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The longitudinal influences of peers, parents, motivation, and mathematics course-taking on high school math achievement

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ABSTRACT

Little is known about how parent expectations and math motivation work in concert with math course taking to promote math achievement. This longitudinal structural equation modeling (SEM) study examined expectancy-value and self-determination theory motivation constructs and math development among a nationally representative sample of U.S. high school students. The role of mathematics course-taking was also examined. As predicted, parent expectations, student expectations, and peer interest predicted math intrinsic motivation in 9th grade, which predicted student mathematics achievement in 11th grade, even when controlling for SES, race/ethnicity, gender and prior math achievement. Intrinsic motivation for math and parent expectations also predicted taking higher-level math courses (e.g., trigonometry or calculus) over the next 2.5 years, which predicted further math achievement. Parent expectations were a stronger predictor than student expectations of intrinsic motivation for math, course taking, and achievement. Implications for math achievement interventions are discussed.

1. Introduction

Preparation in mathematics is essential to both college and career readiness (Adelman, 2003; Maruyama, 2012). The strongest predictors of mathematics achievement in high school are prior achievement and high school mathematics course rigor (Davenport et al., 2013; Riegl-Crumb, 2006). Both achievement in high school and math course taking rigor are predicted by motivation to learn math (Froiland & Worrell, 2016a; Gottfried, Marcoulides, Gottfried, & Oliver, 2013). In this study, we used extensive longitudinal data to investigate the effects of peer interest, parent expectations, intrinsic motivation, and mathematics course rigor on mathematics achievement after controlling for effects of prior achievement, SES, gender, and ethnicity.

Students' intrinsic motivation promotes the development of classroom engagement (Froiland & Oros, 2014; Froiland & Worrell, 2016a; Jang, Kim, & Reeve, 2012), positive emotions toward homework and school (Froiland, 2011), happiness, and achievement among students (Froiland, Mayor, & Herlevi, 2015; Froiland, Oros, Smith, & Hirchert, 2012; Lepper, Corpus, & Iyengar, 2005; Reiss, 2009). Due to the fact that intrinsic motivation is vital for children's wellbeing, it is important to examine factors that influence student motivation, the influence that motivation has on achievement, and the ways in which motivation has indirect effects on achievement. Furthermore, parent expectations are a robust predictor of adolescent achievement (e.g., Froiland, Peterson, & Davison, 2013). Expectancy-value theory posits that parent expectations largely exert an effect on achievement via elevated student expectancy (Wigfield & Eccles, 2000). Parent expectations are also thought to only indirectly affect value for learning (i.e., intrinsic value, such as interest in learning; attainment value or the perceived importance of doing well; and utility value, such as studying in order to obtain a better job in the future) via student expectancies (Wigfield & Eccles, 2000). But, the current study indicates that parent expectations have stronger direct effects than student expectations on math intrinsic motivation, math course-taking, and math achievement. This suggests that self-determination theorists should no overlook long-term parent expectations and that expectancy-value theorists may need to consider that parent expectations may have multiple pathways to elevating achievement related choices and achievement.

2. Intrinsic motivation for math and math achievement

According to self-determination theory, intrinsic motivation to learn involves engaging with learning opportunities due to finding them enjoyable or interesting (Author; Ryan & Deci, 2000). Students are most likely to experience intrinsic motivation when their needs for autonomy, competence, and relatedness are met by parents, peers, and other adults (Froiland & Worrell, 2016b; Ryan & Deci, 2000). However, self-determination theorists focused on parenting have articulated that structure (e.g., providing clear expectations about homework) also support student's intrinsic motivation to learn (Farkas & Grolnick, 2010). Gottfried, Fleming, and Gottfried (2001) add that intrinsic motivation

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for math includes the enjoyment of challenging tasks, which is important due to the of complex math problems and the fact that many students describe math as difficult (Gottfried et al., 2001). Another important aspect of autonomous motivation is integration, which involves synthesizing a pursuit with one's sense of self (Ryan & Deci, 2000). Seeing oneself as a math person is an example of integration. Both integration and intrinsic motivation have strong, positive relationships to each other, and both are associated with many positive outcomes (Ryan & Deci, 2000). Intrinsic motivation in self-determination theory is nearly identical to intrinsic value in expectancy-value theory (Wigfield & Eccles, 2000), although self-determination theory posits intrinsic motivation to be the highest form of motivation, whereas expectancy-value theory does not emphasize a value hierarchy (e.g., both a high intrinsic value and a high utility value can be seen as motivationally advantageous to students). Many studies have found a positive association between intrinsic motivation for math and math achievement (e.g., Areepattamannil, Freeman, & Klinger, 2011; Zhu & Leung, 2011). Children who enjoy math employ strategies for deeper comprehension of what they learn (Chatzistamatiou, Dermitzaki, Efklides, & Leondari, 2013).

3. Mathematics course-taking and math achievement

Researchers have found that the level of mathematics courses taken in high school plays an important role in math achievement (Davenport et al., 2013; Davison & Davenport, 2002; Ma & Wilkins, 2007). Gottfried et al. (2013) found that intrinsic motivation for math and math achievement both predict that students will take higher level math courses in high school and that this, in turn, contributes to educational attainment in adulthood. Their study involved 114 students from California and employed very few control variables. Harackiewicz, Rozek, Hulleman, and Hyde (2012) developed an intervention, based upon expectancy-value theory, that empowers parents to support students' science and math-course taking by helping students see the relevance of math and science in everyday life, as well as the way in which math and science prepare students for college and STEM careers. This intervention led to increases in parents seeing STEM courses as important for their high school students' life, which in turn promoted student development of greater utility value for science and math. Perhaps parent and student expectations for success in college were also elevated through this intervention. In general, intrinsic motivation plays a crucial role in promoting high levels of diverse high school students' behavioral engagement with learning (Froiland & Worrell, 2016a) and math-course taking might be seen as another vital aspect of engagement.

4. Intrinsic motivation for math among peers

Radel, Sarrazin, Legrain, and Wild (2010) employed social contagion theory and self-determination theory to assess how intrinsic motivation spreads among peers. Among 48 high school physical education students in France, half were randomly assigned to be tutored by peers with higher intrinsic motivation and the other half were tutored by less motivated peers. Perceptions of peer tutors' motivation predicted the interest and enjoyment of participants in the study, indicating that intrinsic motivation can spread among students, because intrinsically motivated peers communicate about learning in an autonomy supportive way and exhibit more positive emotions while learning (Radel et al., 2010). If peers, who may or may not be friends, can influence each other's intrinsic motivation, there is an even greater potential for friends to influence each other's intrinsic motivation, due to friends more strongly meeting the need for relatedness, according to self-determination theory (Ryan & Deci, 2000).

In a cross-sectional study involving approximately two hundred eighth grade students from a rural school in the U.S., researchers examined whether friends' intrinsic motivation for math would predict students' own intrinsic motivation, while controlling for gender and scores from a group administered mathematics test (Bissell-Havran & Loken, 2009). Findings indicated that students' intrinsic motivation for math was higher when they perceived that their friends' had higher intrinsic motivation. These results suggest that friends may affect each other's intrinsic motivation; however, larger studies with individually administered achievement tests are needed that replicate such findings longitudinally with probability samples so that we can be confident that such findings generalize to students across the population.

5. Parent expectations, math achievement, and intrinsic motivation for math

Parent involvement is an important contributor to children's achievement (e.g., Froiland, Powell, & Diamond, 2014; Froiland, Powell, Diamond, & Son, 2013) and development of mathematics skills in particular (e.g., Powell, Son, File, & Froiland, 2012). Numerous studies have found that parents' expectations for their children's long-term educational attainment predict better achievement development among adolescents (e.g., Froiland & Davison, 2014; Froiland, Peterson, & Davison, 2013). In fact, parent expectations have the largest effects out of any parent involvement variables in numerous longitudinal studies (Jeynes, 2012).

Parent expectations predict the autonomy of young adults, as well as positive educational outcomes (Doren, Gau, & Lindstrom, 2012). In a nationally representative study in the U.S., Fan and Williams (2010) found that parent expectations for their high school students' long-term educational attainment predicted students' intrinsic motivation for math, while controlling for SES and gender. Perhaps the direct relation between parent expectations and intrinsic motivation is due to the high value on education conveyed by parents who expect that their students will obtain a college or graduate degree. Namely, inherent in the expectation that one's high school student will obtain high levels of postsecondary education is a deep value placed upon education. Self-determination theory considers parent expectations in general (e.g., providing clear expectations about homework) as a part of structure, which promotes children's motivation (Farkas & Grolnick, 2010). However, measures of structure based on self-determination theory have been focused more on expectations involving everyday life, rather than years into the future.

6. Youth expectations, motivation, and achievement

According to expectancy-value theory, parental expectations are transmitted to children and children's expectations directly affect achievement (Eccles & Wigfield, 2002). In accordance, Froiland, Peterson, and Davison (2013) found that parental expectations predicted student expectations years later, which in turn predicted achievement, but parent expectations also had a direct effect on achievement that was equivalent to the effect of student expectations. Likewise, Bandura, Barbaranelli, Caprara, and Pastorelli (2001) found that parent expectations directly predict achievement and student expectations. Although expectancy-value theory most often focuses on specific expectations within a domain or task (e.g., “How well do you expect to do at math this year?”, p. 70, Wigfield & Eccles, 2000), long-term expectations for educational attainment hold within them numerous expectations for adequate success in every class in high school (for those that believe they will finish high school, college, or a graduate degree). Whereas most expectancy-value theory researchers measure expectancy in terms of self-concept (e.g., “I am good at math”; Harackiewicz et al., 2012; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006), long-term expectations for educational attainment can provide a robust indicator of expectancy over long periods of time. This may be especially appropriate for multi-year longitudinal studies.

Research on expectancy-value theory has found that expectancy for success and value are moderately positively associated (e.g., Nagengast et al., 2011). Likewise, Suárez-Álvarez, Fernández-

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