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Engineering Art: Democratizing creative expression using normative rules

Dr. Thomas E Ask P.E., Pennsylvania College of Technology

Thomas Ask is a licensed Professional Engineer and a professor of industrial design at the Pennsylvania College of Technology, an affiliate of Penn State University.

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Thomas Ask
Professor of Industrial Design
Pennsylvania College of Technology

ABSTRACT

This paper offers a presentation on the use of normative rules to create works of art and music as well the use of this approach in encouraging creative expression in engineering and design students.

Identifying patterns found in art and music allow untrained people to employ these rules, thereby broadening access to creative expressions. The democratizing implications of technology is already apparent in applications such as additive manufacturing and digital manipulation of imagery. These applications of technology allow people without artisanal skills of a sculpture or painter to move their mental conjuring into physical embodiments. Identifying normative rules that undergird many artistic and musical expressions allow their prescriptive usage by less trained individuals to create art and music, which represent rich expression of creativity. Relying upon heuristics to move ideas forward into tangible expressions embolden students to use their abilities to create designs and solve engineering challenges.

This paper identifies normative rules used in some forms of art and music, then uses these rules to produce alluring works. Use of AI generated art from DALL-E is compared with the author's artwork as a foundation for a presentation of individual style and the intersection of AI and human creativity. This paper also shares experiences with artistic exercises in an introductory mechanical engineering class.

INTRODUCTION

People were not meant to be ignored. They desire to communicate ideas with the transcendence permitted by art and music. Employing rules to bring personal mental images or musical creations to an audience broadens access to these processes. Seeking to communicate creative impulses with rules and structure extracted from cultural norms and other sources democratized artistic and musical expression. Children learn normative rules in speaking and writing that quickly let them use these abilities to express individual thoughts. A parent understands, "I miss daddy" as well as a lengthy narrative about loneliness and familial connections. A child's stick figure drawing showing two people holding hands, presents as clear a meaning as a painting of the same thing.

We can quickly use normative rules to engage in art forms that may have traditionally been moderated by human gatekeepers. Introducing these rules in engineering education and showing how they can be used opens a corridor for richer expression of ideas. Moreover, coupling these

rules with intuitive software, online instruction, and the unfettered communications on the internet, allows more inclusive entrance into creating art and music.

Rules can guide the novice. For example, in music the relationship between notes that make up a chord are established and culturally conditioned. Moreover, the progression of these chords follow commonly recognized sequences. Therefore, one can couple lyrics with a chord progression that turns poetry into music. The visual arts also have rules related to guiding compositions and color. Moreover, artificial intelligence has been used in music and the visual arts to identify and redeploy patterns in new work.

The richest tapestry of normative rules can be identified by machine learning systems. Platforms for generating AI created music are widely available and AI image tools are growing. These machine learning systems have tremendous potential to democratize music and art. This paper compares AI generated art and the author's art to provide insights in the human potential to control personal style and expression.

The author uses the term "rules" for simplicity, but one must recognize the term is used here to encompass the specific and nonadaptive notion of an algorithm as well as the adaptive notion of heuristics.

BACKGROUND

Human response to art and music ranges from dopamine system response to memory connections. It also includes a balance of fulfilling and surprising expectations as well as connecting us with our personal and group identity. We are awash in other people's art, music, and other creative expressions, but many have a desire to publicly present their individual creative ideas.

Moving ideas from the creator to the user involves technology, such as a pen and paper to write a story, or a piano to express a musical composition. The physiology of the receiver is also a vital element because the process of sensing, neural transmission, and cognition differ between individuals. People can only see and hear certain ranges of frequencies. Moreover, human physiology can be manipulated such as by saturating photoreceptors in laser video projection or using sound frequencies above old people's hearing range. Moreover, cultural-determined manipulation can be employed, such as using D minor chords to incite sadness. Sometimes the creator has physiological differences from the observer. For example, late in Claude Monet's life he painted with vivid blue hues in his compositions. This intensity of the blue was in response to his reduced ability to see the color blue.

While the creator's idea has a potentially uninhibited reality in their own mind, the technology used to portray the creation relies upon the someone else's tools, whether a clarinet, canvas, or computer. Often the creator needs to interface with the technology to fully develop the idea. There is often exists a dialogue between the mind and the other senses during the process of creating something tangible.

A summary of these stages of creative expression can be reduced to:

1. Imagination of creator
2. Technology to implement creation
3. Physiology of viewer

For painting:

1. Creator's Imagination
2. Paint
3. Observer's Vision

For music:

1. Creator's Imagination
2. Musical Performance
3. Listener's Hearing

Commonly, feedback is required between the creator and the technology, such as the composer and the keyboard. This can have higher levels of complexity, such as a musician working through a music producer and musicians for a particular venue. The same is true in the fine arts, where interaction with the media is part of the creative process. In addition to the technology/media, user critiques can encourage the creator to make modifications. For example, cubist painters Pablo Picasso and Georges Braque critiqued each other constantly. Picasso claimed he would not consider a painting finished unless Braque also felt it was complete.

This relationship is similar to the Universal Systems Model of *input*, *process*, *output*, *feedback*. In this model, inputs are the elements that go into a system, process are the activities required to get a desired result, outputs are the result of the input and process. Finally, feedback is the reaction of the input, process, and output of a system [1].

Figure 1 shows this feedback system for the example of Braque critiquing Picasso's work.

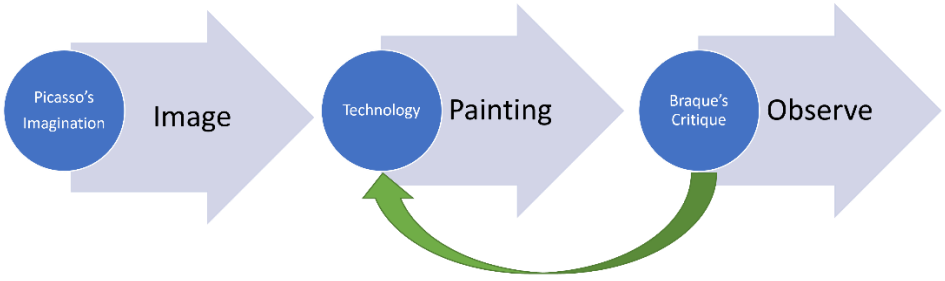


Figure 1 – *Universal Systems Model of Picasso's Artwork*.

More generally, Figure 2 represents a generic creation feedback cycle using music and painting as examples.

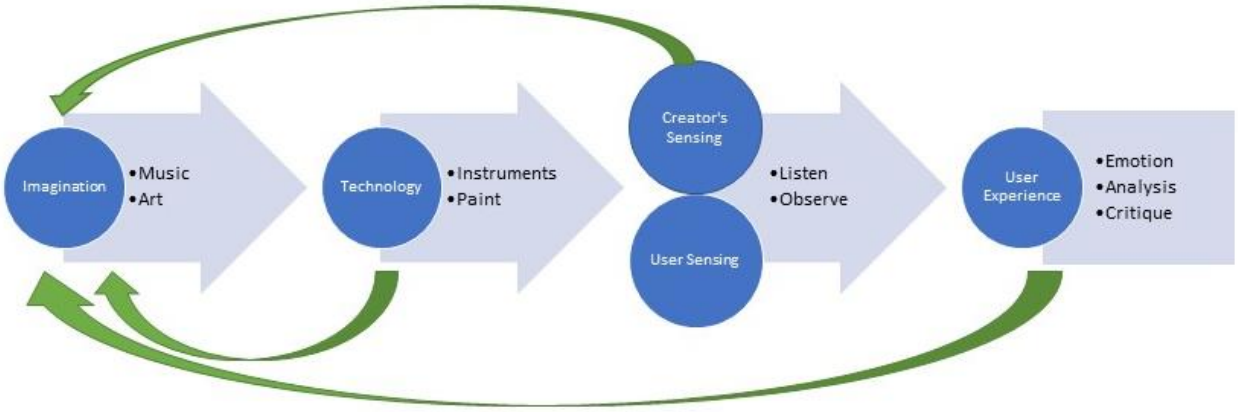


Figure 2 – *Music and Painting Creation to Experience Cycle*.

MUSIC

Chordal Sequences

Musical notes and intervals between notes are culturally established. For example, Indonesian Gamelan music will sound unusual and discordant to the Western ear, with fewer and differing notes per octave as shown in Figure 2. Chord structure and chord progression are also culturally connected and are repeated frequently in compositions. Some harmonic sequences are so frequently used they are given names, such as *Passamezzo* and *Romanesca*. Romanesca was commonly used to accompany poetry in 16th and 17th century Italy. Western popular music also has well established chord progressions that are satisfyingly familiar. Whereas music such as Gregorian chants elevate the lyrics, the familiarity of simultaneous notes separated by thirds are stable consonances that feel stable to most listeners.

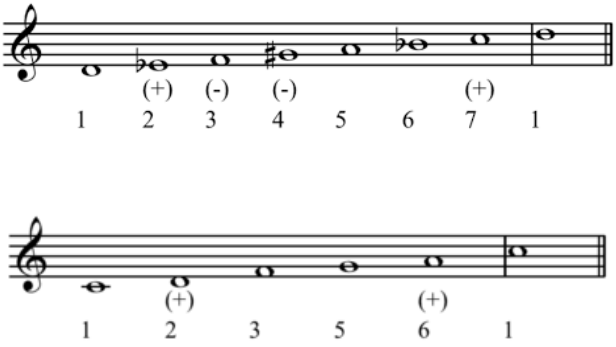


Figure 3 – Two scales used in Gamelan music, Pelog and Slendro. The notes do not match Western scales precisely [2] [3].

A statistical relationship in chord progressions can be determined by sampling music, such as a likely progression from F to G to A minor or C [4]. Asserting that appealing chord progressions are merely a tool, much like a hammer, is offensive to those with musical training. However, employing these statistical relationships is not composing music in a traditional sense, it is a rule following that allows one to use appealing music as an element of communication. It can become an adjunct to poetry, such as with Romanesca. However, the usage of established chord progression is an inclusive tool for creating songs.

Music Sampling

Reworking digital media is easy, whether music or images. For example, "sampled" music takes existing music and includes it in a new composition. The sampled music may be modified in a variety of ways, such as changing the tempo or pitch. Some elements of music, such as the drum solo from the 1969 Winston's song *Amen, Brother* has been included in thousands of other songs [5]. Music is also *interpolated*, which is rerecording the melody and lyrics. DJ decks are used to make mashups of several songs. These devices can automatically synchronize tracks and have the ability to change tempo without changing pitch.

Sampled music leads into a gray zone of content origination. For example, a legal challenge was recently settled in a copyright infringement case between Tracy Chapman and Nicki Minaj. Minaj used samples of music through a third party and the provenance of the original music was alleged to have been lost. Moreover, the original judgment allowed the usage of sampling as "fair use" with the judge opining, "a ruling uprooting these common practices would limit creativity and stifle innovation with the music industry" [6].

AI Generated Music

AI generated music and art have great potential for allowing easy access to the general population. Computer generated music is an old idea. A composer and mathematician at the University of Illinois worked together in 1957 to program the Illinois Automatic Computer (ILLIAC I) to generate an orchestral piece, which was entitled, *Illiac Suite for String Quartet*. AI generated music has blossomed into commercially viable products in this decade.

AI created music is a rapidly growing field that has been commercialized with a variety of high performing platforms. These AI systems are guided by either music theory or an examination of user-provided music samples. Music across many genres have been created by AI systems. This approach to music generation is especially attractive for background music in video content because no royalty payments are required. The programs cater to this need by allowing one to enter the duration of music required so it can properly match up with the video content.

VISUAL ART

Mental Imagery

We all have mental images that spontaneously wash our conscious thoughts. These random thoughts, which are unrelated to accomplishing a specific task, are referred to as Task-Unrelated Images or Thoughts (TUIT or TUTs). These TUITs are likely the raw material of creative work [7]. Turning mental imagery into physical entities is a challenge. While sketching is our first response, artistic rendering allows for deeper expression of ideas and identifying normative rules broadens access to artistic presentations.

In the visual arts, if one considers painting and other two-dimensional compositions, many of the guidelines derive from experience in nature. For example, the "rule of thirds" reflects our perception of the sky to ground ratio when we are outside. Rhythm reflects our familiarity with variations of facial expressions and vegetation. Proportion is anticipated in familiar spatial relationships such as in our finger segments (phalanges). The ratio of human finger segments is in accordance with the so-called "golden" ratio of 1.618.

People respond favorably to other harmonic ratios also, such as one third, one quarter, one half, two thirds, and three quarters [8]. These ratios can be presented graphically with a harmonic armature. Elements of an image that are at intersections of the armature's lines are related in a pleasing manner. This is demonstrated by the overlay of a harmonic armature over Jusepe de Ribera's painting *Martyrdom of Saint Philip* in Figure 3.

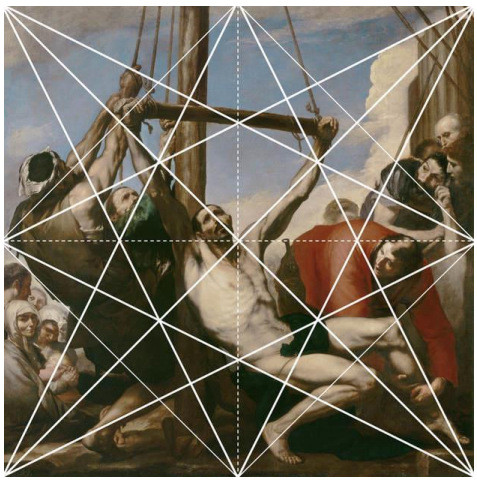


Figure 4 – *Martyrdom of Saint Philip* by Jusepe de Ribera [9].

Image Manipulation

As with music, digital imagery can easily be obtained and modified to produce one's own artwork. Image manipulation arose long before digital manipulation was possible; however, software facilitates easy and indiscernible changes to imagery. Digital image manipulation is one

of the most profound points of access for untrained artists and photographers to express personal creativity.

Digital generation and manipulations of surfaces and solids has long been available and additive manufacturing (AM) allows easy digital sculpting. Software supporting AM has become easy to use and increasingly employs intuitive drag and drop features and free-form surface modeling that make three-dimensional sculpting technically easier. Even traditional subtractive manufacturing has become greatly simplified by technology.

AI Generated Artwork

Computer generated artwork has been produced as far back as Harold Cohen's *AARON* program in 1973. This technology is now fueled by AI, such as generative adversarial networks that create unique images. A 2018 AI generated piece, a blurry portraiture entitled *Edmond de Belamy*, sold for $432,500 [10].

Numerous tools have recently been developed for AI image generation. OpenAI's DALL-E and DALL-E2 as well as Stable Diffusion's DreamStudio are prominent examples of a machine learning model that uses natural language descriptions to produce visual images. Users enter text descriptions and the image generators create visual imagery connected with the prompt. These AI programs rely upon public datasets for their learning base. These datasets may contain copyrighted images so the legal framework is still in flux, especially with DALL-E2 now being allowed for use in commercial projects. Currently there is no legal structure to assign the algorithm as the creator, which reveals the possible need for new roles for copyright and intellectual property ownership.

An ideal relationship between the creator and the technology, without external critique, is offered in Figure 4.

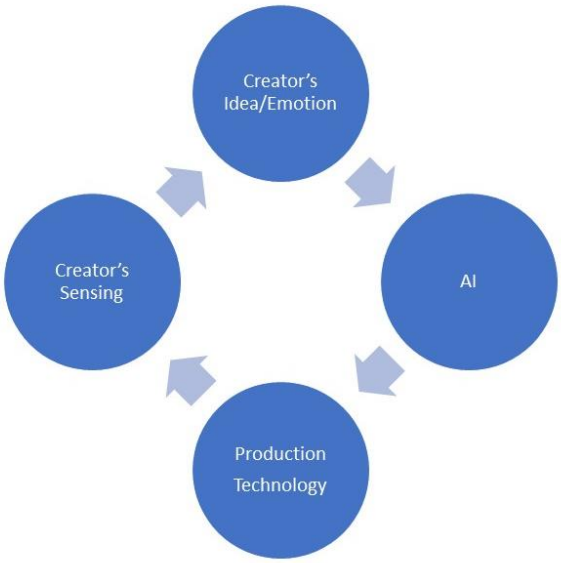


Figure 5 – Creation to Experience Cycle with AI and Production Technology.

RULES

Rules are helpful and carry some level of truth. Our ability to discern rules is rooted in seeking associations and making assumptions rooted in inference. Gatekeepers of disciplines may struggle with the ease of access to facets of their discipline. Behavior rules may govern the gatekeepers and the behavior within a discipline or community. Collet suggests the following rules moderate behavior: 1) determine articulated rules, 2) recognize infringement of rules, 3) recognize sanctions for rule breaking and 4) observe behavior patterns [11].

The danger of rule-driven artistic processes is the problem with, "who makes the rules?" Moreover, rules can stifle. One forfeits the "blank sheet of paper" when one borrows and modifies an established library of musical notes, chord progressions, color palettes, and digital imagery. Who moderates the repository of great creative works and the rules that flow from them? The rules are sometimes broken, but this can be the domain of a special breed that has complete mastery of a topic. Picasso was thought to have said it took him his whole life to learn to paint like a child. Employing rules to bring personal mental images or musical creations to an audience broadens access to these processes. However, rules can trivialize art. It is easy to impute anger in art. The rule is to simply identify a value or belief the viewer holds dear and mock it. This is an example of trivial, rule-based art.

Surprise

The ability to surprise is a distinctive human attribute that is a challenging notion for AI. However, surprise in one's environment may be threatening. Both behavioral and neural responses may be rooted in minimizing surprise. Surprise is the inverse of the probability of observing the outcome. People's expectations are moderated by experience or education to reduce surprise [12]. A baby is surprised by snow falling from the sky, the surprise soon goes away. However, surprise can be enjoyable because it upsets the norm. Too much surprise is unappealing or even frightening, while too little is boring.

Surprise falls between the design concepts of unity (or familiarity/expectations) and variety (or novelty/tension). Unity refers to the manner in which different aspects of art combine to form a sense of wholeness. This is achieved by such means as repetition of visual elements in artwork or audible elements in music. Variety is the opposite. It disrupts repetition by including changing elements. People enjoy variety, such as watching people's faces. They are symmetrical left to right but not top to bottom; however, they relate in a pleasing way. There is a rhythm to facial movement. In visual art, variety can be the inclusion of different colors, shapes, and textures. In music, variety can be using notes outside the key or by syncopation.

Music and art have many examples of surprise, and these normally carry the distinguishing names of artistic movements, from Impressionism to Jazz. The rules within a tradition are challenged by such works as Marcel Duchamp's 1917 *Fountain* and Igor Stravinsky's 1913 *Rite of Spring*. These were overt affronts to the status quo.

Are rule-driven art and music surprising? Perhaps not. Can AI generated art and music be surprising? Perhaps yes. It seems that surprise remains a delightfully irrational element that derives from outside the weight of science. Methodological naturalism cannot contend with irrationality. How does one include surprise in art, music, or design? Surprise moves from being too extreme so as not to be accepted by some recipients to being so subtle that the surprising elements need to be explained, and therefore not very surprising.

Personal Style

The preserve of humans to own their personal style is ostensibly challenged by AI's ability to identify patterns that can then nurture rule creation. However, people have the ability to 1) change their style and 2) incorporate influences serendipitously. The randomness and mistakes people make do not rest in the datasets that machine learning requires. Moreover, people respond and appreciate the sacrificial time and effort offered by other artists and musicians.

What is personal style and how much of it is simply a product of cultural imputation and the copying of influencers? Do we own our own sense of style? These are unanswerable questions; however, people can take surprising actions that upset rule-based approaches. People have the ability to shed rules and explore new ways of thinking and acting. Additionally, people can be exposed to events that modifies their personal style. This serendipitous stumbling can lead to a surprising randomness in style.

EXPERIMENTS

The author developed a song and a painting using normative rules. The song used a familiar chord progression and the painting used an obvious harmonic armature. In addition, several of the author's artworks that communicated a specific theme were compared to AI text to image generators.

Experiments in Music

All cultures have traditions of accompanying poetry to music. Applying music to lyrics can take many forms, from simple Gregorian chants to the "standardized" Romanesca harmonic sequence described earlier. European troubadours were perhaps influenced by Arab's using the *muwashshah* traditions to connect lyrics and music in a structured manner [13].

Moving poetry into music has been explored by many people, from Franz Shubert to the ethnomusicologist, Robert Zollitsch, who works with ancient Chinese poetry from the Tang and Song dynasties. Musicologists and professional songwriters/composers can offer guidance about creating music. Undoubtably this guidance can lead to amazing creations; however, executing this guidance is beyond the reach of many with lesser music education and talent.

One approachable technique the author has used is to write a poem and listen to a variety of chord sequences until an appealing sequence arises. This is a simple trial-and-error process, but it yields a satisfactory result. Obviously, this technique is not musical innovation, but rather it uses

music as an adjunct to poetry. However, this technique creates a song and is at the least a starting point for additional development.

Below is an example of a few verses that derived from a poem the author wrote about being an empty-nester and walking in a declining shopping mall the family used to visit. The words were accompanied by a chord sequence of D-A-Bm-G.

Darkened glass once held color
Silent corner once held laughter
Hands held hands and feet gathered
A place to be alone together

An old man reads a book
His wife looks at things not needed
Gather all their little shopping
Memories of children aisle hopping

Repeating chord progressions lack variety, so a refrain with a different chord progression is appealing. This poem, with more verses, a drum backing track, and the injection of a refrain with a chordal progression of C-Bm-G, becomes a song. While music-generating AI platforms would be another technique to create music, it seems to lack the simple exploration allowed by chordal progressions.

Experiments in Painting

The author painted a harmonic armature with a few variations. Following the establishment of this pattern, with its prominent armature lines, he used different colors within the resulting shapes to communicate the Garden of Eden.

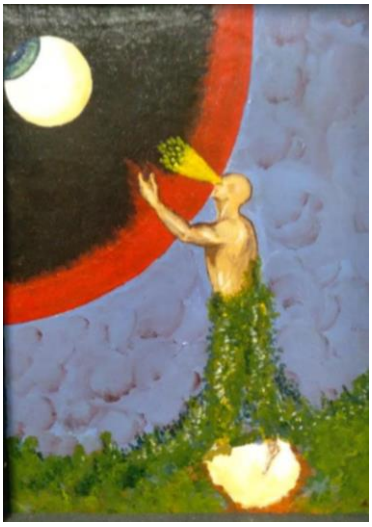
In addition, the author compared two of his paintings and one of his charcoal drawing with images generated by OpenAI's DALL-E and Stable Diffusion's DreamStudio Lite. Specifically, the author created paintings and a drawing that conveyed a specific theme or intent, one of which was formally constricted to a harmonic armature, as described previously. The paintings and drawing were determinately intended to convey an idea, one was an allegory. When this intent was entered into the DALL-E and DreamStudio Lite interface, the author's artworks were not replicated. The closest matches are presented in the following figures. For the painting based upon a harmonic armature, the author tried many variations of text, including using "in the style of Piet Mondrian" for the Garden of Eden painting, because it echoes his style. The results are shown in Figure 5. The results of another painting comparison, in which the author's intent was provided, is shown in Figures 6. The allegorical drawing comparison is shown in Figure 7. The text prompts not only included the intent, namely "evil constrained", but the use of an egg as an allegory.

Author's Painting

DreamStudio Lite

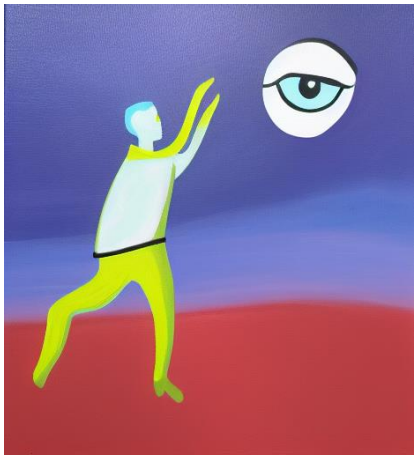
DreamStudio Lite

Figures 6 – Author's painting compared to two images from DreamStudio Lite. The author's intended theme is basically: Garden of Eden contained within spaces of a harmonic armature.



Author's Painting

DALL-E



DreamStudio Lite

Figures 7 – Author's painting compared to DALL-E and DreamStudio Lite. The author's intended theme is basically: Man exploring space, while rooted in the Earth.

Author's Drawing DALL-E DreamStudio Lite

Figures 8 – Author's allegorical charcoal drawing compared to DALL-E and DreamStudio Lite. The author's intended theme was: evil constrained.

APPLICATION FOR ENGINEERING EDUCATION

Engineers are comfortable with the rapid distillation of numerous ideas as they blend creative and analytic abilities. Faculty can encourage both of these abilities in students. One example the author uses is an exercise in an introductory mechanical engineering course in which the students are asked to draw an abstract image based on an abstract noun prompt, such as "trust". They cannot draw an allegorical presentation but only an abstraction that employs lines, value, and texture. The majority of the students are pleased with their work and students were often surprised at what they produced. Typical exemplar quotations were: "I didn't know I was an artist" and "I was surprised at what I could do" [14]. We also have an annual painting party at our Society of Inventors and Mad Scientists student organization. We set out acrylic paints, brushes, canvases and let the students explore.

In a prototyping class, we use harmonic armatures and other compositional design principles to develop appealing layouts for landscape dioramas. The structure of the harmonic armature compels student to avoid simple symmetry and include compelling variety in their layouts.

In considering the imposition of AI in the engineering discipline, we need to highlight that machine learning relies on a curated dataset. Moreover, AI systems do not get to ask the questions nor can they predict the randomness of personal stylistic changes. To prompt the convergence of analytic and creative thinking, I challenged the students to make a painting of deep space (and I did so myself) immediately before the James Webb telescope was deployed. This was a unique time where we could imagine what space would look like before the penetrating images of the Webb telescope further constrained us with facts.

CONCLUSION

If one imagines a clever image or writes a beautiful collection of words, how are they turned into artistic expressions? The rational mind can recognize patterns of aesthetic appeal, such as in music and the visual arts. These patterns can be adjuncts to communicating ideas. Interpretive epistemologies can recognize rules and culturally moderated patterns that can be employed to "engineer" art and music. While engineering normally works within a positivistic framework with closed regularities that do not allow exceptions, using normative rules derived in the constructivist tradition allows entrance into the arts by those with little training.

Musical composers should be offended at the notion of creating music by simply accompanying lyrics with a rule-based (or sampled) approach. This offends the depth, breadth, and creative majesty of musical composition. A traditionally trained artist will likewise be offended at artwork produced by morphing existing images and applying colors from a standardized color scheme. However, musical and artistic creation can be democratized by identifying patterns and normative rules which are redeployed in a new, personal form.

The engineering profession is distinctive in its ability to create new possibilities from analysis and insight. Engineers know how to use rules and tools as adjuncts to their innate talents and educated abilities. Recognizing rules related to art and music can open up a wonderful dimension of human potential. Human expression is empowered when engineers are asked to be artistic by those who establish their intellectual ecology, thereby encouraging an often silent voice to add alluring qualities and expressive communication to the world of engineering. The merging of human creativity with development tools provides inclusivity for those who have rich potential, but lack specific art and music skills.

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