Mathemalchemy: What is it, and how did it start?

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INTRODUCTION

Ingrid Daubechies: What is Mathemalchemy and how did it come to be? Mathemalchemy is the art and math exhibit that is currently being shown in the Juniata College Museum of Art. This is a story that has several beginnings, like every story. I am a mathematician and I enjoy doing this type of work. Moreover, I have been long fascinated by mathematical art. There are many different collaborations within this piece to include all sorts of creative aspects. Mathemalchemy is a pertinent work for your college because it reflects the integration of the arts and sciences. In what follows we will continue to expand on this synergy.

BACKGROUND

Dominique Ehrmann: I can do art because I have time in my life to explore. More specifically, the reason I do fiber and fabric art now is because of a fishing trip. My husband, Stéphan Lacourse, is a private fisherman. In 2005, he asked, "Will you go camping and fishing with me for a month-long trip?" At that time in my professional life, I was a chocolatier and truly wondered what I would be doing while Stéphan was fishing. Since I enjoyed casual sewing, I requested that Stéphan create a sewing machine that could be used without any electricity. He organized everything. As he was out catching dinner, I used my new, solar-powered sewing machine. That became the beginning. Sewing took me on an unexpected path towards a life as a fabric sculptor and fiber engineer.

I originally thought that my first fabric landscape would take only a couple of days. I was completely wrong. It ended up being a three month-long project. As I worked on it at home, I gave myself challenges. I would write a pattern and then transcribe it onto a panel with the sewing machine. In 2007, I left my chocolatier position. Making, decorating, and shaping chocolate was an outlet for me to express art but in a non-permanent way. I was very comfortable with that for years. At this point, I felt a new

drive and yearned for a transition to making art works that would last. I cleaned my chocolate workshop and I started to experiment with different types of fabric, including paper. I was hooked on doing something other than traditional pieces.

I wanted to test my skills and creativity and build a larger project, which became *Come and Follow Me*. I was looking for a structure to build the project on. To start this process, I began looking at books to gain the information I was missing. When I opened a pop-up book, all the information I needed was there. I knew how to create it, build it, and adapt to challenges. I started the process drawing, like I always do, and made a precise small-scale model, and then enlarged it to full-size (which interestingly, required a change of aspect ratio to keep working well) (Figure 1). For the next piece, *Kinetic Quilt*, I wanted to control more elements. I ultimately created a quilt that turns with the wind (Figures 2 and 3). In yet another piece, *Luminescent*, I added in several kinds of fabric and experimented with them by layering. I placed the cutouts to allow the perception of the quilt's color to be changed by the lighting. Finally, I composed an even larger and sculptural piece that integrated many of my earlier experiments – this was *Time to Break Free*. This was the piece Ingrid saw. She liked both the full composition, and also the detailing of the designs. Ingrid contacted me and I answered the first message asking to explore a partnership; this ultimately became the Mathemalchemy project.

Figure 1. "Come and Follow Me," art by Dominique Ehrmann. Photo: the artist.

Figure 2. "Kinetic Quilt A," artwork by Dominique Ehrmann. Photo: the artist.

Figure 3. "Kinetic Quilt B," artwork by Dominique Ehrmann. Photo: the artist.

Figure 4. "Time to Break Free," artwork by Dominique Ehrmann. Photo: the artist.

THE LAUNCH

Daubechies: I had seen her work. I knew the level of quality Dominique is capable of. My first job was to tell her the idea of Mathemalchemy. It is a collaborative experiment that brings together people with exquisite skills in mathematical art. I pointed her to a number of websites of some of those people already doing mathematical art. She quickly accepted. Together With Dominique we were now ready to complete this proposal. I sent her many books on mathematics and art. They detailed all the methods that we could use for illustrations and explanations of several concepts at the same time.

Ehrmann: I was reading around two to three hours every morning along with some light reading in the afternoon, which was a new experience for me in exploring a project.

Daubechies: Dominique and I were talking every week. We have been talking every week since September 19th, 2019, to be exact. We would talk, Dominique would make drawings, and then she would show me those drawings for us to expand upon and move forward with our ideas.

SESSION AT THE JOINT MATHEMATICS MEETINGS

Dominique constructed a 1:8 size scale maquette that fit into a small suitcase to travel to the Joint Mathematics Meetings so that we could present our project on January 20, 2020. The JMM meeting usually hosts 5,000-6,000 people. We had formulated a presentation sketching out the idea of Mathemalchemy. We gave the presentation jointly. We also made sure to highlight that the aim is for it to be collaborative. In other words, while we had some initial ideas, they were also up for discussion. As a matter of fact, the end result became extremely different from the first complete design. When we asked people to sign up, Kim Roth, a Professor of Statistics and Mathematics at Juniata College, signed up that day along with many other talented people.

TEAM OF MATHEMALCHEMISTS

Daubechies & Ehrmann (intermingled): We didn't know whether our idea would work. We were open to the very real possibility that no one would be interested. The creators on the team would need to have the drive, the passion, and the urge to do this project, and do it together. Many of the people in the audience had a background in building mathematical art, but were used to working by themselves. We were delighted that many signed up right there. Even after the Joint Mathematics Meetings, we continued to have more people sign up. This influx of people was due to the connections of the people already involved. They were friends of team members who-held complementary skills. The final count of team members was 24. We call ourselves the Mathemalchemists because the project is the alchemy of art and mathematics. It was also an alchemy of many different personalities.

Once we had a team, we needed to organize. The general plan moving forward was to have a multitude of workshops during which we would design and collaborate on fabrication. We secured funding for travel and materials, and we were set to go.

COLLABORATION

Daubechies: The first workshop was planned to be at Duke University in March of 2020; later workshops would follow in May or June, and then wrap up between August and September. Then the Covid-19 Pandemic happened. In March of 2020, Duke was not allowing visitors on campus. It was closed, like everything else at the time. Instead, we did lots and lots of Zoom. We had a two-day workshop collaborating over Zoom to replace the in-person March plans. During the time of the original timeline, we did the Zoom workshop and worked out the basic organization of the installation. We continued for several months in weekly meetings. We zoomed, we made decisions, and broke up into little work groups. We even had an instructional meeting that was extremely effective for people who did not know how to zoom yet. I am still impressed that people stuck around for all those Zoom meetings – there were *many* of them.

Originally, we thought that we would be able to exhibit the work in January of 2021; we decided, given the pandemic, to move this timeline and to plan to be ready in January 2022.

Because of the pandemic, we were all sheltering at home, and this led to new challenges. To create an installation in which the different components would harmonize with each other, we needed a color chart system to which all 24 mathematician artists would consistently adhere. To this end, Dominique got paint chip samples that she sent to everyone. Several little work groups that would meet during the week and then report back to the weekly Sunday meetings of the whole team. It was very intense, but it was a community. We were building a community that helped us remain optimistic and alive and fun during the pandemic. I personally felt enthusiasm and feelings of inspiration every time we meet with each other. Dominique and I also our own two-person meeting every week to steer organizational details. We often marveled at the sense of family that was developing in our group.

Ehrmann: Each time we discussed a new, large addition to the structure it was my role to see if it would work, if it would fit, and if it would go together. I would go to my workshop and work on a small model of the entire build. I went through a few very small-scale models at first, and then concentrated on a 1:4 model that incorporated all the different elements and scenes, which I built in August of 2020.

TECHNIQUES AND CRAFTS USED AND LAYERS IN THE INSTALLATION

Many different craft techniques were used in the fabrication: beading, weaving, sewing, quilting, needle felting, temari ball and standard embroidery, woodworking, knitting, crochet, stained glass, steel welding, painting, wire bending, ceramics, polymer clay, laser cutting, light projection, and 3D printing.

Besides these creative crafting techniques there are many layers to the content of the installation. Essentially, the Mathemalchemy structure shows a magical world. In that world objects and customs are slightly different from our own world. We called it *Through the Mathemalchemy Looking Glass*. In this world, many different scenes are depicted and many stories are playing out.

SCENES WITHIN THE MAGICAL WORLD

Ehrmann: Let's look at one of the first stories to develop . Tess the Tortoise is the protagonist in this story. As we adapted and refined Mathemalchemy, Tess ~~w~~as also adapted. This installation shows Tess going out on an adventure while learning about limits and infinite processes.

The Curio Shop

One scene here is a curio shop named Conway's Curios, in tribute to famous mathematician~~,~~ John Horton Conway, who died in 2020 from Covid-19. Conway, who is known for many things, is most famous for his contributions to combinatorial game theory and surreal numbers. Beyond Conway's Curios, there is the Terrace with Horton (named after Conway) the bower bird, who is looking out of a miniature telescope to watch what is happening in Knotical Bay. He wonders what kind of strange nautical creatures the boat has captured.

The Bakery

In the Bakery, Baker Arnold, who is a cat, has just filled a cookie sheet with pi-shaped cookies with the help of his assistant Mose, who is a mouse. The names of the ~~baker~~ and his assistant are a nod to the famous mathematicians Vladimir Arnold and Jürgen Moser, who worked on Dynamical Systems and founded the Kolmogorov-Arnold-Moser (K.A.M.) theory. Arnold is a cat because the mathematician Arnold first mapped motion on a two-dimensional torus using a diagram of a cat; mathematicians working in this area are all familiar with Arnold's cat. The pi-shaped cookies are designed to be tiled, so that after punching out the shapes and transferring them to a baking sheet, there are fewer scraps to roll out again.

One wall in the Bakery has a very particular wallpaper, illustrating nine different ways in which a simple pattern (in this case, the sketch of a mouse) can be repeated in a wallpaper-like pattern – these are known as *wallpaper groups*. There are 17 wallpaper groups in total, the nine in the Bakery are only those

that involve reflections and glide motions, but no rotations, because the Bakery wallpaper was made by knitting, a technique that doesn't lend itself well to rotations. The missing eight patterns can also be found nearby, in the Curio Shop and the Terrace, where they are realized in cross-stitch embroidery and patchwork.

The Playground

Daubechies: In the Playground, the chipmunks play a game to find prime numbers. (A prime number is an integer greater than 1 that can be written as a product only of itself and 1.) For each number they count out, they lay the exact number of acorns out and then see whether they can arrange them in rows of a fixed length, checking whether that works out evenly or leaves a remainder. In the Meadow, the squirrels are holding their annual Sieving of the Primes festival. In other words, they take a more advanced approach to finding primes using a Sieve of Eratosthenes than the chipmunks do. As they count, skipping numbers that are already veiled, they discover the primes one by one, continuing to eliminate multiples of each new prime.

Knotical Bay

Ehrmann: Another significant part of the installation is Knotical Bay. Knot theory is a part of mathematics. It has to do with the shape of how things twist and turn. That is why the nautical scene is spelled with a K. There is a grand structure, the lighthouse, standing tall. It illuminates the way for those at sea to a safe port. On top of the lighthouse, you have a beautiful structure. The stereographic projection beacon is designed by Dr. Henry Segerman. The light from the very bottom of the sphere that extends onto the ceiling making for a beautiful alternative to stars at night.

Books

The little girl sitting on a stack of books was an early component of the project. However, that stack of books is not just a stack of books. They represent the world or the knowledge that is there to support the little girl. We did not know until the delivery of the installation that the layers of books would acquire much a bigger life on their own.

Daubechies: We realized that the books needed a sound structure. The little girl is in fact sitting on a stack of models of real books. They were interesting to use, especially on the wood floor. To anchor her on, there is a piece of metal running of the stack that attaches to the girl. It is not visible, but it is just as important as the other designs.

Ehrmann: We also had to decide what books are the most important books to include in Mathemalchemy. However, this was not an easy decision as the concepts included in the project come

from all cultures. There are four categories of books: historically important books going back to the very roots of mathematical thinking in different cultures, more contemporary mathematics books in a serious way, contemporary mathematics books in a playful light (both of which have concepts in the exhibition), and books that illustrate the importance of mathematical approaches in unexpected areas. For each book, a bookmark or two is inserted that has a portrait of a particular person linked to that book.

The Quilt

Daubechies: The Cryptography Quilt is another structure that is a large component in Mathemalchemy. It is a real quilt with a real stitched pattern and vibrant blue and white tones. Every block in the center of the quilt alludes to one of the scenes in the installation; several have coded messages for the audience to decode if they wish. The outer blocks illustrate cryptographic concepts developed throughout history. The patchwork and quilting are done mostly by sewing machine; attaching the finished quilt to the underlying structure was done by hand. The solid internal structure plays an important support role: the quilt is free-standing, with both sides exposed. This thing has been standing here at Juniata College for five months and it is still in perfect condition.

Ehrmann: On the other side of the Quilt is the Doodle Page. We originally had the idea to explain various types of mathematics on it, but the team had mixed feelings on moving forward with that choice. The line of thinking was that adding those details would not accentuate the whimsical and fun feeling we wanted the audience to perceive with this section. After many discussions, we decided to put on the Doodle Page the drawings and doodles of six different women mathematicians to blend their different disciplines as well as different epochs. Those six mathematicians are Ada Lovelace, Gladys West, Alicia Boole Stott, Maryam Mirzakhani, Sofya Kovelevskaya, and Caroline Series; the border of this quilt showcases tilings by nonregular (but identical) pentagons by a seventh (non-professional) mathematician, Marjorie Rice.

CELBRATION OF WOMEN

The majority of people who signed up to work on Mathemalchemy are women, even though women are a minority in the mathematical community. As a team with lots of women on board, we made it a priority to celebrate women in mathematics. We picked women from many different backgrounds and roles to include in the project's details. A large contribution is the Doodle Page. Alicia Boole Stott did not have a college degree because her family could not afford to educate a woman in the family. Despite having no higher education, she had incredible realizations dealing with four-dimensional geometry. Those ideas led her to receive honorary degrees later in life. There is also work by Gladys West, who was

an African American woman working for NASA. She analyzed data from space that was absolutely fundamental for modeling the earth to establish accurate geostationary networks for GPS navigation.

CONCLUSION

Daubechies: Every piece of art has a unique balance. We sized the structure of Mathemalchemy, and we knew about the mountain of work we needed to do to accomplish the piece. Because of our excellent team, we were able to incorporate an enormous number of ideas successfully into the installation.

Ehrmann: This is an extremely precise project. It took attention to detail to bring this project together. Ultimately, if you can draw something, then you can sew it. It is the same thing. It is the transference of paper ideas into physical creations. Mathemalchemy came into being because of the abilities of our team and the hard work over the months it took to get to this point, and the unflagging enthusiasm of all the team members.