Seeing Mathematics as a Physics Major

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Mathematics is an area where the content's relevancy reveals itself with time. After all, the way we're taught mathematics can seem the opposite of how we're taught other subjects. Traditionally, we first learn computational techniques, then, maybe even years later, we learn theory and application. This is why when most people think of math, they think only of computation. We can easily see the relevancy of arithmetic in our daily activities involving basic operations: counting money, taking measurements, sharing a pizza. It's safe to say there is a consensus around its use in our mundane tasks. But what happens when we are instead confronted with more abstract ideas?

In the summer of 2018, I took Introduction to Linear Algebra. At the time, the level of my math education went up to Calculus II. As an early physics major with only classical mechanics under my belt, I found calculus to make sense. Dealing with rates of change and finding areas over surfaces, or under curves, were skills that directly bridged the two subjects. Therefore, in the first couple of weeks of linear algebra, all I wanted to do was to apply the techniques of solving linear equations to something physical. That's what I had been used to, and what I had come to expect. However, this was not the case. While at first I experienced, let's say, a mild frustration, I came to realize the benefit of being stretched outside of my awareness of mathematics.

Our professor implemented instruction that supported our understanding of the world of linear algebra, outside straightforward computation. We completed projects utilizing mathematical software that produced visualizations of linear systems. We used these visualizations to consider what it meant for a system to be linearly dependent or independent, as well as to support our comprehension of span and subspaces. We also watched *Flatland· The Movie,* adapted from the novel by Edwin A. Abbott. We were asked to ponder spatial dimensions beyond our own 3-dimensional world, just as the characters in the film and book were presented with dimensions beyond their own. Although it was difficult to visualize hypercubes, hyperplanes, etc., we were able to reason about their characteristics based on mathematics. By this point in the course, I was intrigued by the concepts themselves and was less demanding of real-world application.

In order to supplement our growth as mathematicians, our professor encouraged us to attend events in the city, or to visit the National Museum of Mathematics, MoMath. I visited the museum on one of our days off from class. Everything in the museum was interactive, of course, and to my recollection, I didn't need paper and pencil for any of the exhibits. The activities I took part in at the museum were not directly related to linear algebra; I manipulated a track in order to explore acceleration, I entered "mazes" where one had to follow specific patterns in order to exit, I rode a tricycle with square "wheels" on a floor made of rounded beams, creating a smooth ride. Yes, I had fun. But more pertinently, these activities reinforced the idea that our common perception of mathematics is limiting.

As I've continued in my physics courses, I've now encountered topics where the skill set of linear algebra applies. In Introduction to Quantum Mechanics, for example, we employ linear operators and commutators on wavefunctions in order to determine eigenfunctions and eigenvalues. We have also touched on matrix representations of operators, specifically, on how to express the raising power operator of the harmonic oscillator in matrix form. While the procedures we utilize are not the same as the ones from linear algebra, exposure to the concepts has been extremely beneficial. It's provided me with a foundation on how to think about what I'm learning. Just like hypercubes, it's difficult to visualize the superposition of stationary states of a wavefunction, for example. However, by applying mathematics, we can "observe" some of its characteristics. Mathematics isn't just the act of crunching numbers; it's a tool for seeing beyond what our eyes allow.

By pushing outside of our comfort zones and contemplating abstract concepts, we can begin to expand our understanding of mathematics. This serves to prepare us for those moments when we are presented with new topics as we progress in our areas of interest. I look forward to more challenges as I continue to grow at New York City College of Technology, in an environment that is conducive to learning, research and cutting-edge application.

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