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Exposing biology teachers' tacit views about the knowledge that is required for teaching using the repertory grid technique

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ABSTRACT

Several types of knowledge are known to be required for teaching, including content knowledge (CK) and pedagogical content knowledge (PCK). Exploring the relationships between CK and PCK is not a straightforward task due to their complex and tacit nature. Here we aim to expose biology teachers' views about the knowledge required for teaching biology and their tacit views about the relationships between CK and PCK using the repertory grid technique. Data collected from 23 in-service experienced high-school biology teachers revealed that CK is viewed by the participating teachers as an important component of knowledge for teaching. Analysis of their tacit views about the relationships between CK and PCK revealed that CK is viewed by and large as distinct from PCK.

1. Rational

Experienced teachers possess special knowledge, acquired during their teaching. Considerable effort has been made in the last three decades to construct a well-established conception of science teachers' knowledge. It was Shulman (1986) who first suggested that there are several types of knowledge required for teaching, including content knowledge (CK) and pedagogical content knowledge (PCK). Shulman defined CK as the amount and organization of subject-matter knowledge per se in the teacher's mind, and PCK as a unique amalgam of content and pedagogical knowledge that reflects the ways in which the subject is presented and formulated to make it comprehensible to others (Shulman, 1986, 1987).

Both CK and PCK are considered critical professional development resources for teachers, each requiring special attention during teacher training and classroom teaching practice (Baumert et al., 2010). While many scholars agree with Shulman's (1986) categorization of science teachers' knowledge which distinguishes CK from PCK (Grossman, 1990; Krauss et al., 2008; Lederman & Gess-Newsome, 1992; Magnusson, Krajcik, & Borko, 1999), others refer to CK as an integral part of PCK (Ball, Thames, & Phelps, 2008; Hill, 2008; Lee & Luft, 2008; Marks, 1990).

Various methods have been developed to measure the knowledge required for teaching. These include meta-analysis (Zeidler, 2002), interviews, and multiple-choice and open-ended questionnaires about teaching and learning situations (Baumert et al., 2010; Hill, 2008; Käpylä, Heikkinen, & Asunta, 2009), as well as classroom observation (Rozenszajn & Yarden, 2011, 2014a). CK may be easier to expose, because of its explicit nature, than PCK, which is largely tacit. Moreover, the relationships between CK and PCK are largely tacit, complicating their examination due to their complex nature and internal tacit construct (Loughran, Milroy, Berry, Gunstone, & Mulhall, 2001), as well as their dependence on context (Driel, Verloop, & De Vos, 1998). Indeed, in-service teachers who develop expertise in teaching hold tacit or intuitive knowledge—the experts know what they should do while teaching, but cannot necessarily explain why it is done (Björklund, 2008). The exploration of explicit knowledge may therefore reveal only part of the teachers' knowledge, calling for the need to elicit teachers' implicit knowledge and their views about this knowledge to obtain a full picture.

Here we used the repertory grid technique (RGT), which has been previously used to elicit experts' personal views (Fransella, Bell, & Bannister, 2004; Jankowicz, 2001). This study focused on high-school biology teachers who were participating in a long-term professional development program that was specifically

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designed for outstanding science teachers (see research context below). The goals of this study were to expose in-service biology teachers' views about the knowledge required for teaching biology in general and their tacit views about the relationships between CK and PCK in particular, using the RGT.

2. Theoretical framework

2.1. Teachers' knowledge base

Teachers hold a large and unique teaching knowledge. It was Shulman (1986) who first suggested referring to teachers' knowledge as a special knowledge domain. He divided this special knowledge into three categories: (a) subject matter CK—the amount and organization of knowledge per se in the teacher's mind; (b) PCK—the dimension of subject matter for teaching, namely the ways of presenting and formulating the subject to make it comprehensible to others, and (c) curricular knowledge—the knowledge of alternative curriculum materials for a given subject or topic within a grade (Shulman, 1986).

Shulman's PCK model was further discussed and revised by various science educators, suggesting more detailed representations. Grossman (1990) proposed a model that provides four categories of PCK: conceptions of purposes for teaching a particular subject matter, knowledge of student understanding, curricular knowledge, and knowledge of instructional strategies. Magnusson et al. (1999) changed Grossman's use of the term 'purposes' to 'orientation', added beliefs to knowledge, and added an additional category: knowledge and beliefs about assessment. Since then, major effort has been devoted to understanding the notion of PCK and constructing a well-established conception for PCK and its related categories (Gess-Newsome, 1999; Lee & Luft, 2008; Park & Oliver, 2008; Rozenszajn & Yarden, 2011, 2014a, 2014b).

By and large, it is agreed that PCK is used in the context of teaching a specific content (Ball et al., 2008; De Jong & Van Der Valk, 2007; Lee & Luft, 2008; Loughran et al., 2001; Loughran, Mulhall, & Berry, 2008; Magnusson et al., 1999), but resolution of the term "specific content" is still under debate. While some researchers refer to the term "content" of the construct PCK as the knowledge of teaching a specific subject matter (De Jong & Van Der Valk, 2007; Henze, Van Driel, & Verloop, 2008; Loughran et al., 2008; Rozenszajn & Yarden, 2014a; Van Driel et al., 1998), others refer to it as "the knowledge of teaching all the topics they teach" (Magnusson et al., 1999; Shulman, 1987).

In addition to the need to understand PCK, the relationships between PCK components and CK as an integral part of teachers' knowledge for practice have been discussed. Some researchers suggest that CK enhances teachers' quality of teaching. For example, in mathematics education, the breadth, depth, and flexibility of teachers' understanding of the mathematics they teach afford them a broader and more varied repertoire of teaching strategies (Ball et al., 2008; Baumert et al., 2010; Even, 2011; Krauss et al., 2008), while limited CK has been shown to be detrimental to PCK, limiting the scope of its development (Baumert et al., 2010). Moreover, it has been suggested that the degree of cognitive connectedness between CK and PCK among secondary mathematics teachers is a function of their degree of mathematical expertise (Krauss et al., 2008). In contrast, other studies have indicated that science teachers' subject-matter knowledge is not automatically transferred to classroom practice (Lederman & Gess-Newsome, 1992; Zeidler, 2002), implying that CK and PCK are different and distinct domains within the teacher's cognitive structures (Grossman, 1990; Großschedla, Mahlera, Kleickmann, & Harmsa, 2014; Magnusson et al., 1999; Shulman, 1986). Examining the relationships between CK and PCK is complicated because expert teachers hold tacit knowledge about the role of PCK in their practice (Björklund, 2008) which is not easily revealed.

2.2. Tacit knowledge and the personal construct psychology theory

Tacit knowledge is contextual and situated. It is often acquired through repeated experiences with a certain domain. Experts in a field are those who repeatedly have certain experiences and effectively learn from them. Therefore, they are usually able to recognize meaningful patterns faster than novices (Chi, 2006; Dreyfus, 2004), but they will be unable to verbalize this and will often be unaware of it (Polanyi, 1966). Namely, experts facing an unfamiliar situation will intuitively identify what should be done: they do not even seem to think about it. They just do what normally works and, of course, it usually does (Dreyfus, 2004). Nevertheless, their general inability to verbalize their 'know-how' (Björklund, 2008) means that they hold tacit knowledge (Polanyi, 1966).

Experienced teachers are usually able to function automatically. Many of their activities in class, such as their interactions with students, are behavioral patterns that they can invoke and perform without any conscious effort. Experienced teachers seem to have organized their knowledge of students and classrooms in particularly effective patterns that can be retrieved unconsciously from their long-term memory via classroom cues (Johansson & Kroksmark, 2004).

The inability to verbalize tacit knowledge, and the fact that teachers may not even know that it is there controlling their decisions and actions, led us to search for a suitable method to elicit teachers' tacit non-verbal views about the knowledge required for teaching. Such a method was suggested by the American psychologist, George Kelly, who formulated the Personal Construct Psychology theory (Kelly, 1955).

Kelly (1955) argued that people have different views of events in the world. These views are organized uniquely within each person's cognitive structure. Kelly (1955) established a psychological theory, the Personal Construct Psychology, which argues that each person makes use of unique personal criteria—constructs—to help him or her construe meaning from events. The Personal Construct Psychology theory states that people's views of the objects and events with which they interact are made up of a collection of related similarity–difference dimensions, referred to as personal constructs (Kelly, 1955, 1969). These constructs serve as mental models that enable individuals to formulate testable hypotheses about future events, and then test them against their experience and revise them (Ben-Zvi Assaraf & Damri, 2009; Duit & Glynn, 1996; Duit & Treagust, 2003). Kelly drew explicit parallels between the processes that guide scientific research and those involved in everyday activities (Bezzi, 1996; Bradshaw, Ford, Adams-Webber, & Boose, 1993). Like scientists, people tend to predict and control the course of events in their environment by controlling mental models of the world. Such acts or judgments of events are often experienced as intuition or gut feelings (Jankowicz, 2001) because of their tacit nature.

Following the formulation of the Personal Construct Psychology theory, Kelly (1955) designed a method to elicit personal constructs, namely tacit knowledge, which is known as the repertory grid technique (RGT). The RGT has been used in clinical psychology for over 50 years but has recently found new uses in a variety of research areas (Jankowicz, 2004). The findings from experimental psychology and cognitive science on implicit learning and knowledge, and the interest in tacit knowledge, have given rise to new expectations for the use of this method in the area of educational research (Björklund, 2008).

Tacit cognitive constructs in the area of science education have been previously elicited to probe students' system-thinking skills