Relations of mathematics self-concept and its calibration with mathematics achievement: Cultural differences among fifteen-year-olds in 34 countries

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Abstract

We examined the effects of mathematics self-concept (MSC) and MSC calibration on mathematics achievement through multilevel analyses of the mathematics tests and questionnaire responses of 88,590 15-year olds who participated in the Organization for Economic Cooperation and Development's (OECD) Program for International Student Assessment (PISA). Students with higher MSC or MSC calibration had higher mathematics scores. Students' MSC was more strongly linked to mathematics achievement in countries that were wealthier, more egalitarian, more tolerant of uncertainty, or more flexible regarding gender roles. Calibration of MSC was more strongly linked to mathematics achievement for boys, for low-achievers, and for students in countries that were wealthier, more egalitarian, or more tolerant of uncertainty. Students overestimating their mathematics competence often had low mathematics scores.
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1. Introduction

Cultural differences in self-beliefs can challenge the foundations of current theories and provide new ways of looking at the self. Current Western-based motivation theories are built on an understanding of the self that may differ from those in non-Western cultural settings (Markus & Kitayama, 1991). Researchers have shown that self-concept may operate differently across cultures (Oettingen & Zosuls, 2006), but few studies have compared more than three countries in their analyses or explored cross-cultural variations in the calibration of self-concept, that is, the relationship between self-concept and actual achievement. Examining cross-cultural differences in self-concept and achievement might yield more contextualized knowledge of students' motivation and self-beliefs.

In the present study, we extend this line of research by examining the mathematics self-concept (MSC), MSC calibration, and mathematics achievement of 88,590 fifteen-year-olds in 34 countries who participated in the Organization for Economic Cooperation and Development's (OECD) Program for International Student Assessment (PISA). We chose to examine mathematics self-concept for three reasons. First, mathematics is a core subject with similar curricula across countries, compared to other subjects such as history or literature (Third International Mathematics and Science Study [TIMSS], 1995; Wang, 2006). Second, mathematics is a critical academic filter for educational and occupational pathways in many countries (Crombie et al., 2005; OECD, 2003). Third, students with greater mathematics-related motivation beliefs like self-concept have higher mathematics performance (e.g., Ireson & Hallam, 2009; Viljaranta, Lerkkanen, Poikkeus, Aunola, & Nurmi, 2009).

After examining whether students with higher MSC have higher mathematics scores across countries, we tested whether closer MSC calibration with mathematics achievement is linked to higher mathematics scores. Second, we tested

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whether students who overestimate (rather than underestimate) their mathematics competence (i.e., MSC) relative to their actual mathematics achievement had higher mathematics scores. Third, we analyzed how cultural values were linked to mathematics achievement and whether they moderated the above links of MSC and MSC calibration with mathematics achievement.

In what follows, we begin by defining self-concept (and MSC) and describing how self-concept operates in adolescence. Then, we define calibration of self-concept and examine the links of calibration of self-concept with performance, followed by the relations of under- or overestimation of one's competence with actual performance. Finally, we explore possible cultural effects on mathematics achievement, MSC, and MSC calibration.

1.1. Self-concept

Social cognitive theory contends that human behavior, the environment, and personal factors (like cognition, emotion, and motivation) operate reciprocally on one another. Self-concept is defined as self-perceptions about one's abilities and competences (Byrne & Shavelson, 1986) that influence the likelihood of success in a wide range of endeavours. When people have positive self-concept, they show more motivated behaviors and greater perseverance with challenging tasks (Stipek, 1998). However, self-concept also involves feelings one has about oneself (i.e., self-esteem; Harter, 1985) as well as self-efficacy and perceptions of others' responses to one's self (Dermitzaki & Efklides, 2000); that is, self-concept consists of self-beliefs that are formed through interaction with the environment. Self-concept is a multidimensional, hierarchical construct that is influenced by social comparison, causal attribution, appraisals from significant others, and mastery experiences (Bong & Skaalvik, 2003). Furthermore, intra-person self-concept varies according to domain, with only weak correlations between verbal and mathematics self-concepts (Marsh, Craven, & Debus, 1998). Specifically, mathematics self-concept captures beliefs in one's competence about mathematics abilities (''I'm good at math''; Marsh et al., 1998), and is positively related to mathematics achievement in a variety of settings across schools and across countries (Dermitzaki, Leondari, & Goudas, 2009; Ireson & Hallam, 2009; Marsh & Hau, 2004; Trautwein, Lüdtke, Marsh, Köller, & Baumert, 2006).

Self-concept develops early in a child's schooling, with a strong relationship between self-concept and achievement established within two years of starting school (Chapman, Tunmer, & Prochnow, 2000). As children become adolescents, previously optimistic children experience an increasing awareness of peers and their relative abilities (Stipek, 1998). Children's domain-specific attitudes, overall school-related attitudes, and achievement motivation often plummet during this phase through comparisons with peers (Anderman & Maehr, 1994). Adolescents' self-concept may also fall due to uncertainties resulting from school transitions, less personalized instruction, and perceptions of increased academic

pressures (Pajares & Cheong, 2003), rather than an objective fall in actual ability or performance.

1.2. Calibration of self-concept

''Calibration of self-concept'' refers to the degree to which judgments of one's competence in a domain accurately reflect actual performance (Bol, Hacker, O'Shea, & Allen, 2005). Self-assessment is a challenging cognitive task (Harter, 1998), and inaccurate calibration can result from information deficit, uncertain or misinterpreted feedback from others, incomplete perception of competence, neglect of relevant information, or an exclusive focus on one's own competence while neglecting others' competences (Dunning, Heath, & Suls, 2004). In many contexts, students, especially low-achieving ones, tend to overestimate their competence (Dunning et al., 2004).

As children enter adolescence, the accuracy of their self-beliefs increases (Schunk & Pajares, 2002); they become more aware of their own competence, more realistic about task demands, and more sensitive to social comparisons (Harter, 1998). Whereas young children are typically optimistic in their self-beliefs, adolescents gain the cognitive capability to be more self-perceptive and aware of their own abilities and limitations (Stipek, 1998). Hence, an adolescent decline in self-beliefs may actually be a sign of greater self-awareness and an improvement in calibration skills.

1.3. Underestimation vs. overestimation of competence

To examine how the direction of a student's calibration of self-concept is linked to academic performance, we define the terms *underestimation* and *overestimation* as judgments of competence in which people consider their ability as lower or higher compared to their actual ability (Schaefer, Williams, Goodie, & Campbell, 2003). Hence, a person can have superior MSC (90%), have superior mathematics competence (95%), and still underestimate his/her competence ($90\% - 95\% = -5\%$). Underestimation or overestimation of self-concept refers to judgments of past and present competence in a particular domain.

In social cognitive theory, moderately positive self-beliefs provide an impetus to individuals to attempt tasks they have not yet mastered, whereas more cautious self-beliefs stifle individuals from generating the extra effort needed to surpass their normal accomplishments (Bandura, 1997). Some individuals underestimate their potential performance due to self-handicapping tendencies, in which they underestimate their abilities in order to protect their self-esteem (Elliot & Church, 2003). Underestimation of one's competence (i.e., lower than warranted self-concept) may show a negative effect on performance, as individuals might accomplish more if they feel more positively about their skills and abilities (Marsh & Hau, 2004).

However, several studies showed that overestimation of one's potential performance or self-efficacy can lead to poor preparation and lower performance (Vancouver & Kendall, 2006). As many people believe that they are outperforming