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Theory of Knowledge essay

"Science is built of facts the way a house is built of bricks: but an accumulation of facts is no more science than a pile of bricks is a house" (Henri Poincaré). Discuss in relation to science and at least one other area of knowledge.

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"What I want is facts. Facts alone are wanted in life"[1], says Mr Gradgrind in Charles Dicken's novel *Hard Times*. Mr Gradgrind's statement seems like the opposite of Poincarés, and although Gradgrind was not a scientist, his statement deserves serious consideration. This essay will seek to answer the question: *What, if anything, distinguishes science and other areas of knowledge from an accumulation of facts?*

What are then the facts that Mr Gradgrind so cherished? We shall define a fact as an observated truth, something that is the case and has been observed. It belongs to the category of primary or raw data. Statements such as: *This computer has a mass of 2.8 kg* or *Napoleon was the emperor of France* are facts. A theory or a concept is not a fact.

What is then meant by science? (Science and natural sciences will here be used synonymously). The question is not easily answerable and no doubt many essays could be written on the subject. The approach we will take towards science is descriptive: we will examine the activities that are commonly referred to as science in western culture. Inevitably, this gives our investigation a strong cultural and historical bias. In another culture or at another time in history, it would have been different. Thus, activities that are commonly seen as pseudoscientific such as astrology or homeopathy will not be examined. This does not imply any value judgment from my side, only an acceptance of the fact that some practices are considered pseudoscientific in western culture. If another approach had been adopted – defining a methodology or a logical structure as the scientific, the question of the essay would have been answered by the definition itself.

In the natural sciences, the common way of attaining facts is through experiments (with some exceptions like astronomy or some biology where experiments are often impossible or hard to carry out). If we look at the history of science we will find that there are some experiments which are very famous, such as for example the Michelson-Morley experiment in physics[2], which showed that the speed of light was the same regardless of the speed of the earth and thus suggested that the ether – the medium in which it was believed that light travelled, did not exist. The question we must ask ourselves is: What distinguishes the Michelson-Morley experiment from the innumerable other experiments which have been carried out by scientists? All these experiments produced facts, and some of them more facts than others, but it is not the quantity of facts which seems to be the important issue. Nor is the Michelson-Morley experiment famous because it was carried out with more accurate measuring instruments or because the scientists had better control over all the variables involved. The difference seems to lie somewhere else. The experiment is famous because the facts it yielded can be put in a certain context where they are given a meaning. Put in the context of the ether theory, the facts that the experiment produced seemed to contradict the theory. Facts without context do not seem to interest scientist, a scientist does not collect facts like a stamp collector collects stamps.

From an experimental result the scientist can generalize. We use induction to go from our particular data to a general theory. For instance, when I did a physics lab to examine the specific heat of a substance, I added a certain amount of heat to that substance, while measuring how its temperature developed. The experiment produced some facts, such as:
At 12.00 the amount of heat that had been poured in was 5 J
At 12.00 the temperature of the water was 18 C.
Etc.

But it was not for these facts that I had carried out the experiment. Rather, what I wanted to do was a generalisation. I noted a linear relation between the amount of heat added and the temperature,

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1 Dickens, C. "Hard Times". http://en.wikisource.org/wiki/Hard_Times/First_Book/Chapter_I
2 An account of the Michelson-Morley experiment can be found in Giancoli, D. (2005). p. 730

and plotted this relation as a trendline. Using this trendline I could now extrapolate: I could now predict how much energy I need to increase the temperature of a substance with X degrees. Thus we can propose a first answer to our question: it seems that science differs from a collection of facts in that it generalizes these facts into a theory, which in turn can predict new facts.

One might now argue that although science obviously comprises generalisations as well as facts, the basic structure, the "hard core" of science, is still the facts. From a certain accumulation of facts would then arise certain generalisations. However, this would be to ignore the central importance of hypothesis in science. When I am performing an experiment in physics, I usually have an idea, a hypothesis of what the resulting formula will look like. The formula which describes the kinetic energy of an object in classical mechanics can be derived from other formulas (which I had done prior to the experiment). My hypothesis is not the result of observations but of theoretical derivations. I am expecting a certain result and I will set up my experiment so that it is clear whether or not I got the expected result.

We shall now turn our attention at another area of knowledge: history. Again, there are many historical facts. I was born in February, but so was Abraham Lincoln, and the latter would be considered by many to be a more interesting and relevant historical fact. The facts which are presented in historical studies have been chosen by the historian for a reason. The actions and lives of powerful men throughout history have traditionally been studied with more depth than those of common people, which the poet Bertolt Brecht illustrated:

Every page a victory.
Who cooked the feast for the victors?

Every ten years a great man.
Who paid the bill?[3]

Brecht is critical what he perceives as an incorrect emphasis on the history of the ruling classes, but this is only an example of a movement in history. Depending on his theoretical views, a historian may see the lives of kings and presidents or the economic, or cultural, development as more relevant, a more decisive element in history. Then it follows that the historical studies conducted by these historians will consist mainly of biographical or economic or cultural facts respectively. Theory inevitably shapes the selection of facts. This is not only a conscious process: a historian that has adopted an economist view of history will probably note interesting facts in history that another historian would not have paid attention to (and thus not consciously filter away).

Facts are also influenced by theory in other ways. When we make observations, we automatically structure them according to concepts that are part of our theories. The statement:
The mass of my computer is 2.8 kg
uses the concept of mass. This concept is not theory neutral, in relativist physics, mass is considered to be relative to the reference frame of the observer, and the statement on its own would thus lack meaning.[4]

Facts are most often recorded in language. And the language used in different theories can produce ambiguity. The word *class* can for example have different meanings in different schools of sociology. A Marxist sees classes as the fundamental historical agents defined by their place in production[5]. Many other scholars concerned with society use *class* in a more loose sense, it simply

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3 Brecht. B., "Questions from a Worker Who Reads", http://www.marxists.org/subject/art/literature/brecht
[4] Giancoli, D. (2005). p. 742
[5] See for instance Marx' text on contemporary French politics. Marx. K. (2003).. p. 149

signifies a certain group in a society defined by wealth or social status[6]. Thus the fact:
The working class in France finds itself being driven into a state of passivity and stagnation[7]
is ambiguous. The language in which facts are formulated is therefore problematic. The solution to this problem is of course to introduce rigorous scientific terminology which distinguishes between different concepts. However, this shows that language plays an important role in relation to facts.

Thus we can conclude that Poincaré was right. An accumulation of facts is not science, it is even not the material of science. Rather it is the scientist himself who accumulates and selects his facts in order to explain them through his theories. Furthermore, the facts themselves are formulated and observed in terms of theoretical concepts.

An important implication of this view on facts and science is that it leads to a realization that the methods with which scientists and historians solve conflicts and choose between different theories in are not as straightforward and easy, and perhaps also not as rational as is commonly thought. A "fact-centric" view would imply that there is always a simple objective test for scientific theories, while our discussion seems to imply that this objective criterion is influenced by the very theories we want to evaluate. This statement should not be seen as a totally relativist position, science is ultimately accountable to the real world and thus to facts, but the manner in which theories are accountable must be discussed in the light of our conclusion.

Poincaré was right in criticising the primacy of facts. Perhaps his error was that he did not go far enough. As Dickens showed in his novel, Mr Gradgrind's world is a very dull one.

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