THE RITCHEY SCIENCE & ENGINEERING FAIR AT WEBER STATE UNIVERSITY

Science & Engineering Fair: Scientific Practices vs. Engineering/Computer Processes

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This notes version of the presentation given in the Ritchey SEF workshop is provided to fill in some of the back story of the presentation and to assist in remembering the important points. It is also a way of passing along the links, which should be live in the notes section of this document.

What's What?

Science	Engineering/Computer
How does nature work?	Put nature to work: create something new
Exploring and/or observing for the sake of knowledge	Inventing or creating
Can be theoretical or applied	Can be investigating "how" a device works
Identify a problem	Identify a need
Design a fair test to explore the problem	Create a solution to solve the need or problem
Must control variables and be falsifiable	Must be practical

Comparing the Two Approaches

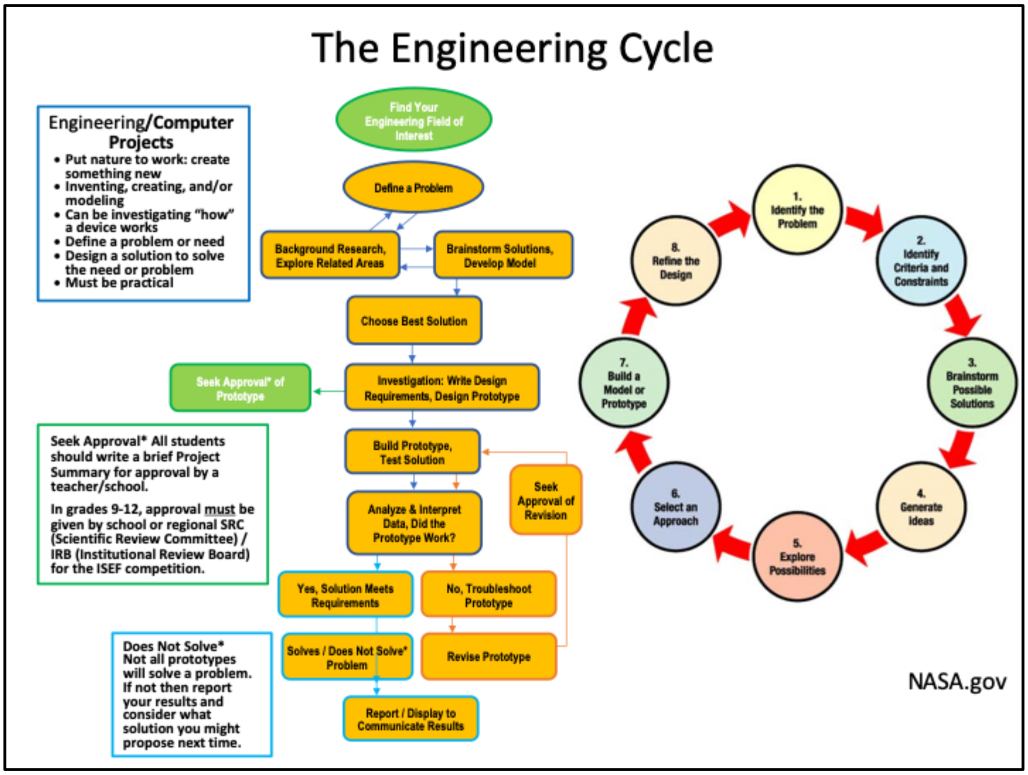
Scientific Practices	Engineering Design Process
State your question	Define the problem
Do background research	Do background research
Formulate your hypothesis, identify variables	Specify requirements
Design experiment, establish procedure	Create alternative solutions, choose the best one and develop it
Test your hypothesis by doing an experiment	Build a prototype
Analyze your results and draw conclusions	Test and redesign as necessary
Communicate results	Communicate results

https://www.sciencebuddies.org/

https://www.sciencebuddies.org/

Engineering Projects, Complete Details:
https://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml?from=Blog#theengineeringdesignprocess

Scientific Projects, Complete Details: https://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml?from=Blog#overviewofthescientificmethod



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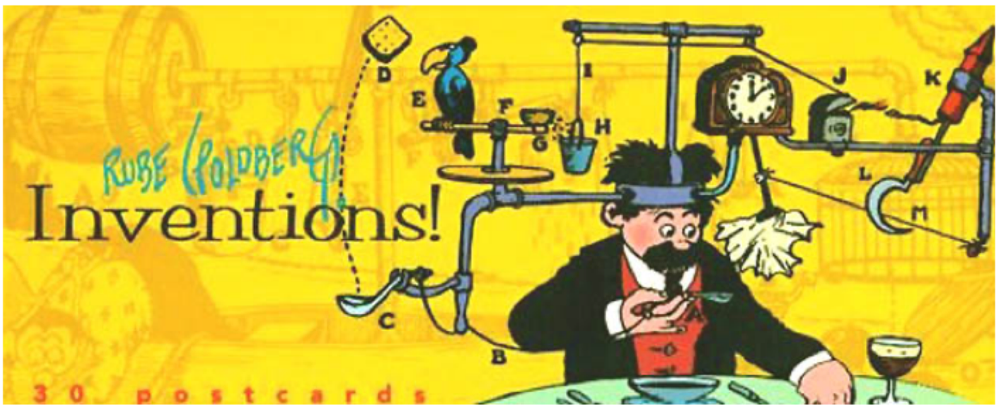
Engineering/Computer Science Problem Definition

- The problem you are solving must be real.
- The problem must be clearly stated.
- The solution must be user friendly and better than the problem.
- The solution must clearly address the problem.
- The solution must be practical.
- The solution must be cost effective.

No Rube Goldberg solutions!

No Rube Goldberg Inventions!



Automatic napkin. Cover art from book: *Rube Goldberg's Inventions!* ©1996

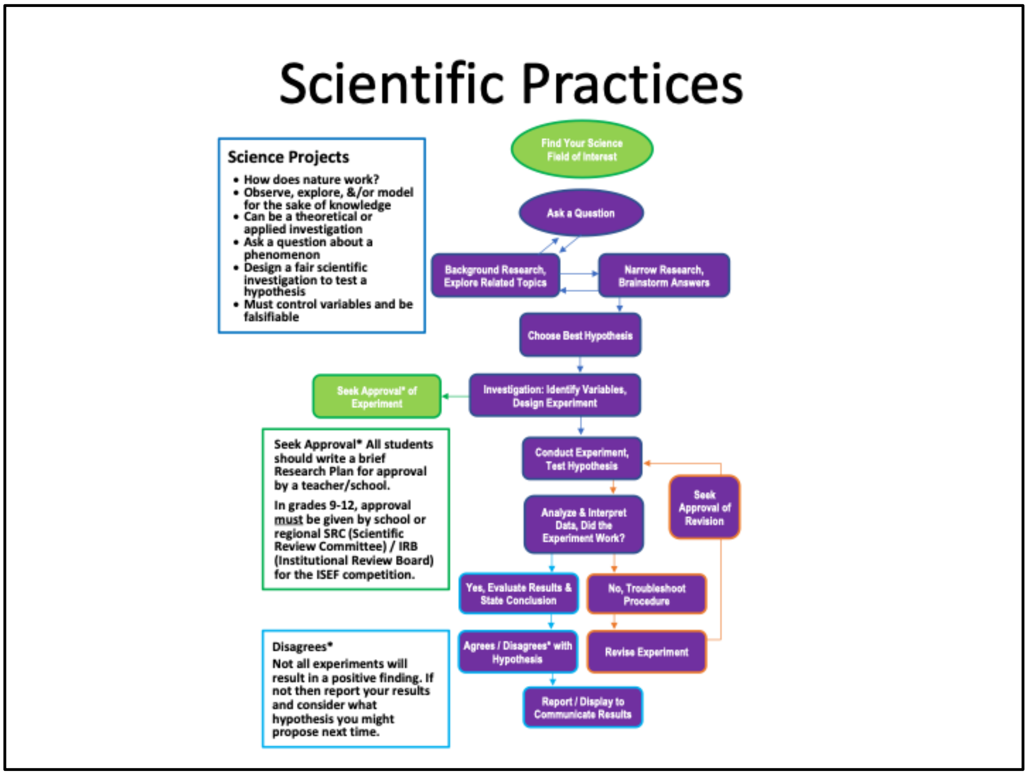
Important Engineering Prototype Issues

- You must test your system thoroughly.
- Your tests must make sense.
  - Units must match the concepts. Power in watts, energy in joules, etc.
  - You must understand why you are doing a test and what the results mean.
  - Results should be "actionable." (Guide decisions)
- Redesigns must be evidence driven.

Actionable results are results that show you where you can improve the design or that show clear advantage of one design over another so that a decision can be made.

Reporting Engineering/Computer Results

- You need performance data.
- Tests must result in graphs, data, interviews, etc. that match the problem solving goals.
- Ideally, redesigns should clearly address the performance data.
- Great projects with poor data will die early. ISEF Judges know.



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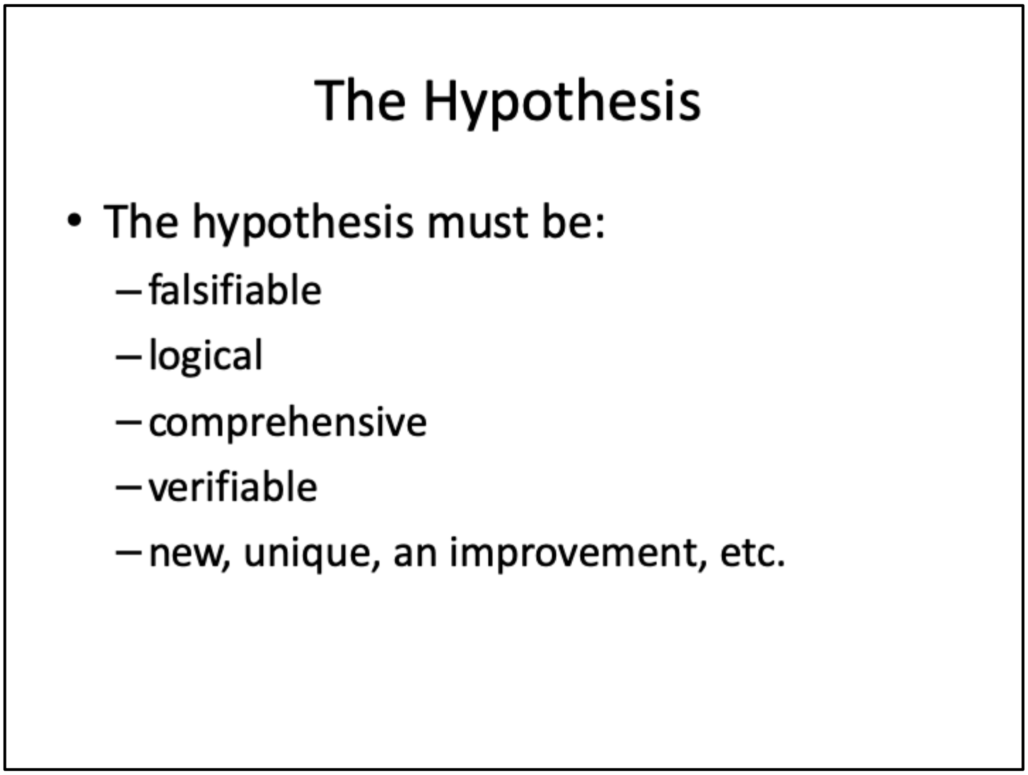
Scientific Question

- Scientists study nature, the question must be "real" and of interest.
- The question must be clearly stated.
- Should be a complete question not an observation:

~~"Burrowing owls nest underground."~~

"Why do burrowing owls nest underground rather than in trees?"



FiLCHeRS:

- Falsifiability - “Prove me wrong!” Claims must be testable.
- Logic - Arguments must be sound. Conclusion follows from the premises which must be true and sound.
- Comprehensiveness - ALL available evidence must be considered. Results not based on anecdotal evidence.
- Honesty - No self deception and willing to change belief.
- Repeatability - Others must be able to reproduce your results.
- Sufficiency - Evidence must be adequate. Results/conclusions not based on authority or testimony. Must be based on evidence rather than lack of evidence. “Nothing says I’m wrong.”

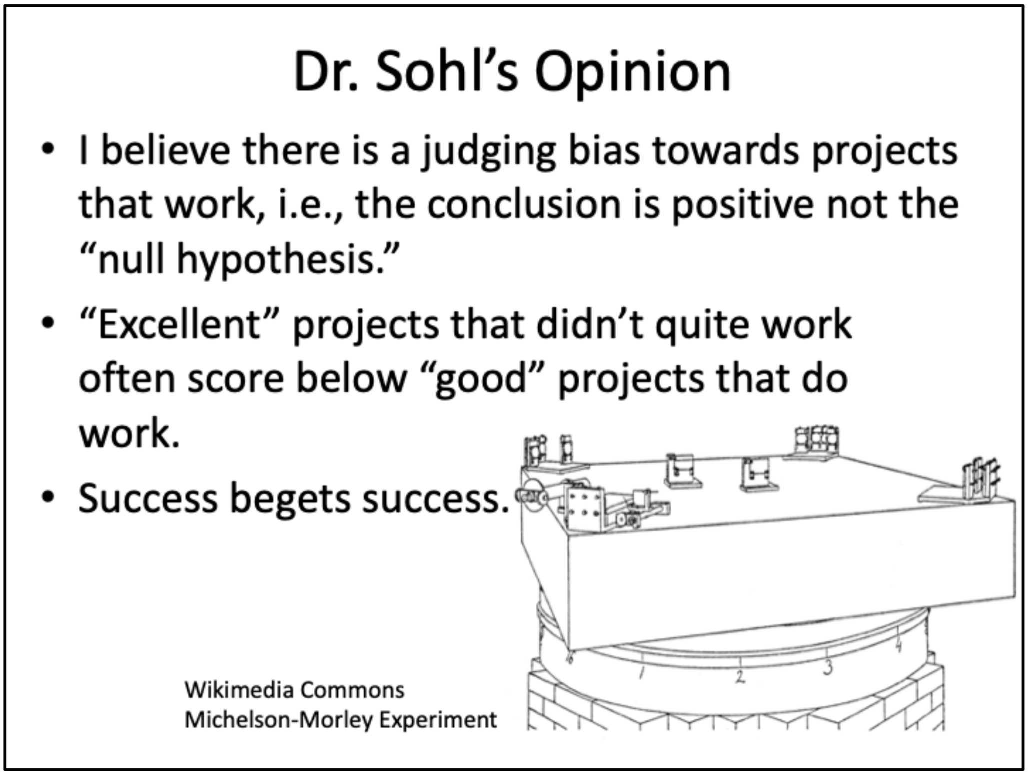
Data Collection

- **Comprehensive**; all data/evidence must be considered, not just positive results.
- **Double-blind** (no self deception)
- **Sufficiency**: Must be based on evidence, not lack of evidence.
- **Repeatability**: Multiple data runs must agree!
- Great projects with poor data will die early. ISEF Judges know.

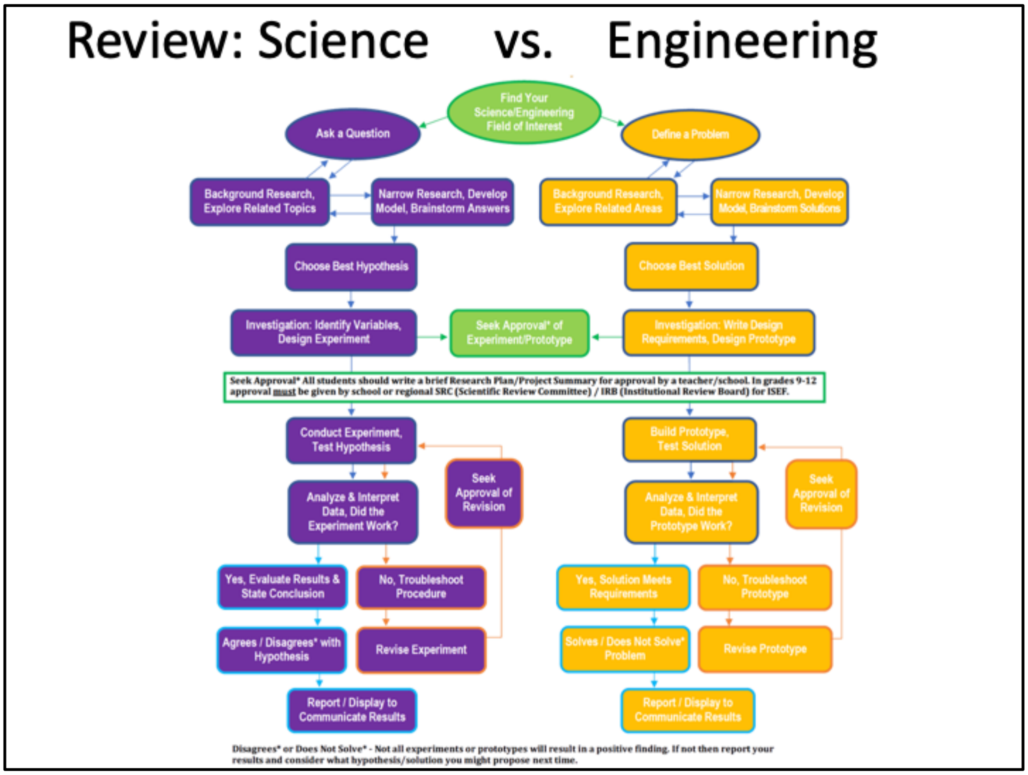
Evidence vs. lack: Harry Potter and the resurrection stone when Xenophilius Lovegood says that you have to look at every stone to prove him wrong.

Conclusions

- Conclusions **must follow from the data** not from your desires.
- Conclusions should be:
  - complete
  - concise
  - clear
  - address the points in the hypothesis



This can be applied to both engineering and scientific projects.
This is especially true at the local level.
This is true professionally too. An excellent example is the 1887 work by Michelson and Morley on the lack of detection of the luminiferous eather. The results were basically ignored until after 1905 and Einstein’s discovery of special relativity. It was a reasonably obscure experiment for nearly 20 years and even Einstein didn’t seem to be particularly aware of it until after he developed special relativity. Michelson got the 1907 Nobel Prize in Physics but not for this experiment! He got it for his incredible optical instruments. Morley never received the Nobel.



This chart is included as a handout in your folder.