Necessity of Refinement the Oversimplified Depiction of the Nature of Science – A View from Physics Education

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Abstract. A short list of nature of science (NOS) features is frequently published and often quoted as "consensus view". I argue that a refinement of the claims of that list may enrich and sometimes reverse them. The refinement shows necessity to address a span of variation of each particular aspect of NOS, illustrate it with the events from the history of science in order to adequately represent this important subject. Using the knowledge organization in a discipline-culture structure and addressing plural scientific methodology may be helpful in actual teaching and learning of physics at schools and constructing its authentic image.

1. Introduction

During the past twenty years, a new discourse has been developed [1]. It deals with the features of scientific knowledge and scientific inquiry, that is, with epistemology of science labeled as NOS – nature of science [2]. The intention of the discourse is to familiarize students with the fundamental features of science already in regular teaching at school, at all its levels, in order to make the learning of science more meaningful and the teaching more representative. This intention inevitably implies simplification of the epistemological claims to adjust them to school students. As a result, certain claims may distort the traditionally understood features of science and physics in particular, such as when the idea of objectiveness of physics knowledge is replace with the claim of science being subjective. The NOS-discourse produced several lists if NOS features of which the list of seven items by Lederman and his colleagues (L-list) [2] is often mentioned as "consensus view" [1]. Its apparent advantage is its being short and straightforward in claims, which make it simple to discuss. In this study, I analyze the claims of this list in order to show that they need refinement in order not to pervert the true nature of physics knowledge.

2. Critical refinement

The following features are included in the considered list of NOS [2]:

a. Scientific knowledge, owing to scientists' theoretical commitments, beliefs, previous knowledge, training experiences, and expectations is unavoidably *subjective*
b. The distinction between *theories and laws*. Laws are statements or descriptions of the relationships among observable phenomena. Theories, by contrast, are inferred explanations for observable phenomena.
c. The development of scientific knowledge involves human imagination and creativity
d. The empirical nature of scientific knowledge. The distinction between observation and inference.
e. The social and cultural embeddedness of science. Scientific knowledge affects and is affected by the various elements and intellectual spheres of the culture
f. The tentative nature of scientific knowledge. Scientific knowledge is never absolute or certain. This knowledge, including "facts," theories, and laws, is inherently tentative or subject to change

g. Myth of the scientific method (absence of unique recipe-like stepwise procedure)

The claims of the L-list address science in general. However, physics knowledge, being the most fundamental scientific knowledge about Nature is addressed directly and therefore deserves consideration by physics educators.

Drawing on the examples from physics, I will present a refinement of the claims arguing that are needed in teaching physics to prevent an inappropriate image held on behalf teachers and students of physics class. For example, the traditional belief in objectivity of physics knowledge taught at schools is questioned by the first claim of L-list (*subjectivity* of physics). In response to that, I argue that physics knowledge is *objective* in the sense that it does not depend on personal will and values. Though physics *inquiry* may include subjective elements in form and interpretation, they are excluded in the context of knowledge *justification*. Exclusion of subjective aspects takes place through the continuous many-faceted experimentation within iterative investigation and community discourse.

Another claim, claim 6, states tentativeness of all products in physics contradicts to actual practice of physics products. In fact, physics products may vary from hypothetical to certain statements, and replacing this broad variety with a univocal status of "tentativeness" is not representative for physics knowledge.

3. DISCUSSION AND CONCLUSION

The refinement of the claims regarding NOS is beneficial for its facing the challenge of L-list which, while trying to update the epistemological aspects of science curriculum, made obscure the traditional perspective on physics knowledge. Thus, a univocal claim of subjectivity shakes the basis of physics instruction challenging its validity in eyes of a novice. The complexity is in the wide spectrum of possible perspectives. It is important, therefore, to learn the views of scientists and the argumentation for the status of scientific knowledge [4]. Furthermore, it appeared that discipline-culture structure of a theory [5] may help in clarification of the important aspect of physics knowledge – the limited area of validity of any physics theory. Without such understanding, students easily fail to resist the claim that all physics knowledge is merely tentative. The tripartite structure of a theory furnishes clarification of relationships theory with reality, theory with laws, laws with models, and the status of being proved in physics. The possible development of the study will be mentioned.

References

[1] Hodson, D.. Nature of Science in the Science Curriculum: Origin, Development, Implications and Shifting Emphases. In M. R. Matthews (ed.), International Handbook of Research in History, Philosophy and Science Teaching (pp. 911-970), 2014. Erduran, S. & Dagher, Z. R.. Reconceptualizing the Nature of Science for Science Education, Springer, Dordrecht, The Netherlands, 2014.

[2] N. G. Lederman, P.D. Wade & R. L. Bell, Assessing understanding of the nature of science: A historical perspective, in W. McComas (Ed.), The nature of science in science education: Rationales and strategies (pp. 331-350). Kluwer Academic Publishers, Dordrecht, The Netherlands, 1998. N. G. Lederman, F. Abd-El-Khalick & R. Schwartz, Measurement of NOS, in R. Gunstone (ed.) Encyclopedia of Science Education (pp. 704-708), Springer, Dordrecht, 2015.

[3] M. R. Matthews, Changing the focus: From nature of science (NOS) to features of science (FOS). Chapter 1 in M. S. Khine (ed.), Advances in Nature of Science Research: Concepts and Methodologies (pp. 3–26). Springer, Dordrecht, The Netherlands, 2012.

[4] S. L.Wong & D. Hodson, From the horse's mouth: What scientists say about scientific investigation and scientific knowledge, Scie. & Educ., **93** (2009), 109–130; S. Weinberg, Facing up. Science and Its Cultural Adversaries, Harvard University Press, Cambridge, Mass., 2001.

[5] I. Galili, Promotion of Content Cultural Knowledge through the use of the History and Philosophy of Science, Scie. & Educ., **21** (2012), 1283-1316.