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Students' self-concept and self-efficacy in the sciences: Differential relations to antecedents and educational outcomes

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ABSTRACT

Self-concept and self-efficacy are two of the most important motivational predictors of educational outcomes. As most research has studied these constructs separately, little is known about their differential relations to peer ability, opportunities-to-learn in classrooms, and educational outcomes. We investigated these relations by applying (multilevel) structural equation modeling to the German PISA 2006 data set. We found a correlation of ρ = .57 between self-concept and self-efficacy in science, advocating distinguishable constructs. Furthermore, science self-concept was better predicted by the average peer achievement (*Big-Fish-Little-Pond Effect*), whereas science self-efficacy was more strongly affected by inquiry-based learning opportunities. There were also differences in the predictive potential for educational outcomes: Self-concept was a better predictor of future-oriented motivation to aspire a career in the sciences, whereas self-efficacy was a better predictor of current ability. The study at hand provides strong evidence for the related but distinct nature of the two constructs and extends existing research on students' competence beliefs toward social comparisons and opportunities-to-learn. Further implications for the relevance of inquiry-based classroom activities and for the assessment of competence beliefs are discussed.

1. Introduction

Students' competence beliefs, that is, their academic self-concept (ASC) and self-efficacy (ASE), are positively related to various desirable scholastic outcomes such as achievement, effort, and attainment (Huang, 2011; Marsh & Martin, 2011; Nagengast et al., 2011; Pajares, 1996; Swann, Chang-Schneider, & Larsen McClarty, 2007; Trautwein, Lüdtke, Schnyder, & Niggli, 2006; Valentine, DuBois, & Cooper, 2004). Similarities but also meaningful differences in the conceptualizations and operationalizations of the two constructs have been pointed out (Bong & Clark, 1999; Bong & Skaalvik, 2003). However, studies have rarely investigated whether the two constructs show differential relations to antecedents of competence beliefs and educational outcomes or are merely different labels for the same construct (*jangle-fallacy*, Kelley, 1927; Marsh, Craven, Hinkley, & Debus, 2003; Reschly & Christenson, 2012). More precisely, little is known about the potentially differential effects of social comparisons with peers and instructional activities such as inquiry-based learning on competence beliefs. Further, only few studies have focused on these differences in the domain of science even though science education in high-school classrooms may offer different antecedents of competence beliefs when compared with other subjects. Moreover, predicting educational outcomes in the sciences using motivational factors is seen as critically important in both research and educational policy (Bybee & McCrae, 2011, OECD, 2007; Osborne, Simon, & Collins, 2003; Taskinen, Schütte, & Prenzel, 2013; Tsai, Jessie Ho, Liang, & Lin, 2011; Wigfield & Eccles, 2000).

The main goals of the present study were to analyze the empirical differences between ASC and ASE in science and to disentangle their potential differential relations to a selected set of covariates and outcomes. In the following, we will first describe the conceptual differences between ASC and ASE that have been identified in theoretical reviews. Subsequently, we will sketch a conceptual research model for studying this distinction that describes the assumed relations between social comparisons and opportunities-to-learn as sources of competence beliefs, competence beliefs, and educational outcomes. From this model and previous empirical research on the relation between ASE and ASC, we derived and tested specific hypotheses.

1.1. Conceptual differences between self-concept and self-efficacy

In their reviews, Bong and colleagues described similarities and differences in the conceptualizations and operationalizations of ASE and ASC in detail (Bong, Cho, Ahn, & Kim, 2012; Bong & Clark, 1999;

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Bong & Skaalvik, 2003). Among others, the authors identified differences with regard to the nature and the sources of judgment on which the competence beliefs were based and their predictive validity for certain outcomes. These differences will be briefly summarized in the following paragraphs.

Broadly speaking, ASC refers to the self-evaluation of one's general ability in a domain (Marsh & Martin, 2011). ASC is assumed to be a relatively stable, multidimensional, hierarchical, and domain-specific construct and is most commonly studied at the level of school subjects such as mathematics, English, and science (Marsh, 1990; Shavelson, Hubner, & Stanton, 1976). Even though based on "objective" achievement feedback such as grades, ASC is still a subjective evaluation of one's own achievement (Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014). For example, when students respond to an item such as "I do well in science", their interpretation of what "well" means will vary based on their own standards and frames of references. Therefore, different comparison processes using different frames of reference are assumed to the most important sources of ASCs (Möller & Marsh, 2013). At least three distinct comparison processes affect self-concept development: First, students compare their performance in one domain with the performance of their peers in the same domain (*social comparisons*; Festinger, 1954; Marsh, 1987; Seaton, Marsh, & Craven, 2009). Second, students compare their performance in one domain with their previous performance in the same domain (*temporal comparisons*; Albert, 1977; Möller, 2005). Third, they compare their performance in one domain with their own performance in other domains thus developing a profile of self-perceived strengths and weaknesses (*dimensional comparisons*; Marsh, 1986; Marsh et al., 2015; Möller & Marsh, 2013). Even though considerations of comparison processes have guided much of self-concept research, it should be noted that there are further influential sources of ASCs such as teachers' and parents' appraisal or stereotype endorsement with respect to gender and ethnicity (Kessels & Hannover, 2008; Okeke, Howard, Kurtz-Costes, & Rowley, 2009; Spinath & Spinath, 2005; Tiedemann, 2000).

ASE, on the other hand, refers to a student's perception of his or her ability to successfully complete a specific academic task or reach an academic goal (Pajares, 1996). According to Bandura (1997), self-efficacy refers to 'beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations' (p. 2). It is considered a multidimensional task- and domain-specific construct, but somewhat less stable and hierarchical compared with ASC (Bong & Skaalvik, 2003). Furthermore, it is assumed to influence the choice and pursuance of tasks and actions. Compared with ASC, ASE more strongly relies on specific judgments of whether a task can be carried out successfully or a goal can be achieved. There are four major sources of self-efficacy (Bandura, 1997; Usher & Pajares, 2009). If students are asked to estimate their probability of successfully solving a math problem, their past experience with similar math problems will be the most informative source of judgment (Usher & Pajares, 2009). Conceptually speaking, students' ASE is most strongly affected by *mastery experiences*, whereas social and dimensional comparisons play subordinate roles (Pajares, 1996; Usher & Pajares, 2009). These experiences are considered the most powerful source of self-efficacy and occur when students successfully complete academic tasks and achieve goals. However, students' social context is also assumed to affect the development of ASE through two path ways, especially when students do not have sufficient experience with a given task to draw on previous experience (Usher & Pajares, 2009). *Vicarious experiences* result from the observation of peers performing certain tasks; students use this as a source of information for their own ability to perform that specific task ("If someone like me can do it, I might be able to do it as well"). *Social persuasions* refer to encouragement from peers, teachers, and parents which can enhance students' confidence in performing certain tasks. Finally, their own *physiological state* (i.e., perceived stress or anxiety when confronted with a task) is assumed to be an additional source of self-efficacy as students "learn to interpret their physiological arousal as an indicator of personal competence by evaluating their own performances under differing conditions" (Usher & Pajares, 2009; p. 90).

Both competence beliefs are assumed not only to be affected by ability (*skill development model*; Helmke & van Aken, 1995) but also to affect ability (*self-enhancement model*) and academic achievement (e.g., school grades, standardized test scores, grade retention). Due to the conceptual distinction between ASC and ASE, differences in their relations to educational outcomes have been assumed (Bong & Skaalvik, 2003). Besides affecting achievement (see "reciprocal effects model"; Marsh & Martin, 2011), ASC should also influence course choices, educational aspirations, and affective reactions such as school anxiety (Nagengast & Marsh, 2012). By contrast, ASE is assumed to affect motivational constructs such as goal orientations, goal setting, persistence, and task choices during learning processes in addition to educational achievement (e.g., Pajares, 1996; Pajares, Britner, & Valiante, 2000; Parker et al., 2014).

1.2. A research model for studying the empirical distinction between self-concept and self-efficacy

The conceptual differences described so far not only imply that ASC and ASE are distinct constructs both in their conceptualization and measurement, but may also rely on different sources of information and show differential relations to educational outcomes. A research model for studying the distinction between ASC and ASE should therefore account for these aspects. In our research model (see Fig. 1), we first assume that ASC and ASE can be separated in measurement. On the basis of this assumption, we focus on selected antecedents that have rarely been taken into account when juxtaposing the two competence beliefs. More precisely, we study the effects of social comparisons and the opportunities-to-learn in science classrooms on ASC and ASE. These characteristics of the learning environment include classroom activities that might evoke mastery experiences and the average ability of peers. Peers serve both as a social frame of references for comparing one's own ability and as a source of vicarious experiences. Third, we juxtapose ASC and ASE according to their predictive potential toward educational outcomes such as science achievement and students' future-oriented motivation in science. These outcomes can be regarded as cognitive and motivational indicators of school success. In the following, we describe the research model in more detail by presenting empirical evidence for the relations assumed in the model.

1.2.1. Relation between ASC and ASE

The evidence with regard to the factor structures of ASC and ASE is inconclusive, including the separability of the two constructs as well as the magnitude of their relation. Some studies found high correlations indicating that a distinct assessment of the two constructs might be difficult (Bong et al., 2012; Marsh, Dowson, Pietsch, & Walker, 2004), whereas others found only moderate correlations (Ferla, Valcke, & Cai, 2009; Ferla, Valcke, & Schuyten, 2010). As evident from these large disparities, the operationalization of the constructs is crucial and affects their degree of relatedness. The operationalization of ASC is relatively straightforward and agreed upon. The questionnaire items used in large-scale assessment studies such as PISA or TIMSS rely on established items identically or similarly worded as well-established questionnaires such as the Self-Description-Questionnaire. For example, items that represent general self-evaluations of ability in a domain such as "*I learn quickly in [domain]*" (SDQ), "*I get good marks in [domain]*", "*I learn [domain] topics quickly*" (PISA 2006) or "*I usually do well in [domain]*" (TIMSS 2011).