



Exploring non-cognitive predictors of mathematics achievement among 9th grade students



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ABSTRACT

This article explores the role of mathematics self-beliefs, as well as personality traits, social attitudes and well-being in students' mathematics achievement. The analysis builds on a Web survey of 9th grade students in Latvia ($N = 3083$). Based on a hierarchical multilevel regression analysis we find that personality, social attitudes and wellbeing variables matter more for mathematics achievement than sociodemographic variables, yet mathematics self-beliefs account for an even larger amount of variance over and above that accounted for by sociodemographic variables and personality, social attitudes and well-being. Mathematics self-beliefs, most of all mathematics self-concept, were among the most powerful predictors of mathematics achievement, along with personality traits of Openness and Conscientiousness, social attitudes of Domination and Contentment, values like Universalism and Stimulation. Mathematics achievement was negatively affected by Extraversion, social attitudes of both Self-Interest and Compassion, values of Tradition and Power, as well as Depression.

1. Introduction

The search for constructs determining students' learning outcomes in different subjects, especially in such a significant subject as mathematics, is at the top of the list for educational psychologists. A growing number of studies has been focusing on how academic achievement is affected by non-cognitive variables, i.e., those not captured by the assessment of cognitive ability and knowledge (Caprara, Vecchione, Alessandri, Gerbino, & Barbaranelli, 2011; Chan, Zadeh, Jhang, & Mak, 2008; Conard, 2006; De Fruyt & Mervielde, 1996; Pullmann & Allik, 2008, etc.).

Recently advanced 'predictability gradient' hypothesis (Stankov, 2013a; Stankov & Lee, 2014a) describes the potential predictive validity of various non-cognitive measures associated with academic achievement. The authors of this hypothesis denote it as a timely reaction to the need of the educational community for a bigger picture of constructs influencing the academic achievement of the majority of students. They suggest considering the effect size and comparing the predictive validity of different constructs. The predictability gradient has been constructed based on an approach similar to the meta-analysis including a broad range of large-scale studies conducted by the authors of the hypothesis, several other scholars and international assessment organizations (TIMSS, PISA). The hypothesis synthesizes the most recent studies with significant effect sizes and those whose results have

supported the null hypothesis (see Stankov, 2013a; Stankov & Lee, 2014a).

According to this hypothesis, academic achievement is most strongly linked to the judgement of the quality of one's recent cognitive activity (i.e., confidence about the test performance) (Morony, Kleitman, Lee, & Stankov, 2013). Somewhat less powerful predictors should be the long-term outcomes of previous cognitive performance such as the acquired self-efficacy or anxiety. They are followed by the domain-specific self-concept, measures of rationality (thinking dispositions, probabilistic and scientific reasoning, decision making), and self-assessment of intelligence. Somewhat smaller should be the predictive power of the personality dimension of Openness, while the least powerful predictors of academic achievement should be the other four personality dimensions of Big Five (Costa & McCrae, 1992) and non-cognitive measures such as motivation, depression, well-being and social attitudes. This paper aims to test Stankov and colleagues' hypothesis in the domain of mathematics achievement, building on the results of a study of 9th grade students in Latvia.

So far research on the determinants of mathematics achievement has predominantly focused on countries with advanced and relatively stable learning environment and teaching standards. Since regaining independence from the Soviet Union in 1991, Latvia has experienced ground-breaking political, economic, social and cultural changes and reforms of the educational system (Lepik, Pipere, & Hannula, 2012).

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While a few studies on the psychological and socio-economic predictors of academic achievement have been published in relation to the neighbouring Estonia and Lithuania (Laidra, Pullmann, & Allik, 2007; Mikk, 2007), none has focused on Latvian students. By exploring which non-cognitive factors predict Latvian students' mathematics achievement, this study will add some certitude to previous studies mainly in English-speaking countries and enable further cross-national comparisons in terms of predictors of mathematics achievement in adolescence.

Adolescents seem to be an important target group for a study, considering a general decline in grades, interest in school and learning motivation at this age (Gillet, Vallerand, & Lafrenière, 2012; Peetsma, Hascher, van der Veen, & Roede, 2005). For students it is a time of challenge, critically important for academic achievement (Blackwell, Trzesniewski, & Dweck, 2007; Lesson, Ciarrochi, & Heaven, 2008). Exploring various predictors beyond intelligence and narrow measures of personality as well as using test-based measures of academic performance for adolescents would allow to compare them with other age groups in terms of non-cognitive predictors of academic performance (Kappe & van der Flier, 2012; O'Connor & Paunonen, 2007). Besides, the more traditional samples of college students are specific self-selected groups in terms of their cognitive aptitude, and it is important to study more diverse samples of adolescent population (Lesson et al., 2008).

To provide a theoretical background on the architecture of relationships between the main layers and variables included in the predictability gradient hypothesis, we will use the Ability-Motivation-Opportunity (AMO) theory and a broader view on personality including both traits and self-processes. Individual performance develops in the context of both external (background) factors and internal factors. The background factors are traditionally linked with the socioeconomic status that relates to individual's opportunity to perform (Poropat, 2009) while internal factors include 1) knowledge, skills, and intelligence (cognitive factors) that are reflected in the ability to perform and 2) motivation, cultural norms, and personality that are related to the willingness to perform (Blumberg & Pringle, 1982). The AMO theory (Appelbaum, Bailey, Berg, & Kalleberg, 2000; Boxall & Purcell, 2003) suggests that "ability sets capability of employees to perform, motivation influences the degree to which employees enact their ability to perform, and opportunity refers to the infrastructure available to employees to enact ability and motivation to perform" (Hyde, Harris, Boaden, & Cortvriend, 2009, pp. 703–704). Although originally this theory has been applied to the work-performance and human resource management, it seems reasonable that individuals' academic performance might also be predicted by the individuals' ability to perform the assigned academic tasks, their motivation as regards to these tasks, and the provided opportunity to perform them.

The predictability gradient hypothesis omits the first component of the AMO theory (cognitive abilities) and focuses on the willingness to perform and on the opportunity to perform. Willingness to perform or motivational factors in our study include both personality, well-being, social attitudes and academic (mathematics) self-beliefs. Although, personality and self-beliefs "address different structures and processes and operate at different levels and at different distance from academic performance" (Caprara et al., 2011, p. 79), they can both be viewed as important for the academic achievement. The theory of personality traits and social cognitive theory accounting for self-beliefs can be viewed as complementary approaches to the main individual differences. Caprara, Alessandri, Di Giunta, Panerai, and Eisenberg (2010) suggest that "whereas trait theorists focus on basic universal tendencies conducive to respond isomorphically to environment demands, social cognitive theorists focus on the self-regulatory processes and mechanisms attesting to individuals' propensities to self-reflect and to accord behaviour to ones' own pursuits and standard" (p. 38). Therefore, the predictability gradient hypothesis grasps the personality related predictors on two different levels: the trait level and the level of self-processes. It was found that the perceived academic self-efficacy predicted

junior high-school performance, even after controlling for self-reported global personality dispositions, such as the Big Five Factors (Caprara, Barbaranelli, Pastorelli, & Cervone, 2004). When exploring the incremental role of personality traits, self-efficacy, and interests in explaining the level of educational aspirations, research found a gradual contribution of 10%, 26%, and 29% for personality traits, self-efficacy, and interest, respectively (Rottinghaus, Lindley, Green, & Borgen, 2002). Hence, we can assume that self-beliefs operate at the middle level between the personality traits that may be viewed as a level of broad dispositions, and the specific behavior (i.e., academic performance).

The third component of the AMO theory – the opportunity to perform, in our study is conceptualized and measured as a broad range of socio-demographic background variables that, in comparison with the personality and self-beliefs, are more stable measures. Empirically, personality traits accounted for significantly more variance in undergraduates' achievement and behavior in mathematics than did gender (Alcock, Attridge, Kenny, & Inglis, 2014), so the socio-demographic variables can be viewed as the external layer of the model operating as the "infrastructure" of the personality.

Accordingly, in this paper we explore three broad categories of factors affecting students' performance in mathematics: i) socio-demographic background variables; ii) personality, social attitudes and well-being and iii) mathematics self-beliefs. In terms of their ability to predict mathematics achievement, predictability gradient hypothesis (Stankov, 2013a; Stankov & Lee, 2014a) suggests that personality, attitudes and well-being should be positioned 'in between' the socio-demographic factors (less important) and mathematics self-beliefs (more important). Hence, we formulate the following hypotheses:

Hypothesis 1. Personality, social attitudes and well-being variables account for a significant amount of variance in mathematics achievement over and above that accounted for by socio-demographic variables.

Hypothesis 2. Mathematics self-beliefs account for a significant amount of variance in mathematics achievement over and above that accounted for by socio-demographic variables and personality, social attitudes and well-being.

Hypothesis 3. Personality, social attitudes and well-being (together) have more impact on mathematics achievement than socio-demographic background variables.

Hypothesis 4. Controlled for socio-demographic variables, mathematics self-beliefs have more impact on mathematics achievement than personality, social attitudes and well-being.

We begin our analysis with a brief overview of the literature concerning the importance of individual mathematics self-beliefs, personality, attitudinal, and well-being factors for students' mathematics achievement, operationalizing the concepts and outlining the individual factors that underlie them. We then turn to the description of data and methods, followed by the preliminary analysis of results. The final chapter concludes with the discussion of findings and provides some thoughts on limitations, further research and practical implications of the presented study.

2. Predictors of academic achievement in mathematics

Although the predictability gradient hypothesis was created through the meta-analysis of empirical studies, in our research we will use it as a conceptual model enabling its' empirical testing through the inclusion of the suggested hypothetical variables in an aggregate statistical analysis. We will group the predictors of academic achievement in mathematics according to their place in the hypothetical model and shortly describe them in terms of their theoretical underpinnings, previous empirical relationships and our expectations regarding the

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