INVESTIGATING TEACHERS' IDEAS ABOUT MODELS AND MODELLING – SOME ISSUES OF AUTHENTICITY

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ABSTRACT

'Models and modelling' has made an increased contribution to research in science education in recent years. Almost all the papers published discuss either the ideas expressed by teachers/students or the implications of such ideas for the practice of science teaching/learning. Here we focus on the research instruments that we have developed in the last six years to investigate teachers' ideas about the theme. The paper discusses the strengths and limitations of the instruments and their influence on the 'authenticity' of the knowledge so gained.

1. INTRODUCTION

The importance of models in science emerges from the recognition that they are non-unique partial representations of an object, an event, a process, or an idea, that are used for specific purposes (Gilbert, Boulter & Rutherford, 1998). Scientific knowledge is developed by the dynamic process of modelling phenomena. Therefore, in order to learn science in a comprehensive and contextualised way, students should learn not only the main scientific/historical models, but also their scope and limitations and issues concerning their development. Moreover, students should develop their ability to create, express, and test their own models.

A distinction has to be established in science education between *curricular models* – simplified versions of scientific or historical models that are taught to students – and *teaching models* – representations that are created with the specific purpose of facilitating students' understanding of such models (Gilbert & Boulter, 1995).

Science teachers must have specific knowledge (Shulman, 1987) in order to guide students in the learning of science from such a perspective. Thus:

1. Teachers' subject content knowledge should include a comprehensive understanding of the curricular models that they are required to teach. This will include an understanding of the entities of which they were constructed and the cause-effect relationships operating within them. They must understand the scope and limitations of each of these models: the purposes to which they can be put and the quality of the explanations to which they give rise. Such understanding should not be taken for granted, given the widespread occurrence of misconceptions of all kinds amongst teachers (Gilbert & Watts, 1983).

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2. Teachers' subject content knowledge should include a comprehensive understanding of the nature of what a model is *per se* (Justi & Gilbert, 2002a).
3. Teachers' curricular knowledge should include when, how, and why both the general idea of models and the natures of specific scientific/historical models should be introduced into the curriculum. In other words, teachers should be able to develop and/or change existing *curricular models* related to the topics that have to be taught in their classes.
4. Teachers' pedagogical content knowledge should include: their ability to develop good *teaching models*, their ability to conduct modelling activities in their classes, their understanding of how their students construct their own mental models, and how they should deal with the resulting expressed models in class (Gilbert et al., 1998).

The recognition of the role of models and modelling in science education is fairly recent (e.g. Gilbert & Osborne, 1980; Norman, 1983; Clement, 1989; Mayer, 1989; Nersessian, 1999; Harrison & Treagust, 2000). Consequently, many science teachers all over the world have not been explicitly equipped with such knowledge and skills. In our view, the initial step in this process has to be the investigation of their current knowledge about models and modelling. Our involvement with such an investigation has resulted in a dynamic process of proposition, testing, and changing of a series of research instruments, as well as in the reframing of our own ideas on models and modelling.

In the first project that we jointly conducted in this area, a semi-structured interview was used with Brazilian science teachers. Due to the time consumed in conducting and analysing the interviews, we then developed a 'closed item' (a Likert-type) questionnaire for application to larger samples. The results obtained with this questionnaire suggested that respondents were sometimes influenced by the precise wording used. Combining the results of these two enquiries, we subsequently developed an 'open item' questionnaire that was applied to samples of Brazilian, British, Dutch, and Finnish science teachers, its application being followed by interviews in some cases. A comparison of the analyses of both the questionnaires and the sets of interviews has enabled us to address issues of validity and reliability (authenticity) in such studies. In this paper, we detail the process of proposing, testing, and changing each of the instruments or parts of the instruments. The aim of the paper is not to discuss the results obtained from each instrument, but to address issues of 'authenticity' in the outcomes produced by the different methods of enquiry.

2. AUTHENTICITY IN QUALITATIVE ENQUIRY

The enquiries that we conducted were essentially *qualitative* in nature: we wanted to identify teachers' *personal* meanings for the words 'model' and 'modelling'. We were therefore concerned to ensure the *authenticity* of the data that we collected. It had to show *internal validity,* reporting their understanding of 'model and modelling' as *they* saw it (LeCompte & Preissle, 1993). This means that such data should show: