5. To what extent do you agree with the claim “all models are wrong, but some are useful” (attributed to George Box)? Discuss with reference to mathematics and one other area of knowledge.

Word count:1572

Really steady work overall

Targets

Clarity of expression and ideas

Focus – on the title (avoid repetition and revise structure of some paragraphs – freeing up words for further…

Evaluation

Points of view

Intro and conclusion need refinement

‘All models are wrong; some are useful.’ Statistician George Box’s thought-provoking statement drives at the heart of a knowledge creation paradox of simplicity and utility {(Helen Goncalves: Is the paradox not simplicity vs complexity? Because BOTH simplicity AND utility can be really positive characteristics of models for building knowledge...)} {(Mingzhou Li (3549): From sentecen suggested, the paradox is simplicity(it worng because of it) and ultility(useful))}. Models are powerful tools for describing and predicting complex phenomena, but they are necessarily inaccurate as they are based on known approximation assumptions in order to / because……. {(Helen Goncalves: Why is it necessary to use approximation assupmtions?)} But these imperfections {(Helen Goncalves: Only assumptions? What about limited variables? etc)}are part of their value for….because they can still provide insights into ABC {(Helen Goncalves: WHAT? Kind of knowledge is produced by a model based on approximations, assumptions, controlled variables? ExplanationPrediction etc)}and practical applications. The concept of model is defined as a simplified representation of reality that is built to explain, predict or analyse some portion(s) of the existing world {(Helen Goncalves: Could be incorporated into previous sentences)}. Also, the claim suggests to me that models are “wrong” because they’re based on approximations and assumptions which don’t describe reality completely. However, they are ‘useful’ to the extent that they yield functional insights leading to a better understanding and decision making process – finding solutions?. {(Helen Goncalves: Again these ideas could be incorporation into preceeding sentences)}This essay will therefore focus on mathematics and natural science as Areas of Knowledge (AOKs) to examine this claim. The selection of mathematics is because its abstract models are the basis for logical reasoning – patterns, trends, prediction, optimisation, theory etc…… and problem solving {(Helen Goncalves: How else to maths models help?e.g. explain, predict….? Develop ideas here based on your analysis of the examples that will follow)}and natural science on the other hand use a few {(Helen Goncalves: ?)}models to explain {(Helen Goncalves: How else do NS models produce different types of knowledge - develop ideas...)}natural phenomena; with historical example illustrating how even misleading theories facilitated scientific progress. {(Helen Goncalves: Only in NS?)}

The AOK of mathematics relies on abstract models and logical structures in its operation of the patterns of patterns {(Helen Goncalves: ?)}and in the solution of problems. While ALL? mathematical models rely on assumptions and fail to account for real conditions exactly, they are still very useful tools for prediction, optimization, and theory. This is why it can be argued that despite the inherent limitations of mathematical models, they remain absolutely essential tools for understanding and solving complex problems. The models give structured ways to analyse patterns, predict outcomes, as well as optimize decisions. Bayesian probability is one such statistical approach that believes in {(Helen Goncalves: ? Accepts? What do you mean here?)}prior probabilities and revises those beliefs after? seeing new evidence. In spite of the use of subjective priors {(Helen Goncalves: ?)}that do not always reflect reality, Bayesian models are used in many fields such as?, as showing that ‘wrong’ models can be very useful {(Helen Goncalves: You can´t reach this interim conclusion without describing or explaining how the model works)}. Bayes' theorem makes you calculate the probability of an event occurring by using prior knowledge to help you calculate this probability. The assumption is that the system has an initial probability distribution, which is obtained continuously being refined as we get more data. And so the starting point assumptions could be wrong, but the iterative process will yield increasingly valid predictions. For instance, spam filters on the backs of artificial intelligence utilize Bayesian networks to alter the probabilities depending on user activity and email evolution of patterns in the email content. In the same way, Bayesian inference is used by doctors to compute disease probabilities from test and prior medical data in medical diagnostics. Despite having uncertain assumptions, Bayesian models are valuable as decision making tools because their adaptation process makes them useful in these applications. Collectively, Bayesian models show that even models built from inadequate assumptions can be very informative. It is the ability of them to tailor knowledge over time and to adapt to changing environments that make them useful. This provides support for the argument that models are always ‘wrong’, because they are simplified, {(Helen Goncalves: Did you explain in what specific ways this model was simplified at the start of this paragraph? )}but they are useful for guiding practical applications. As such, mathematical models are not judged exclusively by their absolute correctness, but by their usefulness for producing effective solutions and for facilitating understanding through successive refinement. {(Helen Goncalves: ALL of this should go BEFORE trying to reach an interim conclusion - and it seems you repeat this conclusion anyway at the end of this paragraph)}

This text should be broken into 2 separate paragraphs for FOCUS on the title. Do you really need all these words to describe and explore this model?

However, ALL – SOME? mathematical models can be too simplified and yield incorrect results or even crises in the real world {(Helen Goncalves: ?)}. For example, the Black-Scholes financial model for pricing stock options is an example. Although it was groundbreaking in financial mathematics, {(Helen Goncalves: Why? and CITE)}however this model was based on unfeasible {(Helen Goncalves: unrealistic)} assumptions such as constant volatility, rational market behaviour, frictionless trading making a role in the financial instability that was witnessed in the 2008 financial crisis. It assumeD that market participants are {(Helen Goncalves: WERE (past tense))}rational and under Black-Scholes model, stock prices are supposed to behave under normal distribution. The fact is that actual financial markets are not simply made up by rational behavior with no news {(Helen Goncalves: ?)}. Many traders and financial institutions used this model in early 2000s, without even adequate argumentation {(Helen Goncalves: ? Discussion? )}of the limitations. Why would they be so foolish? And CITE It was when the fundamentals of how markets were supposed to behave in response to these faulty assumptions were sustained too long, derivative trading was over used and without downside limitations, the major financial institutions collapsed. The Black–Scholes model assumeD market rationality and predictable stock prices that follow the normal distribution. However, such irrational behaviour and sudden shocks, and unexpected fluctuations, are common in financial markets. Many traders and financial institutions used this model in early 2000s without proper argumentation of its limitations. {(Helen Goncalves: Repetition ?)}The collapse of major financial institutions played a huge role in derivative trading in its overuse at a time when the market began to act in unpredictable ways based on these flawed assumptions. Interim conclusion in response to the title?

Moving on to, natural science, there are such even with models that are later proven to be wrong, are commonly used as important frameworks for developing improved understanding natural phenomena over time. Thus, one may argue that any {(Helen Goncalves: Careful - not ALL historical models may be wrongSOME?)} historical models are ultimately "wrong" but that they nonetheless have a crucial function for development of scientific knowledge. The phlogiston theory of combustion was a striking example, prevalent in scientific thought in the 17th and 18th centuries. Later debunked, it nonetheless acted as an advance post for later development of modern chemistry and thermodynamics, showing that even a wrong model can be extraordinarily helpful. CITE According to the phlogiston theory, a substance phlogiston was released during combustion. The model of this type was widely accepted and even guided the early scientific experiments, because it outlined the pattern of classification of materials on the basis of their combustibility. This theory however could not explain why some metals increased in mass when they were burned. However, it was eventually disproven by Antoine Lavoisier who showed that combustion was about oxygen and thus taught what we know about oxidation and reactions. CITE Although the phlogiston theory did not stand the test of time, it was valuable, for it inspired experimental methods and systematic inquiry into the law of combustion, even if the result was merely a more refined misunderstanding of it. It shows how incorrect models can also be propitious for advancement by requiring improvements and alterations. Similarly, natural science physics? in today’s time still utilizes modern historic models such as Newtonian mechanics in use in engineering and basic everyday applications such as? even though it has been overthrown by Einstein’s theory of relativity when applied in extreme {(Helen Goncalves: Large? Or extreme AND large?)} scales. CITE This supports the statement that while all {(Helen Goncalves: ALL? Can you really reach this conclusion from ONE model in NS?)} models are imperfect, their imperfections and limitations justify the need for further information. Natural science models are constantly refined or disposed of when evidence is provided that indicates they are no longer the prior belief {(Helen Goncalves: clarify)}. So, the usefulness of a model does not solely depend on its accuracy but it depends upon its ability to, aid in the discovery of new knowledge and to contribute to the development of scientific knowledge and provide practical applications.

Conversely, Yet improper models can serve as useful stepping stones in natural science but can preclude scientific progress if they become institutionally rooted or are ignored for their limitations. One such example was the caloric theory of heat that persisted in ongoing for over a century before modern thermodynamic principles replaced it. CITE An example of how flawed theories can sometimes slow scientific progress rather than promote it is illustrated by this outdated model in which heat was incorrectly viewed as a fluid like substance. In the 18th century the caloric theory was developed that heat was a weightless, invisible fluid called caloric that flowed from hot to cold objects. While it explained some heat transfer phenomena, it did not satisfy experiments on mechanical work generating heat, by Benjamin Thompson (Count Rumford). CITE While his observation that heat was generated from friction posed a threat to the caloric model, scientific institutions refused to give it up. WHY? What power dynamics – or context meant science ignored new evidence? The reluctance to accept emerging evidence delayed the development of thermodynamics and the acceptance of heat as a form of energy, which did not arrive until the work of James Joule and Rudolf Clausius in the 19th century. CITE The caloric theory is an example of how institutional biases and the inertia of science {(Helen Goncalves: CITE)}can keep flawed models around past their usefulness. While the phlogiston theory had produced productive experimentation, the caloric model held back progress by leaving little room for alternative ideas. This reveals how a critical danger in using improper models: If wrong models already are ingrained in scientific thought, then the shift to better theories can be slow. Therefore, it follows that wrong models are nonetheless useful insomuch as they are {(Helen Goncalves: Only if they are)}subjected to critical analysis. A model can become a hindrance to further knowledge if its limitations are ignored or if it is kept in spite of contradictory evidence. This drives this point home: Models must be constantly questioned to ensure they serve as tools for progress, not barriers to truth. {(Helen Goncalves: Good! )}

Finally, the examples suggest that, although all models {(Helen Goncalves: Are you SURE? ALL models in BOTH AOKS? Perhaps some models are much more ´perfect´ and subject to less revision than others???)}are imperfect, their utility is derived from their ability to produce new knowledge {(Helen Goncalves: Remind the reader of the functions of how both maths and NS models produced WHAT kinds of knowledge )}and practical applications, not their perfect correctness. In the end, we should think of models as useful for inquiry, developing X, driving progress etc – develop with reference to arguments you already made and not as final truths. They evidence in their effectiveness in being adaptive and in critically evaluating themselves. {(Helen Goncalves: ?)}We need to get the right balance between utility and accuracy {(Helen Goncalves: ?)}, such that models are used to push forward knowledge, but we keep in mind their limits and not lose sight in our beliefs. {(Helen Goncalves: ? What do you mean? How embedded scientific assumptions may affect the way a model is interpreted? )}

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