Thinking Skills and Creativity 18 (2015) 53–64

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: http://www.elsevier.com/locate/tsc

General and specific thinking skills and schooling: Preparing the mind to new learning

Mari-Pauliina Vainikainen*, Jarkko Hautamäki, Risto Hotulainen, Sirkku Kupiainen

University of Helsinki, Department of Teacher Education, Centre for Educational Assessment, Finland

ARTICLE INFO

Article history:
Received 3 October 2014
Received in revised form 17 April 2015
Accepted 23 April 2015
Available online 30 April 2015

Keywords:
Thinking skills
Cognitive development
Formal thinking
Class-effect on thinking skills
Nested multilevel factorial models

ABSTRACT

Enhancing thinking skills is an important goal of formal education. It is often embedded in national curricula, which, however, are seldom based on theoretical understanding of the structure of the skills or how they should be taught. Accordingly, there is only limited information available about schools' success in this important task. The present study has two goals: firstly, to find support for the theoretical assumption of the nested structure of thinking skills with a core factor of formal thinking and specialised structures for verbal and quantitative reasoning; and secondly, to test the differentiated development of these skills in school. This was done by studying class-level variation of sixth graders' thinking skills in a multilevel factor analysis when initial between-class differences at grade three had been taken into account. The data ($N \approx 1543$) were drawn from a learning to learn panel study in one of the major cities of Finland. The results showed that the core factor for formal thinking could be identified at both the individual and the class level, and that at the individual level there were statistically significant residual factors for verbal and quantitative reasoning. Initial between-class differences explained only a third of the variance of class-level formal thinking. This was interpreted to indicate the effect of schooling.

1. General and specific thinking skills and schooling

Discussions of current working environments and of the skills necessary for work call for a new approach towards learning. In the continuously changing work environments people need to make coherent decisions with access to unlimited information in a limited time, to think creatively, to adjust their actions and attitudes according to possible risks and problems, to learn quickly, and to trust their problem solving skills (Halpern, 2008). Hence, educational policy makers world-wide have lately become interested in concepts, such as learning to learn, thinking skills, and 21st century skills (Recommendation 2006/962/EC of the European Parliament and of the Council, 2006; Rocard et al., 2007; Organisation for Economic Co-operation and Development (OECD), 2013a).

The common core for the new or newly introduced concepts is that they all tap underlying cognitive competences and non-curricular domain-general skills that regard an individual's overall learning preparedness. Depending on the framework, these skills are referred to as cross-curricular, learning to learn (LTL), transversal, or 21st century skills (Deakin Crick, Stringer, & Ren, 2014). Regardless of the term, these definitions emphasise the importance of developing thinking skills as

* Corresponding author at: Centre for Educational Assessment, University of Helsinki, P.O. Box 9, 00014 Helsinki, Finland. Tel.: +358 503465050.
E-mail address: mari-pauliina.vainikainen@helsinki.fi (M.-P. Vainikainen).

http://dx.doi.org/10.1016/j.tsc.2015.04.006
1871-1871/

a basis for future learning from core processes and specialised structural systems to critical thinking (Demetriou, 2014). Enhancing thinking skills have been considered as a central goal of education already for decades (Resnick, 1987), but it is still quite rare that educational systems promote such development deliberately (an interesting exception is Hungary, where new frameworks in reading, mathematics and science are all based on ideas of general and specific thinking as an explicit part, see Csapó & Szapo, 2014). Even though thinking skills are expected to improve when pupils proceed through their formal schooling, strategies for evaluating educational outcomes and effectiveness of schooling mainly centre on the measurement of subject-specific knowledge and skills or at best their application. In Finland, the assessment of general cognitive competences and the affective factors which support their effective use, together labelled LTL, were defined as one of the measurable outcomes of education already in the 1990s (Hautamäki et al., 2002; National Board of Education, 1999). Since then, they have been used as one indicator for monitoring the effectiveness of education.

LTL is defined as the cognitive competence and willingness to adopt to novel tasks and new learning (Hautamäki et al., 2002; Hautamäki, Hautamäki, & Kupiainen, 2010). In empirical assessment of LTL, the assessment tasks are seen to activate a complex of interrelated competences and beliefs, leading to an attempt to solve the tasks. Competence refers to the application of general cognitive schemas and the already acquired knowledge or scholastic achievement to new situations. Beliefs refer to anticipated emotions which, once activated, lead to commitment or refusal. Defined this way, LTL competences are related to intelligence, understood in a Piagetian framework as the active use of formal operational schemas. From this follows the hypothesis that the cognitive LTL tasks measure general thinking skills (see Adey & Csapó, 2014). LTL as an educational goal is an explicit part of the EU definition of key competences and of the 21st century skills in the global context. However, neither of the two presents an empirically tested model to measure the competences. The Finnish LTL Framework and scales are one of few attempts to offer a tool to assess both the cognitive and the willingness- or commitment-related components of LTL (Deakin Crick et al., 2014).

The aim of the present study is on the one hand to test the theoretical assumption that the thinking skills measured with the Finnish LTL construct have a nested structure (cf., Härnqvist, Gustafsson, Muthén, & Nelson, 1994) with formal operational thinking (see Shayer, 1979) at its core and with specialised residual factors for verbal proportional and quantitative reasoning (see Demetriou, Spanoudis, & Mouyi, 2011). On the other hand, the aim is to evaluate whether schooling has an effect on these skills in the Finnish context, where thinking skills are defined as a goal embedded in all school subjects in the national core curriculum (National Board of Education, 2004) but details regarding their teaching are missing.

1.1. Development of thinking

Developmental psychologists have long studied the development of thinking. The theory of cognitive development proposed by Demetriou et al. (2011) and Demetriou (2014) involves both central and general mechanisms, and specialised capacity systems for different domains of knowledge or relations. The spatial, verbal, quantitative, categorical, causal, and social reasoning systems have been identified by methods from different theoretical origins, and they are considered as autonomous domains of understanding, thinking, and problem solving. A critical feature of this theory is that the development of the specialised systems is both limited by and is the route into the development of the general intellectual processor and its executive control (self-regulation). That is, the general factor is also amenable to educational influence. There is evidence from other theoretical backgrounds that high performance on a general level facilitates the acquisition of new domain specific skills especially on the early phases of the learning process (Francis, Fletcher, Maxwell, & Satz, 1989; Gustafsson, 2008). But when learning is based on already acquired skills, the gains are more likely to depend on earlier domain-specific knowledge. Accordingly, the improvements are likely to be domain-specific. All this means that good subject-specific teaching makes the connection between specific knowledge, e.g. the use of specific concepts, with the general use of concepts, rules and their application. This gradually leads to gains also in the functioning of the general mechanisms (Demetriou et al., 2011; Gustafsson, 2008).

One of the most studied constructs in the development of general thinking skills and the functioning of the general mechanisms (cf., Demetriou et al., 2011) is the control of variables strategy (CV), which is also often referred to as the vary-one-thing-at-a-time (VOTAT) strategy. It was first introduced by Inhelder and Piaget (1958) as part of the formal operational thinking construct (see Shayer, 1979). Regardless of criticisms concerning explicitness of Inhelder and Piaget's work it still provides overarching illustration how adolescents' cognitive competences develop during the second decade of their life (Kuhn, 2008). The emergence of formal operations at around age 12–15 involves reasoning based on hypotheses, independent of concrete objects, which means "the real is subordinated to the realm of the possible" (Piaget, 2006). Age variation is seen to be ingrained in the differing intellectual stimuli in children's environments and to depend on personal interests and experiences. However, formal thinking is not necessarily applied all the time or across all domains (Piaget, 1972, 2006). Even if individual differences in formal operational thinking are related to intelligence, verbal ability and executive functions, these are considered to be partly culturally bound (Emick & Welsh, 2005). It has been shown that that the control of variables strategy is central to science and an essential skill attainable and trainable by the time children are cognitively advancing from a concrete toward a formal operational level (Neimark, 1975; Shayer, 2008).

In this study, we use the CV-schema as the apex of our interpretation of the cognitive component of learning to learn. In psychometric studies, the apex is general (*g*) or fluid (gf) intelligence (Carroll, 1989; Gustafsson, 2008), but it seems that there are also other possibilities for the apex due to the law of positive correlations amongst reliable cognitive tasks. In the psychologically oriented approach to education, *g* is mainly used as an explanatory factor (Deary, Strand, Smith, &