

**Title:**

1 + 1 Is Not Always 2: Variation in the Relations Between Mathematics Self-Efficacy Development and Longitudinal Mathematics Achievement Growth

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## **Background / Context:**

Preparing every student to be college and career ready by the time they graduate from high school has become a national policy priority. Standards developers advocate for early, targeted college and career readiness supports (Common Core State Standards Initiative, 2010), and researchers have begun to call for the implementation of college and career readiness programs as early as middle school with preliminary supports developed in the elementary grades (Wimberly & Noeth, 2005). Intra and interpersonal skills (i.e. self-efficacy, academic self-confidence, self-appraisal, resourcefulness, perseverance) are also essential factors in supporting college and career readiness (Levin, 2013), and work in concert with academic skills to facilitate positive post-secondary outcomes. In fact, some researchers contend that much of the long term academic success attributed to early intervention programs can actually be attributed to program features that boost intra and interpersonal skill development (Heckman, 2006; Heckman & Rubinstein, 2001). Supporting college and career readiness by identifying the relationships between trajectories of academic achievement growth and the development of critical intra and interpersonal skills, and the extent to which those relationships hold across demographic categories may have ramifications for educational planning and instruction as early as kindergarten; however, these relationships are currently largely unknown.

Many of the factors considered here have robust research histories and are fairly widely understood. For example, (a) early mathematics achievement predicts later mathematics achievement (Claessens & Engel, 2013; Duncan, et al., 2007; Morgan, Farkas, & Wu, 2009), (b) academic achievement and self-efficacy have a complementary relationship where high academic achievement is associated with high academic self-efficacy and academic difficulties are related to low reports of self-efficacy (Caprara, Vecchione, Alessandri, Gerbino, & Barbaranelli, 2011; Diseth, 2011), and (c) demographic characteristics are associated with educational outcomes and define a number of persistent achievement gaps (Burchinal et al., 2011; Nowell & Hedges, 1998; Reardon, 2011). However, the extent to which mathematics achievement growth is related to mathematics self-efficacy growth and the ways in which the relationships between mathematics achievement growth and mathematics self-efficacy growth differ for students based on gender, socioeconomic status (SES), and race/ethnicity remain relatively unexplored.

## **Mathematics Achievement**

Although a variety of academic skills are required for postsecondary success, mathematics achievement is a particularly influential factor in college and career readiness (Pellegrino & Hilton, 2012). Research suggests that college and career readiness efforts in mathematics likely need to start in the primary grades because kindergarten academic skills, measured upon school entry are highly predictive of academic performance at the end of first grade and well beyond. Numerous longitudinal studies of mathematics development have shown that deficits observed as early as kindergarten are difficult to overcome and often compound over time (Duncan, et al., 2007; Morgan, Farkas, & Wu, 2009), and mathematics learning in kindergarten and first grade is associated with later mathematics achievement (Claessens, Duncan, & Engel, 2009; Duncan & Murnane, 2011). Additionally, mathematics attainment in secondary school largely dictates college course taking and degree completion (Lee, 2012) and secondary mathematics achievement is indicative of career earnings (Achieve, 2008). Whereas early mathematics performance is known to predict later mathematics performance, a detailed exploration of the relationship between Grades K–1 and Grades 3–8 mathematics achievement growth has utility for identifying patterns of mathematical learning within and between each time

frame. These understandings can inform mathematics and college and career readiness intervention development across the elementary and middle school years.

### **Self-Efficacy**

Mastery of academic content, as measured by grades and college admissions tests, is one indicator of college readiness, but intra or interpersonal skills are at least equally important in college and career readiness, retention, completion, and advancement (Camara, 2005; Farrington et al., 2012; Pellegrino & Hilton, 2012). Within the spectrum of influential intra and interpersonal skills, self-efficacy alone has been found to be an important indicator of college readiness, academic achievement, and college retention (Bandura, 1986; Di Giunta et al., 2013; Mattern & Shaw, 2010; Pajares & Schunk, 2001). In mathematics specifically, self-efficacy has been correlated both with other intra and interpersonal skills and with mathematics achievement (Shams, Mooghali, & Soleimanpour, 2011), and mathematics self-efficacy is an effective predictor of mathematics performance (Pajares & Miller, 1994), college persistence, and STEM degree attainment (Larson et al., 2014). Furthermore, research on mathematics achievement gaps suggests that achievement gaps decrease when controlling for mathematics self-efficacy (Kitsantas, Cheema, & Ware 2011).

### **Group Differences**

In addition to flexible intra and interpersonal skills such as self-efficacy, traditionally fixed demographic factors (i.e., gender, SES, and race/ethnicity) are also associated with academic achievement growth and contribute greatly to the prediction of postsecondary outcomes. Gender, SES, and race/ethnicity differences in academic performance emerge as early as kindergarten and persist throughout elementary school and beyond (Duncan & Magnuson, 2005; Hair, Halle, Terry-Humen, Lavelle, & Calkins, 2006). Whereas these differences are typically framed as long-term achievement gaps, it is worthwhile to note that there is evidence that differences in academic performance between kindergarten entry and the end of first grade shrink for some students (Reardon & Galindo, 2009). Such findings suggest that the relationships between mathematics achievement, mathematics self-efficacy, and demographic characteristics are likely quite variable. Thus, because previous research suggests that factors that predict postsecondary success differ based on student demographic characteristics (Linver & Davis-Kean, 2005; Tracey & Robbins, 2004) and the presence distinct patterns of achievement based on gender, SES, and race/ethnicity has been documented (Long, Iatarola, & Conger, 2009; Tracey & Robbins, 2004), a deeper investigation of whether mathematics achievement growth trajectories and mathematics self-efficacy development differ based on gender, SES, race/ethnicity and whether the relationship between mathematics achievement and mathematics self-efficacy growth differed based on these same demographic characteristics is warranted.

Previous studies found that gender, SES, eighth grade academic performance, and interactions between each of the factors are uniquely indicative of postsecondary educational choices (Trusty, Robinson, Plata, & Ng, 2000) and racial/ethnic and gender factors are interrelated (Perez-Felkner, McDonald, Schneider, & Grogan, 2012). Thus, it is hypothesized here that gender, SES, and race/ethnicity will be associated with both mathematics achievement and mathematics self-efficacy growth. It is also hypothesized that the relationships between mathematics achievement growth and mathematics self-efficacy growth will be moderated by demographic characteristics such that mathematics achievement growth may be less predictive of mathematics self-efficacy growth for female students, but more predictive of mathematics self-efficacy growth for students who are not white and who come from low-SES backgrounds.

**Purpose / Objective / Research Question / Focus of Study:**

This study represents an attempt to inform college and career readiness programming efforts through an analysis of patterns of mathematics achievement growth and mathematics self-efficacy growth across the elementary and middle school grades in a diverse sample of learners in the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) dataset. The association between features of Grades K–8 mathematics growth trajectories and the development of mathematics self-efficacy in Grades 3–8 will be evaluated, and the moderating effect of demographic factors will be tested. Identifying patterns of mathematics growth that are associated with efficacy in mathematics has implications for curriculum development and intervention implementation. Moreover, understanding how these relations may differ for different groups can inform academic planning so that resources are applied most effectively for all students to ensure that all students receive effective foundational mathematics instruction and develop intra and interpersonal skills that support sustained academic achievement and long term success. This study will investigate the following research questions:

1. Given a diverse, nationally representative sample of students, what is the most appropriate model for estimating mathematics achievement growth in Grades K–8?
2. To what extent is there evidence of unique mathematics achievement growth parameters in Grades K–1 and Grades 3–8 (i.e., are the slopes statistically significantly different in each time period)?
3. What are the relationships between Grades K–1 mathematics achievement growth parameters and Grades 3–8 mathematics achievement growth parameters?
4. To what extent are there significant growth parameters of mathematics self-efficacy in Grades 3–8?
5. What is the relationship between mathematics achievement growth and mathematics self-efficacy development in Grades 3–8 and does Grades 3–8 mathematics achievement growth mediate the relationship between Grades K–1 growth and Grades 3–8 mathematics self-efficacy development?
6. To what extent are there demographic (gender, SES, race/ethnicity) differences in mathematics achievement growth and mathematics self-efficacy development?
7. How do demographic factors moderate the relationships between mathematics achievement growth and mathematics self-efficacy development?

**Data & Setting:**

Data to be analyzed here were collected by the National Center for Educational Statistics (NCES) in the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). Academic and cognitive skills were measured, and demographic and self-report survey data were collected directly from children, their families, teachers, and schools over seven waves of data collection (Tourangeau, Nord, Le, Sorongon, & Najarian, 2009). Assessments and surveys were administered in the fall and spring of both kindergarten and first grade, and follow-up data collection occurred in the third, fifth, and eighth grades.

**Population / Participants / Subjects:**

The ECLS-K study followed a nationally representative sample of approximately 21,000 participating students from kindergarten to eighth grade beginning in the fall of 1998 through the 2007-08 school year. The study utilized a complex sampling design that included oversampling particular students (e.g., students from private schools and students from underrepresented races and ethnicities) to allow for various subgroup analyses. In all, the sample was drawn from 1,413 schools (953 public and 460 private) with 20,578 of 22,813 students responding by the spring of

kindergarten and 8,706 children or 41% of the base-year respondents participating in all five years of data collection in Grades K–8 (Tourangeau et al., 2009). The unweighted kindergarten and first grade ECLS-K sample was approximately 51% male, 52% White, 15% Black, 18% Hispanic, 6% Asian, and a combined 6% Native American, Alaskan Native, Pacific Islander, and/or more than one race, from a range of geographic areas, urban and rural schools, and a range of SES backgrounds.

### **Research Design:**

This descriptive study will utilize an extant, observational, nationally representative dataset to describe and explore relationships between student demographic characteristics, mathematics achievement, and mathematics self-efficacy.

### **Data Collection and Analysis:**

To estimate the extent to which statistically significant growth parameters exist in Grades K–8 mathematics achievement, structural equation growth modeling will be conducted with Mplus 7.1 (Muthén & Muthén, 2013) to evaluate a set of nested mathematics growth trajectories spanning Grades K–8. The proposed two-part growth model (please insert figure 1 here) reflects the anticipated final mathematics achievement growth model that will utilize continuous, longitudinal mathematics achievement measurements to generate intercepts and slopes (i.e., academic year and summer discontinuity parameter) of mathematics achievement growth. The Grades K–1 and Grades 3–8 mathematics achievement growth parameters will be used to predict mathematics self-efficacy growth parameters generated from Grades 3–8 survey scores produced by combining categorical responses to two student mathematics self-efficacy survey items. The main effects of gender, SES, and race/ethnicity on mathematics achievement and mathematics self-efficacy growth will be explored, and the demographic factors will be investigated as potential moderators of the relationships between the mathematics achievement growth and self-efficacy development (please insert figure 2 here).

### **Findings / Results:**

Final analyses are currently being conducted with complete results expected November 2014. Preliminary findings suggest that the relationship between Grades K–1 growth parameters and mathematics self-efficacy may be fully mediated by mathematics skills at Grade 3 entry; however, mathematics self-efficacy growth has not been fully modeled. Additionally, preliminary demographic analyses revealed that all mathematics achievement growth parameters, with the exception of the Grades K–1 summer discontinuity parameter, differed based on socioeconomic status and gender. Gender moderated the relationship between the Grades K–1 growth parameters such that performance at kindergarten entry was more strongly negatively correlated with both cross year slope and summer slope for girls, and there was a positive relationship between the cross year slope and summer slope females and a negative relationship for males. Finally, there were also gender differences in the relationships between mathematics achievement at kindergarten entry and third grade entry. Specifically, there was a positive association for both boys and girls, but the association was much stronger for girls than boys.

### **Conclusions:**

Preliminary findings suggest that early mathematics achievement growth may behave differently based on SES and sex. Complete analyses will allow for a closer examination of the relationships between mathematics achievement and self-efficacy development for different students. This knowledge can support instructional planning and inform the development of targeted interventions that can support academic achievement and intra and interpersonal skill development.

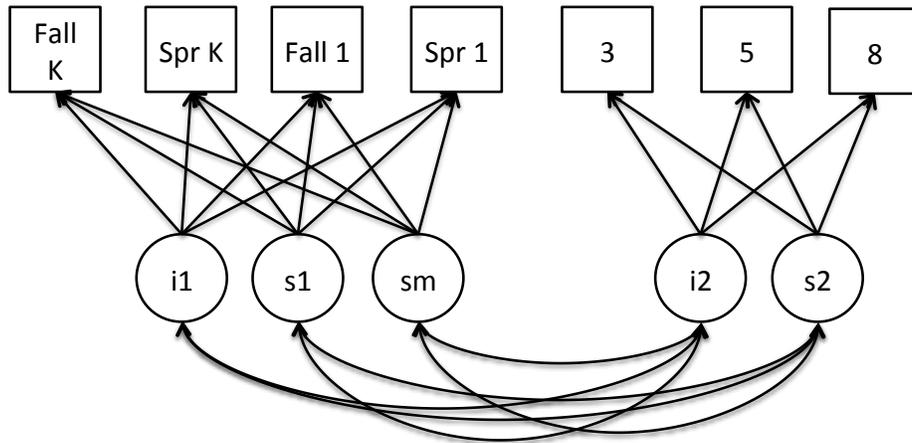
## Appendix A. References

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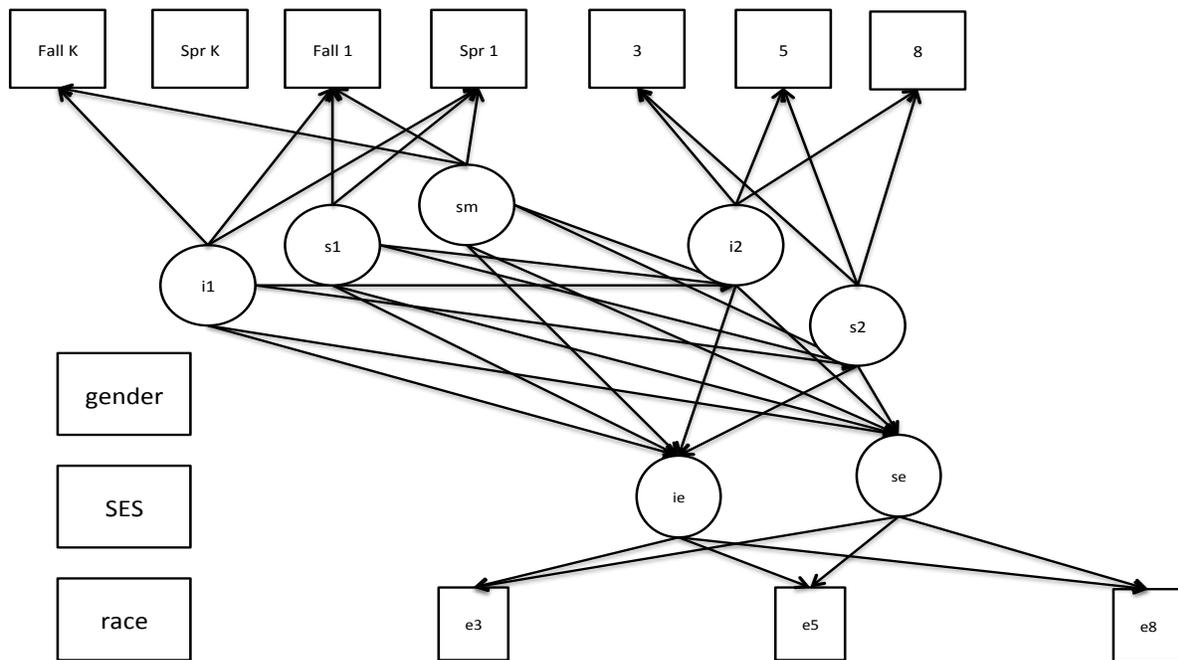
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**Appendix B. Tables and Figures**



*Figure 1*  
Two-part mathematics achievement growth model



*Figure 2*  
Final statistical model for testing relationships between mathematics achievement growth, mathematics self-efficacy growth, and demographic factors including gender, SES, and race/ethnicity