Learning and Individual Differences 54 (2017) 82–91

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Assimilation and contrast effects in the formation of problem-solving self-concept☆,☆☆,☆☆☆

Maida Mustafić *, Christoph Niepel, Samuel Greiff

Education, Culture, Cognition, and Society (ECCS), University of Luxembourg, Luxembourg
ECCS, University of Luxembourg, Luxembourg
University of Luxembourg, Luxembourg

ARTICLE INFO

Article history:
Received 7 March 2016
Received in revised form 7 December 2016
Accepted 5 January 2017
Available online xxxx

Keywords:
Problem-solving self-concept
Complex problem solving
Assimilation
Contrast
Dimensional comparisons

ABSTRACT

Domain-specific self-concepts (e.g., "I am good at mathematics") and general school self-concepts ("I am good at school") have been shown to be good predictors of academic performance, persistence, and even well-being; yet research on the predictors of domain-general (i.e., cross-curricular and nonacademic) self-concepts (e.g., "I am good at solving problems") is scarce. On the basis of the *generalized internal/external frame of reference* model (GI/E model), this study tested potential predictors of the domain-general problem-solving self-concept. Structural equation models revealed—in line with the GI/E model—that self-reported mathematics achievement and complex problem solving exerted assimilation effects on problem-solving self-concept. As expected, there were no relations with self-reported verbal achievement. We also found a high association between mathematics, verbal, and problem-solving self-concepts. Simultaneous control for school track and general fluid ability, assessed using the four subscales of the CFT-20-R, that is, classification, matrices, and typologies, decreased the association between complex problem solving and problem-solving self-concept. We discuss the possible impact of domain-general self-concepts on students' performance.

1. Introduction

The relevance of domain-specific abilities and domain-specific self-concepts (e.g., mathematics and verbal) as well as general school self-concepts is well-researched and well-acknowledged. They play important roles in the lives of students as these constructs have been shown to predict students' academic performance, persistence, and well-being as well as their adaptation to demands at school (e.g., Cimeli, Rothlisberger, Neuenschwander, & Roebers, 2013; Dickhäuser & Reinhard, 2006; Marsh & O'Mara, 2008; Niepel, Brunner, & Preckel, 2014; Poloczek, Karst, Praetorius, & Lipowsky, 2011; see a meta-analysis by Valentine, DuBois, & Cooper, 2004).

Nowadays, however, demands across situations—at school, in private life, and at work—have changed from being routine to being highly dynamic and complex (Autor, Levy, & Murnane, 2003). This is mostly because technological advances have sped up our current lives. More information is transmitted across the world quickly, and concrete knowledge expires rapidly. Consequently, to be fast and efficient, students need to employ domain-general abilities, which enable them to cope with the demands across a variety of domains. One such ability that assists students' functioning across domains is complex problem solving (CPS). As it is a domain-general ability, CPS enables students to apply a variety of cognitive skills across school subjects and across life situations and thereby assists them in their life at school and after school (Greiff, Wüstenberg et al., 2013; OECD, 2004).

Complex problem solving can be defined as an ability to reduce the discrepancy between a person's actual state and a desired state in situations that are complex, nontransparent, interconnected, dynamic, and polytelic (Dörner, Kreuzig, Reither, & Stäudel, 1983, cited in Funke, 2010). Although the initial measures of CPS suffered from low reliability because they were primarily focused on enhancing external validity to reflect functioning in real-life problems, state-of-the-art measures of CPS combine excellent measurement reliability with satisfactory external validity (Greiff, Wüstenberg et al., 2013). Although CPS is related to

☆ This research was supported by the Fonds National de la Recherche Luxembourg (ATTRACT "ASKI21") awarded to Samuel Greiff. All statements expressed in this article are those of the authors and do not reflect the official opinions or policies of the authors' host affiliation or any of the supporting institutions.

☆☆ Samuel Greiff is one of two authors of the commercially available COMPRO-test that is based on the multiple complex systems approach and that employs the same albeit very general assessment principle as MicroDYN. However, for any research and educational purpose, a free version of MicroDYN is available. Samuel Greiff receives royalty fees for COMPRO.

☆☆☆ The authors would like to thank Julia Rudolph and Katarina Krkovic for their valuable involvement in constructing the study as well as their help with the data collection and analysis.

* Corresponding author at: ECCS, University of Luxemburg, 11, Porte des Sciences, 4366 Esch-sur-Alzette, Luxembourg.
E-mail address: maida.mustafic@uni.lu (M. Mustafić).

http://dx.doi.org/10.1016/j.lindif.2017.01.006
1041-6080/

established constructs of cognitive functioning (e.g., $r \approx 0.60$ with reasoning, e.g., Wüstenberg, Greiff, & Funke, 2012), CPS performance predicts academic success and job performance beyond reasoning (e.g., Greiff, Wüstenberg et al., 2013; Sonnleitner, Keller, Martin, & Brunner, 2013). CPS can be situated among other problem-solving concepts; however, compared with other problem-solving approaches that involve domain-specific problems and require domain-specific knowledge, the conceptualization of CPS involves very universal problems and very general problem-solving strategies (Sternberg, 1995).

Although research on problem solving is broadly and internationally acknowledged by scientific and nonscientific authorities with huge political impact as reflected by the inclusion of complex problem solving in PISA 2012, knowledge about *problem-solving self-concept* is still scarce at best. Problem-solving self-concept is likely to play an important role in students' problem-solving performance and is therefore important to study and to understand. To foster the understanding of problem-solving self-concept formation, the goal of this study was to provide the first test of the potential predictors of problem-solving self-concept. The predictions in this study are based on a model that incorporates processes that are likely to be involved in domain-general self-concept formation: the *generalized internal/external frame of reference model* (GI/E model; Möller, Müller-Kalthoff, Helm, Nagy, & Marsh, 2016).

1.1. Self-concept formation: the I/E and GI/E models

Comparisons with social others provide important information when people evaluate themselves (social comparison theory; Festinger, 1954). According to this rationale, students conceptualize their abilities in mathematics by comparing themselves with their peers. The *internal/external frame of reference model* (I/E model; Marsh, 1986)—a comparison process model specifically tailored to educational contexts—claims that not only do external social others (as an external frame of reference) serve as comparison standards, but we ourselves serve as an internal frame of reference as well.

In line with the social comparison theory, within the I/E model it is proposed that students compare their abilities with the abilities of their peers/classmates to construct evaluations of their own abilities (e.g., "I am good at mathematics"). Consequently, when students find themselves in a class that, on average, exhibits low performance in mathematics, their evaluations of their own abilities will likely be better than when students find themselves in a class that exhibits high performance (see also the big-fish-little-pond effect; e.g., Marsh & Parker, 1984).

Going beyond Festinger's (1954) ideas, the I/E model claims that students are likely to compare their abilities with their own internal abilities. According to the I/E model, personal internal abilities serve as comparison standards within the student (see also Möller & Köller, 2001, for experimental evidence). To evaluate his/her own performance in mathematics, the student will likely compare his/her performance in mathematics to his/her performance in German. Internal comparisons with similar academic subjects lead to *assimilation effects*, whereas internal comparisons with different academic subjects lead to *contrast effects*. For example, an assimilation effect is indicated by considerable convergence and strong positive correlations between achievement and self-concepts in mathematics and physics; whereas a contrast effect is indicated by a great deal of divergence and low positive or zero correlations between achievement and self-concepts in mathematics and a language (Marsh, 1986). Assimilation and contrast effects play important roles in domain-specific self-concept formation. For domain-specific self-concepts, the relevance of these effects is well-established and longitudinally replicated (see a comprehensive meta-analysis by Möller, Pohlmann, Köller, & Marsh, 2009; Möller, Streblow, Pohlmann, & Köller, 2006; for longitudinal findings, see Marsh & Yeung, 1997b; Niepel et al., 2014).

Recently, the generalized internal/external frame of reference model (GI/E model; Möller et al., 2016), an extension of the I/E model, was introduced. Going beyond the I/E model, which is applied only to academic achievement and self-concepts, the GI/E model extends the model's predictions to encompass more domains on the levels of both the predictors and the outcomes of the model. The model suggests that on the level of predictors, not only academic achievements but all kinds of school-related variables (e.g., student perceptions, the self-reported instructional quality of classes, teacher ratings, and time spent with homework) impact a variety of criteria (e.g., self-concept, perception, emotion, self-regulation, and motivation) via the comparison processes proposed in the initial I/E model (Möller et al., 2016). For the current study, we used the generalization of assumptions across domains proposed by the GI/E model regarding internal comparisons to test possible predictors of a domain-general self-concept.

Following the rationale of the GI/E model regarding internal comparisons (particularly dimensional comparisons; for more details on internal comparisons see Möller & Marsh, 2013), we expected mathematics achievement as well as CPS performance to be positively associated with problem-solving self-concept (assimilation effect) but not to be associated with verbal achievement. On the level of self-concepts and according to the GI/E model, we expected problem-solving self-concept to be positively associated with mathematics self-concept but not be associated with verbal self-concept.

1.2. Which achievements are associated with problem-solving performance and problem-solving self-concept?

Studies testing the associations between various kinds of school achievement and CPS performance found CPS performance to be primarily positively associated with achievement in mathematics and science (Greiff & Fischer, 2013; Kretzschmar, Neubert, & Greiff, 2014; Martin, Liem, Mok, & Xu, 2012; OECD, 2004; Scherer & Beckmann, 2014; Schweizer, Wüstenberg, & Greiff, 2013). According to the scientific discovery as dual search (SDDS) model (Klahr & Dunbar, 1988), these strong associations are based on principles of scientific discovery, which are core principles of CPS as well as mathematics and science (see Greiff, Firscher, et al., 2013). In this model, good scientific problem solving is ideally a composite of generating hypotheses, experimentally testing them, and revising them on the basis of the results of the experiments. Mathematics, scientific problem solving, and CPS are all based on this SDDS principle.

On the level of performance, the association between mathematics and problem solving is quite well established; however, on the level of self-concept, the association has not been tested before. In the current study, we expected that, due to the conceptual similarity of mathematics and problem solving, students might infer their problem-solving self-concept from their mathematics achievement. Based on the GI/E model's rationale, we also expected that students would refer to an underlying concept of being "scientifically talented" (Möller et al., 2006) when thinking about their mathematics and problem-solving abilities. Therefore, we expected that a high mathematics self-concept would be positively associated with a high problem-solving self-concept.

Regarding the associations between CPS performance and verbal achievement, the research findings have been somewhat inconsistent. One study found a positive association between verbal achievement and CPS (Kretzschmar et al., 2014); however, another study showed no association between verbal achievement and CPS (Schweizer et al., 2013). Findings on PISA data have revealed that differential facets of CPS were nearly equally associated with reading, science, and mathematics (Wirth, Leutner, & Klieme, 2005). The positive association between reading and CPS performance could have emerged because reading abilities enable the test taker to understand the task instructions and thereby facilitate problem solving. CPS tasks are embedded in real-life scenarios (e.g., handball training) and require some written instructions before the task begins. Overall, the findings on verbal and mathematics achievement