

Chapter 3

OPEN-ENDED LABWORK

Introduction

This chapter includes studies on open-ended labwork in which students are required to make some decisions for themselves as to how to act in various types of projects. In order to carry out an open project in an autonomous way, students have to draw upon knowledge and understanding of scientific content and experimental procedures and, frequently, exhibit sophisticated positions regarding the relationship between knowledge claims and experimental data. The presented studies focus mainly on aspects of the understanding and use of scientific procedures on the part of the students, as well as on the improvement of their epistemological knowledge when engaged in investigative work. As a matter of fact, epistemological issues related to labwork have only recently become an object of investigation by researchers. In the present chapter special conceptions of developing epistemological reflections through various forms of projects at university level are discussed, from various perspectives, in all three studies.

We may note that, as in other chapters, all three studies are parts of wider projects, which have been running for years. One study (Guillon and Séré) concerns research-based innovative labwork, while the other two (Lewis and Ryder respectively) investigate existing laboratory courses. The effectiveness of these courses with regard to students' acquisitions after labwork is the main focus of these three studies, rather than what they actually do during labwork, as in Chapter 2.

Guillon and Séré attempt to model the procedures physicists use in investigative work, conceived as a confrontation between a variety of theoretical models and experimental data. The epistemological analysis of scientific procedures carried out by the authors adds to our knowledge of the nature of the procedures from a didactical perspective. The study involves an explicit presentation, to first year physics undergraduates, of epistemological information related to investigation processes and strategies, followed by sequences of labwork to make students familiar with different procedures and a number of open-ended projects within a two-year course. The effectiveness of this strategy is discussed by the authors who,

among other findings, point out that students who were familiar with "one experimental method" to a certain extent found strange the use of a variety of models and strategies during investigative work. In their recommendations the authors stress the need for a combination of conventional and open-ended work, with clearly set objectives, as a means of improving student autonomy.

The second study (Lewis) concerns a specific type of open-ended labwork: the mini projects which are sometimes included in undergraduate courses with the expectation that they will help students make the transition from set practicals to open-ended investigative work. In effect, this Lewis raises the issue of the transition from conventional labwork to open-ended investigations, which seems to be important, as the study by Guillon and Séré suggests and which the next study (Ryder) discusses in a different context. Despite the noted success in developing students' understanding of the nature and processes of scientific research, the mini-projects left many students feeling demoralised and largely unaware of the learning which had taken place. The need for clear objectives clearly set by the tutors is stressed by the author in his recommendation for improving the effectiveness of the mini projects.

In the last study (Ryder), students are taken out of the laboratory to carry out residential field work in geology, at the intention being to develop students' ability to interpret geological data. The learning aims of such a field course included sophisticated epistemological activities such as developing alternative interpretations of a single data set and comparing and evaluating multiple interpretations. The author argues that the field course and particularly its residential nature were effective in getting students to engage with the intended epistemological issues and develop personal interpretations of data instead of simply looking for the correct answer, which is considered as a manifestation of naïve realism.

The Role of Epistemological Information in open-ended Investigative Labwork

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Abstract

At university level, to become a physicist, students have to learn not only about the content of physics but also about strategies of investigation. We developed a two year sequence of labwork to introduce epistemological knowledge, and to allow students to go through an entire investigation strategy in open-ended projects. This study describes the epistemological knowledge passed on to students at undergraduate level, followed by sequences of labwork to make students familiar with different procedures, and open-ended projects. Questionnaires at different times within the sequence assess this teaching sequence. We also analysed the two reports made by each pair of students involved in a project.

Introduction

Teaching epistemological knowledge about physicists' processes through labwork

The aim of this study was to teach epistemological knowledge at undergraduate level, through a teaching sequence involving labwork. 'To help students to get to know scientific processes' is frequently stated as the main aim of labwork. As Hodson (1992) wrote:

Though necessary, conceptual knowledge and knowledge about procedures that scientists can adopt (and may have adopted in particular circumstances in the past) are insufficient in themselves to enable students to engage successfully in scientific inquiry. That ability is only developed through hands – on experience of doing science in a critical and supportive environment

In this study we use the term 'scientific processes' to describe the different strategies of investigation used to answer questions about phenomena. How do physicists use models and theories? How do they carry out experiments? How are data collected and interpreted? How do physicists judge the fit between experimental data and models? We include all these aspects in the following expression: the processes and strategies of investigation of the physicists.

This type of knowledge has an epistemological dimension and, as such, has been conceptualised by several authors. For instance, in line with a tradition from Francis Bacon & Claude Bernard, Develay (1989) describes the experimental process as follows:

To word a question, to set out hypotheses, to test hypotheses by designing experiment, to carry out experiment, to analyse the results, to give an interpretation.

However, if this sequence is considered as chronological, it does not take into account the frequent switches back and forth between theory and practice.

Another conceptualisation is proposed by Gott & Murphy (1987) who consider science as a problem solving activity, but say little about the variety of scientific processes and the roles of models. Vicentini also recognises the need for metareflection about processes and proposes an organisation of an experimental

Teaching and Learning in the Science Laboratory

Psillos, D.; Niedderer, H. (Eds.)

2002, X, 270 p., Hardcover

ISBN: 978-1-4020-1018-7