Chapter 13
Cognitive Learning Through Knowledge Visualization, Art, and the Geometry of Nature

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ABSTRACT

Scientific modeling applied to the study of a mineral structure at the unit level provides a fertile ground from which to extract significant representations. 3D graphics visualization is equal part mathematics, geometry, and design. The geometric structure of 52 minerals was investigated in a specific modeling program to find if meaningful visualization pertaining to the field of art can be extracted from a mathematical and scientific resource. Working with the lines, spheres, and polygons that define crystal at the nanoscale provided the author with an exceptional environment from which to extract coherent visualizations sustainable in the art environment. The results were tested in various interactive platforms and opened a larger debate on cross-pollination between science, humanities, and the arts. Additionally, the experiment provided new ground of investigation for unexpected connections between mathematics, earth sciences, and local cultures.

INTRODUCTION

There is no branch of mathematics, however abstract, which may not some day be applied to phenomena of the real world. - Nikolai Lobachevsky. (G. E. Martin, The Foundations of Geometry, Springer, 1998, p. 225.)

Euclidian and non-Euclidian geometry, algebraic geometry, all share a common thread, defining or describing the space of our physical universe. Geometry, a significant branch of Mathematics, is for many a very abstract world, yet its expression has been with us since antiquity. It can be found in all cultures worldwide and is anchored on a sound observation of nature and the environment.

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While doing a research on mathematics and visual communication, I stumbled upon that sentence from famous mathematician Nikolai Lobachevsky (1792–1856). I often went back to it when I was getting lost in the abstract reasoning of a world I understood very little as an untrained scientist. Mathematics is a science studying theoretical concepts. Yet, it is the source of many improvements in our daily life as well as the engine of future discoveries. It is also, unfortunately, the source of many frustrations for many, unfamiliar with the abstract world mathematics explores and investigates. Mathematicians are aware of this problem, knowing that, ultimately, the mathematical discourse needs to be grounded in the physical reality we live in, to both validate the researchers' reasoning and be comprehended by all benefiting from this unique effort. Can meaningful art communicate in non-mathematical terms the beauty and significance of this language and participate in a constructive manner in the communication effort of the many mathematicians involved in expending the borders of universal knowledge?

Throughout history, artists have often been fascinated by the mathematical sciences and in particular by the beauty of pure geometry. From antiquity to the Renaissance and today, the art world got inspired and expressed in many forms mathematical concerns of the time, from Albrecht Durer in *"Treatise on Mensuration"* (1538) (Swetz & Katz, 2011), or closer to us, Man Ray in "*Shakespearean Equations"* (Grossman, 2015), to mention but a few. Today, our virtual environment and the multiplication of scientific visualization programs help mathematicians and scientists share with the public the exceptional beauty of the universe they explore. Indeed, a large part of the material coming out of highly specialized research labs is abundantly distributed in scientific and non-scientific venues and on public platforms not necessarily specialized in the promotion of science itself. Today, it is not uncommon to find high qualities images of a sophisticated scientific nature such as the fascinating mathematical imagery on Kleinian group limit sets by Jos Leys (2018) relayed in unexpected but influential public venues such as YouTube or Facebook. A substantial number of mathematically inspired works available in these virtual galleries deal mostly with the exploration of geometrical forms and other topological concerns made available through recent technological development in computer visualization and image-processing techniques. A subject I studied recently, testing and implementing mathematical imagery on 12 distinct mathematical visualization programs (Constant, 2016). Lobachevski's citation was very present in my mind at that time, as often I needed to reconnect the abstract beauty of an ever-expanding hyperbole or a 4^{th}-dimensional design to some more tangible reality. It gave me the impetus to follow on this experiment, explore the mathematical world anew. However, instead of studying pure geometric forms for their intrinsic elegance, I set as a goal to bring geometry back in its true context, the definition of the existing world, and try to obtain an outcome I could enjoy, share with others, and be of benefit to all.

A few years ago, I worked on a project based on the structure, and properties of crystals (Constant, 2013). This rewarding project seemed to have a suitable potential to direct this new project, explore geometry in the physical world, develop mathematically coherent visualizations and likewise, be attractive on the perceptual level. Crystals are identified after a very precise set of mathematical and topological rules developed in the mid-1800s, after the work of J. Hessel (1830), who determined that their morphological forms combine to give exactly 32 kinds of crystal symmetry in Euclidean space. Could a study of the geometry of minerals meet Lobachevsky's expectation, bring together such distinct scientific fields asabstract geometry and geoscience, deliver a meaningful statement and be a gateway for larger humanistic and artistic enrichment?