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MATHEMATICS AS A TOOL OF OPPRESSION IN THE UNITED STATES

LAS MATEMATICAS COMO FERRAMENTA DE OPRESSÃO NOS ESTADOS UNIDOS

A MATEMÁTICA COMO HERRAMIENTA DE OPRESION EN LOS ESTADOS UNIDOS

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RESUMO

A recente politização da matemática tem levado a questões sobre sua pedagogia nas escolas dos Estados Unidos, mas essas questões falham em reconhecer a matemática como uma ferramenta potencialmente opressiva. Neste ensaio, demonstro que há forças muito maiores à mão que melhoram a maneira como as pessoas pensam sobre a matemática e como as pessoas a consideram em suas vidas é muito mais valioso. Aqui, exploro brevemente três eras distintas de desenvolvimento matemático que produziram três respostas culturais distintas. O primeiro é Fibonacci, cujo trabalho foi geralmente aceito e evitou críticas. O próximo é Galileu, um matemático que enfrentou um retrocesso significativo e cuja pesquisa e progresso foram interrompidos e banidos. Em seguida, examino os Estados Unidos e destaco a capacidade de um governo de obter o controle das estruturas matemáticas sem a capacidade de sufocar completamente a publicação e a pesquisa. Vou traçar um arco através dessas três eras distintas para concluir a maneira mais eficaz de desmantelar estruturas de poder baseadas na matemática: um esforço mútuo para nivelar hierarquias que envolvem igualmente aqueles que estão no poder e aqueles que estão à mercê da própria estrutura.

Palavras-chave: Galileu. Fibonacci. poder. opressão.

ABSTRACT

Recent politicization of mathematics has driven questions about its pedagogy in U.S. schools, but these questions fail to recognize mathematics as a potentially oppressive tool. In this essay, I demonstrate that there are much larger forces at play and that improving the way people think about mathematics and how people regard it in their lives are much more valuable. Here, I briefly explore three distinct eras of mathematical development that yielded three distinct cultural responses. First is Fibonacci, whose work was generally accepted and steered clear of criticism. Next is Galileo, a mathematician who faced significant pushback and whose research and progress were halted and banned. I then examine the United States and highlight a government's ability to wrest control of mathematics structures absent the ability to completely stifle publication and research. I will draw an arc through these three distinct eras to conclude the most effective way to dismantle mathematically-based power structures: a mutual effort to flatten hierarchies that equally involve those in power and those at the mercy of the structure itself.

Keywords: Galileu. Fibonacci. power. oppression.

RESUMEN

La reciente politización de las matemáticas ha generado cuestionamientos sobre su pedagogía en las escuelas estadounidenses, pero estos problemas no reconocen a las matemáticas como una herramienta potencialmente opresiva. En este ensayo, demuestro que hay fuerzas mucho más grandes disponibles que mejoran la forma en que las personas piensan sobre las matemáticas y cómo las personas las consideran en sus vidas es mucho más valiosa. Aquí, exploro brevemente tres eras distintas de desarrollo matemático que produjeron tres respuestas culturales distintas. El primero es Fibonacci, cuyo trabajo fue generalmente aceptado y evitó las críticas. El siguiente es Galileo, un matemático que enfrentó un importante retroceso y cuya investigación y progreso fueron detenidos y prohibidos. Luego miro a los Estados Unidos y destaco la capacidad de un gobierno para obtener el control de las estructuras matemáticas sin la capacidad de sofocar por completo la publicación y la investigación. Trazaré un arco a través de estas tres eras distintas para concluir la forma más efectiva de desmantelar las estructuras de poder basadas en las matemáticas: un esfuerzo mutuo para nivelar las jerarquías que involucran por igual a quienes están en el poder y a quienes están a merced de la estructura misma.

Palabras clave: Galileu. Fibonacci. poder. opresión.

Introduction

Mathematics innovation in Western Europe and eventually the United States has undergone significant shifts over the last 800 years. Innovation, uninhibited at times, is more often subject to government or religious authorities who see innovation as a threat and treat it accordingly. The United States was once at the forefront of promoting innovation for the common good, but perhaps only before it had jurisdiction to control or stifle its development. By examining power structures in three distinct eras, distinctions can be made to show how math has more often been used to seize control. This is not the fault of mathematics, but rather the power structures. For ruling authorities, power is the aim and not progress. This suffocates discovery and oppresses humanity. The U.S. was not always a global power. As its strength rose during arguably the most rapid and intense century of learning and discovery in our planet's history, factors that either contribute to mathematics being used for good or to oppress can be highlighted.

Phase 1 - Minimal resistance to innovation (pre-15th century): Fibonacci

Leonardo Bonacci (*filius Bonacci* or Fibonacci) developed a model to predict rabbit population growth over generations: the *Fibonacci Sequence*. In the early 13th century he also introduced fractions to Italy (Goetzman, 2004), although they look quite different from how they are used today. His contributions to mathematics may belie their significance, but they far exceed coincidental connections to discoveries before and since. The Golden Ratio can be traced back 4500 years to Giza (Markowsky, 1992), including Greek architecture in the 5th century BCE. Leonardo da Vinci's 1490s *Vitruvian Man* leaned on these concepts (Iosa, 2018).

Fibonacci's understanding of partial numbers may have been limited to a previously little-used or unfamiliar concept of ratios, but today one can quickly derive the sequence {0, 1, 1, 2, 3, …} that models the Golden Ratio[1]. The larger the n, the more accurate the estimate. For example, for n = 6, the estimate is only 3% errant. For $n = 12$, it is 0.009% and by $n = 24$ its accuracy is within 8.81 x 10-8%![2] Discoveries

[1] For any nth number in the sequence, the Golden Ratio can be estimated by $f(n) \div f(n-1)$

[2] These calculations assume the sequence begins at 0, more widely accepted than it starting at 1.

of the ratio and the sequence are separated by nearly two millennia, yet an entire curriculum could be built around its countless connections to nature, construction, and perceived human beauty.

Fibonacci studied extensively with Arab scholars in Northern Africa and largely based *Liber Abaci (The Book of Calculation)* on this international study (Devlin, 2011). The Hindu-Arabic number system then spread to other European countries (Danna, 2021). Fibonacci's work and contributions to mathematics and science are critical. Without undermining his genius, he shares important connections to mathematicians centuries before and since. Despite substantial mathematical and scientific contributions, though, he appears to have steered clear of trouble. His discoveries were terrestrially and not celestially based, though, which is an issue other eras would have to contend with to avert controversy.

Phase 2 - Significant resistance to innovation (~1436 to ~1650): Simon Stevin vis-à-vis Brahmagupta; the Galileis (Galileo and his father)

Before the invention of the printing press (c. 1436), it was much easier to keep mathematical discoveries in the dark. Over a span of roughly 200 years, seismic cultural shifts had dramatic effects on how people related to church, government, and other power structures.[3]

Nearly a millennium earlier and 6,500 km away, Brahmagupta was representing partial numbers with what we today refer to as decimals and fractions (Swain, 2012). He described the quantity of zero, using and discovering notations integral to his quadratic formula solution. Despite the time gap, Simon Stevin (1548-1620) was among the first to push fractions and decimals into common use in the Western World with his 1585 booklet *The Art of Tenths* (Castel-Branco, 2020).

Mathematical and scientific contributions can also be *falsely attributed*. Leibniz's contributions to calculus were underappreciated for many decades (Chandler, 1960) and Nikola Tesla never saw his contributions fully implemented (Brittain, 2005). Stevin's notoriety for assembling and presenting fractions may have been more an issue of *the right place at the right time*. Others presented similar ideas, even in Western Europe but Stevin was able to consolidate others' learning around the quadratic formula, decimals, and fractions (Won, 2009).[4] Stevin's success publicizing a 1,000-year-old idea was a function of *privilege*. Many works misattribute Stevin as "discovering" mathematical principles he simply repackaged.

Stevin was largely inspired by Vincenzo Galilei (1520 - 1591), an accomplished lutist, composer, and music theorist (Palisca, 1983). Stevin would inspire Vincenzo's son, the more well-known *polymath* Galileo Galilei (1564-1642). Stevin split the generational difference between father and son (Castel-Branco, 2020) and the work of all three is intellectually inextricable.

Stevin introduced, popularized, and discovered waterway management and nomenclature for geometry, physics, trigonometry, music theory, and bookkeeping (Geijsbeek et al., 1914). Most of these concepts had nearly no portable vocabulary. Stevin created the language of these fields, so is perhaps responsible for more important neologisms than anyone else in the Western world. Without vocabulary, his contributions would not have found the same traction.

Galileo Galilei: Inadvertent blasphemy

Where Stevin consolidated, named, and implemented principles, Galileo was inspired by Archimedes and Euclid and was drawn to astronomy and physics (de Santillana, 1955). This allowed Galileo to

[3] These events included but are not limited to Columbus' explorations, European settlement of the Americas, the Protestant Reformation, and the Galilean Revolution (c. 1642).

[4] Brahmagupta's contributions to mathematics are indispensable; however, here I focus on examining Western Europe's eventual influence on the Americas. No discredit or misappropriation toward Brahmagupta is intended by this limited focus.

extend discoveries with refracting telescopes (Atreya, 2010). Soon he trod into sacrosanct Roman Catholic territory, though. Galileo believed he was merely extending Stevin's work.

To the Roman Catholic Church, however, two of his topics were far from benign; they were portals to hell (Seife, 2000). He (1) insisted on the existence of the number zero and (2) claimed Earth was not the center of the universe.

Galileo believed the *sun* was the center of the universe. We now know that is false, but the shift from geocentrism alerted the Roman Inquisition. Church leaders deemed Galileo was reinterpreting the Bible and therefore in violation of the Council of Trent (de Santillana, 1955).[5] [bjkm]

Catholic leaders accused Galileo of *Protestantism*. This was tantamount to excommunication just 100 years after Martin Luther's 95 *Theses*. Galileo denied his findings were religious in nature and is generally seen to have been blindsided by the Church's response (de Santillana, 1955). The Church ubiquitously managed the academic work of its citizens, among whom Galileo was counted. He was subsequently found guilty of heresy and forbidden from publishing, as well as other consequences (de Santillana, 1955). One of the finest mathematical minds to ever live was prohibited from further contribution.

It's worth noting the lasting obstinance; the Church's stance on Galileo softened in the century after his death, but papal condemnation of the Church's response did not occur until 1992 (Finocchiaro, 2005). In 2008 Pope Benedict XVI suspended plans to erect a statue in The Vatican, with no apparent plans to resume construction (CBS News, 2008).

Comparing mathematical prowess to the punitive treatment some have received suggests that when a religious or political faction sees mathematics as a threat, that controlling faction seeks one of two options:

1. stifle its discovery and publication through punitive, legal, and corporal means. If this is not practical or possible;
2. seize control and/or ownership of key tenets of its discovery.

Religious positions throughout the centuries have held rigid views on the spherical nature of our planet, evolution, and natural selection, and - as it has been seen - mathematical concepts. Contemporaneous to Stevin and Galileo, the first American colony was established in 1607 (Turner, 2016). Those seeking relief from religious persecution often fled to the New World. European settlement was not unique to North America, though this focus will be on the effects of religious and educational influence on dynamics in what became the United States.

Phase 3 - Punishing discovery instead of controlling innovation (~1650 - today), the United States

The use of partial numbers in the 17th century was novel, even among the elite. With hindsight, we can note how religious and/or political dogmas can stifle scientific discovery. This steers my argument to Colonial America. By the mid-17th century, settlements and colonies were actively populating the eventual United States, primarily by those fleeing Britain. Soon, though, over a period of fewer than 200 years, the United States transitioned from an experiment in a liberal democracy to an innovator of mathematics and science discovery and global power.

During this rapid change of identity (or perhaps *as a result of it*), the United States was heavily involved in chattel slavery, a clear indication they were not invested in prosperity for all. Shifting from an upstart

[5] While acknowledging some still hold a geocentric view, modern astronomical discoveries do not support this as a tenable position (Britannica, 2009).

colony to hegemonic power aligns with a willingness to adopt subjugating systems, even of its own citizens.

In the late 18th century, decimals and fractions were practically untested. The Mint Act of 1792 made the U.S. just the second country to subdivide its currency into base-10 (Allen, 2009). The general population was scarcely aware of fractions in concept, much less in their calculation, making this a bold, yet positive, step.

Despite the novelty of fractions in money and politics, it is inexcusable that just 5 years before the Mint Act, constitutional framers saw fit to consider subdividing *human beings.* Fractions had barely advanced beyond understanding and the use of numerators other than 1, yet U.S. leaders believed they had a firm-enough grasp to create a 'compromise' to fractionally count humans.

Even with the perceived barbary of dividing a human for political purposes, the Northern States (the eventual Union) appear to have pivoted this by agreeing to consider enslaved peoples 60% to benefit their *long game* of eradicating slavery (Harvard, 2020). They used their savvy and power for good. It is uncommon to see governments use superior mathematical knowledge to benefit humanity.

As the United States grew, though, it cared less about promoting the common good. It was one of 17 nations supporting the globalization of the metric system in the 1870s, but never made the switch (House, 1879). Outside medicine and science, no major push for adoption has taken hold since the late 1980s (Fehr, 1992). By virtue of its power, the U.S. government demonstrates its privilege to subjugate its population with an inferior mathematical system.

In less than 125 years the United States went from a mathematical trailblazer to resisting the adoption of a global measurement standard. The government's priorities speak more loudly through this contradiction than any resolutions or laws. It is the latter that drove much of the 20th-century infrastructure boom.

Roadways, telecommunications, and the mail system

In 1914, the United States created a state highway association that secured matching funds to partner with states (Woolbright, 1949). Interstate highways were proposed in 1924. A joint board was established and within 3 years a numbering system was in place (McNichol, 2006). For 25 years there was little change to a numbering hierarchy that allowed for nationwide consistency. Following World War II, establishing a world-class freeway system was deemed a critical priority. The original system (US Highways) intended to connect existing towns; Interstates permitted quicker travel. President Dwight Eisenhower stressed national defense to push through a freeway system that ripped apart communities and neighborhoods.

The Federal Aid Highway Act was a significant overhaul, adopting numbering similar to the US Highways (National Highway Program, 1956). While organized numerically, it sacrificed community vitality. The story not often enough told is of communities permanently dismantled in the name of "progress." When freeways came, Americans quickly changed the way they traveled and what they looked for once there. Pixar's 2006 movie *Cars* told this story as historical fiction (The Psychosocial Implications, 2019). Lower-income and minority communities and neighborhoods were far more likely the populations cleared for these freeways (Pritchett, 2000). Salient examples include Route 710 near Los Angeles, CA (Avila, 2014), U.S. Highway 75 in Omaha, NE (Greenberg et al., 2020), and dozens of expansions in and near Houston, TX (Lin, 1995). In each case, thriving residential and commercial centers in minority neighborhoods were demolished.

In the 1950s and 1960s, *eminent domain* pushed freeways through developed areas in full view, displacing and unhoming millions more. Politicians and workers depended on the construction and maintenance of this new infrastructure, a numerically-based system became more valuable than its people's livelihoods.

In 1947, what are now known as *area codes* were born. Atlantic Telephone & Telegraph (AT&T) published a plan with 86 regions (Goodman, 2019). Priority was given to higher population centers (FCC, 2001). These were some of the same cities the nation was also dismantling for its transportation network. They were largely census-driven, but a 1995 overhaul released numeric restrictions and increased available phone numbers by a factor of 4+ (Proffitt, 1994), providing a unique insight into how a rapid rollout illustrated the system's priorities. By and large, affluent communities received disproportionate benefits (Wikle, 2001).

In 1958 the North American Numbering Plan Administrator (NANPA) assigned 809 to Bermuda and other Caribbean Islands without giving them telephonic autonomy (Petrie, 1963), leading to a disconnect known as the *809 scam*. Calls from 809 are prone to fraud as they are not subject to regulatory oversight. There was no coordination of the rollout with Britain (Bermuda is Britain's territory) or other nations whose Caribbean territories were impacted (Netherlands, France, Venezuela, Colombia). This arrogance has since proved deleterious. In 1963, NANPA was either unaware or unconvinced of its overstep when it assigned codes to Mexico, again offering little autonomy. These area codes stayed in place for nearly thirty years (Los Angeles Times, 1991). Once again, a mathematical system drove decisions, disregarding humans' best interests.

For 75 years the United States has managed to avoid adding extra digits to its phone numbers. A local phone number has always been 10 digits: an area code (3 digits) + an exchange (3) + a suffix (4). This appears to be a singular recent exception of an arithmetic structure with proper oversight and rollout.

The system directing the U.S. Postal Service (USPS) was created in the same post-war infrastructure frenzy with the 1963 introduction of the Zone Improvement Plan (ZIP). Everyone was assigned a ZIP code based on where they lived. Seemingly unsatisfied with 5 digits, the USPS introduced "ZIP+4" in 1983, giving every street in the country a unique ZIP+4. This addition has permitted marketing companies billions of data points to further profile based on residency (Hull & Srihari, 1986). The 9-digit identifiers are demographic stereotypes. The United States has 1 billion potential ZIP+4s, roughly triple its residents.

Initially, the USPS downplayed concerns, claiming ZIP+4 was only required for bulk (500+/day) mailing (Hull & Srihari, 1986), but this mail is sent to us. Enough aggregated data exists after 40 years to pigeonhole every U.S. household and silently control what it does, sees, and how it spends time and money. By 1986, ZIP+4-based direct-mail marketing was a US$367BN[6] industry (Hull & Srihari, 1986). Inflation and continued marketing growth have had indelible effects on how companies target people. Once again the maintenance of a mathematically-driven system is valued more than its citizens.

Conclusion

The decennial U.S. Census is the most critical process for allocating local, state, and federal resources, but is also used to ramrod solutions through an otherwise sluggish bureaucracy. Whether this is the fault of the Census or other entities using its data is an argument for another time.

Education is a significant tool for liberation (Freire, 1970). As outlined above, the United States was once at or near the forefront of innovations but has shifted from innovator to subverting and stymying progress. This portends the re-oppression of its people. Most in the United States are likely unaware of the relevance or helpfulness of Freire's work for America's educational system. Most are also unaware of the depth to which structures and decisions rely on the Census.

There are myriad ways mathematical structures have been used and misused to control humans, including redlining (Meier, 2021), the GI Bill and Veterans Administration loan availability in the wake of World War II (St. John, 2013), and congressional districts (United States Census, 2022). Few - if any

[6] $133 billion in 1986 dollars converted using www.usinflationcalculator.com

- other countries' citizens are as heavily marketed. Most of the structures that allow capitalism to have its way derive information from the Census and reports/results are derived secondarily from this process. The U.S. Census, once used to devalue its residents into partial people, now heavily involves itself in systems that assign resources for telecommunications, mail, transportation, and other critical structures.

Mathematics — including the Census — should be open-source. As long as it is proprietary, systems can work more efficiently to oppress than to support growth and advancement. Behemoth publishers and state governments are gatekeepers to mathematics education, progress, and innovation. Autonomization is common because it is easier, but this will undermine the social character and nature of school and education as a whole (Ani, 2021). Releasing control is not about letting people do whatever they want in the name of freedom and liberation (Seda & Brown, 2021). It must be paired with high expectations and responsibility, but this responsibility cannot be honed until people are first entrusted with it.

The need for mathematics education and innovation can be compared to wooden structures. In the United States, a vast majority of homes are built with wood (Prestemon, 2022). When the wood rots (termites, weather, etc.) the building often needs to be torn down and reconstructed. Mathematics education in the United States has a lot of solid components but keeps adding pieces to a system that has never undergone a significant overhaul. Our mathematics education system was not designed to inspire innovation, nor was it designed to educate *everybody*. This dissonance could be explained away as centuries-old wisdom guiding a dynamic and ever-changing field. If the foundation is rotted, though, the entire structure needs to be rebuilt, just like a wooden home.

The hierarchy needs to be flattened. To do so will require the following path:

1. Identify a structure or system with mathematics as its basis,
2. Identify those in positions of power in this structure,
3. Identify those traditionally at the mercy of this structure, and
4. Bringing these bookends together will flatten and dismantle the hierarchy

Os Advocacy is strengthened by those at (2) and more powerfully delivered by those who have first come from (3). For instance, Drs. Nicole Joseph[7] , Toya Jones Frank[8], and Nicol Howard[9] are part of a growing chorus advocating for the equity and access critical to bridge these points. They give voice to how we arrived where we are, punctuated by deep knowledge of Critical Historical Framework.

Freire (1970) summarized it best: liberation is not a gift. Liberation is not self-achievement or self-actualization. It is a mutual process.

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