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# The Sophisticated Inductive Approach and Science Education

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**Abstract**

**Introduction**: The aim of the present study was to explore the relationship between sophisticated view of induction and science education. **Method:** This study is a critical review on the relation between philosophical approaches to science and science education. Thus, an analytic method is used in investigating the theories of science and their relationship to science education. **Results**: Analysing the arguments against induction, we argue that the sophisticated view of induction is not only resistant against the critiques but also inspiring for science education. **Conclusion**: This paper concludes that the sophisticated view of induction provides the merits of both positivism and falsificationism in science and science education while avoiding their disadvantages. Accordingly, to avoid positivism, science education should reinforce students' imagination and theory development and to avoid falsificationism, it should embrace observation and induction.

*Key words: Sophisticated approach, Induction, Elimination, Science education, Falsification.*

## 1. Introduction

Positivism in science faces serious criticisms which can be categorized in three new visions addressing science: reliance of observations on theories has gained attention, pure observation has been questioned, and the logical validity of induction has been questioned. In the case of reliance of observations on theories, positivists' opinion is ill-founded because every observation a person has is affected by his previous knowledge including theories, assumptions, presuppositions or the conceptual scheme(s) the person has. (Phillips and Burbules, 2000, p. 15). In other words, observation, necessarily, has a mental or psychological aspect to it which refutes the positivists' claim that observation is a solid foundation for scientific knowledge.

Karl Popper (Popper, 1963) following Hume, continued ruthless attacks on induction and claimed that the induction problem has no solution and it cannot be provided with a logical Back-up in order to be defended. Popper holds that enumerative induction that tries to prove a theory based on its positive instances cannot differentiate between positive and confirmative instances.

Despite the sever blows to induction, one cannot claim that it has lost its fans, in fact support for induction has become more sophisticated. Consequently, inductive view in science education will also be resistant against the

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criticisms levelled to induction. In what follows, we first give an account of the sophisticated view on induction. In the meantime, a comparison will be made between the sophisticated view of induction and falsification that Popper suggests. Finally, the sophisticated view's implications for science education will be explained.

## 2. Sophisticated Inductive View

What we refer to as the sophisticated view of induction is what is called eliminative induction. While enumerative induction concludes the confirmation of a theory with emphasis on positive instances, in eliminative induction, focus is directed towards the elimination of rival theories by evidence of one theory. Weinert (2000) holds that even Francis Bacon and John Steward Mill were not after simple enumerative induction when they spoke of induction, but what they had in mind were samples in relation to a theory or a whole. This characteristic has been labelled as "projectibility" by Kitcher (1993, p. 235) and it is regarded as a synonym for law-likeness. Weinert holds that eliminative induction is safe-guarded against Popper's criticisms to induction and it is more potent than his suggestion of falsification.

Popper (1994, p. 104) on the other hand, observes that the feebleness enumerative induction suffers from is shared by eliminative induction, since they are both after creating theories but neglect the fact that rival theories are infinite. Popper endorses one role to empirical evidence i.e. they help us to discover our mistakes, however the number of rival theories remain infinite. Popperians hold that Popper's hypothetico-deductive method is a discourse between the possible and the real and this implies theories are infinite. (Medawar, 1984, p. 46)

However, Popper's critics have not remained idle. They have defended eliminative induction and have focused on its differences with falsification. Grunbaum (1977, p. 121) states that one of the differences is that eliminative induction can reduce the number of infinite theories because with the elimination of one theory all the other theories that are of that sort will be eliminated as well and in this way the space of possibilities is reduced. For example, when Thomson's (1904) model of atom's structure which stated an orbit without a nucleus was eliminated by Rutherford's model (an orbit with a nucleus), all the other theories that neglected nucleus of an atom will be eliminated and therefore, the space of possibility of rival theories is decreased. Grunbaum (1977, p. 121) states that Popper takes only criteria like simplicity, falsification, and empirical corroboration into consideration when examining theories whereas in eliminative induction limiting the space of possibility should also be taken into consideration. On the other hand, while falsification emphasizes on new realities, eliminative induction is keen on confirming evidence.

The final difference between these two is that falsifiability can only be applied to exact theories while eliminative induction considers both models and theories. Weinert elaborates the difference between theory and model as follows: their difference is a matter of degree rather than kind, and this difference is due to the fact that for a model it suffices to be able to come up with a coherent explication of a limited set of data, while a theory should explicate all the phenomena that rest in its realm. In other words, theories should explain in a substantial manner whereas models can merely describe or explain conditionally and based on ad hoc assumptions. (Weinert, 2000)

## 3. Teaching Sciences and Induction

Nearly all the activities related to teaching sciences before the 60s was influenced by positivism. This approach that identifies induction as the method of science emphasizes on the expansion of information and data of the student in order to pave the way for generalization. It is so conceived that offering several scientific realities to students, while he doesn't have a certain pattern in receiving sets of sporadic scientific information, can lead to achieving scientific knowledge.

In this approach, teaching sciences should put emphasis on methods of making information comprehensible and acceptable for students in the best form. Scientific knowledge is considered as a certain and dogmatic issue as well as an objective truth external to the person and independent of him and teaching sciences has the responsibility of transferring it to the students. Student has the role of a complete receiver and is passive in learning sciences, and learning scientific definitions and formulas by heart guarantees learning science. Direct interaction of the student and his active participation in learning experiences is less emphasized. Personal creativity and innovation in the classroom is less paid attention to, because learning sciences is directed towards acceptance of a series of realities and objective truths which are independent of the student.

The explorative approach in teaching sciences is influenced by inductivity's recognition of science. This approach is a reaction to the transferring approach which emphasizes on the transference of science from teacher to student and has no place for experience or participative learning. Since in the transference approach the main goal is engaging more and more with scientific content, scientific works and laboratory activities are of less importance due to the time that they consume. Assessment is also based on evaluating the information students possess relevant to the matters of fact that are stated at the end of the chapters of the teaching book or at the end of the semester. Also in this approach no attention is paid to capabilities and abilities of students in applying scientific knowledge in different situations (Tobin & Lorsbach, 2000, p. 4) in the explorative approach, science is considered as an issue which should be explored by the students and this is realized by direct observation and physical sensing. The teacher in this approach guides the students towards exploring the scientific phenomena with choosing a set of equipments and tools. It is expected that with observing the well-organized experiments the students reach significant scientific conclusions or achievements.

It is clear that the explorative method is very attractive for students. Obviously it is more attractive for the student to find out what metals are affected by magnets himself rather than being told by the teacher. However, the expectations from explorative education are not always fruitful. Acquaintance with philosophy of science enables teachers to evade naïve claims about learning based on explorative approach. Some of these erroneous and naïve claims include: method of science is induction; observation is independent from conceptual understanding; spending time on real subjects results in the exposure of structure of scientific theories. In other words, the conception of science as a certain and dogmatic issue that merely its discovery is expected from students is not accepted anymore and is in contrast with new understandings of philosophy and history of science. In most cases, when there is a word about students' need of laboratory experiment, this implicit assumption exists that scientific method initially requires induction of the data, and precise observation results in exploring laws and principles. This presumption stems from positivist explication of scientific method. (Mattheus, 1994) In fact this approach doesn't pay specific attention to the use of students' ideas.

However, critics of induction and specially advocates of hypothetico-deductive approach have underestimated the role of induction and even naïve induction. Popper in "conjectures and refutations" (1963) states that in classes of philosophy of science suddenly told the students to "observe" and they asked with quandary that what they should observe? Popper concluded from this that observation should always be based on a perspective or a problem or even a theory. Although Popper is right in this claim that observation should have a direction, but one cannot conclude from this that it should be necessarily a theory or a specific problem. Insisting that observation should be always based on theory, in a way that simple gathering of factual states would be imagined impossible is a result of incessant emphasis on theory's role and deductive activity. History of science tells us that sometimes scientists engaged in simple gathering of factual matters and these matters played a significant role in the coming theories. For example, Robert Hooke was the first person who has reported of observing some things under his newly invented microscope in 1665. His observations include a precise description of the cellular structure of fly's eyes, pointing end of a nail, microscopic organisms in water and the like that nobody had been able to observe them till then. Without a shadow of doubt there was a reason for Hooke in choosing these things for observation, but this reason could have been mere inquisitiveness for gaining information and not necessarily based on a specific theory. Hooke also gathered information related to weather changes and although he did this only to understand the difference of seasons, today the information he had jotted down are being used for considering the global warming assumption, while Hooke himself did not have such an assumption in mind. (Nola & Irzick, 2005, p. 209)

## 4. Conclusion

Science education based on philosophical view towards science looks for developing scientific skills in students. Emphasis is directed towards active participation in the learning process and paying attention to scientific skills like making assumptions, prediction and organizing experiments.

The claim that science is a combination of imagination and logic may seem odd to students. Innovating assumptions and theories for imagining how the world functions is as creative as composing a poem, a piece of music or drawing a painting. In fact the process of expressing an assumption and examining it is one of the central activities of scientists. An assumption is useful when it shows which reasons and evidences support it and which refute it. An assumption that doesn't fall for falsification and is always true may seem interesting but it is not a scientific assumption. The national standards of science education in United States consider giving priority to evidences in research based learning of great importance. Evidence let the students to evaluate and expand the explications related to scientific questions. (*Inquiry and National Science Education Standards*, 2003)

Based on the hypothetico-deductive approach, in science education attention should be paid to the deductive process and students should be directed towards coming up with assumptions on an unexpected issue, and then along with the initial conditions of the experiment reach the deductive implications of it and based on falsifying evidence examine the initial assumption and in case of success of falsification they should approach substitute assumptions. For example if we ask a student from the last years of elementary school that why does the paper weigh less when it gets burned, they will propose assumptions that while the paper is burning it will lose some material and that is why it become lighter. If we want to proceed deductively, we can ask them that while bearing their assumption in mind (whatever burns loses some material and becomes lighter) and the initial conditions of an experiment (like putting equal amount of steel on a two pan balance and burning the steel on one pan) consider the deductive implications of an experiment. The deduction is that the pan that contains burned steel will become lighter and will go up. With this experiment the stage of experimental evidence commences. Contrary to the expectations of students the pan encompassing burned steel will become heavier and will go down. Now based on the negation of the antecedent, with the refutation of the deduction, we understand that the precedents of the deduction are refuted. But in the antecedents of the deduction, an assumption exists and a proposition implying initial conditions and because we confirm the initial conditions we can conclude that the assumption was false. Now the students have to propose another assumption and the deductive procedure should follow up likewise, and its conclusions should be evaluated based on the evidences till the point an assumption resists falsification. In this case we will accept this assumption temporarily but we would always await its falsification. (Nola & Irzik 2005, p. 225)

Based on the hypothetico-deductive approach paying attention to the following steps in science curriculum is important: a) making assumptions (via creative estimation) b) assumption examination (via experimental criteria) c) the process of social acceptance and acknowledging scientific knowledge. If these three stages get elaborated for students many of the problems that stem from a lack of coordination between science education and real science would reach minimal status. Nowadays the prevalent approach in science education is based on understanding the concepts and scientific theories and a general understanding of scientific methods and little attention is paid to personal aspects and scientific creativity and even less attention is paid to critique and evaluation of scientific society and credibility and consensus in scientific issues. ‘a’ and ‘c’ are less paid attention to, while having these two in mind, reveals the human aspect of scientific activity more obviously, and eradicates the unchangeable and dogmatic picture from scientific activities. Students should know that objectivity in science doesn’t necessitate people to distance themselves from their tendencies and likes. In fact scientific objectivity becomes meaningful when the assumptions are capable of getting examined experimentally and analytically and become prone to criticism.

To sum, the naïve induction view has been challenged in a number of ways the most important of which is to replace positive aspect of science with the negative aspect as is seen in falsification view of science. However, the sophisticated view of induction or the eliminative induction has the merits of falsification view without being trapped into the problems of naïve induction. In eliminative induction, focus is directed towards the elimination of rival theories by evidence of one theory. The sophisticated view of science supports the explorative approach in teaching sciences. In this way, the merits of falsification view in science education are available without being trapped into the pitfalls of naïve induction.

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