Images of Science Linked to Labwork: A Survey of Secondary School and University Students

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Abstract

This paper presents findings about the images of science drawn upon in laboratory work, by upper secondary and university students, in academic streams with a science focus. Data were collected through four written questions, administered to a total of 368 students. The questions all required students to comment on laboratory investigations carried out by research scientists or by science students. We show that students’ reasoning has an epistemological and an ontological dimension, and that it often differs significantly from accepted perspectives on the nature of science. The issue for teaching appears to be showing students what counts (and what does not count) as appropriate reasoning in actual situations. In other words, explicit teaching about the various relationships that can exist between theory and data would transform labwork towards a more critical process that involves making and justifying decisions.

During their schooling, students acquire images of science and of scientific work. In recent years there have been many studies focused on characterising these images. Several studies have shed light on the images of science actually drawn upon by students, no matter how those images of science were developed. Driver, Leach, Millar and Scott (1996), and Désautels and Larochelle (1998), have made comprehensive reviews of this literature. The findings of studies typically portray students as naïve realists and naïve empiricists. Furthermore, there is some evidence to suggest that many teachers also make naïve statements about the nature of science (e.g., Lederman, 1992), and that teachers’ images of science are communicated to students during teaching (e.g., Brickhouse, 1990; Hodson, 1993).

However, the process of drawing out implications for practice from this literature is not straightforward. There is some evidence to suggest that students (e.g., Rowell & Dawson, 1983) and professional scientists (e.g., Samarapungavan, 1992) who make naïve verbal statements about science, demonstrate more sophisticated tacit knowledge about science in action settings. Furthermore, students’ reasoning about science is intimately connected to context (e.g., Mortimer, 1995; Leach, Millar, Ryder, & Séré, 2000). Quite often, the diagnostic questions used in paper and pencil surveys to elicit students’ and teachers’ images of science do not refer to any specific
context. We refer to such questions as decontextualised questions. For example, Por-lan Ariza, Rivero Garcia and Martin del Pozo (1998) used decontextualised questions to discuss possible relationships between teachers’ epistemological options on one hand, and their teaching options on the other. Koulaidis and Ogborn (1989) presented teachers with a series of general statements, expressing different philosophical views. In both studies, a predefined epistemological position is attributed to each individual student or teacher. This approach elicits the student’s or teacher’s espoused images of science. However, the relationship between these espoused positions, and the knowledge drawn upon by students and teachers to inform actions, is open to question.

In this research, we were interested in eliciting the kind of knowledge that science students might draw upon to inform their actions in the setting of a particular classroom activity, namely labwork. Within the European project ‘Labwork in Science Education’ (LSE) (Séré, 1998), we developed some hypotheses concerning the relationship between science students’ images of science and their actions during labwork at the level of upper secondary school, and the beginning of university education (Leach, in press). In order to investigate these hypotheses, we designed questions which require students to make judgements and comments on specific laboratory situations. The design of these questions recognises that the images of science that students develop and use are intimately connected to the scientific activities engaged in through laboratory work: different laboratory activities involve students in making different links between conceptual knowledge and images of scientific activity. The knowledge at stake during labwork is not only conceptual: knowledge about aspects of the situation such as the relationship between ideas and data, the process of measurement and so on is also involved. We were interested in the knowledge students use in making decisions about how much data to collect, which of the data to use, and what can be concluded from the data available. In the physical sciences, it is often necessary for students to make decisions about the validity of knowledge claims from experimental work, given the accuracy and precision of measurements. In the life sciences, students often have to make decisions about design and sampling in order to collect useful data. Data analysis typically involves dealing with large data sets exhibiting a high degree of variability. We were interested in the representations of the functioning of science that underpinned students’ decisions during labwork.

In the philosophy of science, questions about the nature and status of scientific knowledge are conventionally discussed around two dimensions:

1. an ontological dimension, which addresses the relationship between scientific models and their empirical referents; and
2. an epistemological dimension, which addresses the warranting of knowledge claims as reliable.

These dimensions have been used in the literature to describe conceptual learning (e.g., Chi, 1992; Tyson, Venville, Harrison, & Treagust, 1997; Vosniadou, 1994). In the study reported in this paper, however, we do not address conceptual learning. Rather, we draw upon ontological and epistemological dimensions to describe the