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THE STATE OF SCIENCE IN 2014

Abstract

The state of science in 2014 is presented, comparing to science in earlier times. “Where did we come from, where are we, and where are we going?” Somewhere in the middle of the 20th century, the Scientific Method – described in the paper – has been abandoned in scientific research in favour of something all-encompassing; all research, independent of its type, is now considered science. We argue that this has created some serious problems and the credibility of science is at risk. As an example, science is expected to have benefits for society, while before it was only concerned about knowledge. Moreover, science is forced to be politically correct and essentially prove what people want to hear to be the truth.

Introduction

We all love science. Science is considered a noble endeavour by the society, something to be proud of. It is something that will move forward our society, taking us out of the Dark Ages. Heroically we remember people that were fighting against contemporary opinions and thought-patterns in society. We read historical novels of how individuals were fighting religious indoctrination and thus breaking the hegemony of institutes. They did this in the name of science. As long as we stick to science, so we think, everything will be OK.

Yet, in 2014, science is dead.

Figure 1. Project proposal for the study of Relativity in 2014. © P. Stallinga, 2014

This is quite a strong statement to make. How can something be dead that we all venerate so much? And, if so, how could that have happened? What went wrong, and why? Are there examples to substantiate this pessimistic claim?

Discussion

We first have to introduce to the reader what *is* science, and what it is not. It is amazing to see that nowadays PhDs are given to people graduating from technical high schools. That is, students of a faculty teaching a technology approach get a *philosophical* degree. The reasoning behind it is that technical high schools are of a level as good, if not better, than many universities. It is not fair to call one school a university and the other just a technical high school, implicitly assuming that something that is called a school is of lower value compared to a university. The result is that all high schools have been re-baptized 'university' in many countries. And all students from a university, after doing research (be it science or not) get a PhD. Yet again, the reasoning is that “If it was as difficult to do as science, it deserves a diploma equal to one given in science”. As an example, students from our engineering department, where they formerly would get an Engineering degree, now get a PhD.

This goes even further. Most students getting this philosophical degree never had a single lecture of philosophy in their lives. Most people probably think that

philosophy is just thinking intelligent and complicated. “Since my research was difficult, hard working, intelligent and intellectual, I deserve a PhD”. This makes as much sense as calling a shoemaker a farmer, “because it is just as difficult”.

A PhD should be given to a scientist, and an engineering degree to an engineer. They are different things, and thus deserve their own diplomas. A scientist knows something about philosophy; an engineer knows something about solving problems. In a simple way, one can say that a scientist tries to understand the world, while an engineer tries to use this acquired knowledge to address problems in the world, to make it a better place. Note that no science is directed at making this world a better place. “Anyone who thinks science is trying to make human life easier or more pleasant is utterly mistaken”, as Albert Einstein said. This is already directly busting one myth in society: Science is not 'useful', or anything similar. Science is closer to Art than to Technology. Science may be beautiful, but never intended to be useful.

A better definition is that a scientist is someone who uses the 'scientific method'. So, now the question is: What is this so-called scientific method? Chalmers wrote a very nice summary on this subject in his book “What is this thing called science?”[1]. One basic ingredient is 'falsification', a scientific approach is making a model that may *possibly* be rejected by facts. And, science is then addressed to falsifying the theories. Here is the second myth being busted: Science is not calculating yourself into a stupor until you get what you wanted when you started. Quite the opposite, science is wrecking your brain until you cannot find any more reasons why your ideas could be wrong. Then – and only then – communicate them to the rest of the world, and let the others have a go at wrecking your ideas. We recognize in this the profile of a Sceptic, which tries to see where the ideas of others might be wrong. A scientist is an auto-sceptic. Scepticism is a basic ingredient of science.

We have summed up the scientific method in the following points [2], which were presented by Feynman in his book "The Character of Physical Law" [3, p.156]. While the details may be discussed, the scientific method is made by the following five elements:

1. Based on data acquisition, induction and deduction, a 'hypothesis' is developed, an idea or model of how nature works.

2. Effort is spent on finding out where and how the model fails, i.e., attempting 'falsification'. Moreover, Feynman added: It has to be mentioned by the developer, not only where the model is correct, but also where it is on thin ice. "In other words, we are trying to prove ourselves wrong as quickly as possible, because only that way we can find progress" [3, p. 158]. Falsification is of the type “If model P, then Q is not observable. We observe Q, therefore our model P is wrong”. Falsification is the search for Q. Frequently, research is based on a logic fallacy called 'affirming the consequent': “If model P, then observable Q”, therefore search for Q, – which actually gives no information whatsoever. A hypothesis cannot be proven correct; it may only be proven wrong.

3. The creators of the model should convince the readers that it is the *only* model that can explain reality (the data). In this respect, another form of 'affirming the consequent' is frequently used: “If model P, then observable Q. We observe Q, therefore, our model P is correct”. (“We know our model is correct, because it can explain the data!”). The fallacy here is that many models can explain the data, but – only one of these models may be correct.

4. The model should include a verifiable prediction of an event happening in the future, for instance an experiment that can be done and the outcome of it. "Science is only useful if it tells you about some experiment that has not been done; it is no good if it only tells you what just went on" [3, p. 164].

5. Other scientists can repeat the work presented. This is the so-called 'replication' requirement.

Some comments are in order.

A vague model cannot be proven wrong. While science goes about disproving things (and not *proving* things, something what science can never do), models that do not produce any clearly testable predictions are not scientific.

Bayesian science is not science. This approach adjusts the models every time new data come in. It is named after Bayes, the founder of empirical forecasting,

where past data are used to predict the future and every time new data arrive, the parameters of the distribution of probabilities are adjusted. This directly contrasts the second item of the list above, namely, the new model that explains new as well as the old data immediately makes the old model non-scientific (making us equally doubt the new one, usually coming from the same authors). Apparently, the old model was not the only model to explain the old data – the new model can do that just as well. A lot of published research is not meeting this scientific criterion of model uniqueness.

Related to this, if there are two models that can explain a phenomenon, the simplest one is correct. This according to William of Ockham, a XIV century monk who presented this idea in what is called Ockham's razor; shave away everything that is not needed. If a temperature series is both consistent with constant temperature and a linear rise – that is, if both cannot be excluded – the constant-temperature model is correct (until proven wrong), because it has only one parameter whereas the linear model has two. Then, linearity has priority over parabolic, and so forth.

If a group of scientists presents a paper, “Here is the result of our simulation”, without saying how and on basis of what, that is not science, according to the fourth criterion of the scientific method. Colleague scientists should be able to understand and possibly repeat the research. It should not be about 'believing' or 'trusting' the scientists. It is all about convincing, and that includes reproducibility by others. Replication, however, is perceived ever more like an annoying, stalling part of science [4].

In reality, most of the papers presented in even the most prestigious scientific journal, *Nature*, are not scientific [5]. Most are not aimed at testing a model, but are of the tallying type. That is, either just simply presenting some numbers on the subject (for example, the statistics on species X in biotope Y), or accompanied by a retroactive (Bayesian) type of prediction, also known as 'retrodiction' (for example, species X declined because of phenomenon Y). Science is dead.

How did it get this far? We think it is due to the society that has changed and has demanded that science is somehow useful for the society. Our entire funding scheme is nowadays based on this paradigm of usefulness. People who write project

proposals know that these normally contain 'milestones' and 'deliverables', or in other words, things that should be solved in society. But, that is technology. In technology you can make a future estimation of what will be the result of the work. “We are going to reduce the channel length of transistors from 50 nm to 30 nm”. However, we would like to see Einstein in 2014 writing a proposal titled “Invention and development of Relativity Theory”, or something like that (Fig. 1).

Is that too ridiculous for words? Let's analyze the internet pages describing science at one of the most famous and prestigious universities in the world, the University of California at Berkeley (UCB). It writes there, in How Science Works, that science has three aspects [6] (in brackets our interpretation):

- “Exploration and discovery” (research)
- “Benefits and outcomes” (relevance to society)
- “Community analysis and feedback” (peer reviewing)

Some observations are due here.

First of all, science is not equivalent to research. Research – collecting data, reading literature, modelling, discussion with colleagues, etc. – is an important tool in science, but the two are not equivalent.

Second, science, as discussed above, has no relevance to society. Of course, there may be beneficial side effects, but science itself is not aimed at attaining these. When Galileo developed the telescope, he did so to study the stars, to understand nature better, not to develop the art of lens-making so that problems of people with lack of vision would be solved. In 2014, this has all changed: science is aimed to have benefits and outcomes. The problem with this is that things will tend to be proven correct as long as they make enough money (relevance to society is, like everything else, expressed in monetary terms in 2014). The truth loses significance. People are confusing science with technology. Technology has benefits, science – not necessarily.

A side effect of this, by being embedded in society, is that things in 2014 have to be 'politically correct'. The pages of UCB specifically state this. As an example, in its Misconceptions tab, it is now said that science (philosophy) does not say anything

about religion or the existence of a deity (in “Misconception: science contradicts the existence of God”), where it is moreover denied that science and beliefs are at war. The argument is that this subject is not in the realm of science, science “pronounces on things of the natural world and not the supernatural”. In this way, the scientific community is avoiding difficult discussions with people who believe things (and pay their salary). Believing is a human right, so now it has been made a rule that science cannot make statements about anything a person might believe. It has been declared that science cannot make statements about beliefs or generally make statements that may offend people. Everything has to be politically correct. Make the extra effort to not offend or insult anybody!

This is not correct. While science cannot prove *anything* to be correct, including the existence or not of a deity, as it can only prove things to be *incorrect* (by falsification), it can indeed make statements on any subject, including this one. (And if they offend people or not, is irrelevant). There may be theories, including about deities, and actually, one of the major discussion points of philosophy is the subject of religion. Science also contributes. The scientific reasoning goes like this:

1. There is no need to include a deity to explain the existence of the universe and therefore – scientific observation – no deity exists (see Ockham's razor above). The universe might always have existed.
2. If a deity is needed to explain the existence (creation) of a system as complex as the universe, then
3. This deity is at least as complex as the universe and therefore also needs an explanation. “Who created the creator?”

This is an age-old discussion, but the current state of science is that no universe-creating entity exists or existed. This, of course, is not the end of the discussion. Like with any other subject, including the ones we see as absolutely fully established truths, science cannot prove things to be 100% certified correct. That is science. Do not confuse “not being able to establish undeniable truths” with “not being able to make a statement”. Compare this to a discussion people might have had some centuries ago: “I believe the back of the moon is green. Since you cannot check

it, you cannot make a statement, therefore I am right”. This is false logic, Ockham's razor tells us that the simpler model is that the back of the moon is the same colour as the front. Science therefore makes a statement that the back of the moon is *not* green.

Here is a nice counterargument for the reader, the ontological argument for the existence of a god:

1. God might exist or not;
2. God is by definition perfect, without any imperfections;
3. Non-existence of something is an imperfection of that thing, because a non-existing thing could be more perfect by adding the aspect of existence.

Therefore, God exists. As we see, there can be philosophical statements about the existence of God. The scientific statement is that no god exists, basically because of Ockham's razor. There is nothing wrong with this statement. Yet, it is not politically correct, and that is why UCB makes it clear that they will not say anything against the beliefs of the people that pay for the research. Don't bite the hand that feeds you. We now have a scientific community that goes out of its way to not annoy anybody and delivers any 'truth' the society wishes to hear.

130 years have passed since Engels wrote his disdainful comments on spiritualism in his book "The Dialectics of Nature". In 2014, no comments on spiritualism are allowed, apart from respectful ones. If people believe certain things, then science will let these people in peace and the area unattended.

This way, we have created a consensus in many subjects. We just basically vote for what is the truth, exactly because of the link with a society that pays and that can demand usefulness of science. 'Useful' is by definition 'what the people want'. Therefore, if a consensus in society exists about a certain belief, science is called in to prove it. That, while science *cannot* even aspire to prove a model correct, as stated above.

But, the concept of consensus is diametrically opposing science. Science is trying to extend the boundary of knowledge, there where a consensus is trying to fence it in. Advances in science are always done by individuals and thus against the consensus. To give an example, Einstein was against the contemporary consensus.

Einstein, in the modern approach to science and research funding, would be completely marginalized. “Mr. Einstein, stop being annoying. Gravity has been completely settled! We have reached a consensus on the theory of gravity of Newton”. If not for individuals trying to overcome the boundaries of consensus, science would never advance. A more dramatic example is the aforementioned Galileo. He was forced to renounce his theory that the Earth was revolving around the Sun because the subject was at that time dominated by the church and they dictated the consensus, which placed the Earth at the centre of the universe; a moving Earth was against the consensus. On his deathbed Galileo uttered the famous words “*Eppur si muove*” (and still, it moves), which we now teach in the history of science as a heroic act of scientific rebellion. If we look back at it, the scientific path in history is littered with such individuals fighting the consensus. In 2014, however, a consensus is called heroic. For the present time, the majority is considered heroic, while for the past times the minority had been heroic. This is quite a schizophrenic approach our society has adopted.

Consensus is more so antiscientific, because of the definition of science. Science being essentially 'falsification', a million pieces of evidence cannot prove a theory correct, while a single piece of evidence can prove a theory wrong. Thus, a consensus is not a proof of a theory. It never was and never will be. Closing the debate on a subject, with consensus as an argument, is effectively killing science and making it a political matter.

Still, it is interesting to analyze how a consensus is achieved in scientific literature? What is the mechanism? How is rebellion eliminated from the scientific community?

It has all got to do with the funding structure of science and the peer-reviewing system used in publication. It results in a positive-feedback behaviour which, as we know from control-engineering textbooks, results in saturation. In this case, it results in 100% consensus on any subject. It works as follows: 1) For a manuscript in peer reviewing, referees are selected on basis of their publication record: more publications, more chance of being chosen for reviewing. 2) By 'cognitive bias',

referees are more inclined to accept papers that confirm their belief than papers that go against it. This effect is amplified by the feeling of consensus, especially when consensus has gotten a heroic connotation (the reviewer will feel contributing to society by rejecting a difficult, controversial paper). 3) Authors without (enough) publications lose their job, because they cannot show they are relevant for society. Authors with controversial ideas see their publication rate peter out, eventually losing their job and no longer publishing, even no longer writing papers altogether. After a while, a controversial idea cannot be published, nor studied. Those who break the vicious cycle are scientific philanthropists, people that do not do science for a living, but for their passion of finding the truth. Such people are rare indeed in 2014. Either this or studying irrelevant subjects, which also naturally peter out because of the need to show relevance to society. A perfect example of a scientific philanthropist is Nassim Nicholas Taleb. He made a fortune in the stock market and can now lean back and philosophize about (financial) forecasting and all its pitfalls. In fact, his book The Black Swan [7] can be considered one of the most relevant works of *philosophy* of the last 50 years.

What remains for the researchers to do is technology, developing new products to be sold to a gadget-hungry society. For this purpose, all technical high schools are relabelled universities and all universities are effectively converted into technical high schools, where research is aimed at developing things that are useful for society. Even fundamental research is addressing society-relevant issues, like studying the physical processes in photo-voltaic materials, to be used in solar cells and light-emitting devices, etc.

This reduction in intellectual diversity is further exacerbated by standardization of university courses around the world. An example is the Bologna Treaty that standardizes all the courses in the European Union. We have now wound up in a situation similar to the state of things in the beginning of the 20th century, namely the illusion that everything is known. At that time people thought that knowledge reached its limits and what remained was just 'working out the details'. In many subjects in the 21st century the idea is the same. “Subject X is settled. No need for further thinking”.

How naive we were then; just in a few decades physics was completely revolutionized by the advent of Quantum Mechanics and Relativity Theory. How equally naive we probably are now.

The amount of science remaining in the world is quite small. We would like to express our concern for the lack of pioneering ideas.

Conclusion

We summarized here the appalling state of science in the 21st century. A state that reminds us of previous states in which scientists thought that everything was known, and we only had to work out the details and make use of the knowledge in technological applications. Science is taught in a dogmatic way in schools and universities. “This is the knowledge you have to put in your heads. This is how the universe works”. It is all quite disheartening.

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