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Non-cognitive predictors of academic achievement: Evidence from TIMSS and PISA

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ABSTRACT

We examined the predictability of non-cognitive variables for students' mathematics achievement, based on large-scale international databases of the TIMSS 2003, 2007, and 2011, and the PISA 2003 and 2012. We synthesized empirical evidence about 65 non-cognitive variables, which were categorized into 13 research domains of educational psychology—*affect, curriculum/content exposure, homework, learning and instructional time, motivation, personality traits, planned behavior, school climate, self-beliefs/social-cognitive theory, self-regulatory learning style/strategies, teacher behavior, value,* and *vocational interest*. Our analyses showed that a group of *self-beliefs* constructs, in particular, *self-efficacy* in PISA, *confidence* in TIMSS, and *educational aspiration,* in both TIMSS and PISA, were the best predictors of individual-level student achievement in mathematics. The present review supports the claim that students' projective judgements about their own ability and future selves are particularly important for their academic achievement. We discuss potential educational initiatives to maximize educational outcomes of students from diverse cultural and national backgrounds.

1. Introduction

Various social science disciplines, including economics (e.g., Heckman, Stixrud, & Urzua, 2006), education (Duckworth & Yeager, 2015; Lee & Shute, 2010), sociology (Bowles & Gintis, 1976; Farkas, 2003), and psychology (Richardson, Abraham, & Bond, 2012; Stankov, 2013) have devoted considerable research effort towards identifying which "non-cognitive" attributes are of relevance to students' academic achievement (Cunha, Heckman, & Schennach, 2010). The term "non-cognitive" is commonly used to refer to a broad range of personal attributes, skills and characteristics representing one's attitudinal, behavioral, emotional, motivational and other psychosocial dispositions. Sociologists have used the term "non-cognitive" as a catch-all phrase encompassing variables that are potentially important for academic achievement, but which are not measured by typical achievement or cognitive tests (Bowles & Gintis, 1976, p. 135; Farkas, 2003, p. 542). According to Duckworth and Yeager (2015), no satisfactory replacement label for the term "non-cognitive" has yet been proposed, in spite of recurring criticisms of the term itself in the current research literature. Non-cognitive constructs can be seen as: "(a) conceptually independent from cognitive ability, (b) generally accepted as beneficial to the student and to others in society, (c) relatively rank-order stable over time in the absence of exogenous forces, (d) potentially responsive to intervention, and (e) dependent on situational factors for their expression" (p. 239; see also Messick, 1979, 1996). It is generally believed that students' non-cognitive attributes are open to change through appropriate schooling and interventions (Duckworth & Yeager, 2015; Lee & Shute, 2010), while other environmental factors (e.g., family socioeconomic status) are distal and removed from the direct influence of schooling. A core underlying assumption in much of this literature is that students themselves are the most important factor in the attainment of their educational and life outcomes.

In spite of the importance assigned to non-cognitive constructs, there have been no *conclusive* recommendations as to which non-cognitive attributes are likely to be most useful and have direct relevance to students' academic achievement. What we mean by *conclusive* is that research evidence should be systematically and comprehensively examined and synthesized based on a large number of variables examined in data from international samples so that the findings can be reasonably seen to apply to students from different cultural and national backgrounds. In the present paper, we aim to do so by documenting and integrating empirical evidence of predictive validity of students' non-cognitive attributes in relation to their academic achievement, using databases drawn from two widely-known, recent large-scale

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international assessments: (a) the Trends in International Mathematics and Science Study (TIMSS) administered by the International Association for the Evaluation of Educational Achievement (IEA), and (b) the Programme for International Student Assessment (PISA) administered by the Organisation for Economic Co-operation and Development (OECD). We also compare our results with those of recent review papers that had similar research aims. Noteworthy examples are found in the reviews by Hattie (2009), Richardson et al. (2012), Stankov (2013), and Lee and Shute (2010). These are summarized in the next section.[1]

1.1. Four recent reviews of non-cognitive constructs and academic achievement

1.1.1. Hattie (2009)

Hattie's (2009) book, *Visible Learning*, presents a mega-analysis of the findings from > 800 meta-analytic studies. After evaluating an extensive number of non-cognitive constructs, he concludes that the four "best" student-level constructs in relation to academic achievement are: *engagement and motivation* (Cohen's $d = 0.48$), *self-concept* (Cohen's $d = 0.43$), *anxiety* (Cohen's $d = 0.40$), and *attitude towards mathematics* (Cohen's $d = 0.36$). Although his review finds these variables to be the "best" for comparison purposes, it is worth keeping in mind that the medium effect sizes in terms of Cohen's *d* (e.g., 0.40) are approximately transformed to Pearson product-moment correlations of around $r = 0.20$s (see Rosenthal, 1994). Another noteworthy limitation of Hattie's (2009) conclusion is the omission of self-efficacy from the list even though the author acknowledges the strong predictability of self-efficacy in relation to school outcomes. Several reports of the OECD (e.g., OECD, 2011, 2015) indicate a strong association between self-efficacy and student achievement. Other studies based on large-scale data (Lee, 2009; Lee & Stankov, 2013) and meta-analyses (Holden, Moncher, Schinke, & Barker, 1990; Multon, Brown, & Lent, 1991) have also shown that self-efficacy is potentially the best predictor of students' academic achievement.

1.1.2. Richardson et al. (2012)

Another major recent review of the literature has been conducted by Richardson et al. (2012). This meta-analysis of psychological correlates of academic performance among university students was based on 1105 independent correlations drawn from empirical studies published between 1997 and 2010. Fifty conceptually distinct constructs were analyzed in terms of university student grade point average (GPA), 42 of which belong to one of the following five research domains: *personality traits, motivational factors, self-regulatory learning strategies, students' approaches to learning*, and *psychosocial contextual influences*. Out of 50 measures reviewed, *performance self-efficacy*, which was defined as "the perception of academic performance capability" with an example item of "What is the highest GPA that you feel completely certain you can attain?" (p. 356), shows the largest correlation with GPA ($r = 0.59$). This correlation was higher than the correlations obtained between the university GPA and academic performance measures of: high school GPA ($r = 0.40$), intelligence ($r = 0.20$), and college entrance test performance in the Admission College Test ($r = 0.40$) and Standardized Admission Test ($r = 0.29$).

Other non-cognitive constructs that show moderately strong correlations with university GPA are: *academic self-efficacy* ($r = 0.31$, defined as one's "general perceptions of academic capability" with an example item of "I have a great deal of control over my academic performance in my courses", p. 356), *effort regulation* ($r = 0.32$, defined as making effort "when faced with challenging academic situations" with an example item of "I have enough self-discipline to complete", p. 357), and *grade goal* ($r = 0.35$, defined as "self-assigned minimal goal standards" with an example item of "What is the minimum [i.e., the least you would be satisfied with] percentage grade goal for the next test on a scale of 0% to 100%?", p. 357). However, most constructs included in their analyses show, at best, small correlations with GPA. According to Richardson et al. (2012), constructs that are typically studied in research domains of *learning strategies* and *motivation* theories did not reach a correlation of 0.20. Such constructs include: *attributional style* ($r = 0.01$), *intrinsic motivation* ($r = 0.17$), *extrinsic motivation* ($r = 0.01$), *mastery goal orientation* ($r = 0.10$), *performance goal orientation* ($r = 0.09$), *rehearsal/memorisation* ($r = 0.01$), and *deep approach to learning* ($r = 0.14$).

1.1.3. Stankov (2013)

The review by Stankov (2013) (see also Stankov & Lee, 2014, 2015) evaluated non-cognitive constructs spanning a broad range of educational (e.g., self-efficacy, motivation, learning strategies), cognitive (e.g., self-assessment), clinical (e.g., well-being and depression), and social (e.g., attitudes, values, social axioms and social norms) psychology. The predictability gradient hypothesis was introduced to suggest that non-cognitive processes can be ordered from those that show high correlations to those that have low or essentially zero correlations with academic and cognitive performance. The authors report that measures of *domain-specific self-concept* are often close to the borderline of being noteworthy, its correlations with student achievement typically being around mid $r = .20$s. More consistent and moderately strong correlations with academic achievement were found with *anxiety* (e.g., test anxiety or math anxiety, $r = .30$s) and *self-efficacy* (i.e., $r = .40$s). Measures of *item-based confidence*, which is typically assessed concurrently with some type of cognitive item performance (see Stankov, 2013, pp. 728–9 for the assessment procedure), are reported to correlate up to $r = 0.60$ with achievement.

1.1.4. Lee and Shute (2010)

Another recent comprehensive review of students' non-cognitive attributes was conducted by Lee and Shute (2010). Based on some 600 studies published between 1950 and 2010, the review provides a summary of empirical evidence of > 60 non-cognitive constructs. It concludes that only a dozen non-cognitive constructs appear to have direct, scientifically documented links to students' academic achievement at the K-12 school levels. The list includes *attitude, anxiety, self-beliefs, classroom behaviors, control strategies, elaboration strategies, engagement, enjoyment, extracurricular activity, homework, interest, metacognition, motivation, parental involvement, school climate, sense of belonging, self-confidence, self-concept, self-efficacy, student-teacher relationship, teacher efficacy, teacher support,* and *time spent on tasks*. These variables are further grouped into four major categories: student engagement, learning strategies, school climate, and social-familial influences, with the first two referring to personal dispositions and the latter two classified as social-contextual influences. Although the review successfully recognized a dozen non-cognitive constructs as particularly important for student learning, no specific claims were made about the superiority of any of the reviewed constructs as predictors of student achievement.

1.2. Aims of the present investigation

The general aim of the present study was to identify non-cognitive constructs that have direct and strong linear relationships to students' academic achievement. The four reviews described above had similar research aims, but our study has additional and broader objectives. First, we used the TIMSS and PISA non-cognitive assessment

[1] A large number of variables are included in the four reviews and in our current paper. Thus, providing definitions of each construct is not within the scope of this paper. Readers can obtain definitions of most constructs from the four review articles.