#1 Rule Safety First

SOME NOTES ON SCIENCE, METHOD, AND STEAM

ON SCIENCE – the critical, RIGORous Foundation of STEAM:

- To say, “Science” and “Scientific Method” is redundant:
  - Science is, by definition, a method.
  - Science allows the individual to make discoveries, collect data, and translated that data into a set of hypotheses based upon uniform arguments, such that the exercise is repeatable.
  - Further, any variance in the results can be examined in order to determine if the underlying causality is definable, inexplicable (requiring further study), or simply extraneous (irrelevant).
    - If definable, then the variances are captured in the form of variables that can be further manipulated.
    - If inexplicable, then more work needs to be done – and suggests that the original hypothesis(-es) may be incorrect. This is SIGNIFICANT.

    - If extraneous, then the variance must be accounted for and properly attributed, such that the variance itself is rendered static.
- Method is merely a collection of discrete procedures that are followed with exactness both in terms of sequence and applicability.
- Studies provide for indicators, based on repeatability and strength:
    - Those that report back 60% in favor are useless, and at best present markers or indicators (guides) of potential, however, the original hypothesis is wrong, period. Such results are **not to be considered reportable** to outside sources.
    - Those that report back 75-93% in favor are of high value, in that many of the variables can now be considered definable, and you have a small, workable margin of variability to abstract out for further testing. However, these results still are **not to be considered reportable** to outside sources.
    - Those that report back 93-99% in favor are considered definable and reportable to outside sources, with the expectation that any/all variances will be accounted for through follow-up research. These are considered 2nd Sigma quality.
    - Only when you get up to 99%+ reporting in favor of the original hypothesis are you considered 3rd Sigma, with 6th Sigma (99.9997%, or 3.4 parts per million against) being the ultimate goal of Scientific study.

- Now, I want you to think about this, strongly, when you hear of “scientists” who are working on “studies” and report back 70% results in favor of their respective hypotheses. 70% is NOT reportable, it is merely a guide suggesting you are on the right track (and you might not be).
- Real Science requires RIGOR and discipline. It requires an sense of absolute, in terms of how the research is approached, how the controls are put into place, how the variables are defined, how those variables are restricted (preventing conflation, corruption or cross-contamination), how the data is collected, how the data is analyzed, and how the data is culled into a proper, scientific argument which is mathematically correct, logically sound, and rhetorically void of any illusion or fallacy. That’s RIGOR.
- Such RIGOR can be considered “difficult”, but that’s only if the scientist has not acquired and maintained a proper level of discipline. With discipline, the method is rendered absolute and repeatable – such that variables can now be properly isolated. With discipline, the proper and necessary RIGOR is achieved and maintained “easily”!
- I also want you to think about what we said when it comes to being a “C” or an “A” student: Any results from the effort that report back a 99% or below must be followed-up with via additional research.

    - So, in the real world, be it Machining or Scientific Research or Computer Programming, anything short of near-absolute is simply not good enough.
    - Now, don't take that as an excuse to back out. Getting to the 6th Sigma is not nearly as difficult as you might anticipate – especially if you have RIGOR baked into your method. BE "that individual" who doesn't give up on the 2nd or 3rd, or even 9th try. Think of the example of changing out the locks on a door: first it takes 30+ minutes, then 15, then 8, then 5, then 3, then, ultimately, less than 2 minutes with your eyes closed, resulting in a job well done. Practice with Definiteness of Purpose, and the results will, absolutely, follow.
  - From this point forward, you are a scientist. Why? Because when you embark on any focus (be it biological or chemical or geological, etc.), you will have a "scientific attitude", you will retain discipline, and you will apply RIGOR.
  - From this point forward, you will not be a Chemist, or BioChemist, or NeuroChemist, or Ecologist, or Biologist, or Physicist, or AeroPhysicist, or AstroPhysicist, or Epidemiologist, or Sociologist – you will maintain a "general systems" point of view, even as you hone in on a particular sector. Your 'title' might be BioChemist on the job, but your actual 'Capacity' will be scientist.

ON TECHNOLOGY – the development of the Tools and Materials of STEAM:

- Technology is a social exercise of adding to the contributions of those that preceded you. Without the Mayans, the Egyptians, the Babylonians, the Arabs, the Persians, the Greeks, and many individuals from the Renaissance or Classical eras, we would not have the internet, or computers, or mobile phones, or space rockets.
- Muhammed al-Khwarizmi, who was born in Persia but lived in Baghdad, could not have developed the method of Algebra without the prior contributions of specific mathematical concepts by the Indian mathematician Brahmagupta – and without Algebra, as well as Geometric and Trigonometric concepts provided by the Greeks, Newton could not have derived the theorem of Calculus.
  - On a Side Note: Newton came to calculus as part of his investigations in physics and geometry – viewing calculus as the scientific description of the generation of motion and magnitudes. In comparison, Leibniz focused on the tangent problem and came to believe that calculus was a metaphysical explanation of change. Cite: https://en.wikipedia.org/wiki/History_of_calculus#Newton_and_Leibniz
- The point being, Technology is not, and cannot be, considered outside a constant and consistent, "**continuous function**" of historical contribution to deriving an improved set of advances.
- So how does someone "derive" Technology?

- You start with the Scientific principle of Observation – you are sensitive to and aware of your environment – and you realize that a Problem exists.
- You then use Engineering principles to arrive at a preliminary Solution (which is a specific hypothesis that answers the given Problem).
- You again return to the Scientific Method to test that Solution, and you measure the test results using Mathematical calculations against established metrics (standards). You repeat this step until your Solution fits the Problem within a determined specification or tolerance.
- Once you have vetted (tested) your Solution and arrived at a version that repeatedly sits within the metrics, specification and/or tolerance, then you can officially state that you have contributed a Tool or Material, and therefore, you have advanced the Technology in that area.

ON ENGINEERING – understanding the underlying forces (Physics) of STEAM, and adapting to overcome those forces:

- The easiest way to understand Engineering is to look at how Structural, Mechanical, and Electrical Engineers view the notion or concept of "burden":

- Structural Engineers look at static forces against a particular plane – for instance, how much weight (aka "load") is placed on a particular section of framing. They look at whether the load causes bending (called flexion) in a beam, or any twisting at a joint (torsion). The Structural Engineer will then modify a design to either increase the size of the object being affected (e.g. changing a 4x6 beam to a 4x8 beam), or, they may change material itself, going from a wood beam to a metal I-beam.
- There are two primary types of Mechanical Engineers:
  - Mechanical Engineers in the sense of CNC parts address flexion and torsion, but also tensile strength (the ability to resist tension, being pulled apart) and the ability to resist against compression forces. Think of a bolt in a car engine: if it is to small, or made from too weak of a grade of steel, it will snap, crack, bend or deform. Mechanical Engineers run tests on all metal parts, against specs derived mathematically, in order to determine the appropriate size, alloy type, and even the heat at which the part is tempered.
  - Mechanical Engineers in the sense of HVAC (Heating Ventilation and Air Conditioning), are concerned with proper air flow and area coverage. They use mathematical calculations to determine the size of ducting against the size of the space being heated, cooled and/or ventilated – which is translated into a "load"

  (resistance force) upon the overall system. The larger the space being accommodated, and, the longer the distance from the motor, the larger the ducting and/or strength of the motor (or even number of motors used in line).
  - Electrical Engineers measure the flow of electricity, and determine, through mathematical formulas, the size of wiring needed to account for "load" being presented by all components using a particular circuit. For instance, if you place a Refrigerator, a separate Freezer, a Dishwasher on a single circuit, which is "at capacity" (we've discussed "capacity" before, we will again), then, in order to add another device, say, a Microwave to that same circuit, we need to increase the size of the wiring – or else the heat generated along the circuit, due to resistance against the electron movement, will likely cause a fire.
- Engineering that is tied only to the Solutioning of a Problem is, to a degree, insufficient, and requires Artistic integration.
  - Art allows for access to contextual usecases, to ergonomics, to a wide pallet of textures and colors that serve to abstract out and resolve nuanced connections, and, to elicit emotional appeal through expression.
  - Engineering utilized with Artistic influence, especially when it satisfies a thorough set of usecases, in addition to high tolerances, is called a "good design" – without such influence, it is considered dry and/or unsatisfactory.

ON ART – the highest point of Mastery of all areas of STEAM:

- Art is the tool of expression, of presentation, of communication.
- Art houses and contains the essay posit (the hypothesis), argument (the Engineering work), and the resolution (the Solution).
- Art conveys the Solution in a manner that suggests a complete package – that all stones have been overturned, from Engineering, to Math, to metric, to specification and tolerance, to Scientific RIGOR.

ON MATH – the structural scaffolding that flows throughout all elements of STEAM:

- Mathematics is the language of STEAM.
- Mathematics assures that there is no variance in interpretation – variables are exacting, and can be read by anyone, regardless of their native tongue.
- Mathematics permeates all areas of Science, Technology, Engineering and Art.
- There is so much more to be said about Mathematics going forward.

MORE ON "STEAM"

Notice that I have included Art, formally incorporating it and indeed "integrating" it within the dynamic. "STEM" alone, without Art, is grossly insufficient, and the lacking will fast become apparent. So remember, as you study fiction novels and abstract painting and realistic drawing, etc., you are studying an area that has direct implication to the STEAM dynamic as a whole.

STEAM is a wholly contained dynamic – you can't study and master Science without understanding Problem Solving, Design, Calculation, and the Material components. Same goes for Engineering. Same for Technology. Same for Mathematics. Same for Art. A good Artist understands the Math inherent. A good Mathematician knows the abstracted principles, as well as how those principles translate into application in real-world settings. The combined facility of STEAM allows for proper assessment, evaluation, analysis and manipulation – and uses special cross-checking mechanisms to weed out extraneous variables. Know this concept. Understand it. Live it.