STEAM 2017

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The Commonality of Patterns

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According to the STEM to STEAM website (http://stemtosteam.org), two of the movement's major objectives include transforming research policy such that art and design (A) are integral to science, technology, engineering, and mathematics (STEM) and influencing employers to hire artists and designers to drive innovation. Many significant breakthroughs in the arts, sciences, technology, and design fields have arisen, not from modifications of existing views, but from fundamentally different ways of perceiving the world through the senses or intellect. Artists and scientists are positioned via their respective training and creativity to view the world in different, but yet complementary, ways. STEAM's goal to more creatively address today's challenges will require effective communication as the theories, mathematics, and applications of technology or science find common ground with the images, sounds, and forms of art or design.

Although art and science were closely linked during the time of Galileo and Leonardo, modern trends have almost totally disconnected A (art/design) from the more analytical STEM pursuits. Distinguishing artistic images from rigorous mathematical or scientific descriptions of the world has resulted in less and less interaction between the two groups. Though the expansion of digital media and an international open-source movement could assist in encouraging interactions, a shared computer literacy alone is unlikely to bridge the professional chasm. Whereas similarities between art and science in perceiving and describing the world have been recognized, there are few formalized methods for utilizing those commonalities to enhance

STEAM.

Long-standing arguments as to whether artists can accurately portray the intricacies of scientific theories or whether scientists and engineers are able to recognize the expressive nuances and subtle messages of artistic works may be moot when it comes to STEAM. Physicist David Bohm believed that the value of art to a scientist is not the artist's statement, but rather a perception of the world that sidesteps entrenched thoughts or approaches.**[1]** Similarly, he considered the value of science and math to artists not as capturing theories in artistic works, but instead pondering technical understandings as a means of expanding perspectives on art and the world.

Communication

When considering communication among practitioners from different fields, words or symbols or numbers are often proposed as candidates for a common language, but they may not be the best choice. Spatial and temporal patterns might be more effective simply because they are fundamental to the natural world and have served evolutionarily as indicators of environmental threats or available resources for humans. People's aptitude for recognizing patterns applies to both spatial (e.g., shapes, geometries, relative positions) and temporal (e.g., rhythms, vibrations, cycles) phenomena. The recognition, interpretation, and projection of patterns probably underlie advanced human abilities such as language, music, art, and science.**[2]** Mark Mattson posits that these abilities, which he believes confer competitive advantages in a modern context, are derived from a human neocortex that detects and creates patterns in ever more abstract ways.

Inventor Ray Kurzweil noted that there are no images, maps, audio recordings, or videos stored in the brain, but rather sequences of patterns that are created and retrieved via a sophisticated mode of parallel processing.**[3]** Shapes, numbers, words, and even ideas are all stored as patterns, which themselves are composed of simpler patterns arranged hierarchically. This arrangement probably underlies people's efficiency in recognizing and projecting patterns, such that their thoughts are represented by patterns of interconnected neurons. By contrast, the brain's ability to assess logic and cause-and-effect is more limited, which is evident as people's incongruous ideas or actions.

The notion that patterns could represent a means of communication for scientists, engineers, mathematicians, artists, and designers is actually not a new one. So-called pattern languages have been applied to both technological and natural systems, while art and music have been described in terms of visual patterns and rhythms as a combination of elements that repeat in a predictable or unpredictable fashion. Whereas only certain branches of science specifically focus on patterns and rhythms in nature, the data from many scientific fields can be expressed in terms of cycles, frequencies, vibrations, sequences, and other descriptors of temporal patterns as well as shapes, distributions, geometries, structures, and similar descriptors of spatial patterns.

Regarded as the fundamental language of STEM, mathematics has been presented as rhythmic sounds and movements to teach otherwise abstract subjects such as arithmetic. Additionally, mathematicians themselves seek patterns in data to explain relationships that assist in describing and predicting natural phenomena.**[4,5]** Hierarchies of diverse patterns could be an interesting way to describe the world because humans originate from and embody many of the same physical patterns that they perceive (either consciously or unconsciously) as pleasing and ordered in the world and from which they infer meaning, causation, and familiarity.

Pattern Types

So, what commonalities are inherent in the geometries, cycles, symmetry, balance, and repeated patterns in nature that artists and musicians incorporate into their works and compositions and that scientists and engineers reveal in their theories and mathematics? And how might STEAM members actually communicate with each other using temporal or spatial patterns? A possibility was advanced by architect Christopher Alexander, who designed a pattern language specifically for collaborations among professionals with different backgrounds or people possessing limited knowledge of a particular topic.**[6]** Pattern languages are also popular among software developers because they permit people to discuss strategies and solutions without invoking programming jargon, which is often a barrier to sharing diverse ideas.

Listed below are a few examples of pattern categories and the rationale for their use.

***Archetypal Patterns*:** Among the most fundamental patterns are the Platonic solids, logarithmic spirals, and phi-based structures that are present in nature, music, and art. An inability to identify archetypal patterns in a mural, pyramid, seashell, or Mozart symphony does not preclude their recognition on more subtle levels. By contrast, some crystals and organisms display archetypal patterns that are easily recognized. An icosahedron is the Platonic solid identified during the 19th century as connecting many branches of mathematics, and physicist Garrett Lisi more recently used the 248 vertices, or intersection points, of an icosahedral-based pattern (E8 Lie geometry) to map the known and predicted particles of physics—although the math has yet to be resolved.

***Symmetrical Patterns*:** Symmetry is the property of an object such that changing its position relative to a viewer results in its appearing exactly the same (e.g., a spinning sphere or mirror images of a human face). Patterns with greater symmetry are more attractive to people, perhaps because symmetry is a perceived indicator of quality or because it permits the recognition of objects from different visual orientations. In either case, a human sensory bias for symmetry is evident in both nature and the arts. A desire to impose order on the world through projecting or creating patterns via art and design has been evident throughout human history.

***Fractal Patterns*:** Irregular or asymmetrical objects that appear randomly formed are actually not random from a mathematical perspective. The most familiar irregular objects are fractals, which display a very similar pattern over a wide range of scales. Although not a geometry that is easily identified by humans, it is the most common one in nature (e.g., clouds, waves, trees, mountains, rivers, coastlines). Interestingly, humans display a range of proficiencies in recognizing natural fractal patterns, perhaps because they are produced by complex nonlinear systems that are not easily discerned or comprehended. Nonetheless, the human brain can naively recognize and even strongly prefer certain types of fractal patterns without people being able to explain why.

***Network Patterns*:** Networks are probably the most difficult patterns to identify because their individual components and the interactions between them are not always obvious. Paradoxically, the brain itself functions as a complex network, as do many social, ecological, and technological systems. The dynamism of networks includes temporal patterns that, guided by spatial patterns, are responsible for the observed behavior of complex systems. Christopher Alexander identified his pattern communication in terms of a network whereby individual patterns are related to or dependent upon one another. Networks are evident in art and design as both abstract forms and images that highlight interconnections among human creations and nature.

Universality

In his book *The Self-Made Tapestry*, Philip Ball investigated the appearance and causes of patterns in nature and found that similar patterns within the physical, biological, and geological realms could be attributed to many different forces or mechanisms.**[7]** As such, the universality of patterns seems to transcend their respective causal mechanisms. Perhaps fractality, symmetry, and complexity simply represent different lenses through which we choose to perceive nature's patterns—and then to portray or utilize them in art and design. He posits that pattern seeking is hardwired into our brains, and the belief that nature's patterns were intelligently designed is a consequence of how humans create patterns (i.e., constructing symmetry) rather than how nature creates them (i.e., predominantly breaking symmetry). Ball further noted that similarities among pattern-forming systems serve to dissolve divisions among disciplines, thus permitting scientists, economists, engineers, and others to communicate in the same language.

Identifying a basic collection of patterns, the supporting components, and a few rules for structure could serve as an initial step toward developing a common STEAM language. While proposing protocols and syntax for communicating via patterns is beyond the scope of this brief article, a common language that could bypass the specialized jargon, symbolism, and styles of STEAM participants could enhance their collaboration. Perhaps the perceived beauty of a painting, a scientific theory, and a pristine landscape is related in a way that defies words, but not patterns.

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