

Evidence and Inquiry Certificate

The College of Natural Sciences Honors Center
Home of Polymathic Scholars

The Fourth Dimension in Modern Art

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Nina Ignatchenko

Natural Sciences

Mathematics

● **Describe your field of study. What are some of the questions you would like to answer, and what academic disciplines do you think will be useful in answering them?**

I plan to study the role of the fourth dimension in modern art, specifically in the work of cubists Pablo Picasso and Marcel Duchamp. While Cubism appears to be simply a form of abstract art, it has underlying mathematical significance inspired by Henri Poincaré via Maurice Princet, a member of Picasso's social circle. This 20th-century movement marries mathematics and the fine arts through its visual interpretation of fourth-dimensional mathematics.

The history of a fourth dimension begins around 300 BC with Euclid's fifth postulate, which states that if two lines, which are intersected by a third line to form two angles less than 90 degrees, are extended forever, the lines will eventually meet. The first non-Euclidean geometry to contest this postulate was hyperbolic geometry, developed by Nicòlai Lobachevsky and Janos Bolyai in the early 19th century. In the mid-19th century, Bernhard Riemann introduced elliptic geometry, and he later broke away entirely from the limitations of two and three-dimensional geometry with his idea of higher-dimensional space. In the late 19th century, Henri Poincaré, who took an imaginative outlook on mathematics, created topology, the study of spatial relations that do not involve the size or shape of objects.

The fourth dimension was explored from only mathematical standpoints until Maurice Princet, an early 20th-century actuary with an affinity for avant-garde artists, introduced Poincaré's theories to Pablo Picasso and Marcel Duchamp. The thought that a fourth-dimensional being could see an object from all sides influenced the piece Picasso was working on at the time, *Les Femmes d'Alger*. By depicting a woman's face from the front and profile simultaneously, Picasso gave rise to Cubism, an art form that renounced painting from a single viewpoint. Four years later, Duchamp, likewise motivated by Poincaré's lectures, created *Nude Descending a Staircase*, a depiction of a woman from both different points of view and different points in time. Essentially, both of these crucial modern artists received inspiration from the discussion about fourth-dimensional mathematics.

A central question in my field of study is, To what extent does modern art depict the fourth dimension in a mathematically accurate way? I want to discover how closely mathematics and art are intertwined in this field. Are they different methods of exploring the same concept, or do they diverge into two separate ideas entirely?

The curriculum for my field of study will include courses in Mathematics and Art History.

□ **Why are you interested in studying this topic?**

Since math classes were easy for me in high school, I enjoyed reading about topics that we did not cover in class. One of these that particularly fascinated me was the fourth dimension. Although far from simple, the math behind it was pretty straightforward: just as we can extrapolate knowledge from two dimensions to three, we can predict how fourth dimensional objects will behave mathematically. For example, sweeping out a one-dimensional line in a perpendicular direction gives a two-dimensional square. Stretching this square out in a

direction perpendicular to itself creates a three-dimensional cube. A hypercube, or the fourth-dimensional counterpart of a cube, is simply the result of pulling a cube out in a direction perpendicular to itself. However, I realized that because we live in a three-dimensional world, we cannot visually imagine this direction.

That upset me. I had gotten so excited about hypercubes—what they were theoretically, and what it would mean for them to exist tangibly—only to be told that I could not dream of what one looked like. I failed miserably trying to draw one and decided that, although we could make diagrams and imaginative yet mathematically faulty drawings of hypercubes, they are simply impossible for three-dimensional beings to visualize. Even though I could not picture them, I remained curious about them.

And yet, while studying Futurism in my Art History class, I noticed a resemblance between the woman depicted in Marcel Duchamp's *Nude Descending a Staircase (No. 2)* and the fourth-dimensional figures I had been studying. The painting, at first glance, looks almost nothing like a three-dimensional woman, but at a closer look, it shows multiple views of what is clearly a woman at different points in time and space. Each of these parts alone is recognizable as a different view of the woman, just as each cube making up a hypercube is recognizable when viewed separately.

What's more interesting is that Duchamp was able to depict all of this *on a two-dimensional canvas*. I was, and still am, enthralled. I had finally discovered a way of depicting hyper-dimensional objects, but was it mathematically accurate? Through my field, I can answer this burning question along with many others that were sparked when I realized how the concept of the fourth dimension naturally links my two favorite subjects, mathematics and the visual arts.

- Name two faculty with research interests in your area. Include their home departments and relevant research interests. If a research interest isn't obviously related to your topic, explain its relevance.**

Linda Dalrymple Henderson, Art History

Dr. Henderson is the author of *Fourth Dimension and Non-Euclidean Geometry in Modern Art*, which covers her work concerning the effect that non-Euclidean geometry and the discovery of the fourth dimension had on modern art, including Cubism, Futurism, De Stijl, and Surrealism.

Michael Starbird, Mathematics

One of Dr. Starbird's research interests is Geometric Topology, and he states in an interview that one of his favorite topics is the fourth dimension. He also gave a Distinguished Lecture called "The Fourth Dimension," and he teaches a UGS course, the description of which mentions strategies rooted in subjects ranging from mathematics to art.

- Explain how each course is relevant to this field. What do you hope to learn from each?**

Primary Courses

ARH 386N

Topics in Twentieth-Century Art

When I looked at this course on the UT Syllabi and CVs page, its syllabus from Spring 2013 was titled "Duchamp by Decade." After covering Marcel Duchamp's background in the first lecture, the second lecture went straight into "Science and the Fourth Dimension," which relates exactly to my field. If this class is still available, it would be greatly beneficial for me to take.

M 367K

Topology I

Aside from the additional practice I would get with writing proofs, I think it could be beneficial to learn about manifolds and exotic spheres, and why these have been discovered in every higher dimension but the fourth. This course is taught by one of the professors I listed above, Dr. Starbird, whose passion for the fourth dimension will undoubtedly come out in this class.

ARH 337K

Twentieth Century European Art to 1940

This course, taught by Dr. Henderson, whom I mentioned in Section 3, covers major European visual arts movements during the exact time period that I plan to look at for my field.

UGS 320

Independent Studies

I would like to propose an independent studies course with either of the two professors that I listed for question 3: Dr. Starbird or Dr. Henderson.

M 392

Homotopy Type Theory

This class concentrates on the integration of two different theories about topology: homotopy theory, and type theory. I think it would be relevant to my field of study because it reflects recent advancements in topology. With knowledge of how information about hyperspace has changed throughout the years, I could also analyze whether modern art reflected this change in its depiction of the fourth dimension.

ARH 375

Art Historical Methods

This course would be helpful in giving me formal education on how to analyze works of art.

