LEARNING ABOUT THE NATURE OF SCIENTIFIC KNOWLEDGE: THE IMITATING-SCIENCE PROJECT

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ABSTRACT

This paper reports a small-scale curriculum project aimed at teaching about the nature of science at lower secondary school. The main idea of this project is to stimulate students' learning of science as a process by involving the students in reflections based on personal experience of an open-ended investigation. The paper describes how it is possible to include publication and argumentation of methods and results in a school experiment, as well as findings related to changes in students' epistemological thinking. The students wrote about how researchers conduct research prior to and after the project. Analysis of these texts showed that more students included the idea of testing hypotheses in the post-study texts than in the pre-study texts. Students also expressed more awareness of what researchers might do to enhance the quality of their research. We found that students tended to use words like "facts" and "proofs" in the pre-study texts. In the post-study texts, however, more students emphasised that research findings do not represent final answers but the researcher's argument-based conclusions.

1. INTRODUCTION

"The Imitating-Science Project" aimed to stimulate the development of students' epistemological thinking. The focus of the project was science as a process. In general, science involves processes like examination of literature and generation of hypotheses, empirical data, and factual claims. Science as a process, however, also includes communal aspects. Inherent in the learning objectives of the Imitating-Science Project is therefore knowledge about social processes in science, e.g. publication and critical evaluation of research reports. In this study the imitation of scientific research is not done only to facilitate students' learning of how to make scientific investigations, but to increase their knowledge of communal aspects of science like publication and argumentation.

Researchers who have studied curriculum projects using practical work or "authentic school science" have often found less change in students' ideas about science as a process than expected (Bell *et al.*, 2003; Leach & Paulsen, 1999). There are indications, however, that involving students in *reflection* on the nature of scientific inquiry *throughout* a project might lead to better results (Gess-Newsome, 2002; Lederman, 1992). In this project it was also assumed that including a focus on publication and argumentation would make it easier for students to understand the interpretative nature of science. We hoped this would facilitate a conceptual change

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away from the identification of measurements and research findings as facts, often found among students (Lederman, 1992), towards a more constructivist view of scientific knowledge.

2. THEORETICAL FRAMEWORK

The theoretical framework of this study is threefold. First, our understanding of the concept *scientific literacy* is the basis of the study. Socio-scientific issues which students encounter through, for example the media, often involve disputed scientific arguments, contested frontier science, and real or perceived expert disagreement. In this way, science-related public debate mirrors professional scientific debate to some extent. Adequate interpretation of arguments and factual claims require knowledge of processes involved in developing scientific knowledge. This view is supported by a number of qualitative case studies of lay people's interaction with science and scientists (see Ryder, 2001 for an informative overview). These studies indicate that knowledge of the nature of science and scientific knowledge are at least as important as scientific content knowledge for lay peoples' assessment of science-based arguments (Kolstø, 2001; Ryder, 2001). Also, there is a growing recognition that "social and institutional processes are critically important in determining what comes to be agreed as reliable public scientific knowledge" (Leach & Paulsen, 1999, p. 135). Our curriculum project is therefore based on the view that it is relevant and important to increase students' knowledge about science as a process as well as improving their skills in participating in evaluation and argumentation related to empirical data and scientific knowledge claims.

Second, our constructivist view of science influenced both the design of the curriculum and the analysis of data. This view emphasises interpretation and argumentation related to the production of empirical data and scientific knowledge claims. It also emphasises the difference between two kinds of science (Cole, 1992; Latour, 1987; Ziman, 1968). One kind, denoted as 'core science' by Cole, is characterised by a stable consensus within the scientific community. This is science where the disputes, at the initial stages of the research, have settled and now occurs as facts in textbooks. The other kind, denoted as 'frontier science' by Cole, is science in the process of being researched. At this stage of the production of scientific knowledge, hypotheses are being developed and scrutinised, and results from studies are presented to colleagues and discussed with them (Ziman, 1968). Subjective and unreliable frontier science is transformed into core science, or refused, for example as unreliable, through different social processes characterised by publication, evaluation, and argumentation. Such a constructivist view of science inspired us to include an open debate on methods, interpretations, and conclusions in the project in order to imitate these aspects of science. We also maintain that the main purpose of scientific research is the development of theory. Investigative science should therefore involve the question, "why does this happen?" (Leach & Paulsen, 1999, p. 61), even if it can be argued that authentic school science could include other aspects of science as practised in modern society.

Third, the didactical design of the Imitating-Science Project is inspired by Dewey's (1913) emphasis on the need to base students' learning on practical problem