A Short Primer on Scientific Method

by Joseph “Eliot” Elliott

Children will often apply scientific method: they look without bias and then report with unflinching truthfulness! As we shall soon see, understanding the minimum requirements of scientific method is of great help for all of us—at any age—when identifying which theories may have scientific support. Many people consider a theory "good" if it is backed by science. How do we identify if a theory is actually backed by science? The answer is in knowing the basic requirements of scientific method. To adhere to scientific method, a theory must fulfill three criteria. First, its claims must be testable; second, its explanations must be difficult to vary; and finally, its test results must be truthfully reported.

When identifying whether a theory is meeting the basic requirements of scientific method, we first organize a theory's parts into the form “Claim because Explanation.” For example, if the claim is "the ice will break when you walk on it," and if the explanation is "the ice is too thin," then the "Claim because Explanation" form is, "The ice will break when you walk on it because the ice is too thin." In order to evaluate whether a theory meets the basic requirements of scientific method, the theory must be put into this "Claim because Explanation" form.

Let us look closer at the "Claim" part of a theory. A scientific claim must be constructed to meet the following conditions: the claim must be measurable[1] and the claim must be disprovable[2]. In other words, it must be testable. The claim in our example, "The ice will break when you walk on it," is both measurable and disprovable. The ice breaking or not breaking is measurable, so the claim meets the measurability requirement, and if the ice does not break when walked upon, the claim would be disproved, which meets the requirement that it is possible to disprove the claim. Since the claim exhibits both measurability and disprovability, this claim meets the first requirement of scientific method, testability.

Before we look at the "Explanation" part of a theory, let us investigate an example of a claim that sounds scientific at first, but turns out not to meet the testability requirement of scientific method. Is the claim, “A person cannot live forever,” a scientific claim? To answer, we check whether or not it is measurable. We certainly can measure (observe) if the person is alive or dead. Is the claim disprovable? To disprove the claim, we would need the possibility that someone has lived forever. Since that is not possible, the claim is not disprovable; it does not meet the testability requirement. We note that it is highly reasonable to say, "A person cannot live forever." We are just pointing out that the claim is not constructed in such a way as to meet the testability requirement, and thus is not useful when using the scientific method.

Now that we understand how to check the "Claim" part of a theory, we can move on to the "Explanation" part. To meet the basic requirements of scientific method, an explanation must be difficult to vary. This is not as tricky as one may think. A scientific explanation is one that cannot be easily varied or changed as a result of the collected measurements and observations.[3] To check if an explanation is easy to vary, use the following repeatable sequence: consider possible test results that would disprove the claim, then check whether a slight modification to the explanation can disrupt this disproval. If it is easy to disrupt the disproval with a slight modification, the explanation is highly variable. If it is difficult to disrupt the disproval, then the explanation is difficult to vary. This low variability of the explanation is a requirement when using scientific method. In our example, "The ice will break when you walk on it because the ice is too thin," if the ice does break during the test, then there is no need to vary the explanation. The first and second requirements of scientific method are met. If the ice does not break, disproving the claim, it will be difficult salvage the theory by varying the explanation that the ice was too thin. In the disproved case, the ice did not break; the basic requirements of scientific method are still met. Nevertheless, the claim and explanation are simply wrong, and the theory should be abandoned.

To recap, we now know that a scientific theory's parts should be organized into the "Claim because Explanation" format. We also now know that the "Claim" must be testable (measurable and disprovable), and the "Explanation" must be difficult to vary. The third basic requirement of scientific method is that test results be reported truthfully. Here we must address the fact that scientists are also human. Being human means being prone to human foibles. Scientific method requires truthful reporting of the facts, yet humans are sometimes not truthful. Scientific reporting must also resist taking sides or having bias. It has been said, "Truth doesn't have a side."[4] Humans, including scientists who are reporting results, sometimes make misleading claims, lie by omission, and just outright lie. When this happens, it becomes difficult or impossible to verify results. If the reporting of results is not truthful, a basic requirement of scientific method is not met. Simply put, the scientific method requires the veracity of results. This is why the scientists rely on a public exchange of information, so others can independently confirm or dispute the publicly reported results.

Knowing the basic requirements for scientific method will be of great help when evaluating and sorting the many claims and explanations that are offered. In summary, scientific method requires the theory's claims to have high testability, explanations to have low variability, and results to have honest veracity. Now when someone exclaims with excess enthusiasm that their theory is scientifically "proven," we need not be disadvantaged in our response.

1. Francis Bacon was born on January 22, 1561 in London, England. Bacon took up Aristotelian ideas, arguing for an empirical, inductive approach. biography.com

2. Karl Popper (July 28, 1902—September 17, 1994) defines empirical falsification as follows: a theory in the empirical sciences can never be proven, but it can be falsified, meaning that it can and should be scrutinized by decisive experiments. wikipedia.com

3. David Deutsch (2009), "*A New Way to Explain Explanation*"

4. Bennet Omalu (2017), "*Truth Doesn't Have a Side: My Alarming Discovery about the Danger of Contact Sports*"