Using Laboratory Work for Purposeful Learning about the Practice of Science

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Abstract

Much laboratory work in school science has been criticised for its highly ritualised nature, in which students are led "cook-book" style through a set of instructions to a predetermined end point. Along the way students collect data and answer questions that are presented in a formal report. It has been argued that such an approach is not only an ineffective means of developing students' understanding of science concepts, but also presents a misleading picture of the way in which scientific knowledge develops. This paper describes two different approaches to laboratory work. In each the teacher's purpose was to provide her students with some insight into ways in which knowledge in science is generated, shared and validated.

Subject and problem

Most laboratory work follows a familiar rubric. Students are presented with an aim, a suggested hypothesis, steps for carrying out an experiment (method or procedure), observations and/or measurements that should be recorded and questions that lead to the conclusion, ostensibly drawn from the experiment. Generally, the teacher’s main purpose rests on the belief that, in following this rubric, students will learn (and believe) a particular science ‘fact’ because they ‘see’ it through the experiment, i.e. the experiment reinforces and consolidates learning of ‘theory’. An additional teacher purpose may be that students will be following a method similar to that which led to the original discovery of the relevant fact, i.e. students may learn something about the way that scientists perhaps just understand the world, and therefore understand how scientific knowledge is developed.

Research raises many questions about laboratory work as an effective means for students to learn science content (Hodson, 1993; Millar, 1991) or to obtain a valid picture of how scientific knowledge is produced (Hodson, 1993; Woolnough, 1991). Recent studies (Driver, Leach, Miller & Scott, 1996) have advocated the inclusion of practical investigations in science that help students understand more about the nature and status of scientific knowledge. It is argued that unless students are able to develop and articulate an understanding of the nature of scientific knowledge, they will be ill equipped to interpret the validity of knowledge claims made in the name of science.

Here we report on two different approaches to laboratory work introduced by two teachers working together at the same school. For each teacher, an important purpose was to develop her students’ understanding about science beyond the dominant picture of propositional knowledge and routine procedures.

Data used in this study have been drawn from a larger project that explored student learning in laboratory work. In the larger study we identified several factors...
as important in promoting student learning from laboratory work - the extent of students' prior content knowledge related to the laboratory task, their perceptions of the purposes of the laboratory task and their knowledge of experimental procedures. In addition, a separate but related issue emerged; the impact of students' perceptions of the nature of science on their approach to, and learning from, laboratory tasks. Many of the students we observed appeared to operate from a formula driven view of science. Following the procedure and completing the task became an end in itself, and there was little thinking about the procedures used (for example making careful measurements or repeating measurements) or the importance of these in what students were trying to do. This paper explores what we learned from the work of the two very different teachers about the ways in which laboratory work, designed for specific purposes, impacted on students’ understanding. In this case of the practice of science. We use these two situations as specific cases that purposely challenged the traditional approach to laboratory work.

Our approaches to the exploration of laboratory work in our research have been focussed by information processing and constructivist views of learning, as elaborated by White (1988) and Fensham, Gunstone and White (1994). Within this broad framework, ideas of the importance to conceptual learning of informed intellectual engagement (metacognition) that are advanced in the Project for Enhancement of Effective Learning (e.g., Baird & Northfield, 1992) have been of particular influence on our thinking. The aims of the study being described here were focussed by the broad question "How can laboratory work be used more effectively in the teaching of science?" Specific research questions were

when teachers have clear purposes for laboratory work and design sequences that reflect these purposes, what student learning occurs?

how is this student learning influenced by students knowing the purposes of the teacher?

It was of obvious value to the research that the two teachers shared our concerns and questions. Such teachers have been rare in our work on learning from laboratories.

While the two teachers shared the same broad purposes for the laboratory work described in this study, each had different specific goals. The first, Amanda (a co-author of this paper and at the time a teacher at the school), wanted her year 9 students to become more aware of the socially constructed nature of science knowledge. She designed a chemistry unit in which students were involved in generating, sharing and validating scientific information. She also intended that through using a chemistry context for the laboratory work her students would learn some important chemistry concepts. The second teacher, Susan, disillusioned with the use of laboratory work as a vehicle for improving students’ understanding of science concepts, designed a chemistry unit for her year 10 students which had, as its goal, the development of students’ understanding of the role of experimental work in establishing scientific fact. In her case, the chemistry context was simply the content vehicle for this role, she did not expect specific chemistry to be learnt. Amanda’s expectation that her students would develop an understanding of chemical concepts as a result of their experiences is an important difference between the goals of the two teachers.