USING MULTIPLE ANALOGIES: CASE STUDY OF A CHEMISTRY TEACHER'S PREPARATIONS, PRESENTATIONS AND REFLECTIONS

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ABSTRACT

The use of analogies by teachers is influenced by their existing knowledge base, especially their pedagogical content knowledge (PCK). With respect to teaching with multiple analogies, little is known about the relationship between teachers' classroom practice and their PCK before and after teaching. This study explores that relationship. An expert chemistry teacher was the subject of this study, and three lessons on chemical equilibrium for Grade-12 students were observed. The teacher was interviewed about his teaching intentions, and a reflective post-teaching interview conducted. The analysis indicates a number of relevant correspondences and differences between the teacher's intentions and his classroom practice. After teaching, the teacher appeared to be aware of the relevant correspondences, but was not aware of the differences, especially the absence of his intended attention to the limitations of specific analogies, and the absence of his intended check of students' understanding of links between an analogy and its target. These results underline the need to pay attention to specific aspects of teaching with analogies in the context of science teacher education.

1. INTRODUCTION

The past 20 years has seen a growing interest in the teaching and learning of science using analogies, especially at secondary school level (Duit, 1991; Gabel & Samuel, 1986; Treagust, Harrison & Venville, 1998). There is good reason for this interest because analogies can function as powerful tools facilitating students' understanding of science topics. While most studies of analogy in school science concern physics and biology topics, this study focuses on chemical equilibrium. More precisely, the study concentrates on the conceptions and actions of an expert chemistry teacher as he taught this difficult topic to Grade-12 students.

2. BACKGROUND

Analogies and their use in school science. An analogy can be considered as a relation between structures and functions from two conceptual domains; that is,

K. Boersma et al. (eds.), Research and the Quality of Science Education, 353—364.

similarities exist between the *analog* domain (a familiar object or event) and the *target* domain (in our case, a science concept) (Duit, 1991). An analogy expresses a comparison and is created by mapping similar features from the analog onto the target. Every analogy breaks down somewhere because there are always analog features that do not correspond with target features (Glynn, 1989), and this characteristic restricts the extent of every analogy. Curtis and Reigeluth (1984) have classified analogies under three headings based on each analogy's degree of elaboration. The first type is simple analogy, for example, 'assembling a car is like the mechanism of a chemical reaction'. The second type, enriched analogy, includes the grounds for the likeness, for example 'assembling a car is like the mechanism of a chemical reaction, because both cases proceed step by step'. The third type, extended analogy, consists of multiple simple and/or multiple enriched analogies.

Duit (1991) sees constructivist advantages in analogy use. Analogies give students the opportunity to relate features of daily-life objects or events to similar features of an abstract science topic, and they also may provide mental visualizations which, in turn, enhance student motivation. He warns that analogy use does not guarantee learning outcomes, for instance, students need to be able to 'see' the analogy and teachers need to assess the relevance of students' prior knowledge.

Most studies of concept learning by analogy focus on the teacher's use of analogies in their classroom practice (e.g. Dagher, 1995; Jarman, 1996; Treagust, Duit, Joslin & Lindauer, 1992). A minority of studies also examine student learning when analogies are used (e.g. Dupin & Johsua, 1989; Harrison & Treagust, 1993) and only a few studies are reported in chemistry education. Thiele and Treagust (1994) observed four chemistry teachers' classroom practices and found that they used planned analogies to explain abstract concepts to the whole class, and inserted spontaneous analogies when groups of students demonstrated a lack of understanding. Later, Harrison and Treagust (2000) described students' conceptual changes when multiple analogies were used to teach atoms and molecules in Grade-11 chemistry. The effectiveness of analogy use seems to be related to the teacher's explanatory ability, the students' familiarity with the analog, and the ability of both to map between similar features. Gentner (1983) recommends analogies whose surface similarities provide easy student access to the analogy, and also develop conceptual relationships. No analogy will cover all features of a target, but multiple analogies can address more features and in different ways. Thus, multiple analogies seem to be more effective than single analogies, especially when the target concept is complex and abstract (Thagard, 1992).

Teaching chemical equilibrium. With these ideas in mind, this study reports an expert chemistry teacher's use of analogies when teaching chemical equilibrium. This topic is central to chemical education, and is considered complex because it includes important sub-topics such as reversible reactions, reaction rates, chemical kinetics, and the dynamic nature of equilibria. Many students misunderstand chemical equilibrium believing that the forward reaction finishes before the reverse reaction commences, and that at equilibrium the reaction stops and 'nothing