



FOR ALL

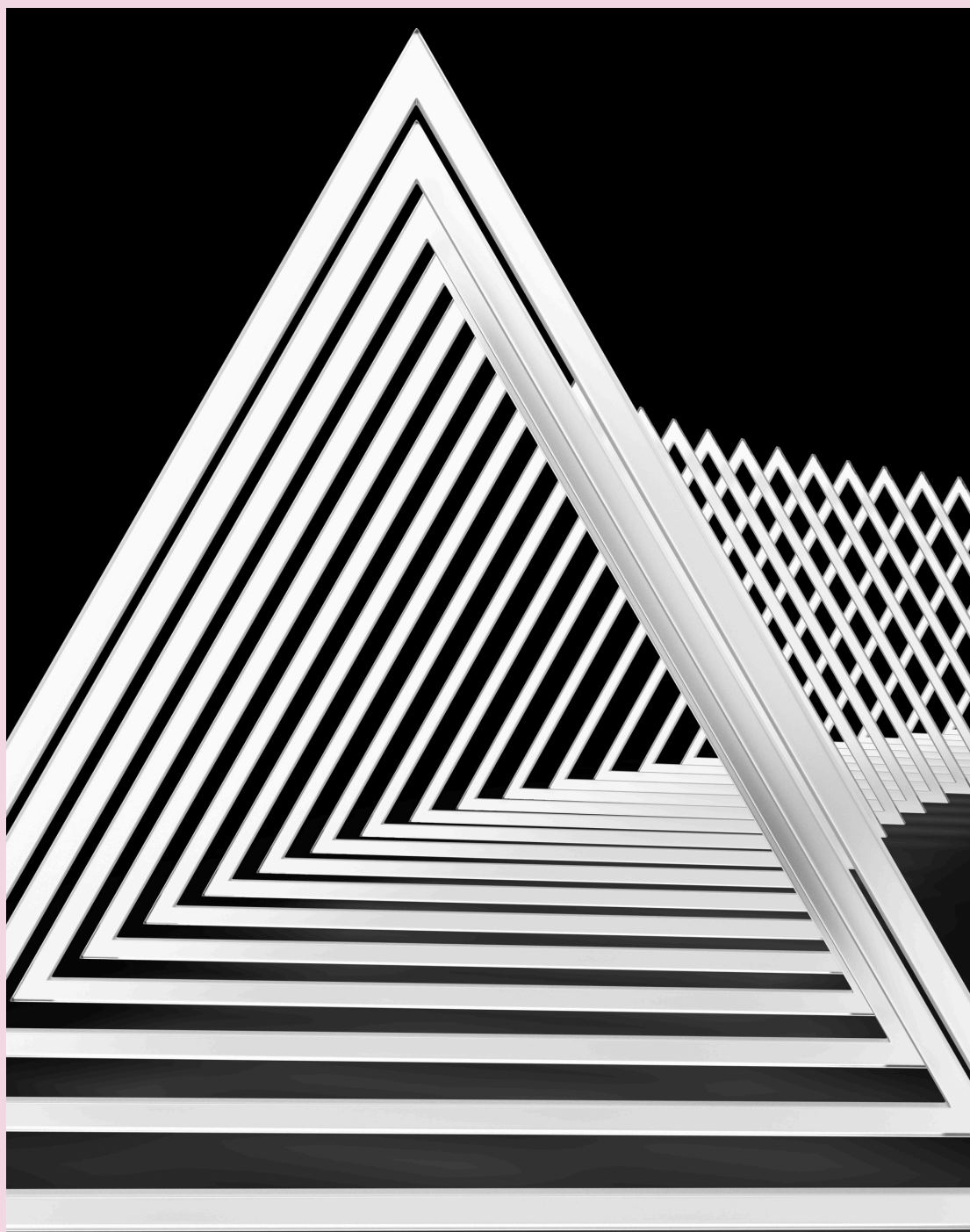
SAINT LOUIS UNIVERSITY.

Beautiful Place.

Saint Louis is our home, and we endeavor to make it a better place by creating inclusive communities that can share in the joy of learning.

ABOUT US

Biannual inclusive mathematics magazine featuring articles and expositions on a wide range of topics related to mathematics and more.



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Welcome to *ForVll*

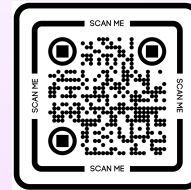
Welcome to another exciting edition of our math magazine ForVLL! We would also like to welcome our new student editor Nathaniel Alloway and thank him for his valuable contribution to this magazine.

As always, we are thrilled to have you on board to explore a wide range of mathematical articles and expand our mathematical thinking together. In this issue, you'll find some applications of modern mathematics and perspectives you might not have seen before, along with a critical analysis of our complex world of mathematics and AI. Last but not least, enjoy the challenge of a new puzzle created for our magazine: a crossword puzzle!

Our main goal is to make math accessible to all, regardless of background. Whether you are an experienced mathematician or just starting your journey, we encourage you to explore, question, and engage with the content within these pages. This being said, we extend a warm invitation for submissions from all - undergraduate students, graduate students, and experienced researchers alike. Your contributions add variety to our journal, and we particularly encourage students to share their unique insights. Whether it is an undergraduate project or a groundbreaking research endeavor, we value the richness each perspective brings to our mathematical community.

Thank you for being a part of our journey, and we hope you find inspiration and enjoyment in the pages that follow.

Follow us and submit your content on our website!



forallmathmagazine.com

This is a journal of the people in our community, and it is strengthened by any art, puzzles, or articles the community can provide.

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Faculty Interview Series

Interviewing: Ana Granados

Interviewed by: Nathaniel Alloway and Kieran Favazza



Introduction

In this exciting edition of our Faculty Interview Series, we hear the unique perspective of Dr. Ana Granados, Professor of Mathematics at the Madrid campus of Saint Louis University. In the chaotic world of STEM careers, Dr. Granados shares a unique perspective on distinguishing what truly matters from what does not. Her life experiences have endowed her with wisdom both mathematical and otherwise, and we are grateful to understand her experiences so that we might follow her example as a contributor to the world, both mathematically and non-mathematically.

Interview

Dr. Granados, how did you become interested in mathematics?

I would say it started around high school. I discovered that I really like sitting with challenging problems and puzzles — I remember being so intrigued when I was introduced to complex numbers — and I ended up finding a group of friends that enjoyed math too. The time we spent together and the math we did certainly influenced me to become a mathematician, and I still speak to my friends today, even though we've branched into entirely different areas of math. I think doing math in a group had a large impact on my fondness for it and the likelihood of doing research later on.

How has your relationship to math changed as you've advanced in your career?

My attitudes towards certain aspects of being a mathematician have certainly changed. I now have much more work to do in a bureaucratic/clerical fashion, which is okay, but I think I used to care a lot about collaborating with this or that accomplished person or working on some specific problem. I now realize what I truly enjoy about the work I do and who I like to do it with. I have a regular group with which I collaborate, and we work on interesting problems as we please. I also love interacting with my community and the outreach I do with high school math students. Since having a family, I've learned to distill parts of math that are important to me and parts that aren't.

How do you balance mathematics with the other important things in your life?

The most important thing is that my partner and I share responsibility. We both work and take care of our family, so we make sure to organize ourselves and follow through on our designated responsibilities. I will still occasionally think about a problem when going to bed or going to the

supermarket, but I am intentional about setting time for myself and my family separately from math.

For many mathematicians, math often bleeds into one's personal life. Do you think that math-obsessed, problem-solving people become mathematicians, or does mathematical training make a person like that?

I think that in any research field, there is a level of obsession. Historians tend to be obsessed with history, mathematicians tend to be obsessed with math, and that is a good thing. It's often like a huge hobby or passion that people have, and I think it's beneficial to the fields and to those people that they have the careers to engage their passions. Of course, too much obsession isn't good for anyone, so it's important to maintain a healthy level of obsession.

What do you like to do outside of math?

I have several hobbies that I love to find time for. I love learning Japanese — I really enjoy learning from shows. I love to read in my free time, I like going to the mountains and exploring the nature of Spain, and I love to have dinner with my friends.

Dr. Granados reminds us of a characteristic of life often forgotten in the chaos of early careers and mathematics — balance. She emphasizes the importance of balancing mathematics with one's life — figuring out one's priorities and making time for them, as well as figuring out one's goals within mathematics. It is important to keep hold of the healthy aspects of one's career to be obsessed about — to collaborate and to enjoy the things that make you happy.

You mentioned your work with high school students. Has outreach always been a big part of your career?

When I finished my post-doctoral studies and came back to Spain, I started to realize that a lot of people, especially young people, hate math. They tend to dislike math because they don't see any use for it, and this saddens me. I think without a realization of how math affects you or how present it is in the world, a person can be manipulated, and they do not gain as deep of an appreciation of the world. I work with several populations, both talented primary/secondary school students and older, senior citizens, and my goal is to increase appreciation for mathematics. We hold seminars and activities with the groups,

and the math is not hard at all, but it is certainly interesting. I want to get more people interested in mathematics and increase their mathematical skills.

In working with such various populations in your career, have you found any keys in increasing people's love/understanding of math?

I think it's important to figure out the parts of math that people do and don't like. When working with younger or older people, I try to avoid the technical parts that put people off of math and focus on the more exciting visual aspects. I try to foster a reverence for pictures and the ideas that they capture. We are still always learning, but my colleagues and I really try to remove the scary math language and focus on concepts and pictures when working with anyone.

Do you feel that an emphasis on pictures helps you in your research?

My research certainly involves a lot of pictures. I often like to consider problems about Riemannian manifolds — if I know the curvature or some data about its shape, how are certain problems/inequalities affected? I draw many pictures to understand how functions influence aspects of spaces — I invoke complex analysis very often in my work, which is a nice connection to my original fascination with math through complex numbers.

Dr. Granados reveals a commonly held, yet forgotten sentiment about mathematics — pictures are key. The activity of math is not held in some abstract, convoluted way of thinking, but in reflecting on the world around oneself and deriving some kind of pleasure and information from it.

The student body at SLU-Madrid varies a lot from year to year since many of the students are only visiting for a semester or two from their home institutions. Are there any challenges in teaching because of this variation in the student body?

The main challenge for basic courses is the variation in students' backgrounds. Different countries will emphasize different aspects of the curriculum, so even though every institution may teach the same basic level of calculus, some places will emphasize more of the geometric aspects, while other places emphasize the algebraic aspects. So when you have a class, everyone has seen some part of the material that you're teaching, but not

some other part.

For advanced courses, the main challenge is to ensure that everyone leaves with the right level. When you have visiting students for a year, you want to make sure they end up at the same level as students from their home institution — you don't want to jeopardize their studies. Also, different universities teach at different depths and workloads. This means that in the same class, you have students who are used to working a lot and other students who are not used to working so much. So for the first few weeks, you have to make sure your work expectations are clear. Afterward, you make sure you keep the same difficulty level for all the students in the same year.

Do you have any teaching tricks for getting people with different backgrounds on the same page for new material?

For low-intermediate courses (up to Calculus III), we have one hour a week where students go up to the blackboard and explain problems. When teaching, one has a particular way of explaining things and rephrasing yourself can be hard. However, students will always say it in a different way, and they will be so much closer to the struggle. So having that one hour per week is wonderful; some students will make mistakes, so everyone learns. And, some students will work or explain things in a different way, so again everyone learns.

It also helps if the students ask questions. But if you have a class where one part of the class is really understanding and another part is struggling, it's hard because people will be afraid of asking questions. In that case, we try to do group work. Sometimes this works very well since the students with better understanding can explain to the others. Other times it doesn't work as some students are still too shy to ask other students questions. It all depends on the class atmosphere and how well the students know each other.

What has been your experience, both as a student and a teacher, as a woman in mathematics?

When I was a graduate student around 1996, about half the math students were women and half were men. When I became a postdoc, it was about the same, so not much changed going up the ladder. Nowadays in Spain, about 70% of

university students in math are men. Ana Portilla¹ and I looked into why the percentage changed. The reason was that in Spain, around 2007 or 2008, math stopped being a teaching job at high schools and became a working job for private companies. That was why the percentages changed. I think maybe as the job market became more competitive, more women didn't think they could make it through, and so the percentage shifted.

In terms of my faculty experience, one difficulty is going abroad or moving for work. This is especially hard if you have a partner, in which case you get a "two-body problem." Sometimes the female partner just follows the male partner when moving. When kids are born, either the social structure is supportive- you have flexibility in work, maternal leave, and so forth- or it is not. I myself never felt attacked for being a woman in mathematics. Math was already competitive for different reasons. I don't like competition; I like working in groups and collaborating. So I only really compete against myself.

But yes, the main challenge is with starting a family. You need all the support, both from the social structure and from your partner. The burden of responsibilities often falls more heavily on women, and there need to be structures in place to offset this and ensure women's success. These pressures and attitudes often lead to more discouragement of women, happening both at late stages in professional life and in early schooling.

How do you think people's self-perceptions that they can't succeed in math should be addressed? How early do these self-perceptions start?

Studies have shown that how people see themselves starts at six years old. There was a metastudy done in the U.S. that showed that people can start thinking that they are poor at math when they are really young. Having role models early on can change that. I know a woman near me who goes everywhere as a math role model - on programs and to high schools - and just because of her, the number of girls who have wanted to do math has increased. So I think it's important that we, mathematicians, go to schools - high schools, middle schools, elementary schools - to tell women and to tell minorities and to tell everybody that you can also become a great mathematician or a scientist.

¹Another mathematics professor at SLU-Madrid

In fact, it's become a huge thing in Spain. There are many other people who do this sort of outreach. Actually, the UN has a day called the International Day of Women and Girls in Science (February 11), where many people do these outreach activities by going out to high schools, being role models, and empowering girls.

Conclusion

Dr. Ana Granados puts her love of and understanding of mathematics into action through her outreach and teaching. She constantly strives to understand more about herself and her students, and she reminds both us and her students that the keys of mathematics are contained in pictures and their ideas, not in clever, though technical mechanics. This identification of what's important and what's not persists in her personal life and in her research — she exemplifies the importance of identifying one's priorities and interests and following them passionately.



What is Happening in Ritter?

Association for Women in Mathematics Student Chapter

The SLU Student Chapter of AWM mentors and encourages women and other minorities as they prepare for careers in mathematical sciences. We encourage conversation in the mathematics community among women and other gender minorities. This includes connecting undergraduate students, graduate students, and faculty at both formal talks and casual mathematics gatherings. While this is a math chapter, it is not only aimed at math students but rather at all neighboring fields and interests. We meet on Mondays at 4:00 pm. Check out the events and more information at the [department's website](#) or through [SLU Groups page](#).



Math Club

The Math/Stats club meets on Wednesdays at 4 pm in the Ritter Hall Lobby. Events include outside speakers, games, competitions, field trips, and other opportunities to socialize with fellow students. Students of any level and faculty are all welcome to attend club events. Find more information about the club on the [SLU Groups page](#).



Colloquium

The department runs weekly colloquia featuring speakers from both SLU and other top national institutions. The events are categorized into researched-focused and education-focused talks. The departmental colloquium meets on Fridays at 4:00 pm with refreshments beforehand in the Ritter Hall Lobby. Check out [department's events website](#) to see the calendar for all departmental events.



How to Draw Audio: An Intuitive Introduction to Spectrograms

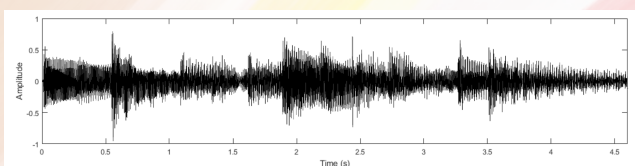
By Daniel Haider and Lukas Köhldorfer

Ph.D. Students, Acoustics Research Institute of the Austrian Academy of Sciences

Considering *audio* as a captured instance of an acoustic event, we might ask whether there is a natural way of representing it. Ideally, such a representation should be readable and interpretable but also contain all the information to reproduce the event. For example, that melody that has been stuck in your head for the last couple of days — somewhere in the depths of your brain there is an abstract representation of it. To formalize it, you could scribble the notes corresponding to the melody on a sheet of music, so that anyone could decode and try to reproduce it.



But no matter how accurately you can represent the melody in musical notation, the actual musical event can never be fully reproduced. So, while this kind of representation is perfectly interpretable, it is not consistent in terms of reproduction. Looking at the flip side of this problem, one could simply record the sound event of someone playing the melody with a microphone and would get an (almost) perfect representation of it. Theoretically, it contains every bit of information with great precision and the event can be reproduced by playing the recording back on some speakers. Plotting (a digitized version of) the recording, however, gives only very little insight into its characteristics. So, except for a vague sense of amplitude and timing, a visualization of an audio signal (represented as a function in time) is not very informative.



What we would like to have is a representation of our audio signal that combines the benefits of

both approaches: We certainly would like to be able to depict its most essential features such as timing, pitch, and tone duration as in a music sheet. At the same time, our representation should contain enough information so that a consistent reproduction is possible. By aligning the frequency information of a signal at any point in time to a 2-D picture that can be read like a sheet of music, a *time-frequency representation* [1] provides exactly that.

Audio signals. Before we can compute a time-frequency representation, we first have to define what an *audio signal* is in mathematical terms. Intuitively, an audio signal describes a sound event by assigning an amplitude value to any point in time. This mapping can be viewed from different perspectives. From the perspective of a tape recorder, it seems natural to think of it as a continuous function $f : \mathbb{R} \rightarrow \mathbb{C}$ with finite energy, meaning that f belongs to the space $\mathbf{L}^2(\mathbb{R}) = \{f : \mathbb{R} \rightarrow \mathbb{C} \text{ measurable} : \int_{\mathbb{R}} |f(t)|^2 dt < \infty\}$. In the context of applications, since a computer can only process a finite amount of information, audio signals are alternatively modeled by elements from the finite-dimensional vector space $\mathbb{R}^L$ (or $\mathbb{C}^L$). For both cases, there is appropriate machinery for computing time-frequency representations.

Basics of time-frequency analysis. The most important tool in time-frequency analysis is the *Fourier transform*. In the continuous setting, for any $f \in \mathbf{L}^1(\mathbb{R}) = \{f : \mathbb{R} \rightarrow \mathbb{C} \text{ measurable} : \int_{\mathbb{R}} |f(t)| dt < \infty\}$, it is defined as

$$\mathcal{F}f(\omega) = \hat{f}(\omega) = \int_{\mathbb{R}} f(t) e^{-2\pi i \omega t} dt.$$

Since $\mathbf{L}^2(\mathbb{R}) \not\subseteq \mathbf{L}^1(\mathbb{R})$ we cannot define the Fourier transform on $\mathbf{L}^2(\mathbb{R})$ directly. However, $\mathcal{F}$ is defined on the dense subspace $\mathbf{L}^1(\mathbb{R}) \cap \mathbf{L}^2(\mathbb{R})$ and through a

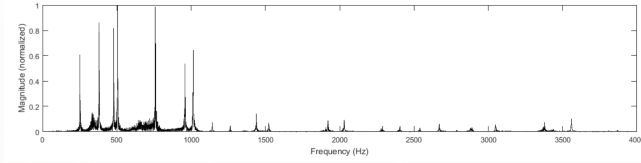
limit process, the Fourier transform can indeed be extended to our signal space $L^2(\mathbb{R})$. Moreover, we find $\mathcal{F}$ to be a unitary operator on $L^2(\mathbb{R})$ and its inverse is given by the relation $(\mathcal{F}^{-1}f)(t) = (\mathcal{F}f)(-t)$ (i.e., the Fourier transform is self-inverse up to a sign change). In other words, we can reproduce any signal f by

$$f(t) = \int_{\mathbb{R}} \hat{f}(\omega) e^{2\pi i t \omega} d\omega.$$

With the eyes of an engineer (or someone who wants to do audio signal processing), $\hat{f}(\omega)$ is understood as the *spectrum* of f , containing the frequency information of f . Musically speaking, this provides us with information about pitch, which is a nice first step towards our goal. To implement the Fourier transform on a computer, we define the discrete Fourier transform [2] for a finite discrete signal $f \in \mathbb{R}^L$ as

$$\hat{f}[k] = \sum_{n=0}^{L-1} f[n] e^{-2\pi i \frac{kn}{L}}.$$

Plotting the values $|\hat{f}[k]|$ shows us which notes are present in our melody and how strong each of them is.



Unfortunately, we have lost all the temporal information during the Fourier transform. To maintain the temporal alignment of the frequency information, we follow the idea hinted at previously: Instead of computing the Fourier transform of the whole signal, we consider the frequency content (i.e., the values of the Fourier transform) of small parts of the signal at a time. What we obtain is a time-ordered series of frequency decompositions. To realize this idea, the following steps are required:

- We multiply our signal f with a suitable (time-localized) *window function* $g \in L^2(\mathbb{R})$. A common choice is the bell-shaped Gaussian $g(t) = e^{-\pi t^2}$, which attains the value 1 at 0 and decays exponentially fast towards 0 as t tends to $\pm\infty$. As a consequence, the function $f(t) \cdot g(t)$ will resemble a bell-shape-compressed — or time-localized — version of f . Metaphorically speaking, we look at “ f through the window g ”.

- Since we are not only interested in the essential information of f around 0, but also around all other time points, we additionally look at f through the translated window $g(t-x)$, which is the same bell-shaped function but centered around x . We obtain the collection of the localized functions $f(t) \cdot g(t-x)$.
- Finally, to obtain the frequency content of each of these localized parts of f , we compute the Fourier transform of $f(t) \cdot g(t-x)$ for every x — or, for compatibility with the inner product on $L^2(\mathbb{R})$, rather that of $f(t) \cdot \overline{g(t-x)}$.

Combining these steps into one transform yields the well-known *Short-time Fourier transform* (STFT), sometimes also called the *Sliding-window transform*. For a fixed window $g \in L^2(\mathbb{R})$, the STFT [1, 2] of $f \in L^2(\mathbb{R})$ is defined by

$$\begin{aligned} \mathcal{V}_g f(x, \omega) &= \mathcal{F}(f \cdot \overline{g(\cdot - x)})(\omega) \\ &= \int_{\mathbb{R}} f(t) \overline{g(t-x)} e^{-2\pi i \omega t} dt \\ &= \langle f, M_\omega T_x g \rangle_{L^2(\mathbb{R})}, \end{aligned}$$

where T_x denotes *translation* by x , and M_ω denotes *modulation* by ω (i.e. multiplication with $e^{2\pi i \omega t}$). If g is non-zero, $\mathcal{V}_g$ is (in some sense) invertible and thus there is always a way to reconstruct f from the information $\mathcal{V}_g f$. To turn $\mathcal{V}_g f$ into a representation that is readable by humans, one considers the *spectrogram* [2] $S_g(f)$ of f , which is obtained by taking the squared magnitude of $\mathcal{V}_g f(x, \omega)$, sampled on a rectangular lattice $a\mathbb{Z} \times b\mathbb{Z}$, i.e.,

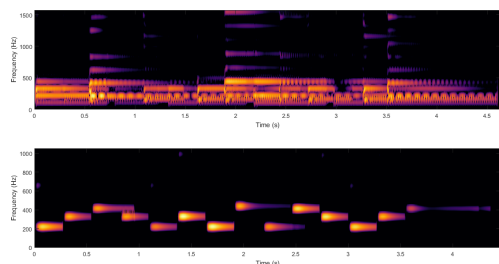
$$S_g(f)[n, m] = |\mathcal{V}_g f(an, bm)|^2, \quad (m, n \in \mathbb{Z}).$$

Again, to implement this representation on a computer, we have to put on our finite-dimensional discrete glasses. So, instead of continuously shifting our window, we make discrete time steps. For a fixed window $g \in \mathbb{R}^L$ the discrete STFT [2] of a vector $f \in \mathbb{R}^L$ is defined by

$$\begin{aligned} \mathbf{V}_g f[m, k] &= \sum_{n=0}^{L-1} f[n] g[(n-m) \bmod L] e^{-2\pi i \frac{kn}{L}}, \\ &\quad (m, k = 0, \dots, L-1). \end{aligned}$$

The spectrogram computed from the values of the matrix $\mathbf{V}_g f$ is now our final time-frequency “drawing”. Horizontal lines correspond to tonal components with sinusoidal characteristics, such as notes in music or vowels in speech. Vertical lines correspond to transient events, which last only for a short time duration and contain many different

frequencies at once, such as drum hits or clicking sounds.



The top plot shows the spectrogram (up to 1500 Hz) of a recording of a classical guitar playing the melody depicted in the partitur (sheet music) from the beginning. The underlying STFT was sampled with $a = 32$, $b = 24$. With a trained eye, one can quickly identify the melody in there. Since a guitar produces lots of harmonics and resonances, the picture is not as clear as the partitur, though. The plot below shows a spectrogram (up to 1000 Hz) of the same melody in MIDI, played by some simple digital synthesizer without harmonics. Now the analogy to the sheet of music becomes more obvious.

Applications. It should be mentioned that time-frequency representations, such as the STFT or the spectrogram, are more than just pretty pictures of audio signals — they are essential tools for analyzing and synthesizing audio signals in many applications. By decomposing a signal into its time-frequency components, different parts of the content are isolated and can be manipulated precisely. This idea lies at the heart of many audio processing algorithms, including compression, denoising, information retrieval, and many more, where targeting particular parts of a signal becomes crucial. Similarly, in audio generation, signals are often constructed directly in the time-frequency domain and later transformed back into a time-domain signal using the inverse transform. This duality — analysis and synthesis — makes time-frequency representations indispensable across a wide range of audio applications.

Further learning. For a visual introduction to the Fourier transform, Grant Sander-son has a video entitled “But what is the Fourier Transform? A visual introduction.” on his YouTube channel 3blue1brown. See <https://www.youtube.com/watch?v=spUNpyF58BY>.

References

- [1] Karlheinz Gröchenig. *Foundations of Time-Frequency Analysis*. Boston, 2001.
- [2] M. Vetterli and J. Kovacevic. *Wavelets and Sub-band Coding*. 1995.

Women Mathematicians Corner

The Association of Women in Mathematics (AWM) started a project called “EvenQuads” to celebrate their fiftieth anniversary by designing a playing deck of cards and honoring notable women mathematicians. Thanks to AWM for permitting us to share these playing cards in our magazine.



Bhamha Srinivasan
(b. 1935)

Srinivasan is from India and did her doctoral work in England. Her career has mostly been at Clark University (Worcester) and the University of Illinois at Chicago. She specializes in the representation theory of finite groups, and has supervised five PhDs, two of them by women. Srinivasan has contributed extensive journal editorial service.

During her term as President of the AWM (1981–1983), the association organized its first international conference, the Noether Symposium. Srinivasan has also had stints at the Institute for Advanced Study (1977), and the Mathematical Sciences Research Institute (1990). She gave the AWM Noether Lecture (1990), and is both an AMS Fellow (2012) and an AWM Fellow (2017).

This poster is part of the EvenQuads project, which combines innovative mathematical card games with learning about amazing women mathematicians. The project celebrates the 50th anniversary of the Association for Women in Mathematics.

If you want to learn more about EvenQuads, scan the QR code below.

EVENQUADS



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Consider the Consequences: Bias in AI

By Aditi Navjith

Undergraduate Student, Department of Mathematics and Statistics and Department of Computer Science, Saint Louis University

Artificial Intelligence was once a fictional dream. Even Mary Shelley's *Frankenstein* considers the implications of intelligence that is influenced by the creation of man. More recently, writers like Philip K. Dick explored themes of identity and reality in works like *Do Androids Dream of Electric Sheep?* (1968), which inspired the film *Blade Runner*. Arguably, even movies like *The Terminator* have influenced real life, through the manifestation of AI in weapons of mass destruction (WMDs) that are actively used in war today. As this technology permeates various aspects of our lives, it is crucial to examine the ethical implications of its development and deployment, particularly those on women and people of color to address representation and perspective gaps. This article will explore how these ethical considerations extend beyond consumer applications to critical areas such as lethal autonomous weapons and education, revealing how these innovations can empower or endanger our society, and emphasizing the need for inclusive and accessible dialogue and governance.

Women in AI

Recently, a friend and I discussed gender ratios in our classes, and it was eye-opening. While STEM fields are often male-dominated, her pre-med classes were nearly balanced, if not skewed toward women. By contrast, my math and computer science classes felt more like a 3:7 ratio of women to men. According to the National Center for Education Statistics, see [4], only 21% of computer and information sciences bachelor's degrees were earned by women in the US during the 2020 graduation season.

This led us to two conclusions: first, nursing and medical sciences may feel more welcoming to women, likely because they align with traditional caregiving roles; second, the reasons for the

disparity in computer science are more complex. Studies from the American Association of University Women, see [1], shows that a girl's upbringing significantly impacts her interest and performance in math. For instance, when teachers and parents encourage girls by telling them that intelligence can grow with effort, girls tend to excel in math tests and express a desire to continue studying the subject.

However, despite efforts to promote STEM for girls, it seems that the focus often leans toward traditional sciences like biology and chemistry, with less attention paid to computer science or math. This disparity might stem from the accessibility challenges in teaching computer science, alongside the ever-evolving nature of technology. Unfortunately, this lack of support likely influences girls' academic choices down the line.

Thankfully, organizations on campus at Saint Louis University like Girls Who Code, the Association for Women in Mathematics, and the Society of Women Engineers are working to bridge this gap. But is it happening fast enough? The underrepresentation of women and people of color in tech development is evident, especially in technologies like facial recognition software.

The Consequences of Bias in AI

Facial recognition technology is becoming ubiquitous, from unlocking our phones to assisting law enforcement. However, a study by the US National Institute of Standards and Technology (NIST) revealed alarming inaccuracies. The tests showed that Black and Asian individuals were up to 100 times more likely to be misidentified than their white counterparts, reflecting the demographics of those developing the technology. As of 2021, [2], 91% of AI specialists are male, and 67% are white. This

could be concerning if the data used to train facial recognition models reflects these biases and leads to models that may perform less accurately for women, people of color, and other underrepresented groups.

The implications of these inaccuracies can be severe. False positives can lead to otherwise unwarranted interrogations, increased tension during police encounters, wrongful convictions, and unnecessary emotional damage to already hurt communities. In one case from 2020, Robert Williams was wrongfully arrested in his home [5], in front of his family after facial recognition technology mistakenly matched him to a blurry photo from a robbery. His story is not isolated; countless individuals have faced similar fates, reinforcing trauma and harmful stereotypes in already marginalized communities.

Such technology is seeming to find larger-scale weapon applications, such as in lethal autonomous weapons (LAWS). Though facial recognition is still largely in development, these weapon systems are deployed by other countries, and it is unclear whether they do depend on any type of facial recognition, or if they are generally used as WMDs. But we also encounter other ethical questions of what it means for an autonomous weapon to be able to take a human life, such as who would be held responsible for the wrongful death of a civilian, or how such weaponry distinguishes between a civilian or a soldier, as killing of a civilian in war is considered a violation of international law [3].

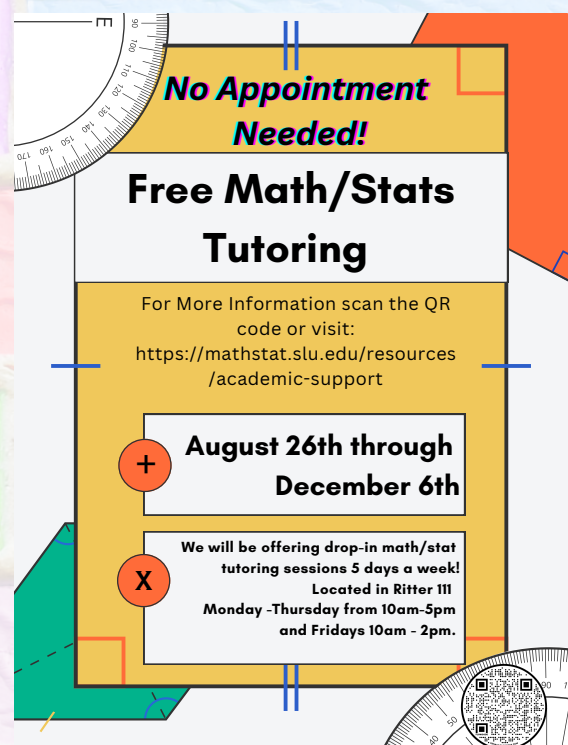
The Path Forward

As we continue to innovate and integrate AI into our daily lives, it's essential to create inclusive environments in tech education and development. By prioritizing representation and amplifying diverse voices in AI, we can mitigate biases that have real-world consequences.

The conversation around AI isn't just about technology; it's about ethics, humanity, and our shared future. Let's ensure that everyone has a seat at the table, shaping the technology that will define our world. It's not just a moral imperative; it's crucial for the safety and dignity of our society.

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Flattening Hypercubes: A Geometric Approach to Power Sums

By Evan Socher

Undergraduate Student, Department of Mathematics and Statistics, Saint Louis University

Power sums are some of the simplest and most natural objects of study, giving rise to questions such as, is there a simple closed formula for the expression $1 + 2 + 3 + \dots + n$? What about for $1^2 + 2^2 + 3^2 + \dots + n^2$ or $1^{2349} + 2^{2349} + 3^{2349} + \dots + n^{2349}$? Many of us are likely familiar with the formula for the sum of the first n integers, supposedly discovered by Gauss at a young age, and some of us may even be familiar with its visual proof as in Figure 1 below.

This Interlocking Staircase proof works by making “steps” of width 1 and height k , where k goes from 1 to n . The combined area of these steps is equal to the sum of the first integers, and cleverly nestling together two copies of these stacks forms a rectangle with base n and height $n + 1$. We can thus infer that twice the sum of the first n integers is equal to the area of the rectangle, $n(n + 1)$, or, equivalently, the sum of the first n integers is equal to half of the area of the rectangle, $n(n + 1)/2$. So, we may ask: could similar reasoning hold for higher powers?

$$\sum_{k=1}^n k + \sum_{k=1}^n k = n(n + 1)$$

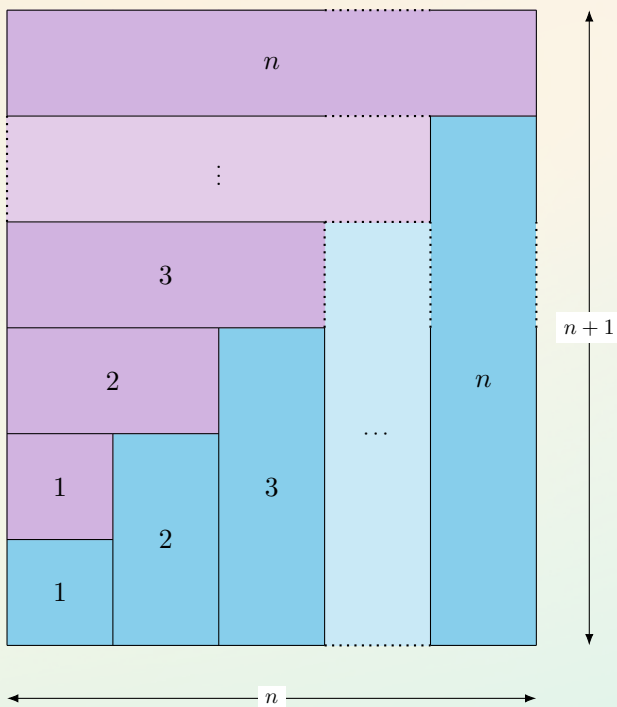


Figure 1: The Interlocking Staircase

$$\sum_{k=1}^n k = (n + 1) \sum_{k=1}^n 1 - \sum_{k=1}^n \sum_{j=1}^k 1$$

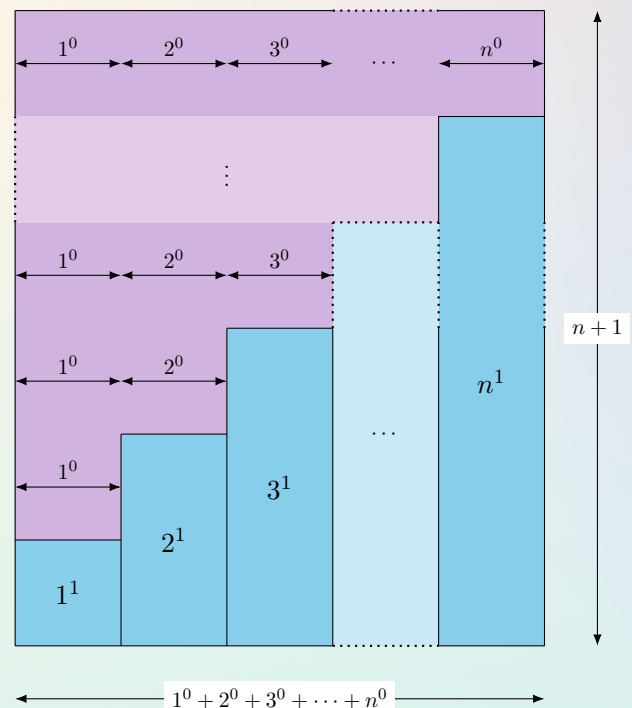


Figure 2: Adapted Staircase

$$\sum_{k=1}^n k^p = (n+1) \sum_{k=1}^n k^{p-1} - \sum_{j=1}^n \sum_{k=1}^j k^{p-1}$$

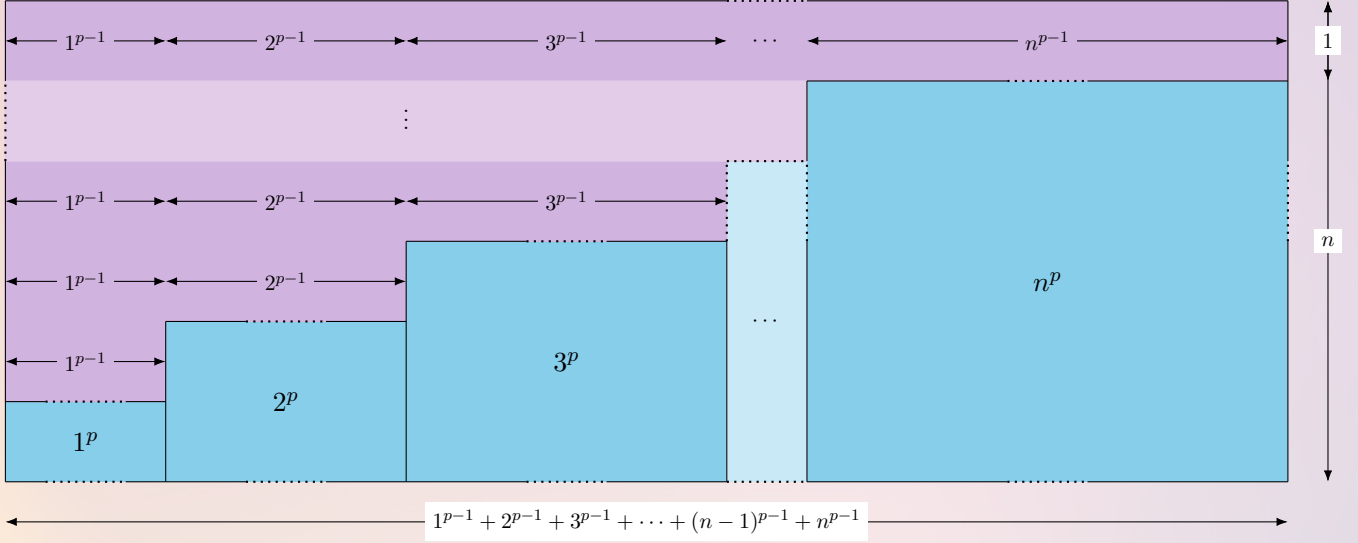


Figure 3: Recursive formula for n^{th} partial sum of k^p

I was first introduced to this staircase visual proof in Calculus II, and, after a bit of work, I was able to deduce the formula I knew to be true for the sum of squares. When I tried to use the same geometric approach for cubes, however, I got stuck trying to wrap my mind around interlocking stacks of cubes, until realizing the simple fact that $k^3 = k \cdot k^2$. This means we could instead stick to 2-dimensions and make use of rectangle steps with base k^2 and height k . From this seemingly trivial realization, the generalization, as well as the idea for the following visual demonstration, was clear. Despite being terribly impractical for large powers (even just $p \geq 4$), this formula illustrates how a simple idea allows us to “flatten” the incomprehensible p -dimensional hypercube, k^p , down to the humble rectangle, $k \cdot k^{p-1}$.

Starting with only the knowledge that $\sum_{k=1}^n k^0 = n$, we can use the formula to arrive at

$$\begin{aligned} \sum_{k=1}^n k &= (n+1) \left[\sum_{k=1}^n k^0 \right] - \sum_{j=1}^n \left[\sum_{k=1}^j k^0 \right] = (n+1)[n] - \sum_{j=1}^n [j] = n(n+1) - \sum_{k=1}^n k \\ &\implies 2 \sum_{k=1}^n k = n(n+1) \implies \sum_{k=1}^n k = \frac{n(n+1)}{2} \end{aligned}$$

We can now use the formula again to arrive at

$$\begin{aligned} \sum_{k=1}^n k^2 &= (n+1) \left[\sum_{k=1}^n k^1 \right] - \sum_{j=1}^n \left[\sum_{k=1}^j k^1 \right] = (n+1) \left[\frac{n(n+1)}{2} \right] - \sum_{j=1}^n \left[\frac{j(j+1)}{2} \right] \\ &= \frac{n(n+1)^2}{2} - \frac{1}{2} \left(\sum_{j=1}^n j^2 + \frac{n(n+1)}{2} \right) = \frac{n(n+1)(2n+1)}{4} - \frac{1}{2} \sum_{k=1}^n k^2 \\ &\implies \frac{3}{2} \sum_{k=1}^n k^2 = \frac{n(n+1)(2n+1)}{4} \implies \sum_{k=1}^n k^2 = \frac{n(n+1)(2n+1)}{6}. \end{aligned}$$

Thoughts on and Images from My Notebook

By Michael Landry

Assistant Professor, Department of Mathematics and Statistics, Saint Louis University

This is a piece about my research, but my goal in writing it is not to convey mathematical content. Rather, I want to give readers, especially undergraduates, a flavor of what mathematics research looks and feels like for me.

On Notebooks

Different people catalog their thoughts in different ways, including mathematicians. Over time, I have found that the way I like best is to write all my ideas in a single notebook. I prefer blank, unlined pages so that I can write and draw in any location and every direction, a preference that means that I usually have to shop at an art supply store. At any given time, I have one notebook that I'm writing in, and into it goes essentially everything: notes taken at talks I attend, conversations with collaborators, random ideas I have in the middle of the night, even drafts of important emails. I fill it up from front to back, and when it is full, it gets stored on my bookshelf.

One pleasant result of this practice is that I can easily go back to my old notebooks and see what I was doing and thinking about at a certain time. For example, when I was researching this article, I was able to find the exact page where Grad Student Me had an idea that led to me writing my first solo paper. I also saw my past self asking questions that I can now answer, which was satisfying. There are plenty of missteps and errors, too: for example, a page of ideas written enthusiastically at a Paris brasserie¹ accompanied by the scrawled note "THIS IS FALSE" from several weeks later.

My notebook contains mostly drawings of and thoughts about mathematical ideas, but since it's often the most accessible writing surface, inevitably

¹I have found that many of the pages prompt memories of my location at the time of writing.

some grocery lists and other ephemera make their way in. Various things I saw while looking through my old notebooks while preparing to write this include:

- a portrait of me drawn by a stranger at a bar
- a list of improvements I was planning to make to my bicycle at some point
- descriptions of restaurants my spouse and I ate at on our honeymoon
- a list of potential alternate careers I made while applying for postdoctoral jobs (example: "move back to Santa Cruz² and pedal a compost bike").

I originally intended to go through all my old notebooks and curate my favorite pages for this piece, but that proved to be too big of a task. I settled on choosing a personally significant notebook, sharing some pages from that, and giving a little of the backstory.

My Lockdown Notebook

The speed at which I fill a notebook varies. In the time since I started saving notebooks midway through grad school, the longest it took me to fill one up was about 14 months, and the shortest was one month. The one-monther was written from mid-March to mid-April in 2020.

In January of 2020, I discovered a mistake in a proof that I had been working on. Essentially, I had been writing an algorithm that took certain kinds of complicated configurations of objects in a 3-dimensional space and made them very simple. What I had been overlooking, and it was painfully obvious once I realized it, was that one of the operations I wanted to use to simplify the configurations had the potential to make them even more complicated. (I found the notebook page where I realized

²My hometown.

I had made a mistake and included it in Figure 1. Including it is technically breaking my own rules for this piece since it came from the notebook before the notebook I am highlighting.)

Mistakes are common in math research, but for various reasons, this one sent me into crisis. One factor was that I was earlier in my career (I earned a PhD in 2019), and my mathematical self-esteem was more fragile than it is now. Another big one was that I had already told two of

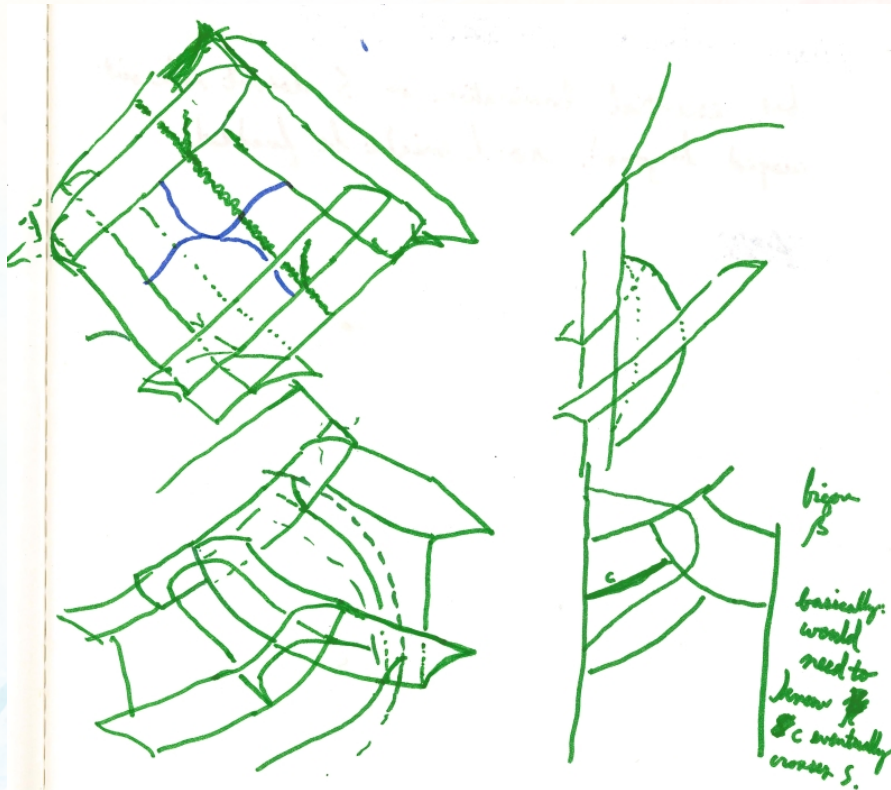


Figure 1: The moment I found a mistake in my proof in January 2020.

my collaborators that the result I had “proved” was true, and we were relying on this “Theorem” in a separate, joint project. It felt like if I couldn’t fix this mistake, not only would all the math I was doing be ruined, but I would be letting my colleagues down.

February 2020 was, therefore, quite a stressful time for me. I was scrambling to find a way to fix my proof while spending most of my time teaching two classes (as a fresh PhD, this was more than I had taught before). I remember oscillating between emotional extremes as several times I thought I had a fix, only to find a reason the fix didn’t quite work.

When the COVID-19 lockdown happened in March 2020, I abruptly had oceans of time to devote to fixing my mistake. I fumbled around with many ideas and began to learn and appreciate the intricacies of my problem that I had previously ignored. Many of my memories of this time are tied to the pandemic: going on walks around my neighborhood, staying far away from everyone I saw, and trying to organize my ideas. The uncertainty that everyone felt about global events was for me accompanied by mathematical uncertainty. Although I kept learning new things about the problem, and it felt like I was making progress, I wasn’t sure it would work out—the statement I was trying to prove was either true or it wasn’t.³

Skipping ahead, the story ends well. After an important epiphany a few weeks into lockdown (I found the corresponding page for this too, see Figure 2), I was able to string together enough lemmas and observations into a long and complicated new proof. This also allowed the other joint project I was

³A lesson I learned from this experience: try very hard to avoid becoming emotionally or professionally dependent on the truth or falsity of a mathematical statement.

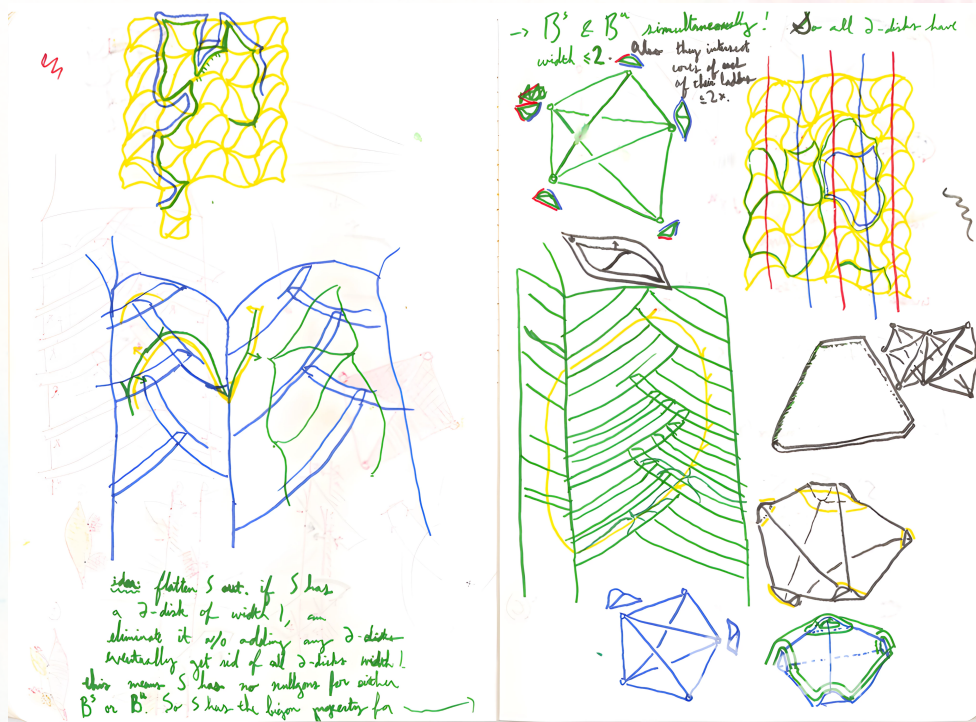
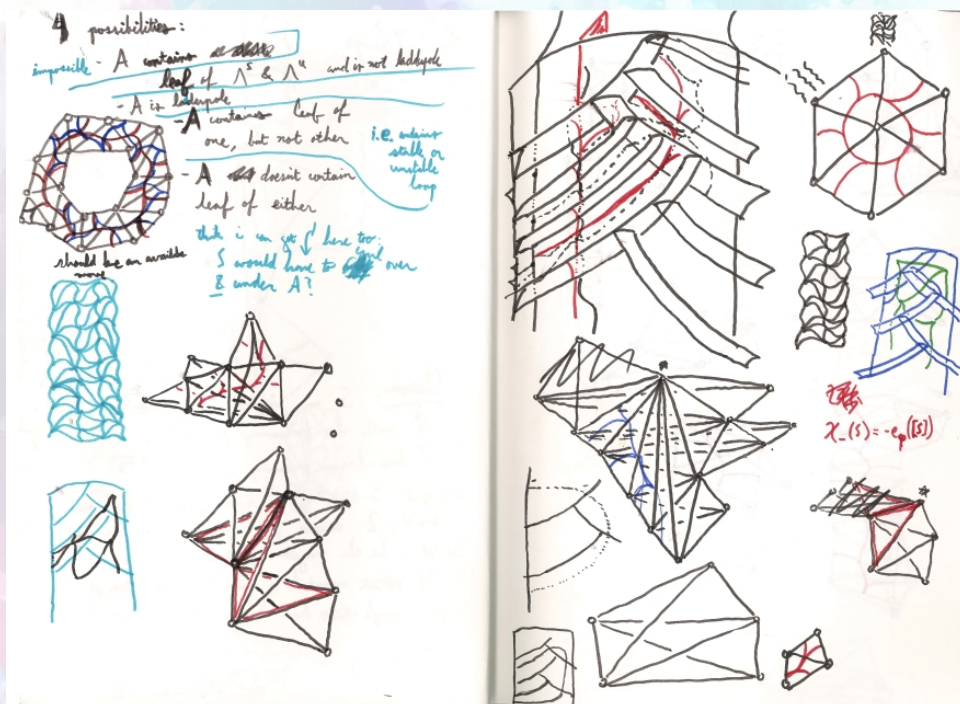


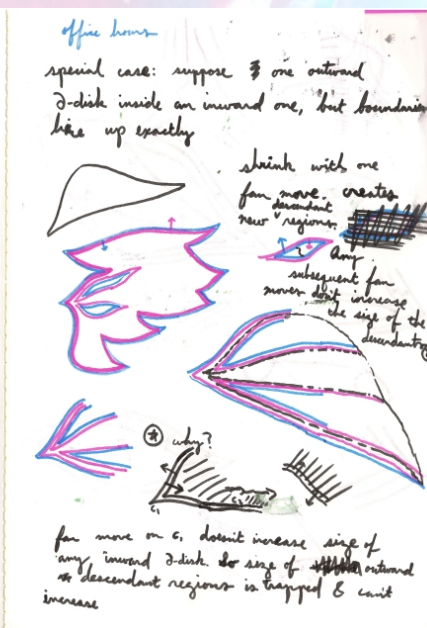
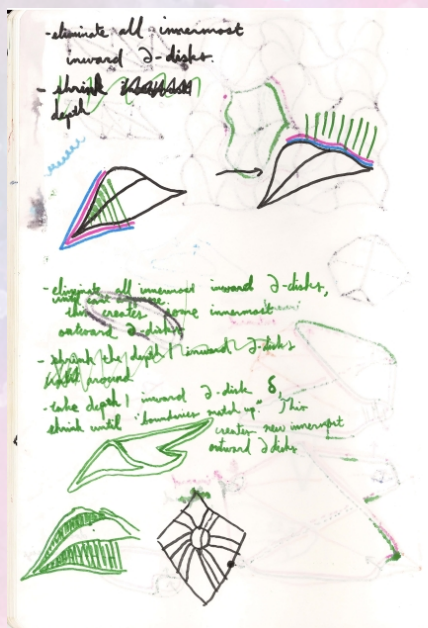
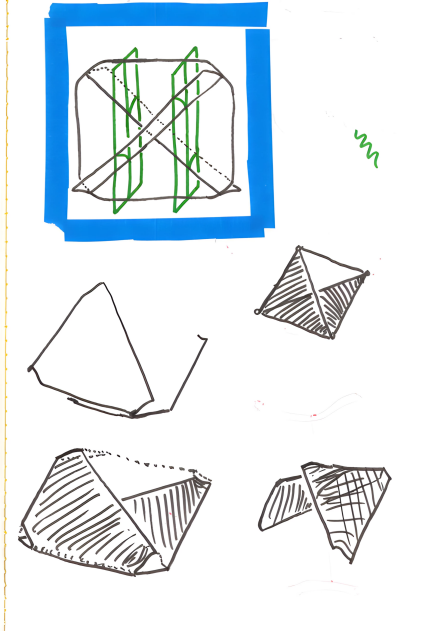
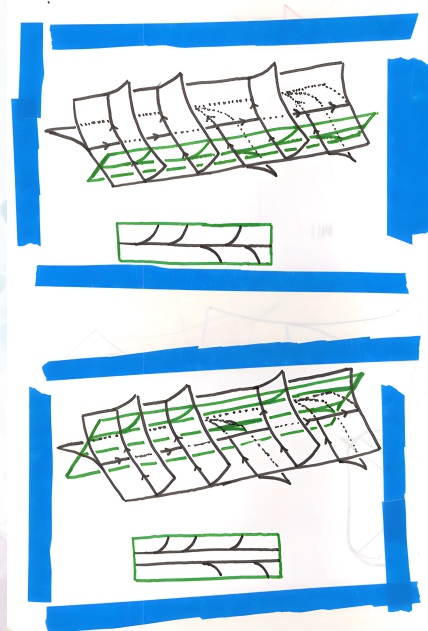
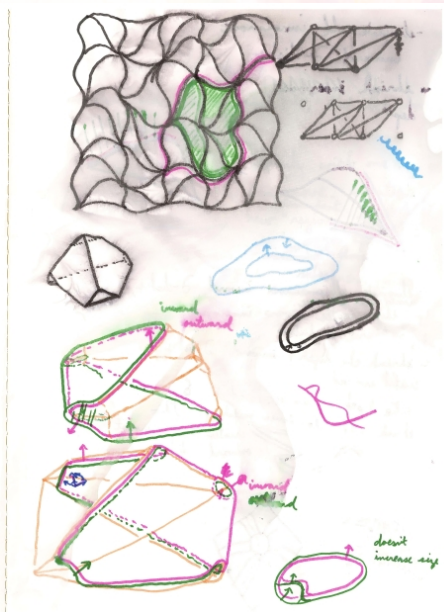
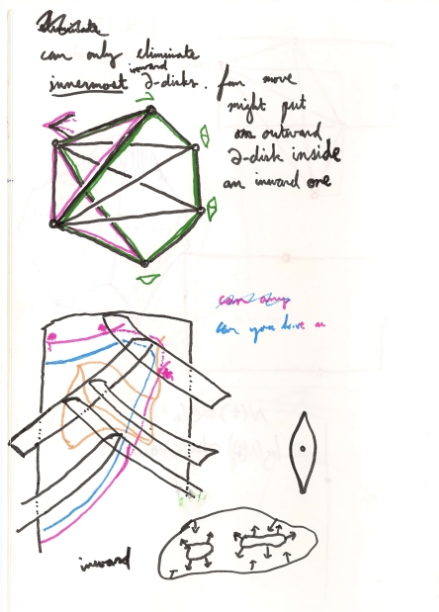
Figure 2: This page was written in my living room when I had a key realization, after which I felt like I was really on the right track. The scribbles read, in part: "So S has the bigon property for B^s and B^u simultaneously!"

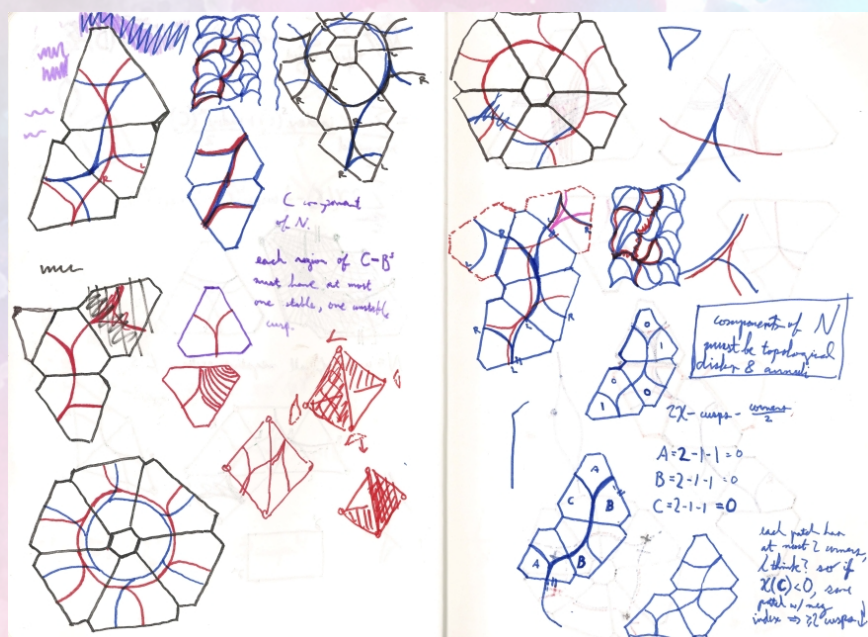
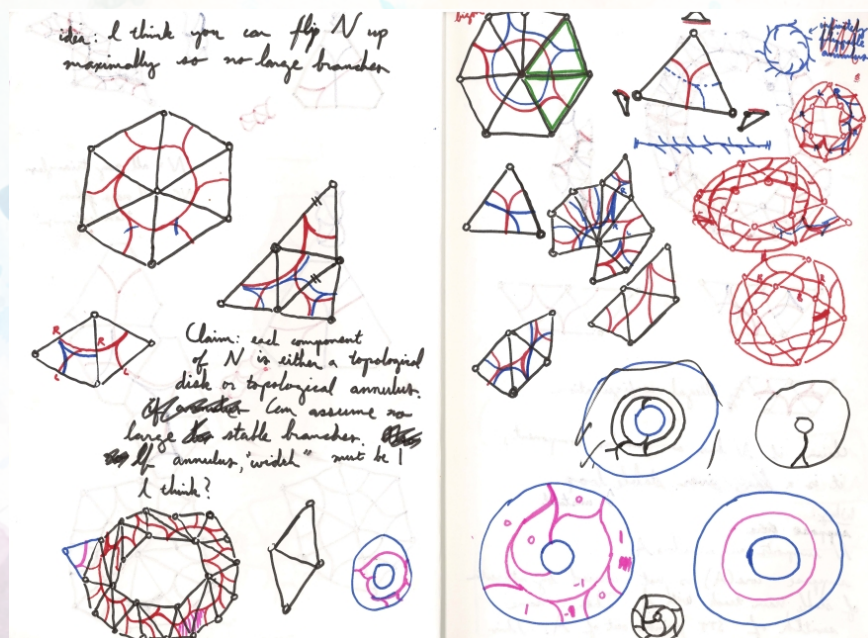
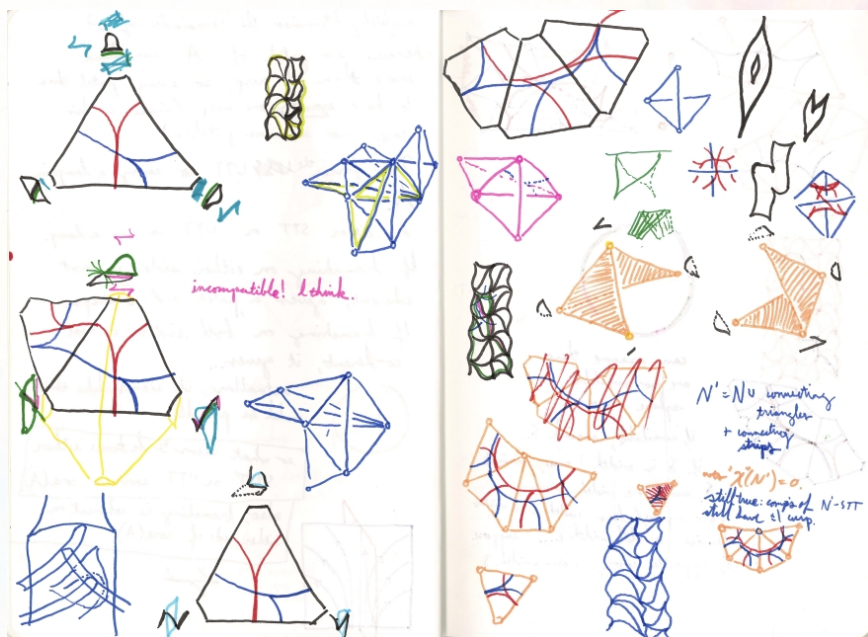
working on to proceed as planned. Through Spring and Summer 2020, I worked steadily on the papers, but the work was much more pleasant and less emotionally fraught since the crucial points had been resolved.

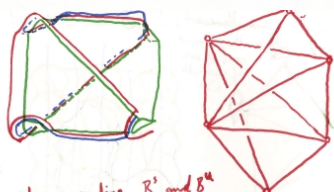
This whole time, I was filling my notebook at a rapid pace. A lot of the ideas were very visual, so the notebook is mostly pictures. Out of all my notebooks, I found that not only was this the one that took the least time to fill, but it was also the most visually interesting to me. With that, here are some of my favorite pages⁴.



⁴For a version with larger images, see mathstat.slu.edu/~landry/notebooks.pdf.







idea: combine B^3 and B^4
index sum.

$$\text{index}^*(P) = \frac{\text{index}^3(P) + \text{index}^4(P)}{2}$$

then $\sum_{P \in S} \text{index}^*(P) = 2\chi(S)$

also $2e_g = \sum_f \text{index}(f) \cdot \langle f, - \rangle$

$$2e_g(S) = \sum_{\text{facet } D} \sum_{\text{facet } T} \text{index}(T) \text{sgn}(D)$$

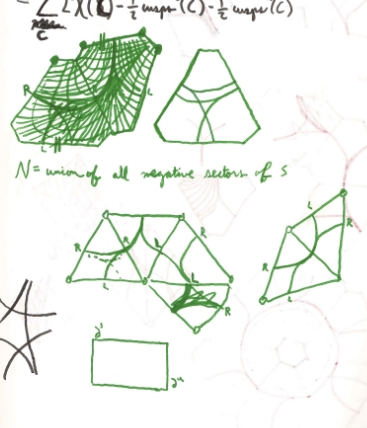
$$\text{index}^*(C) = 2\chi(C) - \frac{1}{2} \text{curvature}^3(C) - \frac{1}{2} \text{curvature}^4(C)$$

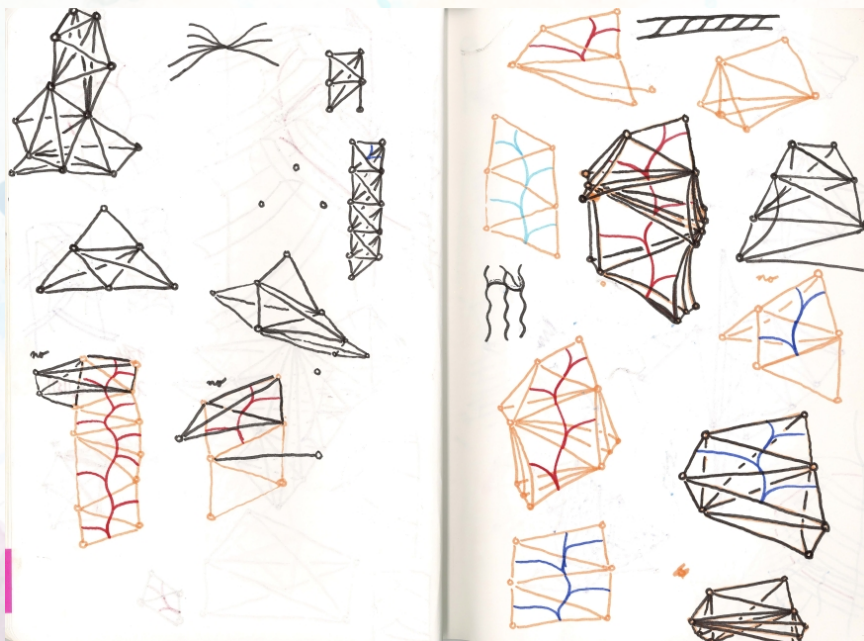
$$\sum_{\text{facet } T} \sum_{\text{facet } D} \text{index}(T) \text{sgn}(D) - \text{index}(D) \frac{1}{2}$$

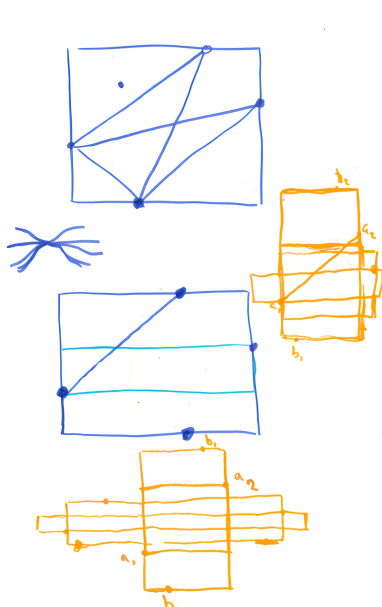
$$= \sum_{\text{non-trivial } C} \frac{\text{index}^3(C) + \text{index}^4(C)}{2}$$

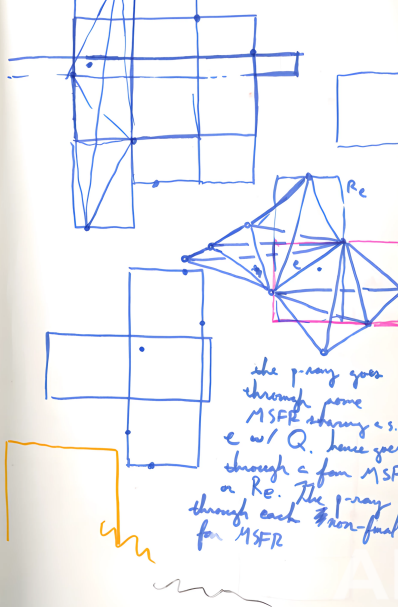
$$= \sum_{\text{non-trivial } C} 2\chi(C) - \frac{1}{2} \text{curvature}^3(C) - \frac{1}{2} \text{curvature}^4(C)$$

$N = \text{union of all negative sectors of } S$

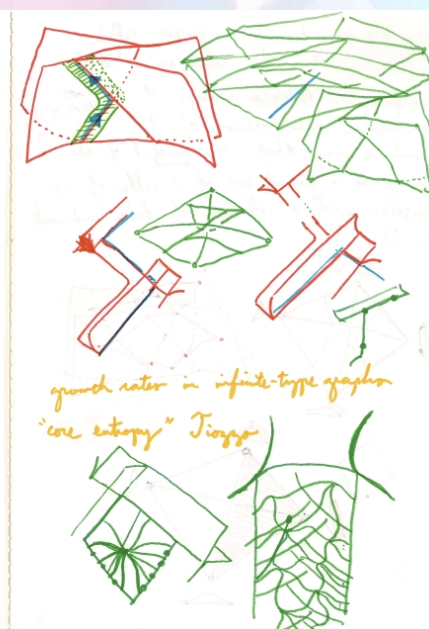
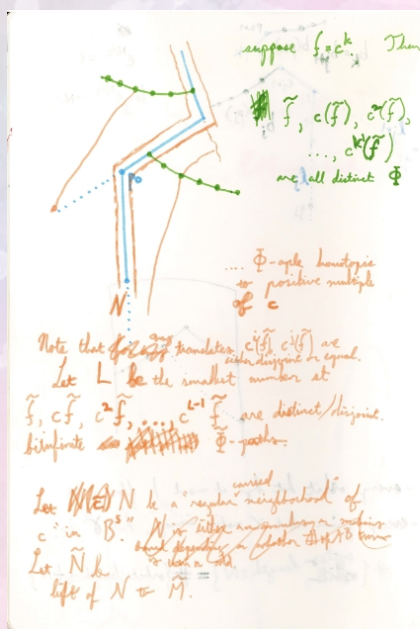
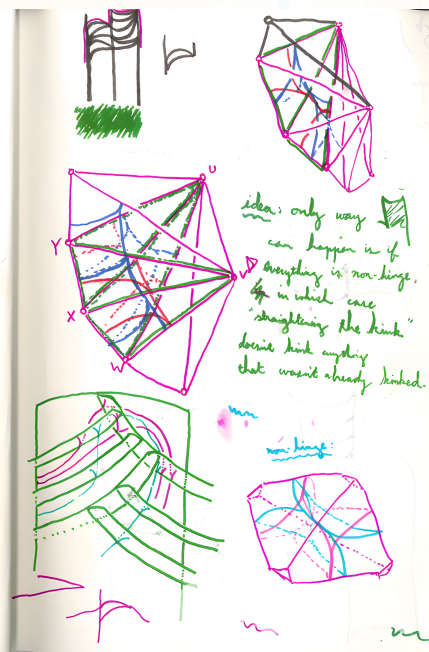
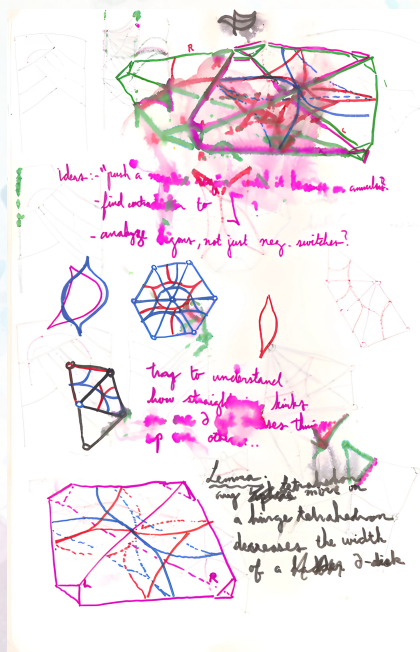
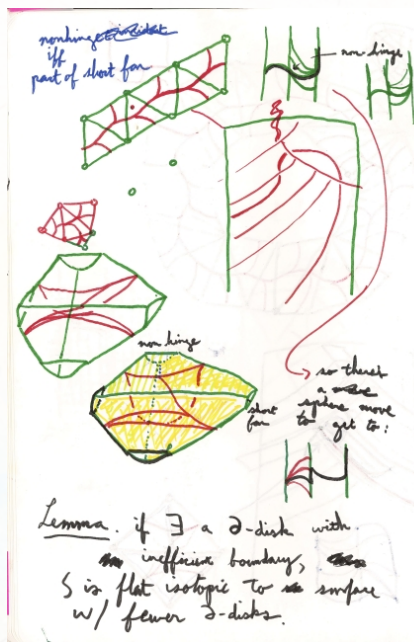


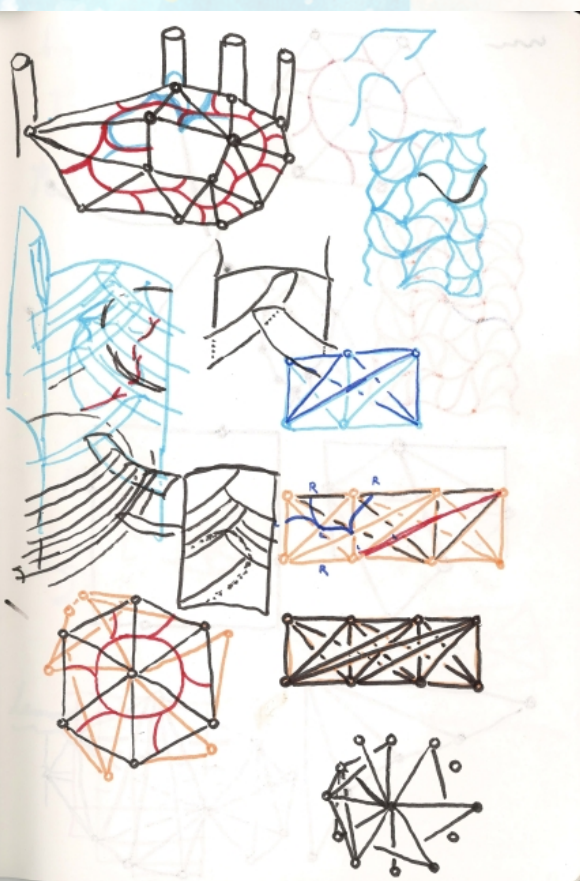
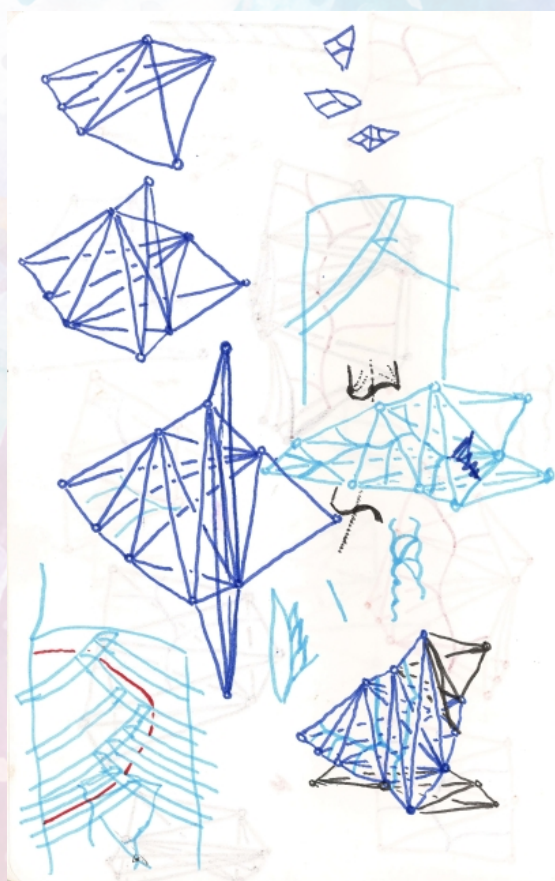
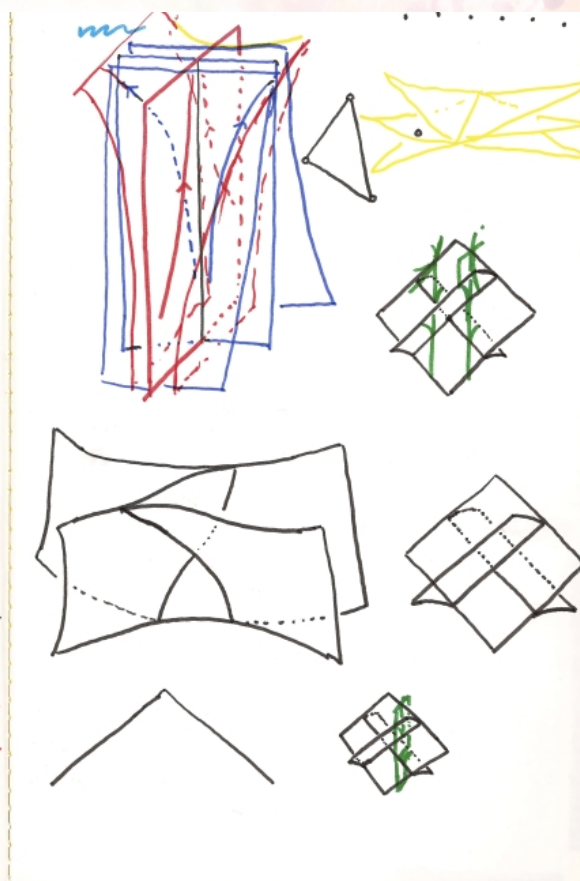






the p-ray goes through some MSFR starting a.s.c. e w/ Q . hence goes through a fan MSFR on P_e . The p-ray through each non-fan for MSFR





Conclusion

In social situations, I am often asked what I do for work, and I generally reply that I teach math and do math research. Sometimes the questioner wants to know what the research is like, and it can be a struggle to explain. To me, what I do is travel through worlds full of strange technology and governed by mysterious laws, trying to systematically piece together how things work and interact. It can be lonely, frustrating, and emotionally draining, but also fun and rewarding. I usually don't say all that, however, because it sounds pretentious and self-important⁵. Pictures might be better for making my point. I hope that looking at the pages I have shared here, as well as reading some of what I was going through at the time, gives you some idea of what I experience when I do research in mathematics.

Acknowledgements

I was supported by NSF grant no. DMS-2405453.



Ilka Agricola
(b. 1973)

Born in the Netherlands, Agricola earned her PhD from Humboldt-Universität zu Berlin (2000) and is currently Full Professor at University of Marburg. From 2014–2018 she was Dean of the Faculty of Mathematics and Computer Science. Agricola directs Marburg's Collection of Mathematical Models, around which she cultivates a lively community. Agricola has co-authored 4 books in global analysis and mathematical physics, has over 30 other publications, and has mentored 8 PhD students. She leads Math4VIP, a program that increases accessibility for mathematics students with visual impairments (2023). In 2016, Agricola was awarded the Ars Legendi Preis Mathematik by the DMV (Germany). She was also president of the DMV (2021–2022) and named a Fellow of the AMS (2022).

This poster is part of the EvenQuads project, which combines innovative mathematical card games with learning about amazing women mathematicians. The project celebrates the 50th anniversary of the Association for Women in Mathematics.

If you want to learn more about EvenQuads, scan the QR code below.



Perla Myers
(b. 1968)

Perla Myers earned her PhD from the University of California, San Diego (1995). She is Professor of Mathematics and Executive Director of the Jacobs Institute for Innovation in Education at the University of San Diego. Myers uses experiential learning pedagogies to build mathematical communities in both K–12 and higher education. She leads culturally relevant STEM learning experiences using Minecraft, origami, and multilevel mathematical mentoring. She also works to cultivate diverse faculty communities through cohort hires. Myers was awarded USD's Innovations in Experiential Education (2002), a 2011 Women of Impact Award, and the MAA Southern California-Nevada section teaching award (2013). Her work is supported by numerous grants including from the NSF S-STEM, NSF-ADVANCE, and NSF ITTEST programs.

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⁵Is this whole article pretentious and self-important? Perhaps!

Welcoming New Faculty and Visiting Scholars

The department welcomes those who joined our faculty in August!

Daniel Haider



Daniel Haider is a research visitor at our department for the fall semester of 2024. His stay is supported by the Marietta-Blau Fellowship of the OeAD (Austria's Agency for Education and Internationalisation). Daniel is a Ph.D. student in Mathematics at the University of Vienna in Austria and is conducting his project "Frame Theory meets Neural Networks" at the Acoustics Research Institute of the Austrian Academy of Sciences under the supervision of Peter Balazs. The project is funded by an individual DOC grant from the OeAW. Daniel is interested in multidisciplinary work across the fields of frame theory, harmonic analysis, audio signal processing, and machine learning. More specifically, he develops frame-theoretic approaches to study the stability and invertibility of neural networks and proposes architecture designs and regularizers to ensure stable invertibility with a particular focus on audio applications.

Outside of research, he is a big outdoor sports enthusiast and loves snowboarding, (any kind of) surfing, rock climbing and simply exploring nature

on trips. He also enjoys writing, producing and performing weird music with his band GRUBER.

Vahan Huroyan



Vahan Huroyan joined our department in August 2024 as an Assistant Professor. He developed a passion for mathematics early on, competing in math olympiads, both nationally and internationally, while attending a specialized physics and mathematics school in Yerevan, Armenia. This experience helped him solidify his decision to pursue mathematics as his future profession. He earned his bachelor's degree in mathematics from Yerevan State University and completed his Ph.D. in 2018 at the University of Minnesota under the supervision of Professor Gilad Lerman, focusing on mathematical data science and machine learning. From 2018 to 2022, he worked as a postdoctoral researcher at the University of Arizona, working with Professor Stephen Kobourov in the Tripods research group, where he specialized in dimensionality reduction and visualization techniques. Although he was initially scheduled to join Saint Louis University in 2022, his start was delayed until 2024. During the interim, from 2022 to 2024, he continued his research at the YerevaNN Research Lab and Yerevan State University, focusing on computer vision and

representation learning tasks. His research interests lie at the intersection of mathematical data science, machine learning, computer vision, and statistics. He is also passionate about teaching machine learning, statistics, probability, and numerical linear algebra.

Lukas Köhldorfer



Lukas Köhldorfer joined our department in October 2024 as a Visiting Scholar. He is a PhD student from Vienna, Austria. His main scientific focus is on frame theory and related areas. In his free time, he enjoys playing drums in a band.

Women Mathematicians Corner

The Association of Women in Mathematics (AWM) started a project called “EvenQuads” to celebrate their fiftieth anniversary by designing a playing deck of cards and honoring notable women mathematicians. Thanks to AWM for permitting us to share these playing cards in our magazine.



Rosemary Guzman
(b. late 1900s)

Guzman is Mexican-American and a Teaching Assistant Professor at the University of Illinois (in Urbana-Champaign). She served two terms as assistant director of the Illinois Geometry Lab. She was also an NSF Alliance postdoctoral fellow at the University of Iowa and an AAUW American postdoctoral fellow at the University of Chicago. Guzman works in hyperbolic 3-manifolds and geometric group theory. Guzman has co-organized three conference sessions focusing on inclusion of traditionally underrepresented groups in mathematics. She has been an invited speaker in the IPAM Latinos in the Mathematical Sciences Conference, and was featured in the Notices of the AMS during Women's History Month in 2018.

This poster is part of the EvenQuads project, which combines innovative mathematical card games with learning about amazing women mathematicians. The project celebrates the 50th anniversary of the Association for Women in Mathematics.

If you want to learn more about EvenQuads, scan the QR code below.

EVENQUADS



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Sijue Wu
(b. 1964)

Wu is from China and completed her graduate work in the US. She is the Browne Professor of Mathematics at the University of Michigan, having previously worked at Northwestern University and the University of Maryland at College Park. Her research focus is on nonlinear partial differential equations in fluid dynamics, and her work has appeared in *Inventiones Mathematicae*. Wu was awarded the AMS's Ruth Lyttle Satter Prize (2001) and she was an invited speaker at the International Congress of Mathematicians (2002). She was the first female recipient of the Morningside Gold Medal (2010), the most prestigious award for mathematicians of Chinese descent given by the International Congress of Chinese Mathematicians.

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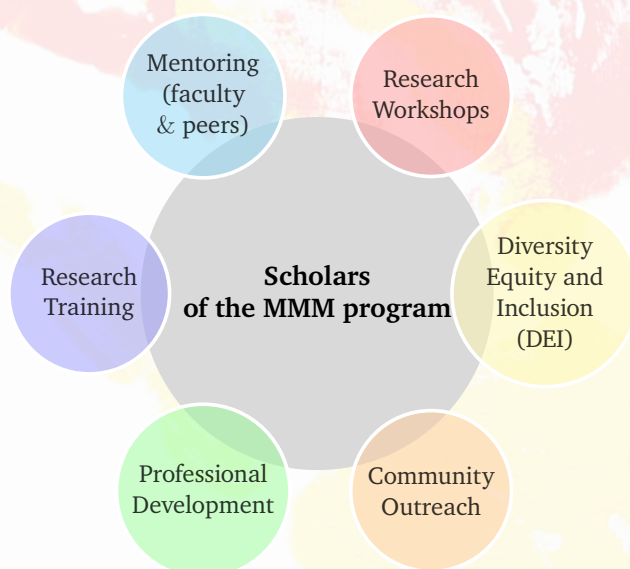


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Mentoring Math Minds Program

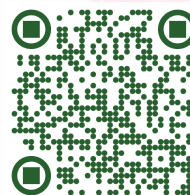
In the Fall of 2024, the Department of Mathematics and Statistics at Saint Louis University launched a Research Mentoring Program tailored for both graduate and undergraduate students, with a strong Diversity, Equity, and Inclusion (DEI) component for the academic year. This program is designed by Dr. Ghoreishi, Dr. Pozzi, and Dr. Uğurlu who share a dedication to mentoring and advising students in mathematics and fostering their professional development.

This is a scholarship-based program, and it provides multiple opportunities to scholars including being involved in research projects, having access to platforms to present their work, attending workshops and conferences, and building a sense of belonging in the mathematics community. All the workshops and activities are carefully designed by the program leaders to ensure the success of scholars.



Application Period January 15 – March 30, 2025

All interested candidates are invited to complete an online application form. Applicants will be asked to submit their resumes, letters of interest, and DEI statements. We welcome applicants from diverse backgrounds to contribute to the richness of this program.



Interested in learning more about the events, application process, and deadlines? Check out the program website at:

mentoringmathmind.wordpress.com

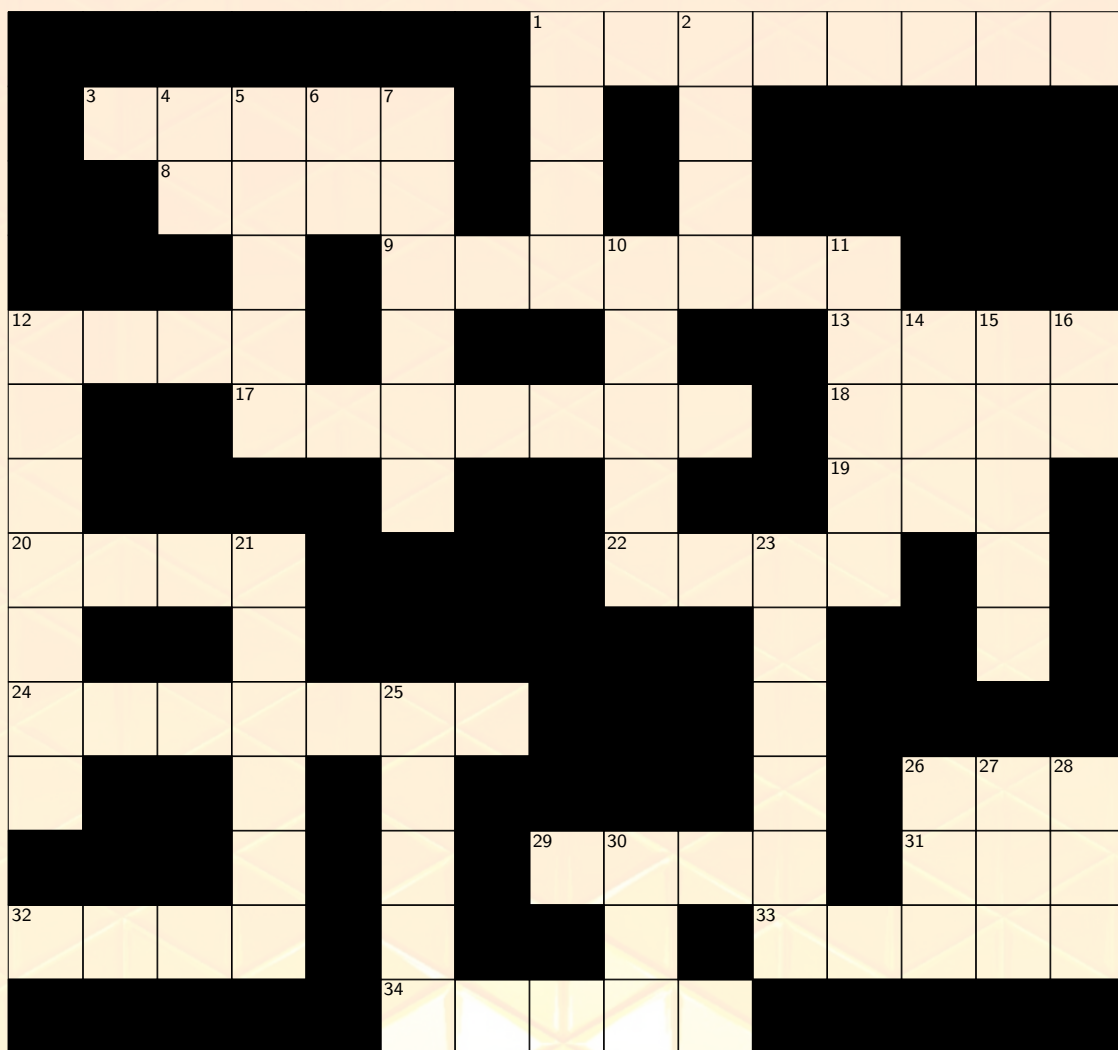
Admission and Community Agreement

Upon admission, successful applicants will be requested to sign a Community Agreement, emphasizing the program's aspects and expectations. This agreement aims to create a safe and supportive environment for all participants.

Inquiries about the program?

Contact us at: mentoring.math@slu.edu

Crossword Puzzle
Created By Kieran Favazza



Across

- 1 Can be written like $\frac{p}{q}$
- 3 Teacher of Riemann
- 8 Represents an element of π_1
- 9 Proposed 23 problems in 1900
- 12 Flow rate of a vector field through a surface
- 13 Zero of a polynomial
- 17 Abelian group = free group + _____ group
- 18 In a ring, an invertible element
- 19 A kind of series where many terms cancel out, abbr.
- 20 Can draw without lifting up the pen, abbr.
- 22 Has a famous equilibrium
- 24 Arithmetic mean
- 26 A group as a collection of matrices, abbr.
- 29 Describes the space of linear functionals
- 31 Al-Khwarizmi invented it, abbr.
- 32 A collection of nested vector spaces: _____ variety
- 33 The most prolific collaborator
- 34 The dreaded $\varepsilon - \delta$ definition

Down

- 1 Not imaginary
- 2 Hawking wrote a brief history of it
- 4 Maybe a nickname for Russell's co-author
- 5 $U(x, t)$
- 6 The special orthogonal group
- 7 The boundary of a ball
- 10 A kind of motion is named after him
- 11 Or falsity
- 12 Like the Sierpiński Gasket or the Cantor Set
- 14 The probability of you enjoying this crossword puzzle
- 15 Sounds like the guy who solved the Basel Problem
- 16 Initials of the Australian Fields medalist
- 21 Pioneer of computer science, unknown for many years
- 23 A function that takes on only finitely many values
- 25 Made many uneasy with his Incompleteness Theorem
- 26 Unit of angle measure, abbr.
- 27 Rating system in zero-sum games
- 28 Your professor might tell you to read a few of them, abbr.
- 30 Subtracting by 1 makes it nilpotent: it's _____ potent

Save the date!

MATH

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