serving my communities at the same time. I believe that, with the support of the NSF GRFP, I can further turn those aspirations to realities.

Relevant Background. Mentored by my undergraduate advisers Dr. David E. Stewart and Dr. Suely Oliveira and in collaboration with Dr. Jared Grove, I contributed to a research project studying the structure of planar graphs and finding balanced vertex partitions of them, alongside developing efficient algorithms to compute these partitions. Marrying ideas in graph theory and numerical optimization, we developed a variant of the k-medoids algorithm, tackling the partitioning problem heuristically. The benefit of this research was multifold: I was able to hone my intuition for graph-theoretic problems and the algorithms that accompany them, learn new analytic and optimization techniques, and make an addition to the growing body of mathematics-for-redistricting literature. In addition to co-authoring a paper on our findings [4], I presented our research and co-led a math-for-redistricting workshop at the Texas Section MAA meeting in Spring 2019 and was invited to do the same in Spring 2020, which was cancelled due to the COVID-19 pandemic.

Alongside my work with Drs. Stewart, Oliveira, and Grove, I continued my theoretical and practical work on the mathematics of redistricting with Dr. Duchin. Borrowing ideas from statistical mechanics, algebraic graph theory, topology, and biology, we worked to prove various properties of and design hyper-specific sampling distributions for the ReCom family of Markov chains [2]. Additionally, we conducted large-scale statistical experiments on the possible electoral outcomes of the Fair Representation Act, proposed federal RCV legislation. Using partisan and racial voting data drawn from multiple 2020 elections, alongside previous work on RCV modeling, we produced a report detailing the efficacy of ranked-choice voting in all fifty states [3]. With these theoretical and practical tools, we were able to support litigation efforts in high-profile redistricting cases across the country (including the Supreme Court cases Merrill v. Milligan and Moore v. Harper), as well as materially inform civil and voting rights policymakers.

After two fulfilling years as a data scientist and researcher I began my PhD at George Mason University, spellbound by MCMC's rich theory and mathematical versatility. As many redistricting questions are difficult-to-intractable even when viewed through a probabilistic lens, I turned to statistical mechanics, hoping to fill out my toolkit while working on more approachable problems. Since Spring 2023, I have worked as a graduate researcher with Dr. Ben Schweinhart, expanding the study of statistical mechanics with ideas borrowed from algebraic topology. Much of the existing literature focuses on the statistical properties of interactions between these models' vertices (atoms) and edges (bonds), but we generalize the theory and accompanying computational processes to use higher-dimensional topological objects. Moreover, we plan to show that the statistical properties we observe in experiments using these higher-dimensional objects are analogous to those we observe in the classical models. Through this work, I am able to both utilize and build upon my foundations in algebra, topology, graph theory, and statistical computing, and hope to amalgamate these ideas in my eventual thesis work.

In addition to my research work, I strive to become a better teacher and communicator of mathematics. My approach to teaching is student-centered, focusing on creating a learning environment that is simultaneously equitable, comfortable, and challenging. Further, I consciously attempt to make my learning environments and teaching strategies socially aware: as a white, cis man in the a teaching and mentorship position in math, I recognize my responsibility to make space for and amplify the voices of traditionally excluded and underserved groups of students. Though I am not teaching this academic year, I served as a graduate instructor for GMU's LaunchPad program this past summer, helping introduce the new cohort of mathematics PhD students to graduate life at George Mason. Additionally, I am a graduate mentor at the Mason Experimental Geometry Lab, working with Dr. Michael Jarret to introduce a team of undergraduates to the world of research mathematics through MCMC for quantum systems.

Intellectual Merit. The combination of theory and practice that my work embodies seeks out knowledge gaps with the intent to fill them in creative and holistic ways. In both the redistricting and statistical mechanics spheres, there is a great deal of theoretical foundation to be laid, and new experimental techniques to explore; each of these, in their own right, make substantial contributions to the larger body of mathematical literature. I believe I am well-qualified to conduct research in these areas based on my academic and professional background in relevant subfields, ability to communicate complex mathematical ideas in approachable ways, and conscious efforts to foster creative, inclusive learning and research environments.

Broader Impacts. Both redistricting and statistical mechanics affect virtually everyone. The former can dictate how and for whom we vote, and the latter forever changed our understanding of the building blocks of our universe. Regardless of how I blend or independently explore these ideas, I believe my research in these areas will have a material impact on political and civil rights outcomes for voters historically denied or unjustly stripped of the right to vote, and our collective theoretical and practical knowledge of complex physical phenomena. To help bring these impacts to bear, I invest significant time and effort in MEGL as a mentor and Lab co-manager, guiding the next generation of scholars through their first forays into research. With support from the NSF GRFP I can compound my investment, better fulfilling MEGL's mission to equip students with the tools they need to pursue their goals and contribute to their academic, professional, and personal communities.

Future Goals. After obtaining my doctorate, my goal is to become a professor who focuses equally on teaching, research, and contributions to each of my respective communities. I plan to couple a broad and deep mathematical foundation with a strong sense of public service, and I am determined to make positive change in a position of leadership. My unique, winding path through academia gives me the tools to shape the direction of research in my fields, bring up new generations of socially-conscious learners, collaborate with scholars and scientists in other disciplines, and work hand-in-hand with social reformers to make our communities more equitable and just.

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