DESIGNING AND EVALUATING SHORT SCIENCE TEACHING SEQUENCES: IMPROVING STUDENT LEARNING

JOHN LEACH, JAUME AMETLLER, ANDY HIND, JENNY LEWIS, PHILIP SCOTT

The University of Leeds, UK

ABSTRACT

This paper reports a study designed to provide evidence about the feasibility of designing short teaching sequences, based on insights from research and scholarship on teaching and learning science, which are measurably better at promoting conceptual understanding amongst students than the teaching approaches usually used by their schools. The research team worked in collaboration with a group of 9 teachers (3 biology, 3 chemistry, 3 physics) to design, implement, and evaluate 3 teaching sequences for use with students aged 11-15. The physics and biology teaching sequences were also implemented by other teachers (11 and 5 respectively) not involved in their design. Teachers implemented the physics and biology teaching sequences in ways broadly consistent with the planned approach. In all cases where a valid comparison can be made, students' responses to diagnostic questions requiring the use of conceptual models to construct explanations were significantly better following the designed teaching sequences, than the responses of comparable students following the school's usual teaching approach. The significance of these findings for research in science education, and for policy and practice relating to science teaching, are discussed.

1. THE PROBLEM ADDRESSED IN THIS PAPER

The literature on students' learning of scientific concepts is extensive (Pfundt & Duit, 2001). However, the impact of this research on the practices of day-to-day science teaching has not been great (Duit & Treagust, 1998). Furthermore, some are sceptical as to whether teaching based on information about students' existing knowledge leads to gains in students' understanding (e.g. Matthews, 1997).

Although there are some studies in the literature that do provide evidence of improvements in student learning against specified goals, following research-informed teaching interventions (for example, Brown & Clement, 1991; Tiberghien, 2000; Viennot & Rainson, 1999), such studies generally say rather little about the role of the teacher in implementing the teaching. Furthermore, the teacher in these studies has often worked very closely, over an extended period of time, with the research team. There is little or no evidence that teachers less closely involved with the research process can replicate the improvements in student learning.

K. Boersma et al. (eds.), Research and the Quality of Science Education, 209—220.

The study reported in this paper was designed to provide evidence about the feasibility of improving student learning against specified curriculum goals, when the design of the teaching is informed by insights from research on students' learning. The study consists of two phases. During the *Development phase*, groups of teachers and researchers worked together to design, implement, and evaluate short teaching sequences. During the *Transfer phase*, two of the sequences were implemented by teachers not involved in the design of the teaching sequence. An important aspect of the evaluation of both phases addressed the extent to which students following the designed teaching approach attained a richer understanding of the target conceptual content, compared to other students of the same ability following the school's usual approach.

2. DESIGN AND METHODOLOGY

Three short teaching sequences were designed, implemented, and evaluated. Each sequence was prepared by a group of three teachers and university-based researchers working together. The teaching sequences were aimed primarily at pupils aged between 11 and 14 and lasted for around 6 hours. The schemes focused upon introductory ideas about plant nutrition, the process of modelling change in terms of a simple particle model of matter, and introductory ideas about electric circuits. These areas were selected on the grounds that there is a significant body of empirical research on students' learning in each area, together with studies describing the design and evaluation of teaching approaches.

The overall shaping of the teaching sequences was informed by a social constructivist perspective on learning (Driver et al., 1994; Leach & Scott, 2003), with particular attention being given to the different communicative approaches (Mortimer & Scott, 2002; Mortimer & Scott, 2003) to be taken by the teacher in promoting learning. In addition, an analysis of the particular learning demands (Leach & Scott, 2002) was made for each of the topic areas, drawing on research evidence about students' learning in those areas; instructional activities were planned to address those learning demands. Each participating teacher then implemented the teaching sequence with at least one class.

The implementation of the teaching sequences was evaluated using multiple data sources. Students' learning against specified goals was measured by comparing responses to diagnostic questions set prior to teaching, immediately after teaching, and after a delay of several weeks.[1] Students of classes who had followed the school's regular teaching approach were evaluated with the same instruments in order to provide baseline information.

A pre-test was used to establish the comparability of the case study and the baseline groups. Pre-test and post-test questionnaires were not identical, as in some

[1] The results of the delayed post-test are not, however, reported as there was evidence in some groups that further relevant teaching had taken place.