Preservice teachers’ and teachers’ conceptions of energy and their ability to predict pupils’ level of understanding

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The study examined (a) the extent to which teachers and preservice teachers understand the concept of energy and adhere to particular preconceptions associated with it; and (b) their ability to predict pupils’ knowledge and understanding of the same concept. Teachers and preservice teachers completed a test by indicating for each item what their response was and what an average sixth-grade pupil’s response might have been, and their predictions were compared to actual pupil performance. Results indicated that teachers’ and preservice teachers’ understanding of the concept was far from complete, and that teachers were, in general, more likely to overestimate pupils' knowledge.

Conceptual change research has contributed extensively to our knowledge of how novices may conceptualise and explain a variety of physical phenomena (Carey, 1985; Clement, 1982; Vosniadou & Brewer, 1992). This research has intensified instructional efforts that take into account pupils’ preconceptions and aim at inducing cognitive conflict (Diakidoy & Kendeou 2001; Novak & Musonda, 1991; Smith, Maclin, Grosslight, & Davis, 1997). However, the success of any instruction ultimately depends, to a great extent, also on the teachers who are to implement it. In particular, teachers’ level of understanding of the concepts to be taught can be expected to influence not only the quality of instruction provided, but also their ability to help pupils overcome any preconceptions that render their prior knowledge incompatible with the new scientific information. A second issue of importance is also the extent to which teachers are aware of the existence of such preconceptions. Teachers’ level of awareness or ability to predict pupils’ level of understanding can be expected to relate to their ability to elicit preconceptions and to design instructional situations that will allow their comparison to scientific concepts. The present study focused on both of the above issues.

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Specifically, preservice teachers’ and teachers’ understanding of one particular scientific concept, that of energy, and their ability to predict pupils’ understanding of this concept were examined.

A substantial amount of research has been devoted to the study of teachers’ beliefs about learning and the nature of knowledge (e.g., Kagan, 1992; Strauss, 1993). On the other hand, relatively little attention has been paid to teachers’ actual content knowledge and understanding of the concepts they are expected to teach or to their awareness of pupils’ prior knowledge. Strauss, Ravid, Magen, and Berliner (1998) have argued that it is beliefs about children’s minds and learning that determine how teachers talk about teaching and the decisions they make, instead of subject matter knowledge. In fact, their research has shown that subject matter knowledge is unrelated to beliefs about learning (Strauss et al., 1998). One could raise no valid objection to the argument that beliefs about learning and specific content knowledge represent separate constructs that may not be related to each other. Moreover, one can expect beliefs about learning to provide the general framework that will guide instructional decision-making. To borrow from Strauss et al. (1998), the belief that complex material is difficult to learn will more than likely induce teachers to simplify it. We believe, however, that the particular way in which material is simplified for instruction is likely to be influenced, at least in part, by teachers’ amount of content knowledge and level of conceptual understanding.

Our belief finds support in the findings of Stein, Baxter, and Leinhardt (1990). Their detailed examination of one mathematics teacher’s knowledge of functions and graphs revealed gaps in his understanding of key ideas and a lack of deeper connections among them. Moreover, observation of a 25-lesson sequence unveiled relationships between the teacher’s level of understanding and the instruction he provided on this topic. Specifically, Stein et al. (1990) identified shortcomings in the fostering of rich representations and meaningful connections that would lay the foundations for future learning as directly related to missing links and uncertainties in the teacher’s knowledge base. Their work supported previous arguments that teachers’ knowledge can influence both the content and the process of instruction (Shulman, 1986).

The importance of teachers’ knowledge and level of understanding is magnified when pupils’ prior knowledge is incompatible with the concepts presented, as is so often the case in science instruction. For one thing, the ability to provide instruction that maximizes the plausibility of scientific concepts and theories (Posner, Strike, Hewson, & Gertzog, 1982) appears to require a solid understanding of these concepts and theories in the first place. Teachers with a rich knowledge base and a deep level of understanding of the concepts they teach can be expected to be better able to help pupils develop the appropriate representations and conceptual connections and to support activity and discourse that would render the new concepts meaningful (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Conversely, lack of knowledge and understanding on the part of the teacher is more likely to reduce instruction to the presentation and rehearsal of facts and rules. This, in turn, could effectively impede the restructuring of incompatible prior knowledge (Vosniadou, 1991).

If there is one instructional implication that conceptual change research has brought to the foreground, then that is the significance of taking into account pupils’ prior knowledge and potential alternative conceptions. Such preconceptions need to be made explicit and questioned in the course of instruction (Posner et al., 1982; Vosniadou, 1991). Linn and Muillenburg (1996) have, further, argued that the best way is to start by having pupils compare their own preconceptions to scientific models. In general, the extent to which prior knowledge is elicited and utilized in order to facilitate understanding can be expected to relate to teachers’ beliefs about children’s minds (Strauss et al., 1998) and about the nature and the locus of knowledge (Shuell, 1987). More specifically, however, the extent to which alternative conceptions are recognized as such can be expected to also depend on teachers’ being at least aware of the possibility of their existence and function. In practice, level of awareness can be reflected in teachers’ ability to predict the degree to which pupils understand a concept prior to instruction as well as the way they understand it. The present study employed this measure by requiring...