

**Title: Rejecting the hypothesis—The Engineering Method as an  
Alternative to the Scientific Method.**

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**Abstract:** The Scientific Method, built around the development and testing of a hypothesis, has been and continues to be fundamental to advancing our knowledge of the world around us. However, sometimes the hypothesis neither helps guide the methodology nor helps to answer the study questions. In these cases, the Engineering Method, which doesn't rely on a hypothesis, can offer a better alternative to the Scientific Method. This article will use examples from a school science fair to demonstrate the shortcomings of the hypothesis based Scientific Method and how the Engineering Method can be effectively applied to answer those same questions. Though the Engineering Method is almost unheard of, it is not a new idea. However, it is time that we introduce the Engineering Method into the classroom and begin an open discussion of when the Scientific Method is appropriate and when it isn't.

**Main Text:**

The Scientific Method. We know it well. It has been taught and drilled into us since our early school years. The familiar paradigm is:

1. Identify a question or problem
2. Gather information through observation
2. Construct a hypothesis
3. Design and conduct an experiment to test the hypothesis
4. Analyze the data and accept or reject the hypothesis

Since high school, there was something about the Scientific Method, particularly around the hypothesis generation that just didn't seem to sit right. This unease became unavoidably apparent later in my adult life during a visit to my daughter's elementary school open house. After meeting her teachers and dutifully viewing her art work hanging on the walls I slipped off to see the fifth-graders' science fair. Twenty-five beaming faces stood by their poster boards and display tables. There were a variety of projects exploring probing questions framed as proper hypotheses. These included: The hard rubber ball will bounce the highest. Popcorn brand XYZ will have the fewest unpopped kernels. ABC cleaner will remove crayon the best. Clearly, they had been carefully taught the Scientific Method as each student's station crisply stated their hypothesis along with a plausible argument to justify their reasoning. They outlined their experimental design used to test each hypothesis and reported their final results. After

reviewing a few projects and talking with the students I noticed a trend—every single hypothesis was shown to be valid. The final total was 25 correct hypotheses and 0 rejected hypothesis. Wow! Was this a class of geniuses? How could they, at the age of ten, have such a command of chemistry, physics, and popcorn agriculture that they could make correct hypotheses every time?

Personally, I could not have a-priori correctly hypothesized 25 times the answers to questions such as, “which bag of popcorn will pop the best?” and yet I knew their dirty little secret. I knew because I did the same thing during most of my school years. You run the experiment first then formulate the hypothesis based on the results. Since you know the answer, you might as well formulate the hypothesis so you look like a genius. Admit it; surely, you’ve done this at least once. This then raises the question, *what value is the scientific method, based around hypothesis formulation and testing, if the experiment is conducted in the same way and the conclusions remain the same regardless of whether an a priori hypothesis was generated or not?* Why then even bother to formulate a hypothesis?

My eureka moment came several years later during a medical imaging conference during a presentation by Houston Baker which touched on the “Engineering Method” (1). Despite having three degrees in engineering I had never heard of an “Engineering Method”. A quick poll of my engineering colleagues confirmed a universal lack of knowledge of even the existence of an Engineering Method. This method was similar to the Scientific Method with some distinct differences (2):

1. Identify a question or problem
2. Identify constraints on solving the problem
3. Propose a solution to test feasibility of solving the problem or answering the question
4. Iterate to an acceptable solution

It suddenly became clear to me that many of the problems we force into the Scientific Method are more appropriately handled by the Engineering Method. Since predicting a priori that “Popcorn brand XYZ will have the fewest unpopped kernels” did not help in the experimental design, the real question should have been, “Which brand of popcorn pops the best based on our constraints?” Properly stating the problem establishes a more natural fit to answering using the Engineering Method.

Using our science fair project examples, the application of each step of the Engineering Method can be further illustrated:

1. Identify a question or problem—this step is the same for both the Engineering Method and the Scientific Method. However, rather than just stating the problem it is valuable to articulate the larger context that is motivating the research. For example, “I hate unpopped popcorn kernels so which brand should I buy to minimize these teeth cracking grains?” It is possible that the question doesn’t have a larger context. Having raised three kids, all who thought the house walls were their canvas, the question, “which cleaner removes crayon the best?” was important to me. However, why does it matter, “which ball bounces higher”? One is not going to start using a hard rubber ball instead of a basketball just because it

bounces higher. This doesn't mean this question shouldn't be investigated; it is just worth an honest statement of the context at the onset of the investigation as this may help guide the experiment.

2. Identify the constraints on solving the problem—Whether using the Scientific or Engineering Methods, it is useful to explicitly state the constraints that impact the experimental design. As an example, there must be hundreds of popcorn brands and it would be impractical to locate and test them all. The problem must be bounded and some reasonable constraints might include only testing brands of microwave popcorn available at the local store. Or perhaps only the economy brands will be tested because Mom will not spend the extra money for premium popcorn regardless of their popping ratio. Time and money will almost always limit our quest to sample all possible solutions so these as well as other constraints should be thoughtfully considered and documented.
3. Propose a solution to test feasibility—this step is similar to the Scientific Method step of, “design and conduct an experiment to test the hypothesis”. Several iterations may be required to find a practical testing approach. The test may be obvious such as counting the number of unpopped kernels in each bag. Or, as in the case of the crayon cleaning project, there may be several options to consider for testing how well each cleaner removed the crayon. These might include measuring the time spent scrubbing or a semi-quantitative quality score of how well each cleaner worked. Understanding the context of the original question or problem and the identified constraints can help guide the test feasibility steps.

4. Iterate to an acceptable solution—in the popcorn problem the solution could simply be selected from the available test samples, perhaps limited by availability at the local store. Alternatively, we could have identified the goal of finding a brand with fewer than ten unpopped kernels and then continued testing until one was found or we ran out of money or time. Iterating to an acceptable solution is a key feature of the Engineering Method. Often, we would like to answer the question, “which is the best?” but often the possible set of options is unconstrained or prohibitively large. Given these potential restrictions the incremental improvements between very good and the best often won’t make a material difference in the success of the outcome. Sometimes an absolute threshold for acceptable can be prescribed while other times it will simply be the best of the available options.

This step of the Engineering Method, as well as the other steps, may require the use of the Scientific Method. For example, sound hypothesis generation could be used to constrain the sample space of our popcorn testing. We might hypothesize that premium brands will pop better. A quick test to validate this hypothesis may allow the testing to then focus exclusively on these higher-end brands. The Engineering and Scientific Methods do not need to be mutually exclusive.

The Scientific Method has been and will continue to be a critical tool in advancing our understanding of our world and universe. However, it is not the only tool and may at times not be the best tool for solving problems or answering questions. We need to go

beyond the Scientific Method and introduce our students to the Engineering Method and we need to teach the appropriate application of each of these methods. Sometimes the generation of a hypothesis does not help advance the science and answer our questions so we need to stop forcing a hypothesis when it is not appropriate.

**References and Notes:**

1. H. Baker, "Understanding and Taking Advantage of the SBIR Program", presented at the 7<sup>th</sup> Annual Meeting of the International Society for Magnetic Resonance in Medicine, Philadelphia, PA, May 1999.

2. For a more detailed discussion on the Engineering Method see:

B.V. Kohn, *Discussion of the Method* (Oxford University Press, New York City, NY, 2003)