

6. “A skeptic is one who is willing to question any knowledge claim, asking for clarity in definition, consistency in logic and adequacy of evidence” (adapted from Paul Kurtz, 1994). Evaluate this approach in two areas of knowledge.

Word Count: 1600

The constant and indiscriminating refrain of “Why?” by children is, as any parent would testify, extremely irritating, as it can go on endlessly. But the child’s perpetual questioning would not work if s/he were questioning mathematics; a knowledge claim here is left unquestioned after a certain point, primarily due to the use of deductive logic. Conversely, the child’s questioning would not only be accepted, but even encouraged in science, as questioning and skepticism are a part of science, and of deriving and refining knowledge claims in relation to reality. This child’s skepticism depends on the AOK, and the extent to which skepticism can be applied. This will be considered specifically in relation to lucid definitions, consistent logic, and adequate evidence.

Consistency in logic is an important aspect when evaluating mathematics, especially due to the use of deductive logic. Deductive logic allows for knowledge claims to be irrefutable, as long as the premises that it rests upon are true (some of which are self-evidently true; axioms). As mathematicians build their knowledge claims upon premises, the different methods of logical reasoning, or the mathematical methods that they rest upon may not be correct. Skepticism plays a role in examining this logical process. For instance, Andrew Wiles's proof of Fermat’s last theorem contained an error in methodology (*Pieprzak*). In such cases, what can be called ‘organized skepticism’ comes into play;

referees evaluate and rectify any mathematical paper for consistent logic, as in Wile's case, after a year (*Pieprzak*)! It is important to specify the time frame for scepticism; after this knowledge claim has been rectified, skepticism no longer plays a role in trying to evaluate the validity of logic, as this has already been proven. This is unlike in science, where counter-evidence can refute, or at least modify a logically pristine knowledge claim, given that this counter-evidence is adequate.

Mathematics is based on a set of axioms, upon which knowledge claims are built upon. The definitions of these axiomatic systems are important in establishing reliable knowledge claims. For example, the real number system was only formally defined in the 1870's by Dedekind, replacing previously vague definitions (*Dedekind's Definition of Real Numbers*). Developing, but more importantly, precisely defining this system has wide-ranging implications on the simplest of mathematics, as it is the number system based on which basic calculations are made, so skepticism does have a bearing on the truth of related claims, especially when it is as fundamental as the real-number system. Contrastingly, skepticism can have no direct bearing on 'truth', but may question conventions. The ongoing debate of replacing the constant ' π ' with ' τ ', in order to redefine the radian and circumference more intuitively (as $\tau = 2\pi$), brings about issues of how mathematics is taught and understood. Thus, skepticism can address aspects other than truth, which are still as cardinal as they still influence mathematical development.

Another facet of skepticism, adequacy and reliability of evidence, can be illustrated in a form of deduction known as proof by exhaustion. For instance, the four-color theorem, investigating the minimum number of colors needed to represent a map, was the first theorem solved by a computer (*Roger*). There were an infinite number of maps, which, through computing, was narrowed down to a limited

number. Initially, scepticism centered on the method of proof, as it was not derived by humans. But over time, mathematicians have accepted this to be a valid form of proof (*Calude*), as computing offers the same certainty as a human, assuming that there is no computing error. Questioning this assumption is where evaluation of 'evidence' comes into play, which, in general, corresponds to the arguments in a proof. Thus, it can be seen that the degree of scepticism changes over time, which suggests that paradigms also determine the role of scepticism. Due to this, there emerges different degrees to scepticism within the AOK itself.

In science, on the other hand, consistency in logic is a bigger issue, due to the use of inductive logic. Empirical evidence supports a conclusion, and can lead to a conclusion being heavily certain. However, in comparison to deductive logic, all the possible cases that can occur are not proven. Any counter-evidence would require a consideration and evaluation of the previously held knowledge claim, and accommodating the counter-evidence through 'tweaking' the current theory, or developing a new one. The skeptical process involves reconciling new evidence and apparent logical contradictions with previously held theories, and occurs over time, in concurrence with paradigm shifts and developments in science. But as it would be the case in mathematics, we need to evaluate the validity of counter-evidence as well.

In science, clarity of definition, another facet of scepticism, is similar to the standards in mathematics, in that they are consistent, lucid and logical. However, skeptical inquiry can actually be counter-intuitive, as seemingly opposite conclusions are reconciled to form theories. This is the case in the wave-particle duality of light, which takes into account the differing behaviours of light (as a particle/wave) in different

circumstances (*Allain*). Definitions play an important role here in completely describing reality, even if it seems contradictory. This leads to maximum rigour and clarity, so that reality can be modelled as accurately as possible. This is similar to Dedekind's goal, to create a specific, but nonetheless, all-encompassing definition of real numbers, just as the wave-particle duality explains behaviour of light in all circumstances. Mathematical and scientific skepticism is similar in this aspect, as both aim for clarity, but more importantly, completeness in definition as well.

It is also important to consider how skepticism plays a large role in science primarily because it is embedded into the AOK. This is because of falsification, an important requirement for a theory (Popper), which does not allow a knowledge claim to become a theory unless it can be falsified by experimentation. This principle recognizes how claims only become more certain, never absolutely true. For something to be scientific, there must be the possibility that it can be proved false, though it may not necessarily be false. For instance, Newtonian mechanics does not apply to some aspects of nature, but quantum theory and relativity account for these aspects. But the qualifying factor of Newtonian mechanics being a scientific theory is that it could be falsified, be further refined, and create a more complete model of the world, which is similar to the role that scepticism plays when evaluating definitions. Thus, there must be the possibility for skepticism, though it may not be necessary for a knowledge claim to be scrutinized skeptically. Falsification and skeptical inquiry is inherently part of science, in contrast to mathematics, where skeptical inquiry focuses on separately evaluating logic, evidence and definition.

In both mathematics and science, there is the element of human error to be considered, which leads to

different limitations for skepticism. In mathematics, extremely long and complex proofs, such as Wile's, would have been susceptible to human error. Although the chances of error fall in proofs such as for the Pythagorean theorem, there is still a probability of error. Therefore, in light of mathematical development, scepticism would reconsider these knowledge claims, to see if it still holds valid. Though there is a theoretical limitation to scepticism, practically, this limit is malleable. By contrast, science acknowledges human and experimental error. When I used the phrase 'within experimental accuracy' in my conclusion for a Physics Design IA, I recognized that my experiment, despite not being completely accurate, was still as accurate as experiment allowed, and was 'pragmatic' enough to be valid i.e. my experiment worked in real life. This leads to the practical suspension of skepticism. Conversely, we can consider the human element of skepticism itself. For instance, many mathematicians were skeptical of the four colour theorem due to its unconventional method of proof; they were used to proving by (human) hand (*Calude*). Therefore, skepticism is susceptible to human bias, something to consider when deciding what *ought* to be the extent of skepticism.

Scientific skepticism also takes a useful cultural, social and religious functions. The reason why scientists encroach upon religion or similar areas is because it offers models of the natural world, but which, in my opinion, may not be logically or empirically valid. Skepticism, by applying the scientific mode of thought, is important in shaping thought. This becomes part of the broader paradigmatic structure of society, influencing other AOK's, such as art, through this. Similarly, mathematical skepticism can include other facets, such as aesthetic considerations. The proof that $\sqrt{2}$ is irrational is not only ingenious, but is mathematically elegant, an aesthetic judgement based on the element of surprise, economy, and 'beauty' in a proof (*Proof by Contradiction - the Standard Example*). This brings in aesthetic elements to

skeptical enquiry of a knowledge claim, bridging the arts and mathematics, especially in the ineffability of beauty in both AOK's.

In general, skepticism does have a larger role in science than mathematics. This concurs with the aims of these AOK's; the mathematical aim for absolute truths, in contrast to the recognition that science cannot have absolute claims, with skepticism playing a role in refining knowledge claims. But there is the theoretical limit in mathematics, and the practical limit in science for skeptical inquiry, explaining the complex roles skepticism has in these AOK's. The role of skepticism varies in the AOK, and over time. In some cases, these roles overlap, or in some cases, skepticism has a larger role in evaluating some claims than others in the AOK. But in the end, these functions lead to the same end, in increasing the certainty of knowledge claims, so the importance of skepticism, despite the varying roles it plays in both AOK's, and within the AOK's themselves, is undisputed.

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