<u>The Pursuit of Mathematical Truths:</u>

A Rich and Meaningful Aesthetic Experience of Inquiry as an End in Itself

Kevin Ulliac

In this paper, I will argue that the pursuit of mathematical truths can be classified as rich and meaningful aesthetic experiences that are ends in themselves, and I will demonstrate this by using John Dewey's philosophy of mathematics, his philosophy of education, and what he takes to be the nature of experience in order substantiate my position. My argument is that mathematical experiences of inquiry can have a meaningful impact on a mathematically inclined individual; this experience is not unlike one's admiration for works of art, such as a painting, or a novel, or a piece of music. The nature of mathematical inquiry, especially in the context of scientific endeavors, is to reflect upon of the nature of reality. Furthermore, all modes of inquiry and the experiences that result are educative experiences that are not merely a means to some end, but they are ends in themselves. The expansion and perpetuation of human flourishing via experiences of inquiry provides an aesthetic experience that is good for its own sake. All pursuits of intellectual experiences are moments of learning, which expand meaning and conscious experience, and are therefore ends in themselves.

In *Experience and Nature* and *Art as Experience*, Dewey explicitly argues that there are two kinds of possible worlds devoid of meaning, a world in constant flux and a world that is never changing. In neither of these worlds is there possibility for meaning or aesthetic experiences. Dewey explains that in a world of constant flux, everything would be in chaos; everything that came into being and everything that happens would be purely arbitrary—there would be no such thing as cause and effect. In a world that is never changing, everything that existed would have always existed and will continue to exist for eternity. Once again there would be no such thing as cause and effect. But our world is a world of both stability *and* change, out of which affords the possibility for cause and effect, which then provides the possibility of meaning—and only in this composite world could we develop mathematical and scientific means to obtain desired ends.[1]

Dewey's philosophy of mathematics describes the totality of mathematics as nothing more than a set of non-existential, atemporal qualities that are capable of abstraction and of formulation. He also recognizes that mathematics has instrumental value. Few would argue with Dewey that mathematics can have instrumental applications and is thus instrumentally valuable. However, mathematics is more than a tool, it is a formal and symbolic language—a medium under which we derive meaning, and as such, it is a valuable mode of inquiry that provides meaningful solutions to meaningful problems. Moreover, I hold that mathematics is like natural languages insofar as it is a tool of tools and that the means of mathematical inquiry is not separate from the ends—there is continuity between the doing of mathematics and the valuable ends it produces. Just as language provides us a medium for inquiry and thought, so too does mathematics, and consequently meaningful experience is housed by the activity of mathematical inquiry just as much meaningful experience finds a home in speaking.

I'll further elaborate on the nature of mathematics to better understand its limits and it powers. Mathematics and logic, being formal and symbolic languages, have a set of symbols that are arranged into 'sentences' that are governed by a given set of syntactical rules. Mathematics *must* hold abstract operational power; it must have the ability to refer to something existential in the world *and* the ability to refer to nothing in particular—i.e., without physical referent. Mathematics and logic, just like any natural language, have a set of symbols and operations, which are combined

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[1] John Dewey, *The Later Works of John Dewey, 1925-1953 (Vol 1): 1925, Experience and Nature*, ed. J. Boydston, (Carbondale, IL: Southern Illinois University Press, 2008), 59-61.
AND
John Dewey, *The Later Works of John Dewey, 1925–1953 (Vol. 10): 1934, Art as Experience*, ed. J. Boydston, (Carbondale, IL: Southern Illinois University Press, 2008), 22-3.

to form 'sentences' that are governed by a given set of syntactical rules. The 'sentences' necessarily convey meaning for they always have a physical or non-physical referent.

Having sufficiently established the nature of mathematics, it will be crucial to illustrate that Dewey believes the nature of human experience is governed by the same essential conditions for life as any other animal. We are governed by the same laws of nature and we require the same natural resources (food, shelter, water, etc.) to survive. Inventing and systematizing agricultural methods helps us secure food; constructing insulated housing helps us maintain living arrangements and to protect us from the seasonal elements; and settling next to a source of fresh water is a sure way of guaranteeing the survival of your society. Let me illustrate the following: For an agricultural civilization to succeed, they need to understand how vegetation grows and flourishes. They also need to understand how the solar cycles and seasons work because one must plant seeds at a certain time of the year to allow enough warm weather and sunshine for their plants to grow and be successfully harvested.

This is where mathematics comes in. For tens of thousands of years, humans have been keeping track of solar and lunar cycles with the use of mathematics and geometry (and with clever methods of engineering too). Archaeologists have found thousands of engraved mammoth tusks that date roughly 30,000 years old, and are said to be the records of lunar cycles in the Paleolithic era.[2] There are also several sophisticated and elaborate ancient structures that keep track of the seasons by measuring the amount of daylight, which in turn allows one to accurately describe and predict the summer and winter solstice, fall and spring equinox, as well as keeping track of lunar cycles.[3]

[2] James E. McClellan III and Harold Dorn, *Science and Technology in World History*, (Baltimore, MD: The Johns Hopkins University Press, 2006), 15.

[3] Many ancient structures remain intact to this day, structures such as the infamous Stonehenge in England and the Great Kiva at Pueblo Bonito in New Mexico.
McClellan and Dorn, *Science and Technology in World History*, 27.

The engraved mammoth tusks, Stonehenge, and the Great Kiva are all primitive calendars—they are time keeping machines. What's important to understand is that to create a functional calendar system, a civilization must first devise a theory of number, must be able to count and to perform basic arithmetic operations, and must also be able to make accurate observations by using accurate and intelligent methods of measurement—the society must first devise a sophisticated system of mathematics and geometry, as well as a sophisticated means of engineering the tools of measurement, and then they must accurately collect data, perform calculations with minimal error, and they must interpret the resulting data appropriately.

I will now turn our attention to what Dewey describes as an "aesthetic experience." In *Art as Experience*, Dewey proposes the following: "Only when the past ceases to trouble and anticipations of the future are not perturbing is a being wholly united with this environment and therefore fully alive."[4] In relation to the development of the calendar, civilizations of the past recognized that the ability to fully understand and calculate the solar, lunar, and seasonal cycles brings tremendous value for securing essential goods, thus, their troubles of the past were diminished and their future secured. The advent of the calendar—which is achieved solely through the understanding of mathematics and its application in astronomy—is largely responsible for civilizations of the past being *united* with their environment as opposed to being subservient to it. The civilizations of the past were free to enjoy the potential riches that their environment affords. Thus, mathematical experiences of inquiry into the nature of the solar, lunar, and seasonal cycles certainly *allow* for the possibility of having an aesthetic experience. My argument goes one step further, namely, I argue that mathematical experiences of inquiry are themselves aesthetic experiences.

One need not, however, understand the entire workings of the solar system to have an aesthetic experience. Dewey also describes how all experiences, regardless of their form, can lead to an aesthetic experience. He writes:

[4] Dewey, *Art as Experience*, 24.

> Because experience is the fulfillment of an organism in its struggles and achievements in a world of things, it is art in germ. Even in its rudimentary forms, it contains the promise of that delightful perception which is esthetic experience.[5]

A mathematical experience of inquiry can also be an aesthetic experience. In the same way that an individual can have an aesthetic experience while admiring a work of art or by reading a piece of poetry, a mathematically inclined individual can have an aesthetic experience while investigating a mathematical formula that expresses something meaningful about the world. Take for instance Newton's equation $F = ma$ and Einstein's equation $E = mc^2$. Both equations have deep philosophical meaning, both in what the symbols represent individually and in their relation to each other. Newton believed that acceleration was only possible if space was an absolute substance—his equation of $F = ma$ reflects the entirety of his ontological view of space and of accelerated motion in such a space. Likewise, Einstein held that all matter and energy are interchangeable and thus can be converted from one to the other. His equation reflects his ontological view of matter and energy; namely, that they are essentially one and the same. Moreover, the logical notion of Modus Tollens, and the Copernican model of the universe are expressed with the use of mathematical symbols and likewise have a great deal of meaning within the equations, the symbols therein, and within the philosophical conclusions they express. Modus Tollens is one logical rendering of principle of cause and effect. It states that: "If **P** then **Q**. ~**Q**, therefore ~**P**." In other words, if it's true that an occurrence **P** always causes an occurrence **Q**, and it is the case that **Q** has not obtained, then it is also the case that **P** has not obtained.[6]

Mathematical models of the universe and of our solar system also have deep philosophical principles embedded within. Ptolemy, a Greek astronomer who lived in the middle of the 2nd century C.E., worked out a geocentric mathematical model of the universe. In so doing, he was

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[5] Ibid., 25.
[6] Merrie Bergmann, *The Logic Book*, (New York, NY: McGraw Hill, 2014), 214-6.

trying to mathematically quantify exactly how the sun, the moon, and the planets move in the night sky in relation to the earth. In his model, he corrected for the apparent retrograde motion of the planets by formulating various epicycles. Ptolemy made several mathematical calculations and determined that the planets were not only in circular motion around the earth, but had an additional state of circular motion within its orbit around the earth—an orbit within an orbit.[7]

Copernicus published *De Revolutionibus*[8] in 1543 in response to his deep dissatisfaction with Ptolemy's model. He thought Ptolemy's model "failed to provide a satisfactory account of the stations and retrogradations of the planets; with its elaborate geometrical constructions, it was an astronomical 'monster'."[9] Copernicus sought to significantly reduce the number of epicycles by putting the sun at the centre of our solar system. He did nothing more than to simplify Ptolemy's model by hypothesizing a heliocentric model—the earth was no longer the center of the universe.[10] Though his model had little empirical evidence, Copernicus' model was far simpler and had a natural explanation for the retrogradations of the planets. Furthermore, Copernicus hypothesized that "the earth rotates once a day on its axis, thus accounting for the apparent daily motion of everything in the heavens, and the earth revolves around the sun once a year, accounting for the sun's apparent annual motion through the heavens."[11] With a simple shift in perspective and a generous employment of mathematical calculations, Copernicus was able to take Ptolemy's convoluted geocentric model and turn it into a simpler and more aesthetic heliocentric model.

An attempt to understand how the universe operates is a deeply philosophical endeavor, one that requires more than just rhetoric and observation. One must employ mathematics, geometry, and the totality of their understanding of physics and astronomy. Thus, to understand the universe and the motions of the heavenly bodies, one must employ a rigorous set of

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[7] Arthur Berry, *A Short History of Astronomy,* (New York, NY: Dover Publications, 1961), 63-72.
[8] *On the Revolutions of the Heavenly Spheres* is the English translation of the title.
[9] McClellan and Dorn, *Science and Technology in World History*, 208-9.
[10] Berry, *A Short History of Astronomy*, 99-107.
[11] Ibid., 210.

mathematical and geometrical modes of inquiry that yield a mathematical and geometrical answer. No other mode of inquiry yields a satisfactory answer. This again demonstrates the power of mathematics and its special ability to enhance meaning and conscious experience. When an inquisitive observer employs their understanding of mathematics, geometry, physics, and astronomy wisely, they can answer meaningful questions about the nature of reality.

I will now borrow from Pollard's essay, "Mathematics and the Good Life." He writes: "Creative mathematical experiences are not only intrinsic goods: they are goods that live again in re-creations that are themselves intrinsically good."[12] Creative mathematical experiences are re-creations in the sense that when an individual teaches another how to solve a mathematical problem, the teacher is in effect, evoking in the student, the same experience of inquiry that the teacher originally had while solving said problem. Anything that contributes to human prosperity is an intrinsic good. Mathematics, given its foundational properties and its stature in scientific explanations and insights in general, is such an intrinsic good.

To further illustrate the importance of mathematical inquiry and its ethical significance, I turn to Dewey's book *Democracy and Education,* where he defines education as an end in itself. Education is that which brings about "a widening and deepening of conscious life, a more intense, disciplined, and expanding realization of meanings."[13] For Dewey, education is the expansion of meaning and conscious experience, thus education in all forms is an intrinsic good. My argument is that a mathematical experience of inquiry is itself a highly educative process, whereby the inquirer reflects upon the nature of reality; the means of mathematical inquiry is part of the educative process at large. A mathematical experience of inquiry is a moment of learning, but it can also be an aesthetic experience, especially when the experience expands meaning and consciousness.

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[12] Stephen Pollard, "Mathematics and the Good Life," *Philosophia Mathematica* (III) 21, no. 1 (December 2013): 102, doi:10.1093/phimat/nks030.
[13] John Dewey, *Democracy and Education,* (New York, NY: The Macmillan Company, 1930), 417.

A working model of the universe, and the understanding of scientific and logical principles such as F = ma, $E = mc^2$, and Modus Tollens, all of these are products of reflexive thought on the nature of the universe—as such, these products of reflexive thought are densely rich in meaning and a mathematically inclined individual will surely have an aesthetic experience when investigating these principles. As Dewey explains, an intellectual experience—whether it be a mathematical experience of inquiry, or any other experience of inquiry—must have an aesthetic quality to it for this experience to be complete. And as I have hopefully demonstrated, mathematical experiences of inquiry are complete aesthetic experiences that expand meaning and conscious experience, they perpetuate human flourishment, and as such, they are ends in themselves.

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