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Girls' and boys' perceived mathematics teacher beliefs, classroom learning environments and mathematical career intentions

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ABSTRACT

This longitudinal study examined the effects of students' perceived mathematics teachers' beliefs (expectations about students' ability and mathematics prestige), classroom goal orientations (mastery and performance-approach), and own mathematics motivational beliefs (success expectancies and task values) at grade 10 (T1), on girls' and boys' career intentions in mathematical fields at grade 11 (T2). Data were collected from 438 students (213 boys) in 5 metropolitan schools in Sydney and Melbourne, Australia. Multilevel SEM revealed links between teacher beliefs, learning environments, student motivations, and mathematical career intentions; different predictors operated at individual and classroom levels. Girls perceived lower teacher expectations than boys, but higher teacher mathematics prestige beliefs. Teachers' expectations and students' motivations were positively related to students' reported prior (grade 9) mathematics achievement. Teacher expectations promoted student-perceived mathematics classroom mastery-goal orientation (MGO) and performance-approach goal orientation (PGO); teachers' mathematics prestige beliefs also promoted PGO. MGO enhanced students' mathematics value, which in turn predicted, together with PGO, their mathematical career plans. Mathematics career plans were positively predicted by aggregate teacher mathematics prestige beliefs and aggregate classroom MGO.
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1. Introduction

Statistical reports show a persistent shortage of individuals entering advanced education in STEM disciplines (science, technology, engineering, and mathematics) among many countries of the OECD (2013), Australia (Marginson, Tytler, Freeman, & Roberts, 2013) and the USA (National Science Board, 2014). In the United States, for example, apparent increases in certain natural science degrees (i.e., physical sciences and mathematics) and in engineering degrees are related to the size of the college-age cohort rather than to a rise in the proportion of students who major in those fields (National Science Board, 2014). Instead, there has been a decline in degrees in certain STEM domains since 2000, such as computer sciences which only stabilized since 2005 (National Science Board, 2014). Across OECD countries, a similar situation has been reported indicating that only one-quarter of tertiary students pursue programs in science, engineering, manufacturing and construction fields (OECD, 2013, p. 294). Particularly among young women in OECD countries (OECD, 2013) participation is low in academic degrees and vocational training in STEM disciplines such as mechanical and electrical engineering, and European statistics reveal an underrepresentation of women (32%) in the labor force in science and engineering (European Commission, 2009). A similar situation exists in Australia concerning low participation in tertiary engineering degrees and a severe gender imbalance in STEM enrolments (AWPA, 2012; Bell, 2010; Marginson et al., 2013).

The trend of decreased participation and gendered career development in STEM has already begun in secondary school, when particularly girls decide not to choose advanced mathematics and science courses (Eccles, Vida, & Barber, 2004; Nagy et al., 2008; Watt, 2005). Drawing on Eccles and colleagues' expectancy-value framework (Eccles, 2005, 2009; Eccles et al., 1983) a large number of studies from the U.S. (e.g., Eccles et al., 2004; Jacobs & Simpkins, 2005; Simpkins, Davis-Kean, & Eccles, 2006), Australia (e.g., Watt, 2005, 2006; Watt et al., 2012) and Europe (Bøe, 2012; Köller, Daniels, Schnabel, & Baumert, 2001; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006; Noack, 2004; Roeder & Gruehn, 1996) have demonstrated the salience of students' motivational beliefs—in terms of expectancies for success and task values—for course choices and career intentions. Students' motivational beliefs are strongly influenced by their learning environments (Anderman & Anderman, 2000; Eccles, 2004; Eccles & Roeser, 2009, 2011; Eccles, Wigfield, &

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Schiefele, 1998) which are frequently examined in terms of classroom goal structures (Anderman & Midgley, 1997; Meece, Anderman, & Anderman, 2006; Urdan, Midgley, & Anderman, 1998), whether mastery (focused on learning and understanding) or performance oriented (focused on competition and grades). Teachers' ability expectations also function as salient predictors of students' own success expectancies (Bohlmann & Weinstein, 2013; Jussim & Eccles, 1992; Jussim, Robustelli, & Cain, 2009) and interest (Madon et al., 2001; Wentzel, Battle, Russell, & Looney, 2010).

Although it is well investigated how each of teachers' beliefs and the classroom environments they create promote or reduce students' positive motivations, and how students' motivations predict their career intentions, there are gaps that need to be addressed. First, relationships between pairs of these sets of factors have been examined, rather than their simultaneous operation; including these factors within the one study allows us to explore their interactions in predicting mathematical career intentions. Second, although multilevel analyses of the effects of classroom environments on student motivations have been undertaken (Lau & Nie, 2008; Wolters, 2004), we ask whether patterns of influence may operate differently at each of the student and classroom levels for the included factors. Taken together, whether and how teacher beliefs and classroom environments indirectly impact gendered career intentions via students' motivations is not yet known, nor how these levels may operate differently at individual student versus collective classroom levels.

Our study examined the mechanisms through which student-perceived teachers' beliefs about student ability and mathematics prestige shape students' perceptions of their mathematics class learning environment (mastery or performance-approach), their motivational beliefs (success expectancies and task values), and mathematics-related career intentions. Multilevel analyses distinguished individual from classroom level effects for each of the predictive factors. Additionally, the role of student gender and prior mathematical achievement was taken into account in perceptions of teachers' beliefs, classroom environment, motivational beliefs, and mathematics-related career intentions.

2. Literature review

2.1. Perceived teacher beliefs, learning environments, and students' motivations

The Eccles and colleagues' expectancy-value framework posits that individuals' choice of and persistence in a given task are predicted by her or his success expectancies and subjective valuing of the task (Eccles, 2005; Eccles et al., 1983). Success expectancies are defined as individuals' beliefs about how well they will do on upcoming tasks (Eccles et al., 1998). Task values are beliefs about the quality of a task, differentiated into four components: interest (*intrinsic value*), perceptions of usefulness and relevance (*utility value*), personal importance of doing well (*attainment value*), and the negative aspects of engaging in the task, such as performance anxiety or lost opportunities (*cost*). Intrinsic, attainment and utility value are sometimes combined to form a global task value factor (e.g., Eccles, Wigfield, Harold, & Blumenfeld, 1993; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002).

Success expectancies and task values are influenced by individuals' perceptions of socializers' beliefs and attitudes (Eccles & Jacobs, 1986; Eccles & Wigfield, 2002; Eccles et al., 1998). Perceived teachers' ability expectations strongly predicted students' own success expectancies in late elementary school (Roeser, Blumenfeld, Eccles, Harold, & Wigfield, 1993) and early high school (Wang, 2012); in adolescence, when students begin to detach from their parents, teachers' beliefs gain increasing influence (Eccles et al., 1993; Jussim & Eccles, 1992; Jussim et al., 2009). Both the level and development of students' mathematics self-efficacy beliefs were also positively predicted by mathematics teachers' mastery goal emphasis, even after controlling for parental goal emphasis (Friedel, Cortina, Turner, & Midgley, 2010).

While research often focuses on the impact of teachers' ability expectations on students' competence beliefs and performance (e.g., Bohlmann & Weinstein, 2013; Jussim & Eccles, 1992), less often are teachers' beliefs examined as antecedents of students' values. Research concerning the relationship between teachers' and students' motivations has shown that student-perceived teachers' enthusiasm (Frenzel, Goetz, Pekrun, & Watt, 2010) and teachers' interest in mathematics (Wentzel, 2002) impact students' mathematics interest. Value transmission processes are suggested by Frenzel, Goetz, Lüdtke, Pekrun, and Sutton (2009) who showed that the relationship between teacher enjoyment of teaching mathematics and student enjoyment during mathematics classes was mediated by teachers' displayed enthusiasm. In other words, teachers' behavior mediates the relation between teachers' and students' beliefs. We therefore examined whether learning environments created by the teacher provide a process mechanism to link teachers' beliefs (ability expectations, mathematics prestige) to students' own motivational beliefs (success expectancies and task values).

The goal structure and characteristics of the classroom learning environments that teachers create are shaped by their beliefs about the subject they teach (Kunter et al., 2008) and their attitudes toward teaching (Patrick, Anderman, Ryan, Edelin, & Midgley, 2001). Teachers' self-efficacy for instruction and student engagement (Wolters & Daugherty, 2007), considering learning as an active process, and enthusiasm for engaging in academic tasks (Patrick et al., 2001) have each been associated with their creation of a mastery environment. More enthusiastic teachers are perceived by their students to create challenging and adaptive learning situations, and carefully guide students through the learning process (Kunter et al., 2008; Marsh, 1994).

Learning environments are frequently differentiated into those which promote a mastery-goal structure, indicating a focus on gain of knowledge, understanding new tasks, and mastering new skills; and those which promote a performance–goal orientation, indicating a focus on competition, social comparison and demonstration of ability (Ames, 1992; Meece et al., 2006; Midgley et al., 2000). Teachers who foster mastery goal structures emphasize the investment of effort, self-improvement and collaboration (Eccles & Roeser, 2011). Student-perceived class mastery goal structure has been shown to predict students' mathematical intrinsic motivation (Murayama & Elliot, 2009) and positive affect (Ames & Archer, 1988; Urdan & Midgley, 2003), as well as use of effective learning strategies, preference for challenging tasks and beliefs that success follows from own effort in mathematics, English, science, and social studies classes (Ames & Archer, 1988).

Performance oriented learning environments have been distinguished into performance-approach and performance-avoidance (Midgley et al., 2000; Murayama & Elliot, 2009). Performance-approach classroom goal structures represent a focus on demonstrating competence; performance-avoidance concerns avoiding the demonstration of incompetence (Midgley, 2002; Midgley et al., 2000). Teachers who promote performance-approach goal structures emphasize competition and use instructional strategies such as ability grouping, special rewards for high achievers, or public evaluation of performance (Eccles & Roeser, 2011). Research has revealed heterogeneous results concerning the impact of performance-approach classroom structures on students' learning outcomes. Some studies reported negative effects on students' intrinsic motivation and self-concept (Murayama & Elliot, 2009), motivation and engagement (Ryan & Patrick, 2001), and affect in school (Urdan & Midgley, 2003). Karabenick (2004) did not found significant effects of classroom performance-approach structure on students'

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