

Historical epistemology, symbolic tools and threshold concepts

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The notion of threshold concepts developed by Meyer and Land is related to a “new and previously inaccessible way of thinking about something” that opens up ways of “seeing things in a new way”.

In science and in engineering, for example, it is common to use mathematics as a symbolic tool to express theories and models and to represent objects and events. Development of new concepts and new tools has, throughout history, enabled mankind to “see things in new and more powerful ways”. Müller¹ stated that: “There is little evidence to show that the mind of modern man is superior to that of the ancients. His tools are incomparably better”.

Wartofsky² in his theory of ‘historical epistemology’ has pointed out that human perception is an *historically* evolved faculty and therefore closely related to the development of human praxis. Dewey and Vygotsky, for example, were well aware, as is evident in their writings, that new cultural tools transform human action.

However, there is ample evidence from education research that students have problems connecting the ‘world’ of theories and models to the ‘world’ of objects and events. Also some of the mathematical tools used are seen as “counter-intuitive” or even “absurd” and therefore are what is called ‘troublesome knowledge’. What many learners see as troublesome corresponds often very well to “thresholds” that have been problematic for mankind to overcome in their development of new tools for making sense of our lifeworld.

In this context we claim that it is essential to take an historical approach and to realize that almost every extension of the number system and several developments of new mathematical tools and physical concepts have been seen as something “absurd” from the beginning. Notions we nowadays see as “natural” have not always been seen as “natural”.

In our paper we will present some cultural and historical views on the notion of ‘troublesome knowledge’, ‘key concepts’ and ‘threshold concepts’. We will give some historical examples of how development of new tools has enabled us to “see things in new and more powerful ways”. We will also show that some of the historically developed terminologies are misleading, for example ‘natural’ and ‘real’ numbers are less suited to describe phenomena in nature than ‘complex’ (imaginary) numbers are, i.e. in a way ‘real’ numbers are less “real” than ‘complex’ numbers. As an example we will relate this historical epistemological approach to our present research into teachers’ and students’ understanding of, and views on, complex numbers and Laplace transforms as tools in electrical engineering.

¹ Müller, R. H. (1940). American Apparatus, Instruments, and Instrumentation. *Industrial and Engineering Chemistry: Analytical Edition*, 12(10), 571-630.

² Wartofsky, M. W. (1979). *Models: Representation and the Scientific Understanding*. Dordrecht: D. Reidel Publishing Company.