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Students' beliefs and attitudes toward mathematics across time: A longitudinal examination of the theory of planned behavior[☆]

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ABSTRACT

The theory of planned behavior (TPB) offers a theoretically meaningful framework for examining students' beliefs and attitudes toward mathematics at school. However, longitudinal investigations of mathematics beliefs and attitudes using the TPB are scarce at best. To redress this imbalance, we examined the predictive validity of mathematics beliefs and attitudes, modeled using the four key constructs of the TPB (i.e., intention, attitude, norms, and control), on mathematics grades across time, while simultaneously controlling for quantitative reasoning. Furthermore, we explored the longitudinal interplay among these key constructs of the TPB. The total sample, drawn from various US middle schools, comprised 752 students at Time 1 and 514 students at Time 2. We used structural equation modeling to address the proposed research questions, and found that intention was associated with students' grades over time above and beyond quantitative reasoning. Additionally, intention at Time 1 was positively associated with control at Time 2, whereas – after controlling for shared variances – attitude at Time 1 showed a negative relation with control at Time 2. Intention and norms were reciprocally related across time. The current study provides the first longitudinal support for the validity of a mathematics beliefs and attitudes model strongly rooted in the TPB.

1. Introduction

At the individual, local, and national levels, mathematics proficiency has been acknowledged as key for personal and economic success (see e.g., Geary, 1996). In light of this, former President Obama made it a priority during his presidency to foster science and mathematics achievement in K-12 education in order to increase the number of students who pursue careers in the highly paid and highly rewarded fields of science, technology, engineering, and mathematics (STEM; whitehouse.gov/issues/education/k-12/educate-innovate [accessed 08/25/2016]). Therefore, the question of which factors can help to predict students' achievement in mathematics and, moreover, their likelihood of further engagement with STEM fields is of importance for educational policy and practice.

The current study focused on students' beliefs and attitudes toward mathematics as a potential facilitator of students' engagement in mathematics. For this purpose, we conceptualized mathematics beliefs and attitudes in terms of the Theory of Planned Behavior (TPB; Ajzen, 1991). We also conducted what we believe to be the first longitudinal test of this model, with two broad aims. First, we investigated the extent that mathematics beliefs and attitudes, as conceptualized by the TPB, could explain mathematics grades as indicators of student achievement in this domain. To this end, we examined the predictive validity of the mathematics beliefs and attitudes components that are part of the TPB framework on changes in students' mathematics grades across time, while simultaneously controlling for students' underlying quantitative reasoning skills. Second, we examined the longitudinal interplay between these different components of mathematics beliefs and attitudes across time, specifically, intention, attitude, subjective norms, and perceived behavioral control (in the remainder of this article, we

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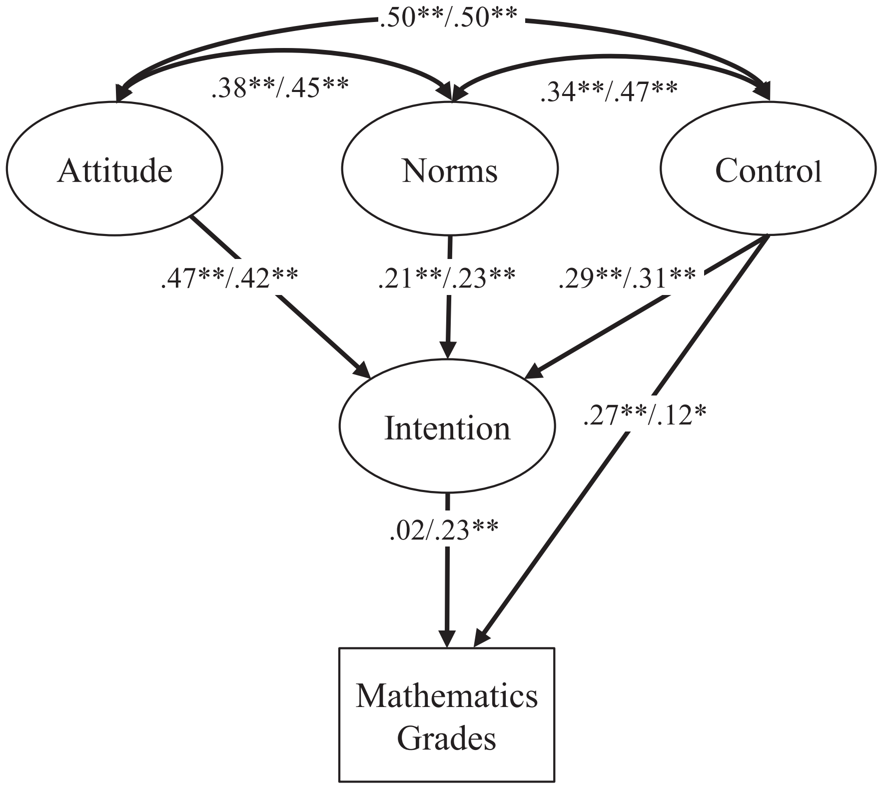

Fig. 1. Model A1 and Model A2: Mathematics belief and attitude components conceptualized in terms of the theory of planned behavior (i.e., Intention, Attitude, Norms, and Control) predicting mathematics grades. For the sake of clarity, control variables and residual variances are not shown in the path diagram. Results for June 2012 (Model A1 for T1) are depicted before the slashes, for November 2012 (Model A2 for T2) after the slashes.
† $p < 0.10$. * $p < 0.05$. ** $p < 0.01$.

subsume all four components under the term *TPB-based mathematics beliefs and attitudes*). In addition, we investigated potential reciprocal links between TPB-based mathematics beliefs and attitudes and grades with the goal of obtaining insight into their developmental dynamics.

1.1. The theory of planned behavior

The TPB aims to explain and predict behavior by focusing on four components (Ajzen, 1991, 2012; for a visualization of the TPB, see Figs. 1 and 2): an individual's (a) intention to carry out a specific behavior as well as the person's (b) attitude (i.e., personal evaluation of a behavior), (c) subjective norms (i.e., perceived social pressures to perform a behavior), and (d) perceived behavioral control (i.e., competence perceptions) with respect to the behavior in question. In particular, the TPB[1] argues that a person's intention to carry out a certain behavior is the best predictor of his or her actual performance of that behavior. This intention, in turn, is determined by the three other components. First, individuals' beliefs about the outcomes of a behavior and their evaluations of these outcomes compose their *attitude* toward that behavior. Second, normative beliefs about the expectations of others and the motivation to comply with these comprise the *subjective norms* against which a behavior is compared. Third, control beliefs about facilitative and inhibitive factors and the perceived power of these factors determine the amount of *perceived behavioral control* over performing a behavior. The TPB assumes that planned behavior is not imperatively motivated behavior; rather, intentions to perform a behavior can be predominantly caused by an attitude *or* subjective norms, whereas a sufficient degree of actual behavioral control, in turn, is necessary to carry out any intention (Ajzen, 1991, 2012). Furthermore, according to the TPB, behavior is directly determined not only by intention but also by control (with control also influencing behavior indirectly via intention; Ajzen, 1991).

1.2. Mathematics beliefs and attitudes and their relationship with performance

Numerous studies have shown that beliefs and attitudes toward mathematics predict mathematics achievement (Ma & Kishor, 1997). Several of these studies have predicted mathematics achievement by drawing from theoretical models that are similar to the TPB. For example, Eccles and colleagues' expectancy-value model (Eccles et al., 1983) is an extensive model that predicts academic performance and choice. Among the central components of the model are: (a) "subjective task values", which are measured in part by items that reflect attitudes, such as a student's perception of how much he or she likes an academic subject and also its perceived usefulness/importance, and (b) "ability self-perceptions", which are measured by items that reflect a student's belief in his or her ability to do well in a subject and his or her expectations about success in that subject. Thus, ability self-perceptions are somewhat analogous to perceived behavioral control in the TPB model. Each of these two components of the model has been shown to predict mathematics achievement. For instance, in a two-year longitudinal study on seventh to ninth grade students, Meece, Wigfield, and Eccles (1990) found that ability self-perceptions in Year 1 predicted Year 2 mathematics grades. In another two-year study of 200 eighth through tenth graders, subjective task values predicted mathematics grades in Year 1 (for males only) and ability self-perceptions predicted mathematics grades in both Years 1 and 2 (for both males and females; Eccles, Adler, & Meece, 1984).

A related line of research is the work on academic self-concept (see, e.g., for an overview: Marsh, 2006). Academic self-concept is typically described as the mental representation of one's academic ability (e.g., Brunner et al., 2010; Niepel, Brunner, & Preckel, 2014) and is therefore "conceptualized as students' beliefs of their own domain-specific and/or global academic capabilities" (Pinxten, Marsh, De Fraine, Van Den Noortgate, & Van Damme, 2013 p. 2). Research on the multidimensionality of widely employed measures of mathematics self-concept found that a two-dimensional model of self-concept fit better than a one-dimensional model (Pinxten et al., 2013). The two dimensions

[1] The following description is adapted from Ajzen (1991, 2012).