Prompt 2: Within areas of knowledge, how can we differentiate between change and progress? Answer with reference to ***two*** *areas of knowledge. (1579 words)*

A look at the history of various areas of knowledge (AoKs) makes it clear that their nature is dynamic. The current knowledge, underlying theories and methods for knowledge production are all constantly changing and progressing. However, depending on the AoK being considered, 'changing' is not necessarily the same as 'progressing'. For example, areas that have more to do with shared knowledge, such as the Sciences or Mathematics, might define change as some sort of paradigm shift, while progress would be making new discoveries or findings. In areas dealing with personal knowledge, such as the Arts, change and progress might mean the same thing to an individual. The same holds true even within closely related AoKs such as Mathematics and the Natural Sciences. There may be cases where there is a clear distinction between the two terms, as well as cases where both carry similar meaning and implications, making them difficult to differentiate. This raises the knowledge question of: How differently is knowledge production influenced by change when compared to progress, within Mathematics and the Natural Sciences?

Within both Mathematics and the Natural Sciences, change can be thought of as the introduction of new ideas and perspectives which widen the scope of how existing knowledge can be interpreted. However, it does not produce any new knowledge. Progress, on the other hand, is more about depth – it sharpens the lens, allowing us to look at existing ideas with more detail to uncover new knowledge. As such, progress is always accompanied with knowledge production. This can help differentiate between 'change' and 'progress', at least within Mathematics. For example, the introduction of the Peano Axioms for natural numbers. For centuries, Mathematicians dealt with the concept of "numbers", which became increasingly complex with the inclusion of negative, real, and complex numbers as Mathematics progressed. However, the fundamental concept of numbers remained quite arbitrary, based almost entirely on intuition. The Peano Axioms introduced a new definition for the natural numbers, providing a new interpretation based on logical axioms. It laid down a stronger foundation for Mathematics but did not introduce new knowledge that built upon the existing concept of numbers. Thus, the Peano Axioms are an example of a change within the area of Mathematics, but not progress.

When it comes to the Natural Sciences, however, it is not always easy to make this distinction. Within the Natural Sciences, change usually occurs when existing theories can no longer be progressed further or are insufficient in some manner, such as when they are unable to explain the results of some experimentation. Thus, when a new interpretation for knowledge is introduced, it is almost always accompanied with new information revealed through that interpretation, which may not have been obvious from existing ones. This new information can be directly translated to progress. In other words, change and progress happen simultaneously, making it difficult to distinguish between the two. A real-life example of this is the Rutherford gold foil experiments. The experiments made observations about the behavior of the atom that could not be explained by the Thomson plum pudding model, which at that time was a widely accepted model of the atomic structure. This led to the conception of the Rutherford model, which was both a different interpretation of the current knowledge on atomic structure, and also a more detailed one. Thus, this was not just a 'change' or 'progress' within science, but rather a mixture of both.

One way to differentiate between change and progress within the Natural Sciences, is to notice that progress is usually gradual, whereas change can be much more sudden. Within sciences, progress is usually the result of experiments that are conducted and re-conducted again and again to verify results and reach reliable conclusions. New experiments are designed based upon these conclusions, and the process continues. Change, on the other hand, is often the result of a sudden realization – a 'eureka' moment – which gives the knower a new perspective or a new way of looking at the natural world. If it provides a better explanation of natural phenomena, many people will accept it. A piece of empirical evidence would further verify it. A good example of this is Albert Einstein's theory of general relativity, which brought a great deal of change within the Natural Sciences by providing a new interpretation for the laws of gravity. The change came when Einstein realized that a person falling down to a surface is no different from the surface accelerating up towards that person. This shift in perspective was key to forming his theory of relativity and provided a new interpretation to large amounts of knowledge within physics.

The above is rarely the case within Mathematics, where change and progress usually happen at almost the same rate. When progress is made through the proof of some long-standing conjecture, it can take years for other experts to first understand and then verify the proof before it can be accepted. Similarly, when new ideas are introduced, that is, when change occurs, it is again a slow process. Mathematics is based purely upon reasoning and logic, and as such is much more abstract. New ideas are not sudden realizations arising from observations of the natural world, but rather the result of careful thinking and reasoning. This is vital in Mathematics because the ideas must be consistent in every aspect, otherwise they would be rejected. In the Natural Sciences, inconsistency in some cases can often be overlooked if the theory applies well in other cases. Newton's older laws of gravitation are still used in many cases, simply because they are more convenient, even though they hold inconsistencies that could be replaced with more accurate but complex theories. In Mathematics, this is not possible. New ideas need to be developed carefully and slowly. An illustrative example of this would be the introduction of type-theoretic foundations for Mathematics, known as univalent foundations. The current foundations of Mathematics had been built upon Set theory, based on the concept of sets made up of some elements. Type theory, on the other hand, built upon the concept of types that consist of members or inhabitants. Although seemingly similar, the two are actually distinct ideas for forming the foundations of Mathematics. As such, the introduction of type theory represents a change in Mathematics. Yet, what is most important is that this was not a sudden change. The univalent foundations approach was developed gradually, as inconsistencies within it were identified and then rectified over time until it could be considered a viable change to the foundations of Mathematics. The change was gradual and developed over time, making it difficult to tell whether it was simply a change, or included progress as well.

One motivation behind type theory was to fix some contradictions arising within set theory, which interestingly leads to a different way in which change and progress can be differentiated, especially within Mathematics. When change occurs, it does not necessarily try to build towards some sort of aim or end goal within the AoK. Rather, change usually stems from some sort of criticism of or flaw within existing ideas, and tries to replace them by providing better alternatives, as in the case of the above example. Progress, on the other hand, builds towards a greater goal within the AoK. A real-life example of this in Mathematics is Andrew Wiles' proof of the Shimura-Taniyama-Weil conjecture in 1995. However, Wiles' aim was not to prove the conjecture itself, but rather his aim was to prove Fermat's Last Theorem, a theorem that had remained unproven for over three centuries and was a famous unsolved problem within Mathematics. The proof of that conjecture allowed Wiles to then prove the Last Theorem finally. In this same manner, Mathematicians make progress by proving theorems and conjectures that can then help them move towards answering more difficult or fundamental problems within Mathematics.

In the Natural Sciences, however, change and progress are both almost always accompanied with the same goals and motivations within the AoK. As mentioned previously, change within Natural Sciences usually occurs when existing theories are insufficient for further progress. This means that when change occurs within this area, it is not motivated merely by some flaw within the existing theories. Rather, its main purpose is to allow further progress and continue towards the primary goals of the disciplines within the Natural Sciences, by providing a completer and more comprehensive picture of how nature functions. This is, of course, the same goal that progress builds towards. For example, the introduction of quantum mechanics provided a vastly different interpretation of natural phenomena. However, this change was not motivated by flaws in existing theories. Instead, it was based on results of new experimentation and the need for a better theory describing the microscopic world. The change brought by quantum mechanics helped greatly progress the understanding of subatomic particles. Similarly, many changes within the Natural Sciences are motivated by the same goals that progress is.

When it comes to knowledge and areas of knowledge, there is no concrete distinction between change and progress. Depending on how we choose to define them, it may make it easy to differentiate between the two in one AoK, while making it difficult in another AoK. Defining the two separately for each AoK can help us better differentiate between them in each area, but this too is only to a certain extent, because their nature is so dynamic that the fine line between change and progress can sometimes be quite blurry.

Bibliography

Tsokos, K., 2010. *Physics for the IB diploma*. 6th ed. Cambridge: Cambridge University Press.

Dombrowski, E., Rotenberg, L. and Bick, M., 2013. *IB theory of knowledge*. 2nd ed. Oxford: Oxford University Press.

Britannica, The Editors of Encyclopaedia. "Fermat's last theorem". Encyclopedia Britannica, 1998, https://www.britannica.com/science/Fermats-last-theorem. Accessed 12 March 2021.