INVESTIGATION OF EFFECTS AND STABILITY IN TEACHING MODEL COMPETENCE

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ABSTRACT

A concept for a curriculum concerning the particle structure of matter, which aimed at the development of students' thinking about models, was developed for grades 9 and 10. Research results in this field indicate that thorough discussions concerning epistemology, models, and reality are necessary in class in order to develop an appropriate understanding of the micro-world (Mikelskis-Seifert, 2002). Accordingly, a learning environment was constructed in which the focus was on developing an understanding of the world of experiences and of the world of models. In this case, students had to distinguish systematically between these worlds (Seifert & Fischler, 2001). When teaching and learning about models, a further objective was that students develop metaconcepts regarding particle conception. As part of an empirical study conducted with 120 students from 8th grade, effects of this approach were analysed; the aim of the analysis was to measure the development of an appropriate understanding of models. We were also interested in the transferability of our approach to an introductory class. The results of this evaluation are presented here.

1. INTRODUCTION

Problems of teaching and learning the particle structure of matter

The use of particle models is an important issue in science education. Particles and atoms are central examples of modelling scientific phenomena in school. However, many empirical studies show that traditional teaching approaches are rather inefficient. Results of such studies indicate that most students have a far from adequate and comprehensive understanding (for example: Kircher, 1986; Ben-Zvi, 1986; Andersson, 1990; Griffiths & Preston, 1992; Duit, 1992; Fischler et al., 1997; Fischler, 1997). The transition into the micro-world is dominated by the macroscopic thinking of students, and the transfer of macroscopic attributes to submicroscopic objects is the central problem of learning about particles and atoms (Seifert & Fischler, 2001). In the opposite direction, the emergence of new macroscopic properties from combining atomic objects is far from being adequately understood. The results of further studies show that the model nature of particles and atoms is also not really understood (i.e. Harrison & Treagust, 1996; Treagust et al., 2002). A common misconception is that students place their models of micro-objects on the same level of reality as e.g. cars or books.

In this project, we focus on the question concerning whether an adequate understanding of particle model of matter can be developed via a special design

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intervention. Such an intervention is based on the reflective interplay of doing experiments and modelling.

Consequences for teaching and learning the discrete structure of matter

All didactic approaches have to face these problems, especially the dilemma of visualization. Some researchers try to avoid any visualization of the micro-world (Buck, 1990); some do not use macroscopic analogies of the micro-world. Other researchers discuss hybrid models between a macro- and micro-world (Justi & Gilbert, 1998). However, students are confronted every day with a lot of colourful pictures of micro-objects in the media and also in common schoolbooks. In any case, we have to deal with the meaning of all these visualizations and discuss them with students.

In this regard, one major teaching problem is the difficulty in achieving an acceptable understanding of the particle world; that is understanding that most of the macroscopic properties of matter with which we are so familiar are lacking in the micro-world. As a consequence, teachers should more strongly emphasize the differences that exist between a scientist's understanding of the world of experiences and the world of models presented to students. In our teaching approach students should be supported in the development of a metaconceptual awareness, and in this case students should be able to differentiate between the world of experiences and the world of models. Thus, the students also become acquainted with the specific characteristics of these two worlds.

Our hypothesis is that students with increased metaconceptual awareness can overcome their misconceptions about the micro world. In another research project, it was found that metaconception is accompanied by a comprehensive, precise, and coherent knowledge (Fischler & Peuckert, 1999). In other words: the transfer of macroscopic properties to particles is done almost exclusively by those students who have a naive-realistic conception about particles.

2. THE APPROACH OF LEARNING ABOUT MODELS

Main objective and basic idea of learning about models

In order to develop an appropriate understanding of the particle structure of matter, it is necessary to focus on the specific nature of the submicroscopic world and the modelling of the micro-world (Mikelskis-Seifert, 2002.) The following teaching activities that concern learning about models are therefore integrated into the curriculum: