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The Associations Between Parental Involvement and Science Achievement via Children's Perceived Academic Competence and Academic Effort

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Abstract

The primary goal of this study was to examine the way in which parental involvement, specifically parents' educational expectations and parent-child communication, are related directly to children's science achievement, and indirectly, through their perceived academic competence and academic effort across gender and race/ethnicity groups using data from the Longitudinal Study of American Youth (LSAY). The ecological model, social cultural contexts of parental academic socialization, the parental involvement framework, and social cognitive theory served as the theoretical frameworks for the study. The sample included 3,116 seventh graders (1,621 male and 1,495 female students) and their parents. Structural regression analysis was performed, as well as multi-group analysis using structural equation modeling. The results indicated that parents' educational expectations had both direct and indirect influence on children's science achievement, while parent-child communication was associated only indirectly with science achievement. With respect to the indirect associations, the study identified three mediation pathways. First, the effect of the two parental involvement variables on children's science achievement was transmitted through children's perceived academic competence. Second, their effect on children's science achievement was transmitted through children's academic effort. Third, their effect on children's science achievement was transmitted through children's perceived academic competence, which in turn, affected academic effort. These findings suggest that parents' educational expectations and parent-child communication can influence the development of children's academic beliefs and efforts, and supported the view of the child as an active contributor to his/her science achievement. In addition, the study demonstrated that the child's gender moderated the associations between parental involvement and children's science achievement via their perceived academic competence and academic

effort. Parents' educational expectations had a stronger effect on boys' perceived academic competence, while parent-child communication had a greater influence on girls' perceived academic competence. Positive perceived academic competence and greater levels of academic effort had a stronger effect on boys' science achievement than on girls'. Further, the study found that the associations above were invariant across racial/ethnic groups. The findings suggested that education programs are necessary to increase parents' awareness of the influential roles their educational expectations and parent-child communication play in establishing children's positive perceptions of competence in learning science and engagement in academic effort, which are crucial factors that determine their science achievement, especially during young adolescence. In addition, educational programs must consider the child's gender, as this study found significant gender differences in the associations between parental involvement, children's perceived academic competence, academic effort, and science achievement. Moreover, the findings suggested that parents' educational expectations and parent-child communication are universally important in young adolescents' science learning, regardless of race/ethnicity.

THE ASSOCIATIONS BETWEEN PARENTAL INVOLVEMENT AND SCIENCE ACHIEVEMENT VIA CHILDREN'S PERCEIVED ACADEMIC COMPETENCE AND ACADEMIC EFFORT

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Chapter 1: Introduction

Young adolescents' science achievement is critically important for their educational development and future careers (Atkinson & Mayo, 2010). Researchers have found that children's early performance in science (e.g., middle school years, 6-8th grades) predicts their science achievement in later years (e.g., high school years, 9-12th grades: Sun, Bradley, & Akers, 2012). Many colleges have set science achievement standards in high school as a prerequisite for university entrance applications and enrollment, and therefore, children who do not meet these standards may suffer a disadvantage in the college recruitment and selection process (Pompa, 2015). Further, their science achievement has significant implications for future career trajectories, as it may translate into skills that are essential in some scientific and technological careers (Jacobs, 2005; Johnson & Hull, 2014; Pompa, 2015).

While the educational subjects of reading and mathematics have long been, and continue to be, the focus of educational research and policy (Feuer, 2013), research that focuses on students' achievement in science is still lacking. Although individual schools and local communities may require students to complete different courses depending on the structure of their academic programs, the three subjects of reading, math, and science are considered core subjects in K-12 education that prepare children to acquire foundational knowledge, abilities, and skills necessary in college, careers, and adult life, all of which are important for students' cognitive development. In 2015, a national assessment report conducted by NAEP (National Assessment of Educational Progress) ranked American eighth-grade students' performance in the core courses of reading, math, and science as basic, proficient, or advanced. The majority of middle school students (76% in reading and 71% in math) performed above the basic level in reading and math, while significantly fewer students (68%) performed above the basic level in science, and 32% were below that level. Such a comparison of student achievement across core subjects illustrates that students may have limited development in science achievement. Given the significance of students' science achievement to their future educational and career opportunities, research on the factors associated with these students' achievement is necessary.

Educational research has emphasized that parents play a critical role in promoting their children's academic achievement overall through their involvement in school education (Fan & Williams, 2010; Vukovic, Roberts & Wright., 2013). Although many different forms of parental involvement practices have been found to be associated with children's academic growth (Froiland, Peterson, & Davison, 2012; Yamamoto & Holloway, 2010), scholars have emphasized two: parents' educational expectations and parent-child communication. These two forms of parental involvement have demonstrated a greater ability to predict children's academic achievement than have others (Castro, Expósito-Casas, López-Martín, Lizasoain, Navarro-Asencio, & Gaviria, 2015). For example, Castro et al. (2015) conducted a meta-analysis of 37 studies of parental involvement and academic achievement that focused on kindergarten, primary, and secondary school students, and identified the effect sizes of each form of parental involvement. Among all the forms documented—including parental supervision of homework, parents reading with children, parental style, and parents' attendance and participation in school activities—the authors found that parents' educational expectations and parent-child communication had the two greatest effects on children's academic achievement and growth. Another meta-analysis (Fan & Chen, 2001) found that parents' educational expectations had the strongest effect on children's academic achievement among the different forms of parental involvement (e.g., communication between parents and children, reading regularly with children, attending and participating in school activities, and having a supportive and helpful parenting style). These findings underscored that parents' educational expectations and parent-child communication are two key forms of parental involvement that contribute significantly to children's academic achievement.

Previous scholars have shown that parents can exert a considerable influence on children's academic achievement, especially as children are highly involved in interactions with their parents and spend the majority of their time with them, at least until adolescence (Urdan, Soleek, & Schoenfelder, 2007). When children experience the transition from childhood to adolescence, young adolescents (i.e., those in the 6-8th grades) are likely to undergo a series of biological and psychological changes (Hill & Tyson, 2009). One significant change during this period is that children's beliefs and values related to their ability become more negative in many ways, at least through early adolescence. Children tend to believe that they are less competent in many school subjects and often are less motivated to learn (Wigfield & Eccles, 2000).

Nevertheless, according to Weiner's (1994) attribution theory, as well as social cognitive theory (Bandura, 1993, 1995), children's beliefs about their ability and behaviors associated with achievement are internal motivations to learn that determine their educational outcomes and can be influenced by other social agents (e.g., parents). These theoretical lenses provide an understanding of children's active role in their academic achievement. Two key academic characteristics researchers have emphasized are children's perceived academic competence (e.g., Akey, 2006; Bouffard, Marcoux, Vezeau & Bordeleau, 2003) and the academic effort they invest (e.g., Dweck, 2006; Moon & Hoffert, 2016; Yeung, 2011). Researchers have highlighted perceived academic competence because it is associated with children's subsequent academic behaviors (e.g., effort and engagement) and academic achievement in many subjects, such as physics, mathematics, and English (Neuenschwander, Vida, Garrett, & Eccles, 2007; Yeung et al., 2010). With respect to academic effort, scholars also have found that it is related to academic achievement in many subjects, including math and English (Schwinger & Stiensmeier-Pelster, 2012; Trautwein, Ludtke, Roberts, Schnyder, & Niggli, 2009).

Thus, the literature has documented widely the crucial roles of parental involvement practices, and has emphasized the effects of parents' educational expectations (e.g., Froiland et al., 2012; Yamamoto & Holloway, 2010), parent-child communication (e.g., Fan, 2001; Houtenville & Conway, 2008; Shute, Hansen, Underwood & Razzouk, 2011), and children's academic characteristics, particularly their perceived academic competence and academic effort invested, on academic achievement. Even so, during young adolescence, when children's motivation to learn is likely to decline, the way in which parents help them succeed in school by promoting their internal motivation remains understood poorly. Although a number of researchers has demonstrated that parents' educational expectations and parent-child communication are associated with children's greater perceived academic competence (e.g., Bhanot & Jovanovic, 2009; Neuenschwander et al., 2007; Yeung et al., 2010), few studies have explored whether these forms of parental involvement are associated with children's academic achievement because they have positive effects on their perceived academic competence and academic effort. In addition, with respect to the specific subjects of academic achievement, the research mentioned above largely has focused on children's math and reading achievement, while little research has investigated science achievement.

Further, specific to the subject of science, a handful of studies has reported an achievement disparity based on children's gender and racial/ethnic groups; boys have shown a higher level of science achievement than have girls (Freeman, 2004), and Asian and Caucasian students tend to have higher science achievement than do other racial/ethnic groups (Else-Quest, Mineo, & Higgins, 2013). Other scholars have observed that a child's gender and race/ethnicity moderate the two critical forms of parental involvement. For example, Tenenbaum and Leaper (2013) found that parents of sons tend to have stronger expectations that their sons will do well in science than do parents of daughters, and Caucasian parents talk more frequently about nature or help their children with science projects than do minority parents (Sy, Rowley, & Schulenberg, 2007). However, few studies have explored further the way in which parents' educational expectations and parent-child communication may contribute to children's science achievement depending upon the child's gender (Debacker & Nelson, 2000; Ing, 2014) and race/ethnicity (McNeal, 1999; Sy et al., 2007) in a specific social cultural context. Thus, there remains a gap in our understanding of the way in which parental involvement practices may contribute to children's science achievement depending upon children's individual and diverse family backgrounds.

To explain this issue, a number of theoretical frameworks provide insight when examining the influence science achievement of parents' educational expectations and parent-child communication. These theoretical frameworks include Bronfenbrenner's ecological model (Bronfenbrenner & Morris, 2006), the social cultural contexts of parental academic socialization

(Tayor, Clayto, & Rowley, 2004), the parental involvement framework (Grolnick & Slowizczek, 1994), and attribution theory from the social cognitive perspective (Bandura, 1993, 1995; Weiner, 1994). Using these theoretical frameworks as a guide, this study investigated: (1) the direct and indirect associations between parents' educational expectations and children's science achievement via children's perceived academic competence and academic effort; (2) the direct and indirect associations between parent-child communication and children's science achievement via children's perceived academic competence and academic effort, and (3) the role of gender and race/ethnicity in the associations between parents' educational expectations, parent-child communication, and science achievement via children's perceived academic competence and academic effort.

The next chapter reviews the empirical literature on the direct and indirect associations between the two parental involvement practices and children's science achievement via their perceived academic competence and academic effort invested. Next, I review studies that have investigated the role of children's gender and race/ethnicity to understand the way in which these parental involvement practices and children's academic characteristics may contribute to children's science achievement among individuals from diverse family backgrounds.

Chapter 2: Literature Review

Direct and Indirect Associations between Parents' Educational Expectations and Children's Science Achievement

Parents' educational expectations are defined as their anticipation of their children's educational progress and achievement (Froiland et al., 2012; Jacobs & Harvey, 2005). Parents' expectations can be understood as a general belief of "how much" education they expect their children to obtain (Wilder, 2014), and are associated closely with the subject area in which parents want their children to succeed (Ing, 2014; Phillipson, 2009). Although scholars have not defined explicitly what concrete educational expectations parents have for their children, the measurements that researchers use reflect two categories of parental expectations. One is their general expectation that their children will obtain an educational degree (e.g., college degree), and the other can be considered parents' subject-specific expectations, which are based on the assessment of a child's academic abilities in a particular subject (e.g., reading or mathematics: Yamamoto & Holloway, 2010).

Parents' educational expectations are considered a crucial component of parental involvement because of their stronger power to predict children's academic achievement compared to other forms (Benner, Boyle, & Sadler, 2016; Wilder, 2014). For example, Benner et al. (2016) conducted a study to examine the associations between various aspects of parental involvement and children's academic achievement, which they measured as primary and secondary students school grades. The forms of parental involvement included academic advice provided at home, participation in school activities, and educational expectations. The results indicated that among these forms of parental involvement, parents' educational expectations were associated positively and more strongly (b = 0.12) with children's academic achievement than were any other forms (coefficient range = 0.02 to 0.08).

Similar evidence that demonstrated the strong predictive power of parents' educational expectations compared to other forms of parental involvement was found in another synthesis study (Wilder, 2014). The author investigated the effect of different forms of parental involvement on children's academic achievement, and collected findings from nine meta-analyses on their association. Among these, parental involvement included home-based involvement, such as parent-child communication about school issues, home supervision, homework assistance, expectation and aspirations, and school-based involvement, such as attendance, participation in school activities, and communication with the school. The results showed consistently that among these, parents' educational expectations exerted the strongest positive effect on children's academic achievement (effect size in Hedges' g measure = 0.58 to 0.88; other forms of parental involvement ranged from 0.22 to 0.42), regardless of the type of achievement measured (e.g., standardized test scores, class grades, subjects of achievement), after other prominent factors were controlled (e.g., ethnicity, prior achievement, and family socioeconomic status). Therefore, parents' educational expectations have been emphasized as they are considered a major contributor to children's academic achievement.

Scholars generally have observed a significant association between parents' educational expectations and children's academic achievement in different subjects. Several studies found a positive association between parents' educational expectations and children's achievement in reading (Davis-Kean, 2005; Gary, Laura, Roderick, & Elizabeth, 2012). For example, Davis-Kean (2005) conducted a national, cross-sectional study among 868 8-12-year-old children from non-Hispanic, Caucasian, and African American groups. After controlling the child's gender and age, family size, and caregiver literacy, he found that parents' educational expectations predicted children's progress in reading achievement significantly in each racial/ethnic group. This positive association between parents' educational expectations and children's reading achievement was consistent with that found throughout the period of Gary, Laura, Roderick, and Elizabeth's (2012) study of 2,088 sixth graders whom they tracked until eighth grade. These findings underscore the importance of parents' educational expectations that appear to show continuity over time, and thereby, continue to affect children's reading achievement.

In addition to reading achievement, another group of studies also has observed a positive association between parents' educational expectations and children's math achievement (Ing, 2014; Vukovic, Roberts, & Wright, 2013). Using nationally representative data from the Longitudinal Study of American Youth (LSAY), Ing (2014) tracked 7th graders' progress in math achievement through the end of high school. The study controlled children's gender, ethnicity, and parents' educational attainment, and found that children's math achievement throughout those school years was associated positively with parents' expectations that their children would do well in math. Consistent with Ing's (2014) finding, Vukovic, Roberts, and Wright (2013) collected data and also found a positive association between parents' educational expectations and children's math achievement on the part of 78 low-income, ethnic minority parents and their children (average 7 years old) living in an urban area in the United States.

Although scholars generally have observed a positive relation between parents' educational expectations and children's academic achievement in reading and math, one study (Hines & Holcomb-McCoy, 2013) found a negative association between parents' educational expectations and academic achievement measured as GPA overall on the part of 53 11th and 12th grade students. Taken together, these studies appear to suggest first, that parents' educational expectations can help promote children's academic achievement in different subjects, such as reading (Davis-Kean, 2005; Gary et al., 2012) and mathematics (Ing, 2014; Vukovic et al., 2013). Second, even when influential factors such as parents' educational attainment were controlled, their educational expectations still were associated with children's academic achievement (Davis-Kean, 2005; Ing, 2014). Third, this positive association was observed among children in elementary (Vukovic, Roberts, & Wright, 2013), middle, and high school (Ing, 2014). Fourth, parents' educational expectations were found to contribute to children's academic achievement across families from diverse sociocultural backgrounds (Davis-Kean, 2005). These findings provide a significant background for understanding the relation between parents' educational expectations and children's science achievement. Based on this background, the next section reviews specifically those studies that have examined the associations between parents' educational expectations and children's science achievement.

Parents' Educational Expectations and Science Achievement

Although much research has suggested that parents' educational expectations promote children's academic achievement in reading and math, studies have shown an inconsistent relation between those expectations and children's science achievement. For example, Sun (2015) tracked science achievement in a group of children from the third to eighth grades. Employing longitudinal data from the Early Childhood Longitudinal Study (ECLS), he found that parents' educational expectations were associated significantly and positively with these students' science achievement from third to fifth grade, but the relation became non-significant when they were in the sixth to eighth grades. In contrast with Sun's (2015) non-significant finding for middle school children, Froiland et al. (2012) observed that parents' educational expectations predicted children's academic achievement significantly, including science during middle school, even after controlling family background characteristics (e.g., socioeconomic status and race/ethnicity).

Byrnes and Miller (2007) studied academic achievement in math and science on the part of a group of high school students. Using secondary data from the National Longitudinal Educational Study (NELS:88), the researchers found that when parents held high expectations for children's long-term educational development and future careers, their science and math achievement were likely to increase during high school.

These studies documented a generally positive relation between parents' educational expectations and children's science achievement throughout the K-12 years, although the findings were contradictory for children in middle school. Thus, the role of parents' educational expectations in children's science achievement, especially when children are in middle school, remains unclear. To advance our understanding of the role of parents' educational expectations in children's science achievement, this study focused specifically on that relation in middle school children. Based on past studies (Froiland et al., 2012; Ing, 2014), this study predicted a positive association between these two variables.

Perceived Academic Competence and Academic Effort as Mediators

In addition to parents' educational expectations, studies have shown children's characteristics can help explain their academic achievement as well, one of which is their perceived academic competence (Eccles & Wigfield, 2002). Perceived academic competence, defined as one's perception of his/her academic skills and abilities (Altermatt & Pomerantz, 2003; Hong, Yoo, You & Wu, 2010), reflects self-judgment and evaluation of their ability to perform given academic tasks. Bouffard et al. (2003) claimed that children with higher perceived academic competence set higher academic goals, devote more effort to overcome academic difficulties, and thereby perform better than do those with lower perceived academic competence. Akey (2006) found that children's perceived academic competence had a stronger correlation with their academic achievement in mathematics and reading, and explained more variance in their achievement than did other variables, such as academic engagement, measured as the degree of students' working hard in school and participating in academic activities. These two studies pointed out the crucial role of children's perceived academic competence in their academic achievement. In addition, scholars have suggested that studying factors that promote this perception has significant implications. This is because during the early adolescent years, children are experiencing social and biological changes associated with puberty, moving from elementary to middle school or junior high school, and thus, experiencing school transition and making adjustments at this time. Scholars (e.g., Eccles, Midgley, & Adler, 1984; Hill & Lynch, 1983) have proposed that these changes can have a significant influence on students' self-perceptions. Eccles, Midgley, and Adler (1984) reviewed evidence showing that many young adolescents become more negative about school and themselves after transition to junior high school. They tend to be anxious about school and may have lower academic intrinsic motivation (Harter, 1981). Studies also show that young adolescents have lower perceived academic competence than do their younger peers (Eccles et al., 1983; Marsh, 1989), although this pattern is not always the case (Harter, 1982). Some scholars suggest that adolescents' beliefs about mathematics become particularly negative (Eccles, Adler, & Meece, 1984). Other researchers have observed that young adolescents become more rely on using information from environment, particularly feedback from significant others (e.g., parents' messages on their competence-relevant feedback), as they construct beliefs about their competence (Jacquez, Cole, & Searle, 2004).

Studies have found that parents' educational expectations are correlated with children's perceived academic competence, which, in turn, is correlated with their academic achievement. For example, Yeung et al. (2010) collected data from a group of 7th graders in Singapore and found that parents' educational expectations were associated indirectly with children's achievement in physics through their perceived academic competence. Neuenschwander and colleagues (2007) studied two samples of six graders from the US longitudinal studies of the Michigan Study of Adolescent Life Transitions (1983) and the Childhood and Beyond study (1990), as well as a representative sample of Swiss sixth graders (2002). The results indicated that parents' educational expectations were associated positively with children's perceived academic competence, which, in turn, was related positively to their mathematics and English achievement. These findings were consistent across the two countries. Thus, taken together, children's perceived academic competence appears to be an important factor that explains the relations between parents' educational expectations and children's academic achievement in different subjects, including physics (Yeung et al., 2010), mathematics, and English (Neuenschwander et al., 2007).

The exploration of perceived academic competence in different subjects also has revealed that this variable is subject-specific (Eccles & Wigfield, 2002; Trautwein, Ludtke, Roberts, Schnyder, & Niggli, 2009), in that children's perceived academic competence can vary across different disciplines (Trautwein et al., 2009) and their self-perception of their competence in one academic area may not necessarily be the same as in other areas. For example, Yeung et al. (2010) found students' perceived physics competence bore no relation to their perceived competence in English. Although scholars have suggested that perceived academic competence plays a mediating role in the relations between parents' educational expectations and children's achievement in physics, mathematics, and English, it is not yet understood well whether the indirect association via children's perceived academic competence can be applied in science. Because this study addressed science achievement, children's perceived academic competence herein refers specifically to perceived academic competence in science. Based on previous studies (Neuenschwander et al., 2007; Yeung et al., 2010) that used perceived academic competence as a mediator of the relation between parents' educational expectations and children's academic achievement in different subjects, this study predicted that children's perceived academic competence mediates the association between parents' educational expectations and science achievement.

In addition to perceived academic competence, another crucial characteristic is the academic effort children exhibit. Several studies (Carbonaro, 2005; Johnson, Crosnoe, & Elder, 2001; Stewart, 2008; Yeung, 2011) have emphasized that academic effort plays a significant role in determining children's academic achievement. For example, Moon and Hoffert (2016) tracked a group of students from kindergarten through fifth grade using data from the Early Childhood Longitudinal Study-Kindergarten (ECLS-K) and found that academic effort was associated strongly and consistently with their achievement in reading and mathematics as they progressed through each grade, suggesting that academic effort is a stable predictor of children's academic achievement. Yeung (2011) claimed that an individual's academic effort may be a crucial factor that contributes to his/her academic achievement and has many advantages over other factors, such as perceived academic competence, because effort is an internal and controllable motivation. Dweck (2006) stressed that an individual's academic effort is the primary factor in knowledge acquisition and the learning process, especially when facing challenges or academic difficulties. Overall, these studies emphasized the significant contribution academic effort makes to one's academic achievement.

Scholars have found that children can motivate or engage themselves actively in effortful behaviors to achieve greater academic achievement. For example, Schwinger and Stiensmeier-Pelster (2012) found that a child's motivation strategies affected whether s/he exerted academic effort, which, in turn, was associated with the child's academic achievement in math and English. Specific motivational strategies used in their study included enhancing interest in learning, and attaching personal significance to the learning task. When students applied these strategies, they increased their level of academic effort and performed better on their tests. Trautwein et al. (2009) found that children's beliefs about confidence, self-awareness, and self-competence contributed to their academic effort, which, in turn, was associated with their achievement in math and English. The researchers emphasized that children's belief in their competence is a significant predictor of the subsequent level of effort that they invest in learning. In their study, students who were confident about their competence in math and English were more likely to invest significantly more effort, persist, and perform better on tests. These two studies focused on children's variables (e.g., self-motivation strategies, self-confidence, and self-competence) and tested academic effort as mediators to explain the relation between these variables and academic achievement. However, other researchers have demonstrated that parents also can promote children's positive characteristics to help them perform better academically. As Yeung et al. (2010) and Neuenschwander et al. (2007) demonstrated, parents' educational expectations can promote children's positive beliefs in their competence, which in turn, contributed to their academic achievement in physics, mathematics, and English. However, these two studies found no connection between parents' educational expectations and children's academic effort. It is not yet understood well whether parents' educational expectations are associated with children's academic effort, and in turn, related to their academic achievement. With respect to achievement, no study has ever tested this issue in science. Therefore, this study evaluated children's academic effort as a mediator to test the association between parents' educational expectations and children's science achievement. Further, based on Trautwein et al.'s (2009) finding that children's perceived academic competence is an important predictor of their subsequent academic effort, the study tested further whether parent's educational expectations are associated with children's perceived academic competence, and in turn, are associated with their academic effort, such that they contribute subsequently to children's academic achievement. Because the study examined children's science achievement specifically, this variable was used as the measure of academic achievement.

Direct and Indirect Associations between Parent-Child Communication and Children's Science Achievement

Parent-child communication, defined as conversations between parents and children about children's school experiences, including school activities and other academic issues (Caro, 2011; Shute, Hansen, Underwood, & Razzouk, 2011), also has been posited to be an important component of parental involvement that facilitates children's academic learning (Caro, 2011; Jeynes, 2007; Park, 2008). Researchers have highlighted the significance of parent-child communication, especially on topics related to school issues, because it has been found to be associated positively with a wide range of children's academic outcomes, including motivation to learn (Hollmann, Gorges, & Wild, 2016), educational aspirations (Hay, Wright, Watson, Allen, Beswick, & Cranston, 2016), academic performance (Hay et al., 2016; McNeely, Nonnemaker, & Blum, 2002), and a lower probability of dropping out of school (Park, 2008).

Park (2008) claimed that parent-child communication is a major indicator of parental involvement because the frequency of communication about school issues reflects directly parents' engagement in their child's school education in daily life (Park, 2008). Other researchers (Ho & Willms, 1996; Wilder, 2014) observed that parent-child communication was a significant contributor to children's academic achievement and was stronger than other parental involvement variables. For example, Ho and Willms (1996) found that, compared to other forms of parental involvement, such as parents' home supervision, communication with teachers, and participation in school activities, parent-child communication contributed the greatest amount of the variance in middle school students' academic achievement in mathematics and reading after family and student background factors (e.g., socioeconomic status, ethnicity, family structure) and the effect of school-level variables (e.g., school's socioeconomic status) were controlled.

Although many researchers have emphasized the salience of parent-child communication in children's educational development, the literature demonstrates inconsistent results with respect to the relation between frequent parent-child communication about school issues and children's academic achievement. A handful of studies has found a positive association between parent-child communication and children's academic achievement in math and reading (e.g., Houtenville & Conway, 2008; Mireles-Rios & Romo, 2010), language studies in Chinese and English (Chi, 2013), and literacy among children in elementary (Chi, 2013; Mireles-Rios & Romo, 2010), middle (Hay et al., 2016), and high school (Houtenville & Conway, 2008). These studies have demonstrated that children who have more discussions with their parents about school activities and plans and course work are more likely to do well in many different subjects throughout their K-12 education.

However, other scholars have observed no significant association between these two variables (Jeynes, 2007; Park, 2008). For example, Jeynes (2007) conducted a meta-analysis of the effect of parental involvement, including parent-child communication, on the academic achievement of students from grades 6 through 12. This research study collected data from 67 studies that evaluated quantitatively the relation between different forms of parental involvement and secondary school students' academic achievement. The researcher found that parent-child communication had no significant effect on children's academic achievement according to various measures (e.g., grades, standardized tests), when parents' educational attainment and family SES were controlled. However, this study did demonstrate the influential role of family background variables in the association between parent-child communication and academic achievement. Consistent with Jeynes (2007), Park (2008) and Hay et al. (2016) also stressed the necessity to control for family background characteristics, such as parents' educational attainment and family structure, because they might affect the association between parent-child communication and academic achievement.

In addition, children's race/ethnicity also influences the effect of parent-child communication on children's academic achievement. For example, using a sample of 12th graders from four racial/ethnic groups (Caucasians, African Americans, Hispanics, and Asians), Yan and Lin (2005) found that parent-child communication about school topics was not associated significantly with mathematics achievement on the part of Asian, Hispanic, and African American students. However, the association was significant for Caucasian students.

Thus far, these studies have reported inconsistent results with respect to the relations between parent-child communication and children's academic achievement (Houtenville & Conway, 2008; Jeynes, 2007; Mireles-Rios & Romo, 2010; Park, 2008; Yan & Lin, 2005). These studies have suggested overall that parents who communicate with their children more are likely to facilitate their academic achievement in various subjects, including reading, math, and languages (e.g., English and Chinese: Chi, 2013; Houtenville & Conway, 2008; Mireles-Rios & Romo, 2010). In addition, it is necessary to consider family structure (Hay et al., 2016) and parents' educational attainment (Jeynes, 2007; Park, 2008), as these factors may play a role in the association between parent-child communication and children's academic achievement. Based on the background of parent-child communication and children's academic achievement, this study explored further the association between parent-child communication and children's science achievement. The next section reviews only those studies relevant to the association between parent-child communication and children's science achievement.

Parent-Child Communication and Science Achievement

Compared to studies that have examined the association between parent-child communication and children's academic achievement in other subjects, there has not been much investigation of the association with respect to science achievement. Only two relevant studies have indicated that parent-child communication also may play an important role in children's science achievement.

Van Voorhis (2003) conducted an experiment to identify the effect of parent-child communication on sixth and eighth graders' science achievement. Data were collected from a middle school in a mid-Atlantic state (*N* = 253 sixth and eighth graders' families). The treatment group included students who participated in a program designed to promote parent-child interaction in home science activities (e.g., parent-child discussions of the results of a science experiment), while the control group included students who did not participate in the program. The researcher found that the treatment group achieved significantly higher science grades as reported by their school than did the control group, suggesting that parent-child communication, specifically, home discussions of science activities, promoted children's science achievement.

However, McNeal (1999) found an inconsistent relation between parent-child communication and children's science achievement across different racial/ethnic groups. Using data from the NELS:88, the author found that parent-child communication was associated positively with Caucasian and African American high school students' science achievement, while there was no significant association with Hispanic and Asian students' achievement.

Although these two studies suggested overall that parent-child communication also may help promote children's science achievement, there are several caveats to consider. First, the parent-child communication in Van Voorhis' (2003) study focused on parents and children's home discussions of science activities, which differs from this study's definition of parent-child communication, which was general conversations about children's school experiences, including school activities and other academic issues. Turning to McNeal's (1999) study, the researcher suggested that children's race/ethnicity played an influential role in the association between parent-child communication and children's science achievement, as this association varied across different racial/ethnic groups. However, it remains unclear how parent-child communication about children's school experiences are associated with their science achievement, considering the influential factors identified in previous literature, such as parents' educational attainment (Jeynes, 2007; Park, 2008) and family structure (Hay et al., 2016).

Perceived Academic Competence and Academic Effort as Mediators

As discussed in the previous sections, a number of studies has emphasized the importance of children's perceived academic competence (Akey, 2006; Bouffard et al., 2003), and it was found to be a significant mediator in explaining the association between different forms of parental involvement and children's academic achievement in various subjects. For example, Marchant et al. (2001) found that parents' participation in school activities and their attitudes about the importance of school success and effort were associated indirectly with children's academic achievement through children's perceived academic competence. Consistently, Roger et al. (2009) found that parents' active management of the learning environment, participation in homework, and encouragement of learning were associated indirectly with children's academic achievement in math, science, language, and art through children's perceived academic competence. Thus, these various forms of parental involvement appeared to facilitate children's achievement in different subjects by promoting children's positive perceptions of their academic competence.

However, given the significant role of parent-child communication, little research has investigated whether it can facilitate children's academic achievement through children's perceived academic competence. Even if there is an indirect association between the two through children's perceived academic competence, the potential to apply this indirect path to science achievement is not yet understood well. Although Bhanot and Jovanovic (2009) observed a positive association between parent-child communication and children's perceived academic competence in science, they did not test perceived academic competence as a mediator. Based on the previous studies that have found an indirect association between other forms of parental involvement and children's academic achievement in various subjects through children's perceived academic competence (Marchant et al., 2001; Roger et al., 2009), this study predicted that parent-child communication is associated with children's science achievement indirectly through perceived academic competence.

In addition to children's perceived academic competence, previous studies have emphasized academic effort as a crucial characteristic of children that contributes to their achievement in many subjects (Carbonaro, 2005; Stewart, 2008; Yeung, 2011; Johnson, Crosnoe, & Elder, 2001). Scholars have demonstrated that children's personal academic characteristics (e.g., perceived academic competence) mediate the association between certain forms of parental involvement practices (e.g., parents' educational expectations) and children's academic achievement in physics (Yeung et al., 2010), mathematics, and English (Neuenschwander et al., 2007). However, the role of parent-child communication and children's perceived academic competence, as well as their academic effort, in academic achievement are not yet understood well. With respect to science achievement, even less research has explored the associations among these factors.

The Role of Child's Gender and Race/Ethnicity

Past studies generally have noted a gender disparity in children's science achievement. For example, Jones, Howe, and Rua (2000) claimed that male students appeared to outperform females in science in elementary and middle school, especially in chemistry, earth science, and physics, although there were no significant differences between boys and girls in biology. However, more recently, Voyer and Voyer (2014) conducted a meta-analysis to investigate gender differences in scholastic achievement with respect to the size of their effect on school grades ($N = 369$ samples). The results revealed that girls had consistently better grades in all course content areas, including science. These findings contradict the popular stereotype that boys excel in math and science (Halpen, Straight, & Stephenson, 2011). Although there are no conclusive results with respect to gender differences in science achievement, these investigations pave the way for researchers to explore further which factors may contribute to gender differences in children's science achievement.

One study (Tenenbaum & Leaper, 2003) found that parents involved in their children's science learning differed based on their child's gender. This study used a sample of 52 Caucasian families and their children (average age of 12 years old) and found that parents of boys were more likely to expect their sons to do well in science and also expected them to pursue a science-related job in the future, while parents of girls had no such expectations. In addition, the study also found that parents of boys tended to engage their sons in science activities more, and stimulated the boys' science thinking more frequently than did parents of girls. This study shed light on issues of children's gender roles in parental involvement practices. Further, Ing (2014) found a link between parental support specifically and science achievement and found a gender difference in the association. The study demonstrated that parental support in learning science when children were in the 7^{th} grade was related to boys' science achievement and their progress in achievement from 7^{th} through 12^{th} grade. However, this association was not significant among girls.

In addition to the exploration of parental involvement practices based on a child's gender, another array of studies found that gender moderated children's own academic characteristics. Debacker and Nelson (2000) measured 242 high school students' (128 boys and 113 girls) perceived academic competence in learning science. Among them, male students reported a significantly higher level of perceived academic competence in science than did female students. Consistent with these findings, Pomerantz et al. (2002) sampled a group of elementary students (N = 932) and reported that girls showed a lower perception of their academic competence in science than did boys, even though they outperformed boys in science tests. Another study (Yeung, 2011) that used a sample of elementary and secondary students in Sydney (N=2200) found a gender difference in academic effort level in which, compared to boys, girls were more likely to make greater efforts to learn all of their academic subjects, including science.

Taken together, the studies above provide meaningful insights that a child's gender is important in understanding parental involvement practices as well as children's academic characteristics. However, the way in which parental involvement practices, especially parents' educational expectations and parent-child communication, interact with children's academic characteristics, such as perceived academic competence and academic effort, to contribute to children's science achievement based on gender has not been explored well to date. Thus, this study explored the gender role in the associations among these factors.

In addition to gender, this study also examined the role of race/ethnicity. There are multiple racial/ethnic groups of people from many culturally distinct backgrounds in the United States (Goldstein & Morning, 2000), and parents with diverse backgrounds may have different goals, values, and parental practices intended to foster children's academic achievement (Huntsinger & Jose, 2009; Steinberg, Dornbusch, & Brown, 1992). Further, children who have different racial/ethnic backgrounds also may have different attitudes about learning or study habits (Chen, 2001). In science specifically, scholars have observed that Asian American students outperformed other ethnic groups (Else-Quest et al., 2013; Patton & Royer, 2009) and demonstrated the highest academic achievement in science. Other statistical resources from the official report by TIMSS (2011) also revealed that for both fourth and eighth graders, the mean of Asian and Caucasian students' standard test scores is higher than that of Hispanic and African-American students.

To explore factors that might be associated with the disparity in science achievement by race/ethnicity, scholars have studied parental involvement practices among different racial/ethnic groups. Using a sample of 23,000 Asian American and Caucasian American kindergarten children drawn from the ECLS-K and followed through 5th grade, Sy et al. (2007) reported that Caucasian parents discussed nature or worked on science projects with their children more frequently than did minority group parents. Further, McNeal (1999) observed that the effect of certain parental involvement practices on children's science achievement differed according to race/ethnicity. The author found a positive association between parent-child communication and students' science achievement among Caucasian students, but no significant relation in African Americans, Hispanic, and Asian Americans. These studies suggested that race/ethnicity plays an influential role in understanding parental involvement practices, as well as their influence on children's science achievement.

Turning to children's academic characteristics, Else-Quest et al. (2013) investigated whether children's science attitudes, specifically their perceived science ability, task value, and their expectations to succeed in learning science varied among different race/ethnic groups (i.e., Caucasians, Hispanics, Asian Americans, and African Americans). The study indicated that there was no significant difference in science attitudes overall depending on children's race/ethnicity. However, between-group comparisons of Caucasian and African American children's perceived science ability differed significantly, in that Caucasian children reported higher perceived ability in science than did African American children. Similarly, Asian American children reported a significantly higher level of perceived ability, task value, and expectations to succeed in science than did African American children. Thus, this study also suggested that race/ethnicity plays an important role in understanding children's academic characteristics.

Although the previous studies reported racial/ethnic differences in parental involvement practices and children's academic characteristics, the way in which the specific practices of parents' educational expectations and parent-child communication interact with children's perceived academic competence and academic effort and contribute to children's science achievement based on race/ethnicity has not yet been explored well. Therefore, this study also explored the role of race/ethnicity in the associations among these factors.

Viewing the prior comparative studies as a whole, they have suggested that a child's gender and race/ethnicity moderate the effects of parental involvement practices and children's academic characteristics, as well as those of parents' educational expectations and parent-child communication on children's science achievement. Based on these studies, this study hypothesized that a child's gender and race/ethnicity modify the effects on children's science achievement of parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort.

Strengths and Limitations

The literature review suggested that parents' educational expectations and parent-child communication are important parental involvement practices that are associated with children's academic achievement in different subjects (e.g., reading and math: Davis-Kean, 2005; Houtenville & Conway, 2008; Ing, 2014). These two practices also may be crucial to children's science achievement (Byrnes & Miller, 2007; Senler & Sungur, 2009; Sun, 2015; Van Voorhis, 2003).

Further, children's individual academic characteristics also are important in their academic achievement. Parents can enhance children's academic achievement by influencing their achievement-related characteristics. Specifically, the literature has suggested that perceived academic competence (Akey, 2006; Bouffard et al., 2003; Eccles & Wigfield, 2002) and academic effort (Moon & Hoffert, 2016; Yeung, 2011) are important academic characteristics of children that were found to be related to children's academic achievement in many subjects (e.g., Neuenschwander et al., 2007; Trautwein et al., 2009). Given their significance in various subjects, it also is necessary to consider the roles children's perceived academic competence and academic effort play in their science achievement.

Moreover, researchers have noted that children's science achievement may vary depending on gender and race/ethnicity (e.g., Else-Quest et al., 2013; Jones et al., 2000). Scholars have suggested potential explanations by examining the role of child's gender and race/ethnicity in parents' educational expectations, parent-child communication (Sy et al., 2007; Tenenbaum & Leaper, 2003), and children's perceived academic competence (Debacker & Nelson, 2000) and academic effort (Yeung, 2011). These studies further our understanding of the way in which children's individual and diverse family background characteristics may contribute to their science achievement.

Nevertheless, there also are several limitations in the existing literature. First, studies of the direct association between parents' educational expectations and children's science achievement yielded inconsistent results when children were in middle school (Froiland et al., 2012; Sun, 2015). More studies that focus on this age group are needed to clarify these results. Second, findings with respect to the direct association between parent-child communication and children's science achievement also have been inconsistent (McNeal, 1999), and influential factors, such as parents' educational attainment and family structure, need to be taken into account (Hay et al., 2016; Park, 2008). Third, although studies have documented a direct association between parents' educational expectations, parent-child communication, and children's science achievement, it is not yet clear whether parents' educational expectations and parent-child communication are associated with children's science achievement through their perceived academic competence and academic effort. Thus, more studies on the indirect associations among these variables are necessary. Fourth, although scholars have noticed that parents' educational expectations (Tenenbaum & Leaper, 2003), parent-child communication (Sy et al., 2007; Tenenbaum & Leaper, 2003), and children's science achievement vary depending upon the child's gender and race/ethnicity, little is known about the role of the child's gender and race/ethnicity in the associations between parents' educational expectations, parent-child communication, and children's science achievement when children's perceived academic competence and academic effort are considered.

To build upon prior work and address these limitations, this study focused on three basic areas. First, it examined the direct and indirect associations between parents' educational expectations, parent-child communication, and children's science achievement. With respect to the indirect associations, the study proposed three indirect pathways: 1) parents' educational expectations and parent-child communication are associated indirectly with children's science achievement through perceived academic competence; 2) the two factors are associated indirectly with children's science achievement through academic effort, and 3) they are associated first with children's perceived academic competence, which, in turn, is associated with academic effort, and ultimately, with children's science achievement.

Second, the study focused on middle schoolers to examine the direct and indirect associations between parents' educational expectations, parent-child communication, and children's science achievement. The reason for focusing on early adolescent middle schoolers is that adolescence is a transition period between childhood and adulthood (Hill & Tyson, 2009) that is marked by a series of changes, including children's physical and psychological development, family relationships, and school adjustments (Fan & Williams, 2010). As they enter adolescence, many children's engagement in school decreases, and parental involvement practices may need to be highlighted (Hill & Tyson, 2009). Investigating this developmental stage in a child's life should offer significant insights into the function of parental practices, children's individual development, and their academic progress.

Third, the study included children's gender and race/ethnicity as moderating variables that affect the association among and between the following: parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and their science achievement between genders and across racial/ethnic groups. The next chapter addresses the theoretical and conceptual models that guided the study, presents the research questions, formulates the hypotheses, constructs the models, and describes the statistical method used to examine the pathways of associations among the variables in this study.

Chapter 3: Theoretical Framework

This chapter focuses on the conceptual models and theories that were used in this study to explain the components of parental involvement that influence children's science achievement directly or indirectly through their academic characteristics across families from diverse sociocultural backgrounds. Specifically, Bronfenbrenner's ecological model served as an overarching framework to view the influence of parental involvement-children's academic characteristics-children's science achievement within a family environment, which is embedded in a larger sociocultural context. Guided by social cultural contexts of parental academic socialization, the influential factors of child's gender and race/ethnicity in the interaction between parental involvement, children's characteristics of perceived academic competence and academic effort and science achievement also were discussed. Next, Grolnick and Slowizczek's (1994) parental involvement framework was used to explain components of parental involvement of interest in the study. Weiner's (1994) attribution theory was used to explain the roles of children's perceived academic competence and academic effort in their science achievement. Further, Bandura's (1995) social cognitive theory was used to examine the way in which parental involvement plays a role in the association between children's perceived academic competence and academic effort, and their science achievement. Each theory or framework informed the examination of parental influence on children's academic development processes and the confluence of all these models helped in developing the research questions, hypotheses, and model. The following sections provide detailed discussions of these guiding frameworks and theories.

Bronfenbrenner's Ecological Model

Bronfenbrenner's ecological model (Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994) served as an overarching framework in the study. When combined with social cognitive theory (Bandura, 1995), the ecological model can help explain contextual factors' effect on parental involvement practices, children's academic characteristics, and their academic achievement. The ecological model posits that children's developmental outcomes are the product of the interaction between the child and his/her multiple environmental systems (Bronfenbrenner, 1979). These systems are nested hierarchically from proximal to distal and center on the child (Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994). The proximal environment, also referred to as the microsystem—the layer closest to the child—is the family environment to which young children are exposed commonly (Bronfenbrenner & Ceci, 1994). Within the family environment, parents may be involved in children's education by engaging in communications with their children about school experiences (Adedokun & Balschweid, 2008; Fan, 2001; Houtenville & Conway, 2008) or expecting that their children will perform well academically (Benner, Boyle, & Sadler, 2016; Wilder, 2014). Such practices may provide specific direction and guidance for children with respect to their education (Hou & Leung, 2011).

Through an ecological lens, these parents' educational practices offer children an education-oriented proximal environment, which, in theory, influences their educational outcomes. In addition, Bronfenbrenner theorized that the proximal environment differs depending on family background characteristics (e.g., parents' educational attainment and family structure), and empirical studies have supported this claim. Park (2008) found that parents with higher educational attainment were more likely to convey and emphasize the importance of education to their offspring effectively, thereby providing them with a more education-focused family environment. Other studies have found that single parents may have limited capacity and energy to provide their children with educational resources compared to those in a two-parent family (Wang et al., 2009).

In addition, ecological theory recognizes the role of personal characteristics in one's academic achievement (Bronfenbrenner & Morris, 2006). The theory states that the proximal environment contributes to an individual's academic achievement, depending on personal characteristics, such as gender, perceived academic competence, and academic effort. This is consistent with Bandura's (1995) social cognitive theory that emphasizes that children are active learners who determine their own academic achievement.

Moreover, researchers who employ the ecological model also have emphasized a distal environment, which consists of the broader social and cultural context, and in which the proximal environment is embedded (Rogers, et al., 2009; Tan & Goldberg, 2009). Therefore, the social and cultural context plays an influential role in both parental involvement practices and children's learning process overall. Accordingly, this study examined parents' educational expectations and parent-child communication as two important parental educational involvement practices that construct a proximal environment that influences children's science achievement. Further, the key role of children's characteristics, including gender, and their academic characteristics of perceived academic competence and academic effort that contribute to their science achievement were considered, as were other contextual family factors, such as parents' educational attainment and family structure, as well as the distal factor of cultural background.

Social Cultural Contexts of Parental Academic Socialization

Parental academic socialization includes parents' beliefs about education and their expectations and behaviors with all of which they guide their children's academic and school-related development (Pomerantz, Ng, Cheung, & Qu, 2014; Tayor, Clayto, & Rowley, 2004). Suizzo and Soon (2006) proposed the term "academic socialization" to describe parental involvement practices from the perspective of child socialization (Taylor, Clayton, & Rowley, 2004). According to the socialization perspective, parents hold goals and values for their children to grow in various developmental aspects (e.g., intellectual development). Therefore, parents are motivated to interact with their children in specific ways to internalize those goals and values (Wentzel, 1999). Several researchers have claimed that a number of factors shape parental behaviors and educational-related beliefs, including their income, educational background, and "sociocultural model" of appropriate socialization goals and strategies (Pomerantz et al., 2014; Tayor et al., 2004).

This theory was used to focus specifically on the way the sociocultural model influences parents as they communicate their educational goals and values to their offspring and the way this influences children's academic belief and behaviors. Each society functions within a system of social roles and customs concerning what males and females are supposed to be and do. Children learn to differentiate and label themselves based on their gender, and to acquire attributes, attitudes, and behaviors that are considered appropriate to each. Children themselves cannot construct their gender roles, and it is necessary instead to consider parental socialization pressure. It should be noted that males and females differ according to their physiological sex, and some comparative studies also have used the term "sex" group (e.g., Fredricks & Eccles, 2002; Ganley & Vasilyeva, 2011). In this study, sex and gender were used interchangeably, because, despite the fact that they differ in nature (Blakemore, Berenbaum, & Liben, 2013), the focus did not require differentiating the two.

According to Eccles, Jacobs, and Harold (1990), the social concept of gender role can influence parents' expectations and interactions with their children because parents treat their boys and girls differently. For example, Tenenbaum and Leaper (2003) conducted a qualitative study of 52 adolescents who ranged in age from 11 to 13 years old, and asked parents about their beliefs about science achievement with respect to their children's gender. The results showed that parents were more likely to believe that science was less interesting and more difficult for daughters than sons. In addition, parents' beliefs were found to be associated with children's interest and self-efficacy in science. Therefore, the socialization perspective provides insight in understanding the influential role of child's gender in parental involvement and children's academic beliefs and behaviors.

Turning to the cultural aspect, families from different cultural backgrounds have different parental involvement practices (i.e., variations in forms and intensity) that transmit their cultural values across generations (Rogoff, 2003; Suizzo & Soon, 2006). The cultural values shared by members of a community motivate parents to behave in accordance with those values and ideologies. Thus, families with different cultural backgrounds are likely to have different socialization goals and practices. For example, studies have shown that parents of East Asian origin are likely to believe that effort is the key to academic success, while European American parents tend to stress ability (Stevenson et al., 1990; Suizzo & Soon, 2006). Stevenson's body of work with parental messages associated with racial socialization as well as adolescent perceptions of racial socialization have demonstrated that for some minority group such as African American, parents often take the responsibilities of promoting cultural pride, preparing children for life in mainstream society, and preparing children to deal with racism and discrimination while raising their children (Stevenson, Reed, & Bodison, 1996). Children's positive identity development are often associated with messages regarding to the promotion of cultural pride. Stevenson et al. (1997) also found that racial socialization messages emphasizing racial barriers were related to adolescents' adaptive anger expression whereas adolescents in families that focused on strategies that promoted cultural pride and heritage showed higher levels of anger control. Other scholars have found that race/ethnicity plays a role in the association between parental involvement and children's academic related beliefs. For example, Suizzo and Soon (2006) captured racial/ethnic group differences in the effects of parental home-based involvement on students' locus of control with respect to academic and school issues. The researchers studied a sample of 249 college students from four ethnic groups (i.e., Caucasian Americans, Hispanics, Asian Americans, and African Americans) and found that parental academic encouragement and emotional support predicted children's locus of control in academic and school issues among Asian American and European American students, but not among Hispanics and African Americans, suggesting that ethnicity moderates the association between parental academic socialization and children's beliefs about academics. In another study, Suizzo and colleagues (2012) demonstrated the moderating role of ethnicity in the relation between parents' demanding hard work and college students' academic self-efficacy, in which the relation was stronger for African Americans than Hispanic Americans.

Taken together, the findings above underscore the moderating role of child's gender and race/ethnicity in the parental academic socialization process. As this model proposes, child's gender and race/ethnicity were viewed herein as moderators that influence the associations between parental involvement practices (e.g., parents' educational expectations and parent-child communication) and children's variables of perceived academic competence and academic effort, and science achievement.

Parental Involvement Framework

Broadly speaking, parental involvement can be understood as the interactions between parents and children that facilitate children's academic progress and success (Hill, Castellino, Lansford, Nowlin, Dodge, Bates, & Pettit, 2004). Some scholars have distinguished parental involvement strategies based on settings, such as home-based (e.g., educational activities and parental supervision, support, and reinforcement of learning at home) and school-based involvement (e.g., communication between parents and teachers or parents' attendance at school events: Conners & Epstein, 1995; Epstein, 1987; Epstein & Sanders, 2002). This classification allows researchers to analyze the associations between the specific components of involvement in different contexts, such as home or school, and important aspects of children's academic development, such as motivation and school performance (Gonzales-DeHass et al., 2005). Later, Grolnick and Slowizczek (1994) suggested dividing parental involvement into three types: behavioral involvement (what parents do, including both home and school-based involvement strategies), cognitive-intellectual involvement (the way parents expose children to educationally stimulating activities and experiences), and personal involvement (which attitudes and expectations parents have for their children's education). Grolnick and Slowizczek's (1994) parental involvement framework was used in this study to guide the exploration of parents' engagement in their children's education and focused on personal involvement. Grolnick and Slowiaczek's (1994) concept of personal involvement emphasizes parents' creating an understanding of the goals and purposes of academic achievement by discussing learning strategies or communicating parental expectations about education. This dimension of parental involvement explains the way parents transmit their educational values and help children set academic goals that influence their educational development.

Recent researchers have focused increasingly on the personal dimension of parental involvement to examine its contribution to children's educational development (Davidson & Cardemil, 2009; Hill & Tyson, 2009; Karbach, Gottschling, Spengler, Hegewald, & Spinath, 2013), and have studied two forms of parental involvement. One is parents' educational expectations (Hill & Tyson, 2009; Karback et al., 2013) and the other is parent-child communication about children's school issues (Karback et al., 2013). The educational expectations that parents have for their children convey their attitudes about education and how much education they expect their children to obtain (Hill & Tyson, 2009). When children perceive parents' educational expectations, such messages may help them develop their educational aspirations and serve to connect their school work and their future goals (Hill & Tyson, 2009), such that they are likely to strive to meet their parents' expectations for their academic achievement (Karback et al., 2013). Empirical studies have found that higher parental educational expectations are associated with greater academic achievement in different subjects, such as reading (Davis-Kean, 2005; Gary, Laura, Roderick, & Elizabeth, 2012) and math (Ing, 2014; Vukovic, Roberts, & Wright, 2013).

Parent-child communication, especially about children's school, is another personal dimension of parental involvement. Parents can instill educational knowledge directly, discuss learning strategies, express the value and purpose of education, or their expectations for their children by communicating with them (Caro, 2011; Chi, 2013; Hay et al., 2016; Hollmann, Gorges, & Wild, 2016; Park, 2008; Tang, McLoyd, & Hallman, 2015). Children are likely to learn through these conversations with their parents or be influenced by their parents' messages regarding education (e.g., the importance of education overall or of learning a specific subject). Scholars have found that a greater level of communication is associated with children's academic achievement in many subjects, including math, reading (e.g., Houtenville & Conway, 2008; Mireles-Rios & Romo, 2010), and language (Chi, 2013).

Using the parental involvement framework (Grolnick & Slowizczek, 1994), parents' educational expectations and parent-child communication were framed as important indicators of parents' personal involvement, and were hypothesized to be associated with science achievement.

Social Cognitive Theory

Social cognitive theory was used herein to understand the association between parental involvement and children's academic characteristics, as well as their academic achievement. The social cognitive theory (Bandura, 1995) states that learning results from an interaction between an individual, his/her behaviors, and the external environment. This theory provides an interactive, yet interdependent paradigm to view individual's learning. According to the theory, children's motivation to learn is a goal-oriented behavior activated and sustained by their own evaluations of their ability to perform a task and the outcomes of the actions they take to reach their goals (Bandura, 1995). Therefore, children's self-evaluation of their ability is important because it motivates subsequent behaviors designed to achieve the goals desired. This study focused on children's self-evaluations of their academic competence, referred to as perceived academic competence. Further, the factor of academic effort, which represents children's engagement in certain behaviors to achieve their goals was examined as well with reference to Weiner's (1994) attribution theory, which was developed from a social cognitive perspective. The following sections introduce the theory.

Attribution Theory

Weiner's (1994) attribution theory explains children's motivation to learn from a cognitive perspective in which individuals understand the causes of learning outcomes based on their self-evaluations of ability and behaviors (Pintrich & Schunk, 1995). These attributions are one's perceptions of the causes of learning outcomes, and are hypothesized to be related to achievement behaviors and outcomes (Weiner, 1985). Weiner identified four important causal attributions of academic success and failure: ability; effort; task difficulty, and luck (Weiner, 1994). The first two were the focus of this study, as they are internal motivations (Weiner 1994). Weiner (1986) believed that effort and ability have different features, in which effort often is understood as controllable and varies in different situations. Individuals can increase their level or degree (time or energy) of task-related coping efforts to increase the probability of successful outcomes, while ability often is perceived as uncontrollable and stable, and is considered an individual trait or a more situational aspect of an individual.

According to Weiner (1995), individuals who attribute their achievement to effort, which is variable and controllable, are more likely to persist and increase their effort to achieve their academic goals. In this situation, effort can be associated independently with achievement without considering ability. In the other situation, individuals who attribute success to their abilities, which are stable but uncontrollable, are more likely to quit or not even try when they face challenges or difficulties, as they do not believe they are able to overcome them. In this case, ability can be associated independently with achievement without considering effort. In addition, there is another situation, in which individuals who attribute their achievement to *both* ability and effort are more likely to undertake challenging or difficult tasks and persist in their efforts to overcome them and reach higher achievement. In this situation, ability is hypothesized to be associated with effort, which in turn, is related to achievement.

Applying these notions here, Weiner's (1994) attribution theory was used to understand the interconnection between children's perceived academic competence and academic effort, and the outcome of science achievement. Perceived academic competence was viewed as "ability," academic effort as "effort," and science achievement as an individual's learning achievement. Recent educators have placed increasing emphasis on children's perceived academic competence (Bouffard et al., 2003; Pinxten et al., 2014) and academic effort (Dweck, 2006; Johnson et al., 2001; Yeung, 2011) in learning and explored ways to strengthen students' efforts to improve their academic performance. The results of several studies have supported attribution theory. For example, Bouffard et al. (2003) conducted a longitudinal study of elementary school children they followed from first to third grade. They found their perceived academic competence in reading and math were related to their academic achievement in these subjects in each grade. Similarly, Pinxten, Marsh, De Fraine, Van Den Noortgate, and Van Damme (2014) examined specifically young children's (4^{th} to 7^{th} grade) perceived math competence and found it was associated with their math achievement after prior performance in mathematics was controlled. Turning to studies of academic effort, Stewart (2008) used a sample of 10^{th} grade students in the National Educational Longitudinal Study (NELS) database and found that students' academic effort played a substantial role in increasing their academic achievement. Consistent with these results, using a sample from the 8^{th} to 10^{th} grade cohort in the NELS data, Carbonaro (2005) found that, compared with low academic achievers, high achievers exerted substantially more effort in learning.

In addition to studies that have examined only perceived academic competence and academic effort, scholars have found support for attribution theory by testing the mediation pathway from one's perceived competence to achievement via effort. For example, Trautwein, Ludtke, Roberts, Schnyder, and Niggli (2009) examined 415 8^{th} graders from academic-track schools in Berlin, Germany. They measured students' academic effort and beliefs in their competence in mathematics. They found that a higher level of perceived academic competence was associated with increased effort, which in turn, was associated with the children's math achievement.

From the perspective of the cognitive aspect of the theory, the child is viewed as an active decision maker who learns to take appropriate actions based on his/her beliefs to achieve the outcomes desired (Bandura, 1995). This aspect of the theory emphasizes that children make their own decisions and choose the paths they will pursue actively. Further, social cognitive theory also underscores the social factor, that students' self-scheme is nested in the social environment in which children interact with other social agents (e.g., parents: Pintrich & Schrauben, 1992). The interaction between children and the outside environment, particularly their parents, plays a substantial role in children's self-evaluations and behavioral choices; therefore, social cognitive theory also provides insight for our understanding of the way individuals interact and adapt to their social environments to achieve their desired goals. Thus, through the lens of social cognitive theory, the parental involvement practices of educational expectations and parent-child communication were viewed as aspects of the social environment that influence children's academic beliefs and behaviors.

Empirical studies have supported social cognitive theory by demonstrating parents' influence on children's self-perceived academic competence. For example, in their study of a sample of 7th grade students in Singapore, Yeung et al. (2010) found that parents' expectations that their children will achieve success in science learning were associated positively with children's beliefs in their ability to learn physics. Another study (Harackiewicz et al., 2012) found that parent-child communication about the importance of math and science courses to children's futures was associated with students' perception of the usefulness of STEM education after graduation.

Development of the Model Hypothesized

Bronfenbrenner's ecological model (Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994), the social cultural contexts of parental academic socialization (Taylor, Clayton, & Rowley, 2004), Grolnick and Slowizczek's (1994) parental involvement framework, Bandura's (1995) social cognitive theory, and Weiner's (1994) attribution theory served as the foundations for the development of the model tested in this study. The literature grounded in the parental involvement framework (Grolnick & Slowizczek, 1994) has highlighted two important parental practices, parents' educational expectations (Davis-Kean, 2005; Gary, Laura, Roderick, &

Elizabeth, 2012; Ing, 2014; Vukovic, Roberts, & Wright, 2013) and parent-child communication (Chi, 2013; Hay et al., 2016; Houtenville & Conway, 2008; Mireles-Rios & Romo, 2010). These two parental involvement practices were considered predictor variables of children's science achievement. Considering parents' educational expectations and parent-child communication were conceptualized as types of parental involvement in nature, they may share some variance, and thus, may correlate with one another (e.g., Parents may express their expectations toward their children through verbal communication with children). However, in this study these two types of parental involvement were conceptualized as two different types of involvement with one focusing on parental belief (i.e., parents' educational expectation) and the other focusing on parental behavior (i.e., parent-child communication). In the later analysis, factor analysis would detect if these two factors should correlate with each other in the hypothesized model.

According to the social cognitive theory (Bandura, 1995) and Weiner's (1994) attribution theory, parents' educational expectations and parent-child communication were hypothesized to be associated indirectly with children's science achievement through three mediation pathways: 1) children's perceived academic competence as a single mediator; 2) academic effort as a single mediator, and 3) children's perceived academic competence as the first mediator, which in turn, is associated with the second mediator, academic effort. The model proposed is shown in Figure 1. Parental academic socialization emphasizes the influential factors of child's gender and race/ethnicity, and therefore, child's gender and race/ethnicity were treated as moderators, and based on Bronfenbrenner's ecological model (Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994), parents' educational attainment and family structure served as covariates.

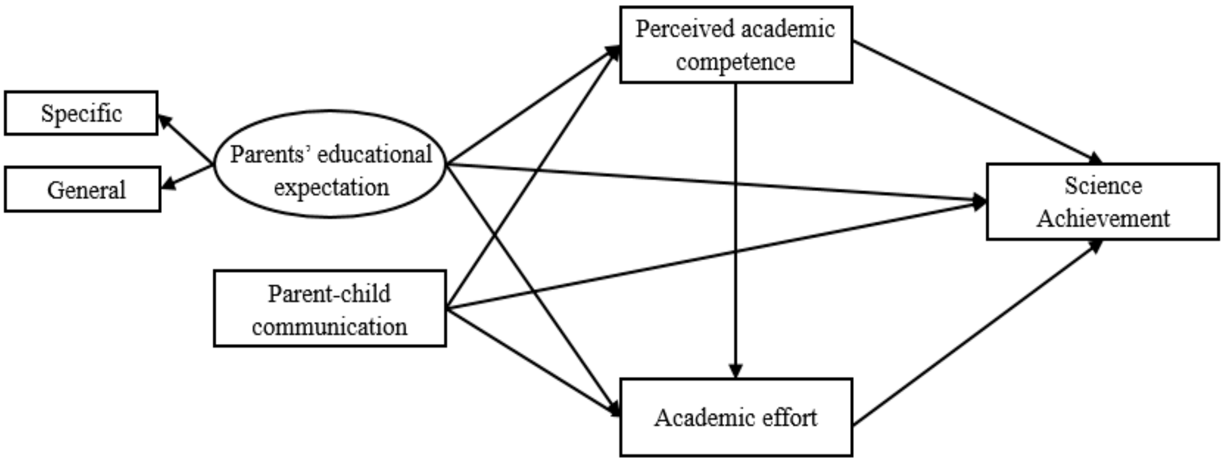

Figure 1. Study conceptual model

Covariates

Previous studies have suggested that parents' educational attainment influences the relation between parent-child communication and children's academic performance (Jeynes, 2007; Park, 2008). However, researchers have found a non-significant association in this relation after parents' educational attainment was controlled (Park, 2008). Parents with more education have higher expectations that their children will do well in school and can convey the enjoyment and importance of learning to their children. Researchers have observed consistently that parents' educational attainment is associated positively with educational expectations (Davis-Kean, 2005; Wood, Kaplan, & McLoyd, 2007), parent-child communication (Caro, 2011; Chi, 2013; Lam & Ducreux, 2013), and children's academic success (Chi, 2013). Therefore, it appears that the level of parents' education plays a role in their involvement in their children's education and academic success.

Other researchers have found that family structure also may play a significant role in parental involvement in children's education and academic success (Caro, 2011; Park, 2008). For example, Kim, Sherraden, and Clancy (2012) found parents' marital status was associated significantly with mothers' educational expectations. Further, married parents had significantly higher educational expectations of their children than did single parents. Children from divorced families tended to perform relatively poorly in school compared to those from non-divorced families (Tillman, 2007), as did those from single-parent families (Tillman, 2007; Potter, 2010). Researchers explained that being raised in a single-parent household might be associated with lower parental educational expectations and less frequent parent-child interactions (Morsy & Rothstein, 2015). Further, Potter (2010) found that children from divorced families may experience a low level of psychosocial well-being, which may explain the connection between divorce and their lower academic achievement.

The findings above all suggest that familial factors, such as parents' educational attainment and family structure, influence parents' educational expectations, parent-child communication, and children's educational development. Therefore, parents' educational attainment and family structure were included in this study as controls.

Research Questions and Hypotheses

The goal of this study was to examine the ways parents' educational expectations and parent-child communication are related directly to children's science achievement and indirectly to children's science achievement through children's perceived academic competence and academic effort (Figure 1). In addition, the moderating role of a child's gender and race/ethnicity were investigated in these associations. The following research questions and hypotheses guided the study:

Research question 1. What are the direct and indirect associations between parents' educational expectations, children's perceived academic competence and effort, and children's science achievement? (Figure 2).

Hypothesis 1a. Parents' educational expectations are associated positively with children's higher science achievement.

Hypothesis 1b. The level of parents' educational expectations is associated positively with children's higher perceived academic competence, which, in turn, is associated positively with higher science achievement.

Hypothesis 1c. A higher level of parents' educational expectations is associated positively with children's greater level of academic effort, which, in turn, is associated positively with higher science achievement.

Hypothesis 1d. A higher level of parents' educational expectations is associated positively with children's greater perceived academic competence, which, in turn, is associated positively with a higher level of academic effort, and, in turn, is associated positively with higher science achievement.

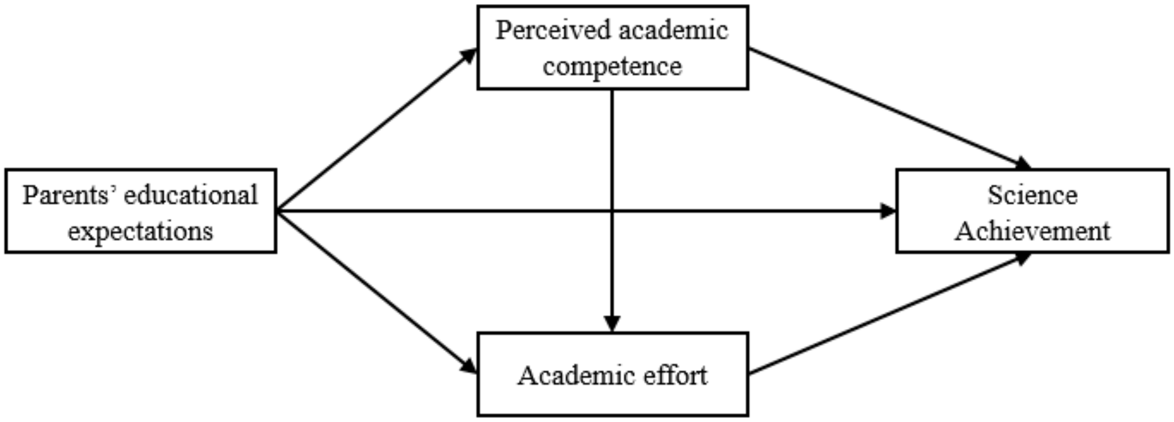

Figure 2. The associations between parents' educational expectations and children's science achievement

Research question 2. What are the direct and indirect associations between parent-child communication, children's perceived academic competence and academic effort, and children's science achievement? (Figure 3).

Hypothesis 2a. A higher level of parent-child communication is associated positively with children's greater science achievement.

Hypothesis 2b. A higher level of parent-child communication is associated positively with children's greater perceived academic competence, which, in turn, is associated positively with higher science achievement.

Hypothesis 2c. A higher level of parent-child communication is associated positively with children's greater level of academic effort, which, in turn, is associated positively with higher science achievement.

Hypothesis 2d. A higher level of parent-child communication is associated positively with children's greater perceived academic competence, which in turn, is associated positively with a higher level of academic effort, and in turn, is associated positively with higher science achievement.

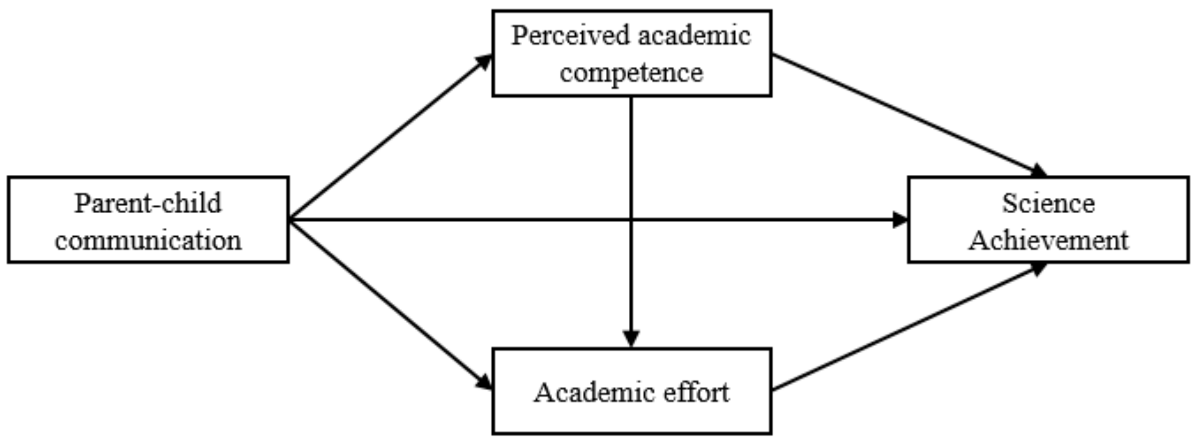

Figure 3. The associations between parent-child communication and children's science achievement

Research question 3. Does a child's gender moderate the associations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and science achievement?

It was hypothesized that the associations between parents' educational expectations, parent-child communication, children's perceived academic competence, academic effort, and children's science achievement varies between genders. Given that there is relatively little literature on this issue, the study explored this research question without providing a specific hypothesis.

Research question 4. Does a child's race/ethnicity moderate the associations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and children's science achievement?

It was hypothesized that the associations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and children's science achievement varies across racial/ethnic groups. Similarly, given that there is relatively little literature on this issue, the study also explored this research question without providing a specific hypothesis.

Chapter 4: Methods

Participants

The sample in this study was drawn from the Longitudinal Study of American Youth (LSAY), a nationwide study funded by the National Science Foundation (NSF) to explore middle and high school students' interest and acquisition of skill in science and mathematics and their future career plans (Miller, 2014). This data source was chosen as the analysis dataset among several resourceful datasets (e.g., TIMSS 2011, NAEP, and ECLS data for eighth graders) for one major reason. That is, it documents families' educational involvement and children's progress in mathematics and science specifically, and it contains necessary variables discussed in the prior literature section (i.e., parents' educational expectations, parent-child communication, children's perceived academic competence, and academic effort), which was suited best to the interests of this study. Other datasets have different goals for data collection. For example, TIMSS 2011 also contains young adolescents' (eighth graders) science achievement information; however, it focused on cross-country comparison in students' achievement across 52 participant countries. Thus, data on US adolescents are limited and does not contain parental involvement factors. Data released from NAEP focused on recording students' achievement progression in different subjects, and thus, limited in science data and does not contain parental involvement as well as children's factors. Data from ECLS does not contain information of children's academic effort. Based on this rationale, the study chose LSAY dataset.

The LSAY research team collected data from two cohorts. The first comprised 2,829 high school students who were in the 10^{th} grade in 1987, and the second 3,116 middle school students who were in the 7^{th} grade. The LSAY tracked the two cohorts until 1994, when the first had graduated high school four years before, and the second one year before. In 2007, the research team resumed data collection on these two student cohorts to examine their educational and occupational outcomes. The follow-up investigation was conducted for five years, from 2007 to 2011 (Miller, 2014). Although the LSAY data were longitudinal, a cross-sectional design was applied here and the second cohort of middle schoolers was chosen as the sample for analysis.

With respect to the sampling strategy, the LSAY used a two-stage stratified probability sampling design for each cohort. The public middle schools were divided into four geographic regions (Northeast, North-central, South, and West) and three levels of urban development (central city, suburban, and nonmetropolitan) to produce a total of twelve strata. Data were collected from fifty-two schools, and an average of 60 students per school were selected randomly. Cohort II, which was limited to 7th graders who participated in the LSAY study in 1987, was used here. Further, data from these students' parents also were included in the sample.

Table 1.

Demographics of Children and Family Characteristics

Characteristic	M	SD
Child		
Child age	13.44	0.69
	%	N
Gender		
Male	52.0	1621
Female	48.0	1495
Race		
Caucasian	73.2	2166
Hispanic American	9.6	284
African American	11.8	349
Asian American	3.8	112
Native American	1.6	47
Family		

Parents' highest education		
Less than high school diploma	8.0	246
High school diploma	46.5	1420
Some college	14.2	433
Four-year college degree	16.7	510
Advanced degree	14.6	447
Current marital status		
Married	77.8	1929
Widowed	2.7	66
Divorced	12.3	306
Never married	4.3	106

The average age of the children in cohort II was 13.44 (*SD* = 0.69) years, with 1,495 (48.0%) female and 1,621 (52.0%) male students. The sample included 9.6% (*N* = 284) Hispanic Americans, 11.8% (*N* = 349) African-Americans, 73.2% (*N* = 2,166) Caucasians, 3.8% (*N* = 112) Asian-Americans, and 1.6% (*N* = 47) Native Americans. Children's family characteristics indicated that the majority (46.5%) of the sample parents' highest educational attainment was a high school diploma (*N* = 1,420); 30.9% (*N* = 943) had a four-year college degree or some college degree; 14.6% (*N* = 447) had an advanced degree, and 8.0% (*N* = 246) had less than a high school diploma. 77.8% (*N* = 1,929) of the families were married and 12.3% (*N* = 306) were divorced. Table 1 presents a summary of the characteristics of the sample children and their families.

Measures

Parents' Educational Expectations

Parents' educational expectations reflect their anticipation of their children's school performance and educational attainment (Froiland, Peterson, & Davison, 2012). The LSAY measured parents' educational expectations with three items that accessed children's perceptions of whether their parents expected them to (1) “complete college,” (2) “do well in science,” and (3) “do well in math.” The first item was consistent with a prior study (Wilder, 2014) that measured parents’ general expectations for their children’s education, and reflected parents’ anticipation of “how much” education their children would obtain. The other two items reflected parents’ subject-specific expectations, as used in prior studies (Ing, 2014; Phillipson, 2009) that quantified a child’s academic capabilities in a specific subject (Yamamoto & Holloway, 2010). Given that the LSAY focused only on tracking youths’ math and science development, the items that measured parents’ subject-specific expectations included only their expectations of children’s math and science performance. Responses for these three items were based on a 2-point scale that ranged from 0 (not checked) to 1 (checked). These data were collected in the LSAY study at the beginning of the 7^{th} grade (fall semester in 1987).

Parent-Child Communication

The measure of parent-child communication reflects the frequency with which parents and children have conversations about children’s school experiences, including school activities and other academic issues. Students were asked to respond to these items at the beginning of the 7^{th} grade. Four items were selected from the LSAY dataset, including the communication between parents and children about “children’s school progress,” “future plans,” “homework,” and “science or technical issues in which students are interested.” Responses were based on a 3-point scale that ranged from 1 (often) to 3 (never). These items were selected based on previous studies that measured parent-child communication (Bumpus & Hill, 2008; Lee, 2010; Tang et al., 2015) and assessed the frequency with which parents and children had conversations about children’s school experiences, performance, classes, or educational goals. The items were recoded to maintain scale consistency, with a higher index score representing more frequent conversations between parents and children. The internal consistency of parent-child communication reported in previous literature (Bumpus & Hill, 2008; Lee, 2010; Tang et al., 2015) ranged from 0.73 to 0.86 among students in elementary and middle school.

Children's Perceived Academic Competence

Based on the definition of perceived academic competence used in prior studies (Altermatt & Pomerantz, 2003; Hong, Yoo, You & Wu, 2010), the measure of this variable reflects children's perception of their academic skills or competence in science, given that the study focused on children's science achievement. In a previous study, Harter (1982) measured perceived academic competence using the items "I am good at schoolwork," "I understand what I read," and "I like school and do well" (Harter, 1982). Other researchers (Marsh, Craven, & Debus, 1999) measured students' perceived academic competence by asking them whether they were successful academically, enjoyed learning, and found work to be easy in different school subjects. Building upon Harter's (1982) and Marsh, Craven, and Debus' (1999) studies, six items from the LSAY dataset were used: "I enjoy science," "I am good at science," "I usually understand science," "Science makes me nervous," "I worry about science test grades," and "I am scared when I open the science book." Students were asked to respond to these items at the beginning of the 7^{th} grade. Responses were recorded on a 5-point scale that ranged from 1 (strongly disagree) to 5 (strongly agree). Three items, "Science makes me nervous," "I worry about science test grades," and "I am scared when I open the science book" were recoded to maintain consistency within the measure of perceived academic competence. A higher index score represented a higher level of perceived science competence.

Academic Effort

Academic effort measures the intensity of students' behavioral investment and their commitment to meet academic requirements in the face of challenging or difficult tasks (Sarrazin, Roberts, Curry, Biddle, & Jean-Pierre, 2002; Stewart, 2008). The item selection was based on Trautwein, Ludtke, Roberts, Schnyder, and Niggli's study (2009). Trautwein et al. (2009) measured academic effort using the following sample items: "I always try to complete my mathematics homework," "Even if my mathematics homework is difficult, I do not give up quickly," and "I did my best to answer all of the questions." These items demonstrated good internal consistency of 0.78 to 0.84 among adolescents with an average age of 14.72 years old (8^{th} grade: Trautwein et al., 2009). Based on the definition of academic effort in this study, as well as Trautwein et al's (2009) sample items, six items from the LSAY dataset were chosen, including "I work on tough problems until I get the answer right," "I would rather keep struggling with a problem than give up on it before I get the answer right," "I give up when I don't understand a problem right away," "I try hard to do my best in school," "I put off studying as long as I can," and "I try harder if I get bad grades." In the LSAY dataset, students were asked to respond to these items at the beginning of the 7^{th} grade. Responses were measured on a 5-point scale that ranged from 1 (never) to 5 (always). Some items (e.g., "I give up when I don't understand a problem right away," "I put off studying as long as I can") to maintain consistency, with a higher index score representing a higher level of academic effort required recoding.

Science Achievement

The LSAY administered a cognitive test as a measure of students' science achievement using the items developed by the National Assessment of Educational Progress (NAEP, 1986a,b). The science test covered three areas: biological, physical, and environmental science. Students' test scores were adjusted using the Item Response Theory (IRT) method across the two cohorts to produce accurate estimates and maintain the ability to make comparisons across cohorts. As was suggested by the LSAY researchers, children's IRT science scores were used here as the indicator of their science achievement. Because the IRT method transforms raw scores into standard scores, these scores normally are computed with a mean of zero and a standard deviation of one, which resulted in the assignment of a negative score to approximately half of the students (Miller, 2014). Therefore, the range of students' science achievement may contain negative values.

Covariates

Parental educational attainment. The LSAY collected the information available from mothers' and fathers' self-reports of their educational attainment and created a new composite variable that described their highest level of education. Responses were based on a 5-point scale of 1 (less than a high school diploma); 2 (high school diploma); 3 (some college); 4 (four-year college degree), and 5 (advanced degree).

Family structure. Family structures were measured with parents' self-reports of their marital status. Either the mother or father in the family was asked about their current marital status: married, divorced, or separated. For analytical purposes, a dummy variable was created here to represent incomplete or intact families by recoding the variable as married (0 = other status, 1 = yes).

Analysis

Preliminary Analysis

Before the main analysis, preliminary analyses were required to determine data quality, sample characteristics, and perform assumption checks for further analysis. Preliminary analysis included detecting missing values, checking normality, assessing the constructs' reliability, and computing descriptive statistics for overall and between-group analyses.

Missing data. First, the data were checked for completeness, as missing data can introduce a potential bias in parameter estimations and affect the results significantly (e.g., statistical power may decrease and standard error may increase: Dong & Peng, 2013). The traditional way to address missing data involves performing a complete-case analysis with listwise deletion, an available case analysis with pairwise deletion, and a single-value imputation with mean replacement. However, these methods are believed to generate biased parameter estimates (Rubin, 1987; Schafer 1997) and should be applied only when the study contains a relatively low proportion of missing data (i.e., less than 5%). Given that items that measured children's perceived academic competence included a large proportion of missing data (36-37%), these traditional methods were not applicable in this study.

Instead, the method of multiple imputation (MI) was used to address missing data. MI is a model-based method that generates several possible values for each missing observation in the data and obtains a parallel completed dataset (Pigott, 2001). This method allows researchers to use the cases available fully to predict the missing values and provides the least biased estimates (Little & Rubin, 2002; Widaman, 2006). Before conducting MI to address missing values, it was necessary to perform a missing pattern analysis to detect whether the assumption necessary to perform data imputation held. If this assumption held—data are missing at random (MAR)—held, an MI with a regression method was performed using Amos 23.0.

Next, a sensitivity analysis was conducted with a series of simple *t*-tests of the mean differences between the groups with missing data and the complete data using MI (Pigott, 2001; Tabachnick & Fidell, 2012). Proceeding in this way, one should obtain insignificant results from the comparison tests, which indicate that the data distributions were unaffected by the use of the MI method.

Normality check. An assumption of multivariate normality is the basic requirement for the subsequent analysis of parameter estimation in structural equation modeling (SEM). Therefore, the normality among variables was assessed following the method of West, Finch, and Curran (1995), which has been used commonly in other studies (Hong & Ho, 2005; Hong et al., 2010; Keith et al., 1998), and the kurtosis and skewness coefficients for each variable were examined. According to Bryne (2010), the kurtosis value should be less than 7 and the skewness value less than 2, as the results may be distorted if this normality assumption is violated severely.

Factor analysis and constructs' reliability. Exploratory factor analyses (EFAs) were conducted using SPSS to identify the number of constructs and underlying factor structures for each. The expected constructs included parents' educational expectations, parent-child communication, children's perceived academic competence, and children's academic effort. The Cronbach value was computed to measure the internal consistency of each construct derived from factor analysis.

Descriptive analysis. To obtain a better understanding of the sample characteristics for the data pattern overall, descriptive statistics were used to calculate the means, standard deviations, and ranges of the main variables. Next, Pearson's correlation analysis was conducted among the study variables to obtain their intercorrelations, after which a series of independent *t*-tests and ANOVAs were performed to determine the variations in the main study variables between child's gender (male vs. female) and among racial/ethnic groups (Caucasian, African American, Hispanic American, and Asian American).

Main Analysis

Three primary objectives were addressed: (a) the direct and indirect associations between parents' educational expectations and children's science achievement via children's perceived academic competence and academic effort; (b) the direct and indirect associations between parent-child communication and children's science achievement via children's perceived academic competence and academic effort, and (c) the roles of gender and race/ethnicity in the associations between parents' educational expectations, parent-child communication, and science achievement via children's perceived academic competence and academic effort. To achieve these three objectives, SEM with structural regression modeling was applied to test the model hypothesized and answer the research questions.

Structural regression model. A structural regression model was employed first to explore the relations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and their science achievement in the model hypothesized. As Figure 1 indicates, parental educational expectations and parent-child communication served as the predictor variables that were hypothesized to correlate with children's science achievement both directly and indirectly through their perceived academic competence and academic effort. The maximum likelihood (ML) technique, which is used widely in the literature, was used to estimate the parameters (Nokali et al., 2010; Plunkett et al., 2009). This method allows researchers to take full advantage of the data because all cases observed can be calculated in the estimation function of ML (Little & Rubin, 2002). Each hypothesis was tested by examining the corresponding fit to the model.

To evaluate the model fit, several model fit indices were used to test whether the current sample supported the model hypothesized, including the goodness-of-fit index (Hu & Bentler, 1999; Schreiber, Nora, Stage, Barlow, & King, 2006) with Chi-square and its corresponding *p*-value, the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). However, given Chi-square's sensitivity in large samples (Hu & Bentler, 1999), model fit indices that are less sensitive to sample size, the normed fit index (NFI) and Tucker-Lewis Index (TLI: Hu & Bentler, 1999), also were reported. Hu and Bentler (1999) suggested that a RMSEA less than 0.05, a CFI of 0.95 or greater, an NFI of 0.95 or greater, and a TLI of 0.95 or greater indicate that the model provides a reasonable fit to the data.

The mediation model. As Figures 4 and 5 illustrate, the mediating roles of children's perceived academic competence and academic effort in the associations between parents' educational expectations, parent-child communication, and science achievement were tested. Specifically, two sets of indirect associations were tested. The first was indirect associations between parents' educational expectations and children's science achievement through perceived academic competence and academic effort (Figure 4), while the second was indirect associations between parent-child communication and children's science achievement through perceived academic competence and academic effort (Figure 5). Three pathways were tested in each set of indirect associations, including those through perceived academic competence and academic effort, and through perceived academic competence, which, in turn, is associated with academic effort.

To illustrate the analysis better, paths a_1, a_2, a_3 b_1, and b_2 in Figure 4, and a_3, a_4 a_5, b_3, and b_4 in Figure 5 were denoted as the path coefficients. The value of $a_n \times b_n$ indicated an indirect effect. The pathways for the first set of indirect associations between parents' educational expectations and children's science achievement can be described as follows:

Pathway 1: parents' educational expectations → perceived academic competence → science achievement is denoted as $a_1 \times b_1$;

Pathway 2: parents' educational expectations → academic effort → science achievement is denoted as $a_2 \times b_2$, and

Pathway 3: parents' educational expectations → perceived academic competence → academic effort → science achievement is denoted as $a_1 a_3 b_2$.

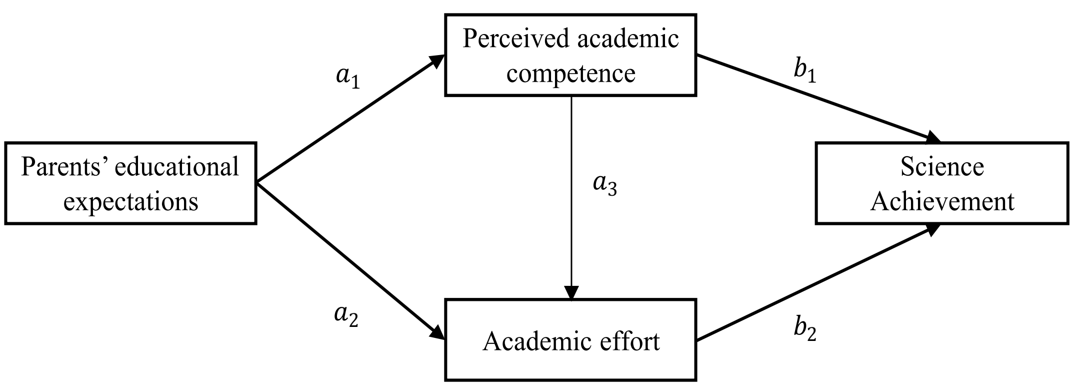

Figure 4. Indirect associations between parents' educational expectations and children's science achievement via their perceived academic competence and academic effort

The pathways for the second set of indirect associations between parent-child communication and children's science achievement were described as follows:

Pathway 1: parent-child communication → perceived academic competence → science achievement is denoted as $a_3 \times b_3$;

Pathway 2: parent-child communication → academic effort → science achievement is denoted as $a_4 \times b_4$, and

Pathway 3: parent-child communication → perceived academic competence → academic effort → science achievement is denoted as $a_3 a_5 b_4$.

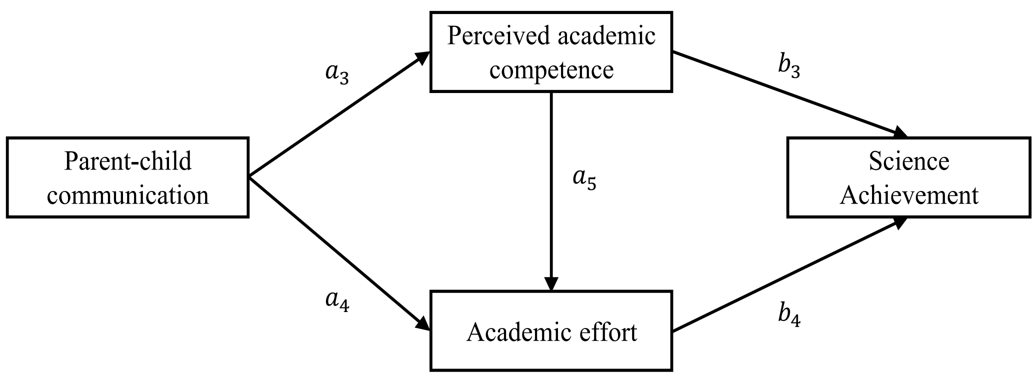

Figure 5. Indirect associations between parent-child communication and children's science achievement via their perceived academic competence and academic effort

Preacher and Hayes' (2008) suggestion to apply a bootstrapping approach to examine the 95% confidence intervals as the criteria to determine the significance of indirect effects was followed. Simulations have shown that the bootstrapping method with bias-corrected intervals is one of the most valid and powerful methods to test mediation effects (MacKinnon et al., 2004; Preacher & Hayes, 2008; Williams & Mackinnon, 2008).

The moderated model. The moderated models were used to test the moderating roles of children's gender and race/ethnicity on the associations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and children's science achievement. A multi-group analysis with SEM was performed to make model comparisons across groups. These moderated models determined whether there was a significant difference in the associations among parents' educational expectations, parent-child communication, and children's perceived academic competence and academic effort between genders and across racial/ethnic groups.

Chapter 5: Results

This chapter presents the results of the preliminary and main analyses, and is organized as follows: (1) Missing value analysis; (2) Normality check of model variables; (3) Factor analysis and reliability of constructs; (4) Descriptive statistics of main constructs, and (5) Structural regression model evaluation and hypothesis testing.

Missing Value Analysis

Given that missing data may introduce bias in parameter estimation (Dong & Peng, 2013), a series of missing value analyses was conducted to maintain maximal completeness and accuracy of the data. Specific procedures included: (1) missing pattern analysis; (2) missing data imputation, and (3) sensitivity analysis.

Missing pattern analysis. Little's MCAR test (1988) was performed using SPSS 23.0 to analyze the missing pattern of the data. The results indicated that the missing data were not missing completely at random (MCAR: $\chi 2 = 2649.44$, $df = 1948$, $p < 0.001$). Thereafter, a separate variance *t*-test was used to test whether the missing pattern was missing at random (MAR). The test yielded significant results in the relations between large-scale missing items (e.g., items of perceived academic competence) and other items (Table 2). These results suggested that the missing variables can be explained by other variables observed, which fulfilled the assumption requirement to perform multiple imputation.

Table 2.

Separate Variance T-Test for Each Item in the Constructs

Variables		PEE_1	PEE_2	PEE_3	PCC_1	PCC_2	PCC_3	PCC_4	PCC_5	PCC_6	AE_1	AE_2	AE_3	AE_4	SA
CPAC_1	*t*	3.2	2.7	2.3	-2.9	2	-1.9	-0.2	0.6	-1.7	-1.8	5	6.9	-2.9	11.6
	df	2294.8	2347.7	2316.4	2256.4	2235.8	2161.7	2213.6	2215.5	2199.8	2023.3	2060.3	1956.8	2094.6	2323.1
	p (2-tailed)	0.002	0.006	0.021	0.004	0.041	0.054	0.841	0.566	0.088	0.065	0	0	0.004	0
CPAC_2	*t*	3.1	2.7	2.5	-3	1.8	-1.9	-0.2	0.4	-1.7	-2.2	4.9	6.8	-2.8	11.6
	df	2317.5	2368.6	2332.8	2272.9	2256	2185	2232.2	2226.5	2225.4	2040.5	2085.6	1988.8	2119.6	2344.7
	p (2-tailed)	0.002	0.008	0.014	0.003	0.079	0.058	0.814	0.694	0.082	0.03	0	0	0.004	0
CPAC_3	*t*	3.2	2.5	2.4	-3	1.8	-2.1	-0.2	0.6	-1.4	-2.2	4.8	6.9	-2.8	11.6
	df	2339	2396.8	2360.5	2295.1	2284.7	2212.8	2257.7	2257.6	2256.4	2061.4	2115.7	2004.8	2146.7	2371.4
	p (2-tailed)	0.001	0.014	0.017	0.003	0.07	0.038	0.83	0.581	0.167	0.03	0	0	0.005	0
CPAC_4	*t*	3	2.7	2.3	-2.5	2.1	-1.7	-0.2	0.5	-1.5	-2.1	5.5	6.9	-2.8	11.5
	df	2367.1	2416.5	2384.5	2327.9	2294.7	2218	2259.8	2269.6	2265.1	2098.9	2101.4	2032.6	2177.6	2398.6
	p (2-tailed)	0.003	0.006	0.019	0.012	0.036	0.083	0.872	0.593	0.123	0.038	0	0	0.005	0
CPAC_5	*t*	3.3	2.8	2.3	-2.9	1.9	-2	-0.2	0.5	-1.9	-2	5	6.9	-2.6	11.6
	df	2328.4	2384.6	2354.1	2295.4	2271	2197.7	2243.8	2239.7	2232.7	2059.3	2090.2	1994.8	2134.7	2357.8
	p (2-tailed)	0.001	0.006	0.021	0.004	0.061	0.047	0.877	0.592	0.062	0.046	0	0	0.008	0
CPAC_6	*t*	3	2.5	2.1	-2.8	1.9	-1.9	0	0.4	-1.7	-2.2	5.3	7	-2.9	11.6
	df	2331.7	2382.4	2353.5	2283.8	2260.8	2191.7	2228.6	2236.6	2222.6	2048.8	2072.9	1990	2125.8	2351.6
	p (2-tailed)	0.003	0.014	0.035	0.006	0.062	0.064	0.991	0.696	0.08	0.031	0	0	0.003	0

Note. CPAC represents children's perceived academic competence, PEE parents' educational expectations, PCC parent-child communication, AE academic effort, and SA science achievement. The number indicates the item number of the construct, for example, CPAC_1 refers to the first item of children's perceived academic competence.

Missing data imputation. Based on the previous missing pattern analysis, multiple imputation (MI) was performed with a regression method using Amos 23.0. Amos provides one completed dataset in a single file with ten completed datasets stacked. According to Rubin (1987), five to ten completed data files generally are sufficient to obtain accurate parameter estimates and standard errors. Next, a sensitivity analysis was performed to assess the effect of approaches that address missing data statistics (Pigott, 2001).

Sensitivity analysis. Pigott (2001) suggested examining data sensitivity by comparing descriptive statistics of missing data and complete data. In this case, the mean differences were compared between missing data and complete data using MI to detect whether the descriptive data values were affected by the way MI addresses missing values. As Table 3 shows, the analysis presented the descriptive statistics of data with and without missing values with a two-sample *t*-test. There was no significant difference in the descriptive statistics (i.e., means and standard deviations) between data with and without missing values, an indication that the descriptive statistics in this dataset were not affected by the use of the MI method.

Table 3.

Descriptive Statistics for Comparison Between Data with and without Missing Values

Variables	Missing Percentage N(%)	Data with Missing Values N	Mean	SD	Completed Data Without Missing Values N	Mean	SD	Comparison Statistic Between with and without Missing Values: Mean difference	SE (Mean diff)	*t* (df)	*p*-value	95% CI
Parents' Educational Expectations												
Item 1	9 (0.3%)	3107	0.69	0.47	3116	0.69	0.47	0.00	0.01	0.00(6221)	1.00	[-0.02, 0.02]
Item 2	9 (0.3%)	3107	0.59	0.49	3116	0.59	0.49	0.00	0.01	0.00(6221)	1.00	[-0.02, 0.02]
Item 3	9 (0.3%)	3107	0.69	0.47	3116	0.69	0.46	0.00	0.01	0.00(6221)	1.00	[-0.02, 0.02]
Parent-child Communication												
Item 1	45 (1.4%)	3071	2.42	0.59	3116	2.42	0.60	0.00	0.02	0.00(6185)	1.00	[-0.03, 0.03]
Item 2	71 (2.3%)	3045	1.99	0.65	3116	1.98	0.65	0.01	0.02	0.60(6159)	0.55	[-0.02, 0.04]
Item 3	74 (2.4%)	3042	2.34	0.63	3116	2.33	0.63	0.01	0.02	0.62(6156)	0.53	[-0.02, 0.04]
Item 4	127 (4.1%)	2989	1.52	0.66	3116	1.51	0.67	0.01	0.02	0.59(6103)	0.56	[-0.02, 0.04]
Children's Perceived Academic Competence												
Item 1	1145 (36.7%)	1971	3.33	1.19	3116	3.32	1.21	0.01	0.04	0.29(5085)	0.77	[-0.06, 0.08]
Item 2	1152 (37%)	1964	3.43	1.05	3116	3.41	1.08	0.02	0.03	0.65(5078)	0.52	[-0.04, 0.08]
Item 3	1161 (37.3%)	1955	3.46	1.04	3116	3.46	1.07	0.00	0.03	0.00(5069)	1.00	[-0.06, 0.06]
Item 4	1169 (37.5%)	1947	3.52	1.05	3116	3.52	1.06	0.00	0.03	0.00(5061)	1.00	[-0.06, 0.06]
Item 5	1158 (37.2%)	1958	2.60	1.12	3116	2.62	1.13	-0.02	0.03	-0.62(5072)	0.54	[-0.08, 0.04]
Item 6	1156 (37.1%)	1960	3.52	1.06	3116	3.53	1.07	-0.01	0.03	-0.33(5074)	0.75	[-0.07, 0.05]
Academic Effort												
Item 1	150 (4.8%)	2966	3.41	1.15	3116	3.41	1.16	0.00	0.03	0.00(6080)	1.00	[-0.06, 0.06]
Item 2	115 (3.7%)	3001	3.58	1.12	3116	3.58	1.13	0.00	0.03	0.00(6115)	1.00	[-0.06, 0.06]
Item 3	108 (3.5%)	3008	3.91	0.95	3116	3.90	0.95	0.01	0.02	0.41(6122)	0.68	[-0.04, 0.06]
Item 4	87 (2.8%)	3029	4.33	1.10	3116	4.33	1.10	0.00	0.03	0.00(6143)	1.00	[-0.06, 0.06]
Item 5	114 (3.7%)	3002	4.23	1.04	3116	4.23	1.05	0.00	0.03	0.00(6116)	1.00	[-0.05, 0.05]
Item 6	124 (4.0%)	2992	3.49	1.13	3116	3.49	1.14	0.00	0.03	0.00(6106)	1.00	[-0.06, 0.06]
Science Achievement	45 (1.4%)	3071	0.00	1.00	3116	0.00	1.00	0.00	0.03	0.06(6185)	0.95	[-0.05, 0.05]

Note. The completed data were obtained by MI with regression estimation

Normality Check of the Model Variables

Given that in the subsequent analysis of model fit, parameter estimation and standard errors can be affected strongly by skewed data, skewness and kurtosis statistics were performed to assess the normality among variables (West, Finch & Curran, 1995). Table 4 presents the skewness and kurtosis values for the main variables in the study. As Table 4 shows, the kurtosis coefficients were less than 7 and the skewness coefficients were less than 2, indicating that the normality assumption was not violated (Bryne, 2010).

Table 4.

Skewness and Kurtosis Values for Items in the Study

Variable	Skewness	Kurtosis
Parents' Educational expectations		
Item 1	-0.80	-1.36
Item 2	-0.37	-1.86
Item 3	-0.81	-1.35
Parent-child Communication		
Item 1	-0.49	-0.66
Item 2	0.01	-0.65
Item 3	-0.40	-0.68
Item 4	0.93	-0.31
Children's Perceived Academic Competence		
Item 1	-0.41	-0.90
Item 2	-0.55	-0.48
Item 3	-0.66	-0.33
Item 4	-0.51	-0.53
Item 5	0.52	-0.67
Item 6	-0.54	-0.45
Academic Effort		
Item 1	-0.39	-0.72
Item 2	-0.55	-0.44
Item 3	-0.76	0.40
Item 4	-1.74	2.22
Item 5	-1.34	1.12
Item 6	-0.45	-0.48
Science Achievement	0.20	-0.46

Factor Analysis and Reliability of Constructs

First, an EFA was conducted in SPSS using the method of principal component factor analysis with varimax rotation for the parent's involvement practices items. The Kaiser-Meyer-Olkin test (KMO) value was 0.63 (> 0.50) and Bartlett's test of sphericity was significant ($p < 0.000$) for items in parents' involvement practices, indicating that there was a sufficient correlation among items to conduct factor analysis. Varimax rotation, which offers the ability to interpret the factors well, was chosen because the orthogonal solution of varimax does not allow high correlations among factors (Hair et al., 2006). The number of factors was determined using the criterion of an eigenvalue greater than 1.00 (Kaiser, 1960). Two constructs in parents' involvement practices (i.e., parents' educational expectations and parent-child communication) emerged.

Based on the factor analysis, no item was dropped because of weak (i.e., < 0.40; Stevens, 2002) or double loadings. The two factors explained 31.94% and 22.11% of the total variance in parental involvement, respectively. Table 5 presents the factor loadings for parents' educational expectations and parent-child communication. Next, a reliability analysis of parents' educational expectations and parent-child communication was conducted. The Cronbach's alpha for the three items of parents' educational expectations was 0.68 and for the four items of parent-child communication was 0.63. Thus, the internal consistency of the two factors was acceptable (> 0.60: Kline, 1998).

Table 3.

Rotated Component Matrix—Parents' Educational expectations and Parent-Child Communication

	Factors	
Parents' Educational expectations	1	2
Parents expect me - do well in math	0.90	
Parents expect me - do well in science	0.89	
Parents expect me - college degree	0.51	
Parent-Child Communication		
Parent-child talk about school progress		0.72
Parent-child talk about future plans		0.72
Parent-child talk about homework		0.67
Parent-child talk about science or technology issues		0.60

In parents' educational expectations, the first item "Parents expect me to do well in math" was correlated highly with the second item "Parents expect me to do well in science" (r = 0.71). Although three items were used to represent parents' educational expectations, the underlying factor structure from the perspective of interpretation (i.e., conceptual sense) suggested that the first two should be combined to represent parents' expectations of their children's study in a specific subject, referred to as *parents' subject-specific expectation*. The item "Parents expect me to reach college degree" represents parents' general expectation of children's educational trajectory, referred to as *parents' general educational expectations*. Next, the Cronbach's value for the two-item construct of parents' subject-specific expectation was computed as well, which was 0.83. The two items were averaged to create a composite score to construct a scale for parents' subject-specific expectation. Parents' educational expectations was treated as a latent variable with the two indicators of parents' subject-specific expectation and parents' general educational expectations. For parent-child communication, a composite score was calculated by averaging the responses across the four items.

The same factor analysis was applied to identify the constructs of children's perceived academic competence and academic effort. The KMO value was 0.73 (> 0.50) and Bartlett's test of sphericity was significant ($p < 0.000$) for items that measured children's perceived academic competence and academic effort. The varimax rotation method indicated that two factors, *children's perceived academic competence* and *academic effort*, emerged. Based on the factor analysis results, one item ("I worry about my science test grades") was dropped because of a low factor loading value (< 0.40: Stevens, 2002). The two factors explained 25.41% and 15.95% of the total variance, respectively. Table 6 presents the factor loadings for children's perceived academic competence and academic effort. Reliability analyses were performed on the factors, and the Cronbach's alpha for perceived academic competence was 0.80 and that for academic effort was 0.61, indicating that the internal consistency of the two factors was acceptable (> 0.60: Kline, 1998). Next, the composite scores for both perceived academic competence and academic effort were calculated by averaging the item scores within each factor.

Table 4.

Rotated Component Matrix-Children's Perceived Academic Competence and Academic Effort

	Factors	
Perceived Academic Competence	1	2
I usually understand science	0.82	
I am good at science	0.81	
I enjoy science	0.73	
Science makes me nervous	0.66	
I am scared when I open science book	0.65	
I worry about science test grades	0.33	
Academic Effort		
I do my best in school		0.65
I won't put off studying		0.59
I won't give up when I don't understand		0.58
I like to keep struggling with problems		0.58
I do not like working on tough problems		0.54
I try harder if I get bad grades		0.51

Thus far, the main constructs have been established. Figure 6 presents the model hypothesized for the main analysis in structural regression model evaluation and hypothesis testing.

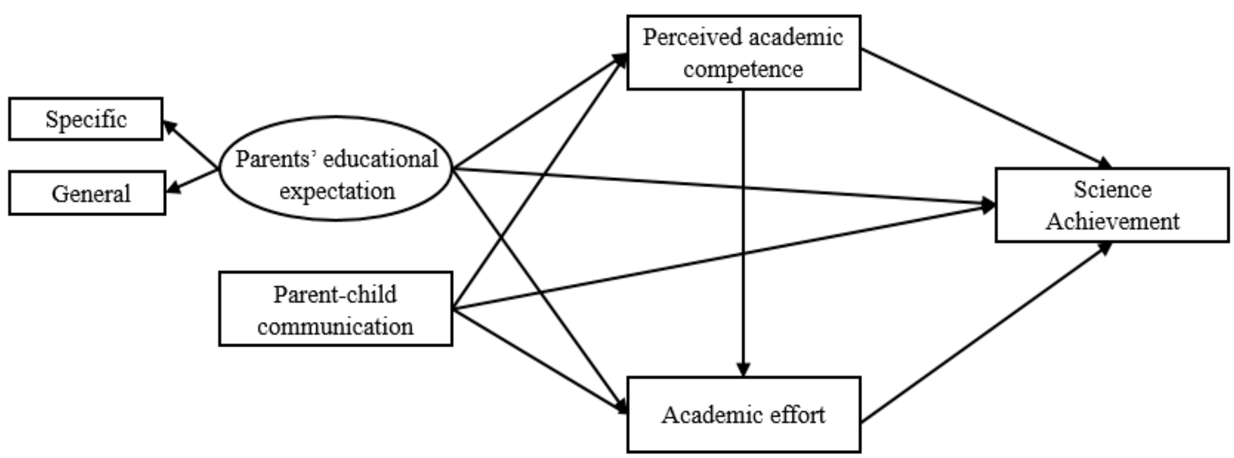

Figure 6. Conceptual model for structural regression model evaluation and hypothesis testing

Before conducting the structural regression model evaluation and hypothesis testing, the following summarizes the descriptive statistics for the main constructs.

Descriptive Statistics for Main Constructs

59.1% (N = 1843) of children indicated that their parents expected them to do well in science, and 68. 6% (N = 2143) reported that their parents expected them to do well in math. 68.5% (N = 2138) stated that their parents expected them to obtain a college degree in future. Parent-child communication on schooling and science-related issues was, on average, 2.07 (SD = 0.43, range 1-3), indicating that they sometimes had conversations about school work or science topics. Children's reports of their perceived academic competence in science were moderately high (3.44, SD = 0.65, range 1-5), while their self-reports of engaging in academic effort was 3.82 (SD = 0.62, range 1-5), indicating a high level of behavioral effort. Children's science achievement showed that the sample of children obtained approximately average science scores (M = 0.00, SD = 1.00).

Gender differences. To understand the sample characteristics better, a series of independent t-tests was performed to explore gender differences in parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and science achievement. Male students (M = 0.06, SD = 1.06) showed significantly higher science achievement than did females (M = -0.07, SD = 0.92, $t_{3103} = -3.80$, $p < 0.001$). According to children's reports, their parents did not demonstrate significant differences in their subject-specific expectations ($t_{3072} = -1.94$, $p > 0.05$) or general educational expectations ($t_{3114} = 0.87$, $p > 0.05$) based on a child's gender, indicating that male and female students' parents may have similar expectations of their math and science performance and college level degree. Parent-child communication was greater among male ($M = 2.09$, $SD = 0.43$) than female students ($M = 2.04$, $SD = 0.43$, $t_{3095} = -2.75$, $p < 0.01$). Further, male students ($M = 3.48$, $SD = 0.61$) reported greater academic competence than did females ($M = 3.40$, $SD = 0.68$, $t_{3008} = -3.29$, $p < 0.01$), while female students ($M = 3.88$, $SD = 0.61$) reported a greater level of academic effort than did males ($M = 3.77$, $SD = 0.64$, $t_{3114} = 4.99$, $p < 0.001$). Table 7 presents a summary of these results.

Table 7.

Gender Difference in the Study Variables

Variables	Male (*N*=1621) M(SD)	Female (*N*=1495) M(SD)	Mean difference	*t*(*df*)
Parents' subject-specific expectations	0.65(0.43)	0.62(0.45)	-0.03	-1.94(3072)
Parents’ general educational expectations	0.68(0.47)	0.69(0.46)	0.01	0.87(3114)
Parent-child communication	2.09(0.43)	2.04(0.43)	-0.04	-2.75(3095)**
Perceived academic competence	3.48(0.61)	3.40(0.68)	-0.08	-3.29(3008)**
Academic effort	3.77(0.64)	3.88(0.61)	0.11	4.99(3114)***
Science achievement	0.07(1.06)	-0.07(0.92)	-0.14	-3.81(3056)***

Note. **$p < 0.01$, ***$p < 0.001$ (two-tailed)

Race/ethnic group differences. A series of ANOVAs with post-hoc analysis with a series of multiple pairwise tests (Bonferroni) was conducted to determine race/ethnic group differences in the study variables across Caucasian (N =2166), African American (N =349), Hispanic American (N =284), and Asian American (N =112) groups. The ANOVAs indicated a significant difference in parents’ subject-specific ($F_{4,2953} = 4.23$, $p < 0.01$) and general educational expectations ($F_{4,2953} = 4.48$, $p < 0.01$). Parent-child communication also differed significantly across racial/ethnic groups ($F_{4,2953} = 3.27$, $p < 0.05$), as did children’s perceived academic competence ($F_{4,2953}$ = 4.19, $p < 0.01$) and academic effort ($F_{4,2953}$ = 9.43, $p < 0.001$). There also was a significant group difference in science achievement ($F_{4,2953}$ = 74.87, $p < 0.001$). To display explicit group variations in these variables, as well as the pattern of children's science achievement, in associations with parents' educational expectations and parent-child communication and perceived academic competence and academic effort, respectively, across different racial/ethnic groups, the exogenous variable of children's science achievement and all other endogenous variables are plotted in the graphs below. As children's science achievement is a standardized variable with a mean of 0 and standard deviation of 1, each of the exogenous variables was standardized and the standard scales were used in the graphs for the purpose of visualization.

As Figure 7 shows, Asian American (*M* = 0.31, *SD* = 0.99) and Caucasian students (*M* = 0.16, *SD* = 0.97) appeared to exhibit higher science achievement than did Hispanic (*M* = -0.45, *SD* = 0.91) and African American students (*M* = -0.63, *SD* = 0.79) (Figure 7). Asian American parents (*M* = 0.24, *SD* = 0.78) tended to have higher math and science expectations than did the other ethnic groups (Caucasian: *M* = 0.00, *SD* = 0.93, Hispanic American: *M* = -0.18, *SD* = 0.93, African American: *M* = 0.03, *SD* = 0.89), while Hispanic American parents had the lowest. Further, Asian (*M* = 0.22, *SD* = 0.89) and African American parents (*M* = 0.12, *SD* = 0.94) tended to have a higher level of general educational expectations than did Caucasian (*M* = -0.02, *SD* = 0.99) and Hispanic American groups (*M* = -0.12, *SD* = 1.00). Bonferroni pairwise tests indicated that Hispanic American students had lower science achievement scores than did Caucasian (M_{diff}= -0.60, *SE*= 0.06, 95% C.I. = [-0.77, -0.44]) and Asian American students (M_{diff}= -0.76, *SE*= 0.11, 95% C.I. = [-1.06, -0.46]). Similarly, African American students also had lower science achievement scores than did Caucasian (M_{diff}= -0.78, *SE* = 0.05, 95% C.I. = [-0.94, -0.64]) and Asian American students (M_{diff}= -0.95, *SE*= 0.10, 95% C.I. = [-1.24, -0.66]). Science achievement scores did not differ significantly between African and Hispanic American students or between Caucasian and Asian American students.

With respect to parents' subject-specific expectations, Caucasian and Asian American parents had significantly higher math and science expectations than did Hispanic American parents (Caucasian vs. Hispanic American: M_{diff} = 0.18, *SE*= 0.06, 95% C.I. = [0.00, 0.32], Asian American vs. Hispanic American: M_{diff} = 0.39, *SE*= 0.10, 95% C.I. = [0.10, 0.68]). There was no significant difference in the level of parents' subject-specific expectations between African American parents and any other ethnic group, or between Caucasian and Asian American parents. With respect to parents' general expectations that their children should obtain a college degree in their future education, Asian and African American parents had significantly higher expectations than did Hispanic American parents (Asian American vs. Hispanic American: M_{diff} = 0.33, *SE*= 0.11, 95% C.I. = [0.02, 0.64], African American vs. Hispanic American: M_{diff} = 0.24, *SE*= 0.08, 95% C.I. = [0.02, 0.47]). There was no significant difference in the level of parents' general expectations between Caucasian and any other ethnic group or between Asian American and African American parents.

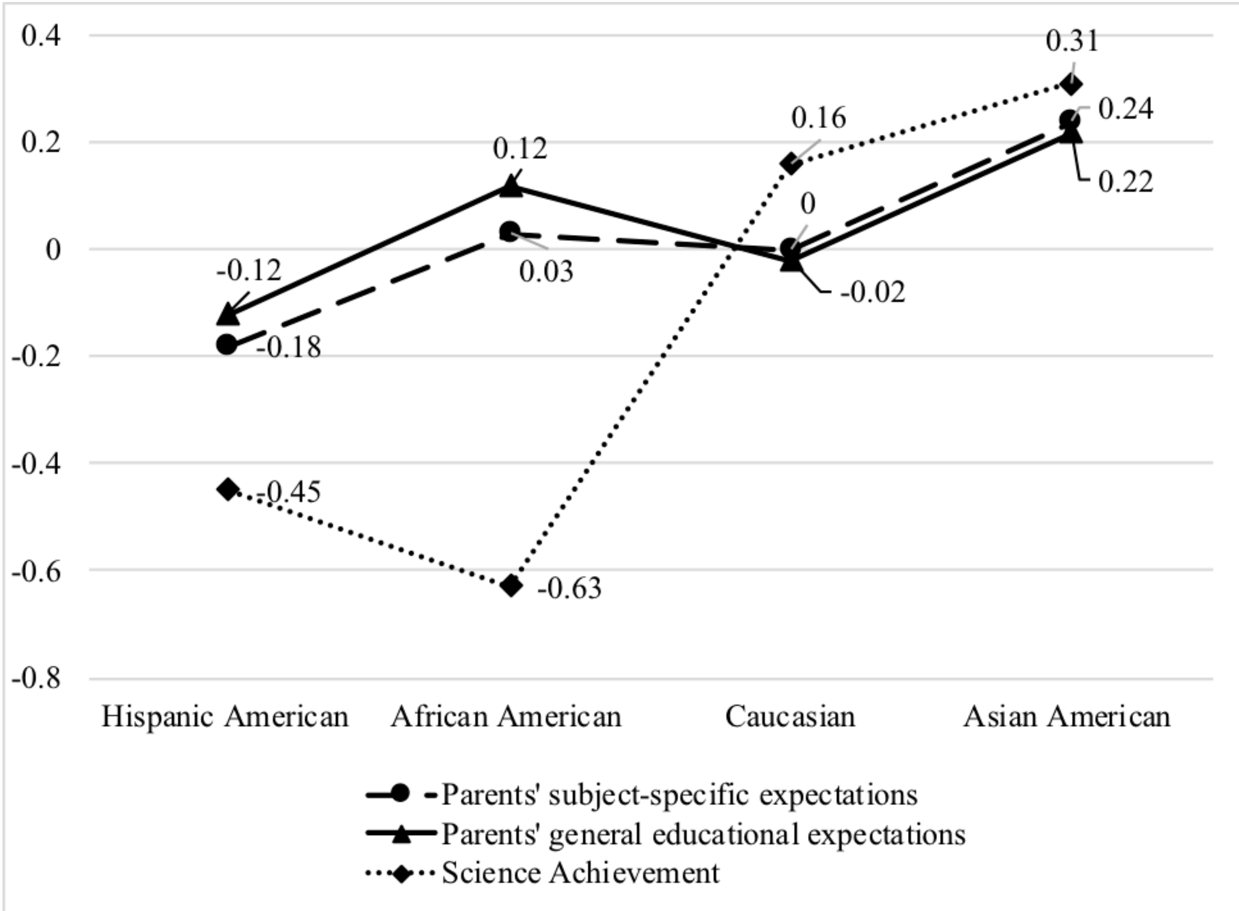

Figure 7. Children’s science achievement and parents’ educational expectations across racial/ethnic groups

Caucasian parents showed a slightly higher level of parent-child communication than did the other three groups (Caucasian: *M* = 0.04, *SD* = 0.68, Asian American: *M* = -0.07, *SD* = 0.66, Hispanic American: *M* = 0.00, *SD* = 0.70, African American: *M* = -0.11, *SD* = 0.68: Figure 8). Bonferroni pairwise tests indicated that there was no significant difference in the level of parent-child communication between Hispanic Americans and any other ethnic group, or between Asian Americans and any other group. Caucasian parents demonstrated a significantly higher level of communication with their children than did African American parents (M_{diff} = 0.15, *SE*= 0.04, 95% C.I. = [0.04, 0.26]).

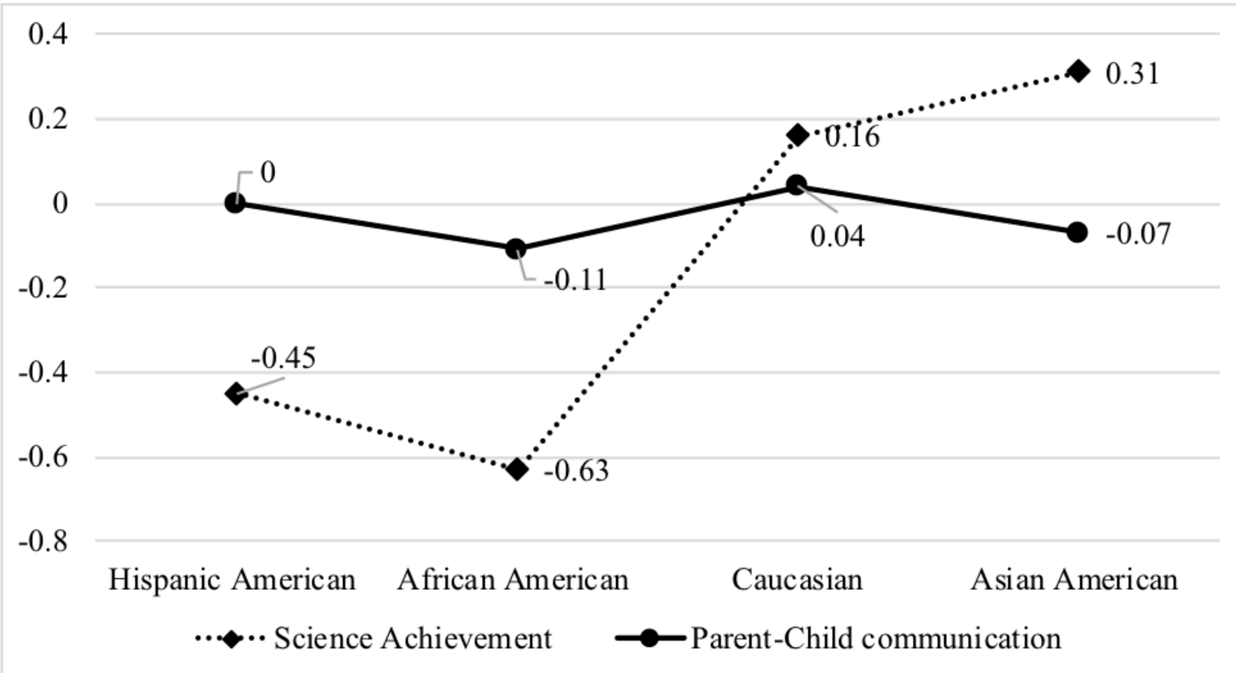

Figure 8. Children's science achievement and parent-child communication across racial/ethnic groups

Figure 9 shows that Asian American children appeared to have the highest level of perceived academic competence among all ethnic groups (Asian American: *M* = 0.07, *SD* = 0.69, Caucasian: *M* = -0.02, *SD* = 0.66, Hispanic American: *M* = -0.09, *SD* = 0.65, African American: *M* = -0.10, *SD* = 0.71). However, Bonferroni pairwise tests showed no significant difference in the level of children's perceived academic competence in a comparison of each pair of racial/ethnic groups.

Figure 9 also shows that African and Asian American children appeared to exhibit a greater level of academic effort than did Hispanic and Caucasian students (African American: *M* = 0.13, *SD* = 0.59, Asian American: *M* = 0.17, *SD* = 0.53, Hispanic American: *M* = -0.07, *SD* = 0.56, Caucasian: *M* = -0.02, *SD* = 0.57). Bonferroni pairwise tests showed that Asian American children invested significantly more academic effort than did Hispanic American and Caucasian children (Asian American vs. Hispanic American: M_{diff} = 0.24, *SE*= 0.06, 95% C.I. = [0.06, 0.42], Asian American vs. Caucasian: M_{diff} = 0.19, *SE*= 0.06, 95% C.I. = [0.04, 0.35]), while African American children invested significantly more academic effort than did Hispanic American and Caucasian children (African American vs. Hispanic American: M_{diff} = 0.20, *SE*= 0.05, 95% C.I. = [0.07, 0.33], African American vs. Caucasian: M_{diff} = 0.16, *SE*= 0.03, 95% C.I. = [0.06, 0.25]). The level of academic effort did not differ significantly between Hispanic American and Caucasian children or between African American and Asian American children.

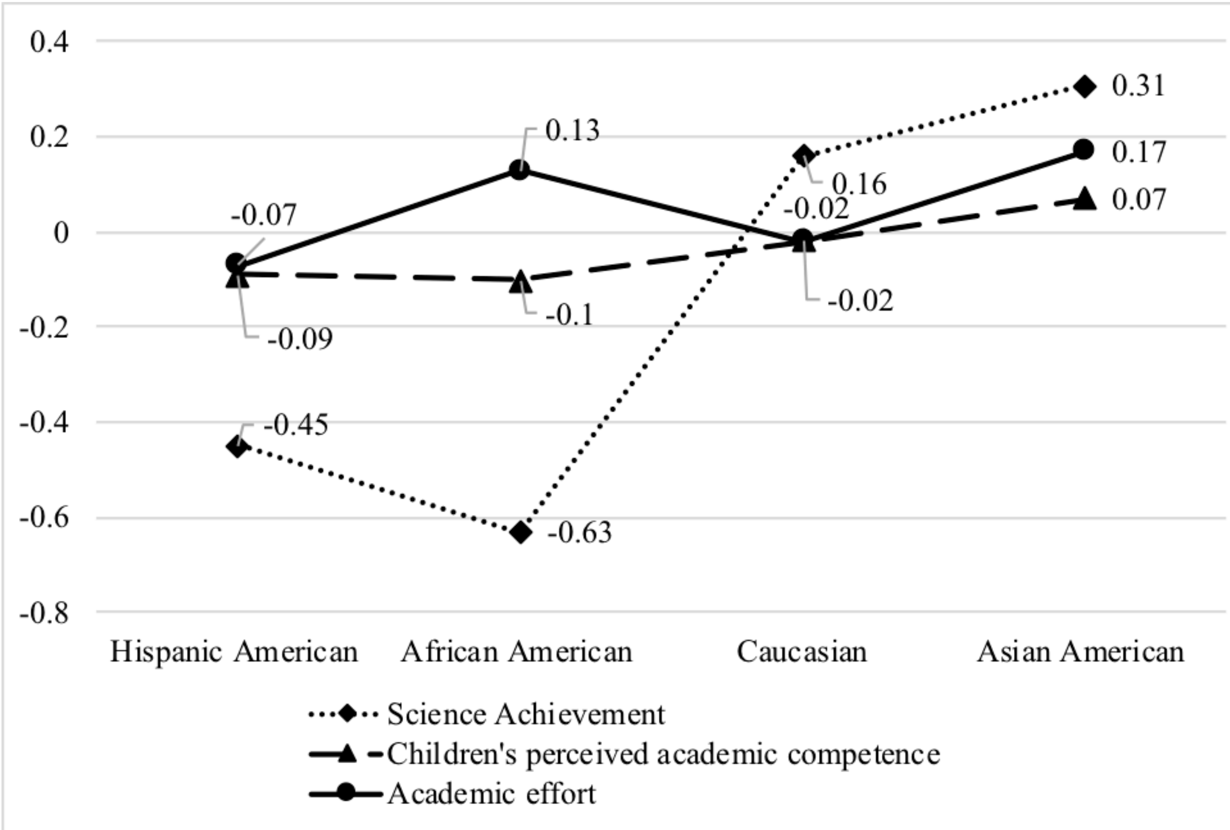

Figure 9. Children's science achievement, and perceived academic competence and academic effort across racial/ethnic groups

Finally, a Pearson correlation test was conducted to detect the binary correlations among the study variables. As Table 8 shows, parents' educational expectations, including their subject-specific expectations in math and science ($r = 0.15$, $p < 0.01$) as well as their general expectations that their children should obtain a college degree ($r = 0.19$, $p < 0.01$) had a significant positive association with children's science achievement. These two types of educational expectations also were associated significantly with children's perceived academic competence and academic effort, in that parents' subject-specific expectations were associated positively both with children's perceived academic competence ($r = 0.08$, $p < 0.01$) and academic effort ($r = 0.10$, $p < 0.01$). Parents' general expectations were associated positively with children's perceived academic competence ($r = 0.10$, $p < 0.01$) and their academic effort ($r = 0.15$, $p < 0.01$). Further, children's perceived academic competence ($r = 0.29$, $p < 0.01$) and academic effort ($r = 0.17$, $p < 0.01$) were associated positively with their science achievement. Parents' marital status was associated positively with children's science achievement ($r = 0.17$, $p < 0.01$), and showed that science achievement tended to be greater in families with married parents. Parents' educational attainment also was associated positively with children's science achievement ($r = 0.28$, $p < 0.01$), which suggests that a higher level of parental educational attainment predicted children's higher science achievement.

Table 5.

Correlation Matrix among the Study Variables

Variables	1	2	3	4	5	6
Parents' subject-specific expectation	-					
Parents' general educational expectations	0.29**	-				
Parent-child communication	0.15**	0.18**	-			
Perceived academic competence	0.12**	0.12**	0.19**	-		
Academic effort	0.10**	0.15**	0.30**	0.20**	-	
Science achievement	0.15**	0.19**	0.12**	0.35**	0.18**	-

Note. $^{**}p < 0.01$ (two-tailed tests).

Structural Regression Model Evaluation and Hypothesis Testing

SEM was used to conduct a structural regression model analysis to assess further the relation between parents' educational expectations, parent-child communication, perceived academic competence and academic effort, and science achievement, and the model hypothesized fit the data well: $\chi 2$ (4, N = 3, 116) = 3.32, $\chi 2/df$ = 0.83, p= 0.51, NFI = 0.99, CFI = 1.00, TLI = 1.00, RMSEA = 0.000, 90% CI [0.000, 0.03]. The model explained 4% of the variance in children's perceived academic competence, 12.7% of the variance in academic effort, and 23% of the variance in science achievement. Research questions 1 and 2 can be answered based on this model.

Research question 1. What are the direct and indirect associations between parents' educational expectations, children's perceived academic competence and academic effort, and children's science achievement?

As Figure 10 shows, parents' educational expectations had a direct positive relation to children's science achievement (β = 0.21, p < 0.001). This confirmed Hypothesis 1a, that higher parental educational expectations are associated with children's greater science achievement. Parents' educational expectations also were associated positively with children's perceived academic competence (β = 0.11, p < 0.001), and perceived academic competence also was associated positively with science achievement (β = 0.22, p < 0.001). The indirect effect of parents' educational expectations on children's science achievement through perceived academic competence was evaluated with a bias-corrected bootstrapping approach with a 95% confidence interval. The results showed that parents' educational expectations were associated indirectly with children's science achievement through perceived academic competence (β = 0.03, 95% CI [0.02, 0.04]), which confirmed Hypothesis 1b. Parents' educational expectations also were related positively to children's academic effort (β = 0.13, p < 0.001), and academic effort was associated positively with science achievement (β = 0.08, p < 0.001). Further, parents' educational expectations also had an indirect effect on children's science achievement through their academic effort (β = 0.01, 95% CI [0.01, 0.02]), which confirmed Hypothesis 1c. Perceived academic competence also was associated positively with children's academic effort (β = 0.09, p < 0.001), and there was a significant indirect effect of parents' educational expectations on children's science achievement through children's perceived academic competence and subsequent academic effort (β = 0.0008, 95% CI [0.000, 0.002]). This result confirmed Hypothesis 1d.

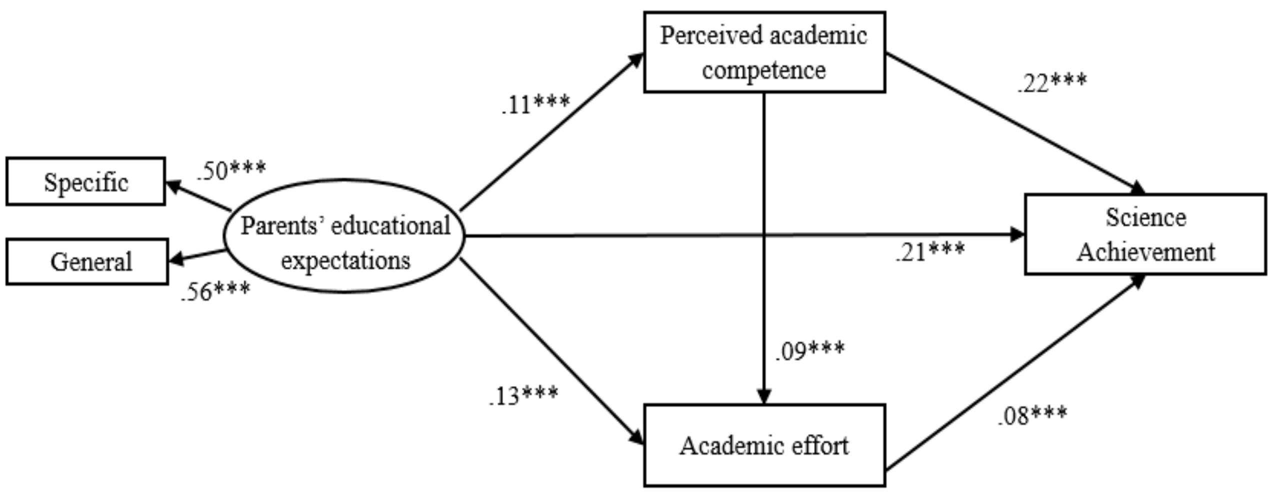

Figure 10. Structural regression model for the direct and indirect associations between parents' educational expectations and science achievement

Research question 2. What are the direct and indirect associations between parent-child communication, children's perceived academic competence and academic effort, and their science achievement?

As Figure 11 shows, contrary to Hypothesis 2a, parent-child communication was not associated significantly with children's science achievement (β = -0.03, p = 0.11). However, parent-child communication was associated positively with children's perceived academic competence (β = 0.10, $p < 0.001$), and perceived academic competence also was associated positively with children's science achievement (β = 0.22, $p < 0.001$). The bias-corrected bootstrapping approach demonstrated a significant indirect effect of parent-child communication on children's science achievement through perceived academic competence (β = 0.02, 95% CI [0.01, 0.03]). These results confirmed Hypothesis 2b, that a higher level of parent-child communication is associated with children's greater perceived academic competence, which in turn, is associated with their higher science achievement. Parent-child communication also was associated positively with children's academic effort (β = 0.26, $p < 0.001$), and academic effort was associated positively with science achievement (β = 0.08, $p < 0.001$). Further, parent-child communication had a significant indirect effect on children's science achievement through their academic effort (β = 0.02, 95% CI [0.01, 0.03]). This result was consistent with Hypothesis 2c, that higher levels of parent-child communication are associated with children's greater level of academic effort, which in turn, is associated with their higher science achievement. Further, the results also indicated that parent-child communication had an indirect effect on children's science achievement through their perceived academic competence and subsequent academic effort (β = 0.0006, 95% CI [0.0002, 0.001]). This result supported Hypothesis 2d.

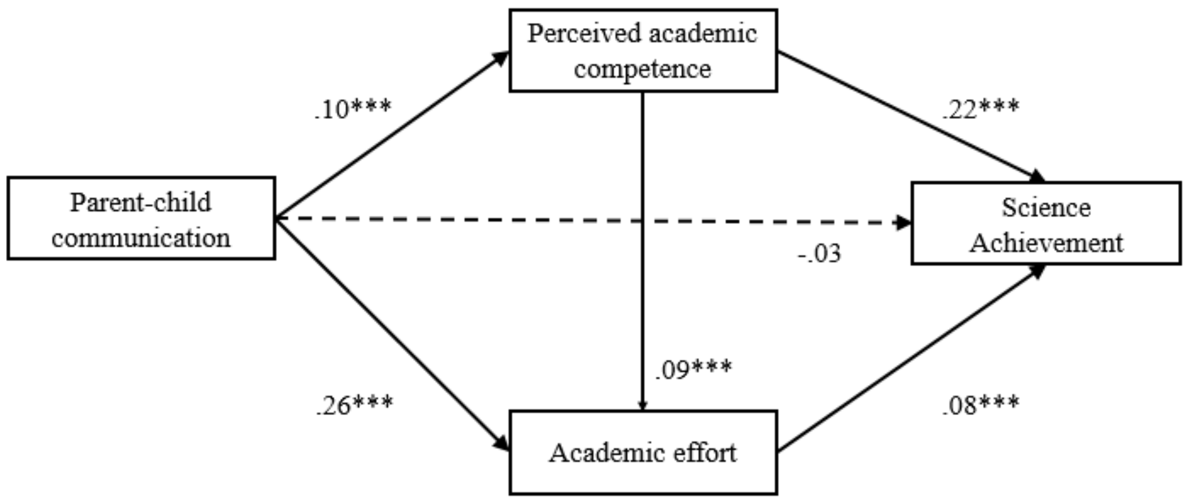

Figure 11. Structural regression model for the direct and indirect associations between parent-child communication and science achievement

Research question 3. Does child's gender moderate the associations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and children's science achievement?

A multi-group analysis was performed with a SEM to examine the gender difference in the structural relations of the model hypothesized. First, the model was fit to male and female samples simultaneously without constraints. The unconstrained model demonstrated a good model fit ($\chi 2$ (10, N = 3, 116) = 8.31, $\chi 2/df$= 0.83, p= 0.60, NFI = 0.99, CFI = 1.00, TLI = 1.00, RMSEA = 0.00, 90% CI [0.00, 0.02]), indicating that the model hypothesized fit for both gender groups. To test gender differences in the structural relations in the model, the prerequisite of measurement invariance was tested first. The model then was fit by constraining the factor loadings to be equal between the gender groups, which showed a good model fit ($\chi 2$ (11, N = 3, 116) = 8.64, $\chi 2/df$= 0.79, p= 0.60, NFI = 0.99, CFI = 1.00, TLI = 1.01, RMSEA = 0.00, 90% CI [0.00, 0.02]). Compared to the unconstrained model fit, the $\Delta\chi 2$ difference test indicated that the model fit did not decrease significantly between genders, suggesting an equal measurement between groups ($\Delta\chi 2$ (1, N = 3116) = 0.33, $p > 0.05$). Based on measurement invariance, the structural paths then were constrained to be equal between the gender groups. The model then was fit again and showed a significant decrease in fit ($\Delta\chi 2$ (9, N = 3116) = 27.63, $p < 0.01$), indicating significant variations in the structural relations within the model between the male and female groups. Table 9 summarizes the model fit indices and Chi-square difference tests for the moderating effects of gender and race/ethnicity, while Figure 12 illustrates the structural relations for each path in the model by male and female groups. The Critical Ratio (CR) of differences in the strength of specific pathways was examined. If the CR value is equal to or greater than 1.96, it indicates that the strength of the association in the path varies across the groups (Garson, 2005). As Figure 12 indicates, parents' educational expectations were associated positively with male ($\beta = 0.21$, $p < 0.001$) and female children's science achievement ($\beta = 0.19$, $p < 0.001$). However, there were no significant associations between parent-child communication and children's science achievement either for males ($\beta = 0.03$, $p > 0.05$) or females ($\beta = 0.03$, $p > 0.05$). Parents' educational expectations were associated positively with male ($\beta = 0.15$, $p < 0.001$) and female ($\beta = 0.10$, $p < 0.05$) children's academic effort, as was parent-child communication for male ($\beta = 0.24$, $p < 0.001$) and female ($\beta = 0.29$, $p < 0.001$) children. Both male ($\beta = 0.08$, $p < 0.01$) and female ($\beta = 0.12$, $p < 0.001$) children's perceived academic competence was associated positively with their academic effort, and did not differ significantly between the genders.

However, parents' educational expectations were associated positively with male children's perceived academic competence ($\beta = 0.16$, $p < 0.001$) but not that of females ($\beta = 0.08$, $p > 0.05$). The relation between parent-child communication and children's perceived academic competence was stronger for female ($\beta = 0.10$, $p < 0.001$) than male children ($\beta = 0.08$, $p < 0.01$, CR = 3.15 > 1.96). Perceived academic competence was associated more strongly with male children's science achievement ($\beta = 0.25$, $p < 0.001$) than that of female children ($\beta = 0.18$, $p < 0.001$, CR = 3.20 > 1.96). Academic effort was associated significantly with male children's science achievement ($\beta = 0.11$, $p < 0.001$) but not that of females ($\beta = 0.05$, $p > 0.05$), and there also was no significant association between academic effort and female children's science achievement.

Taken together, the model explained 4.3% of the variance in male children's perceived academic competence, 13.3% of the variance in their academic effort, and 23.7% of the variance in their science achievement, while it explained 3.6% of the variance in female children's perceived academic competence, 13% of the variance in their academic effort and 21.2% of the variance in their science achievement.

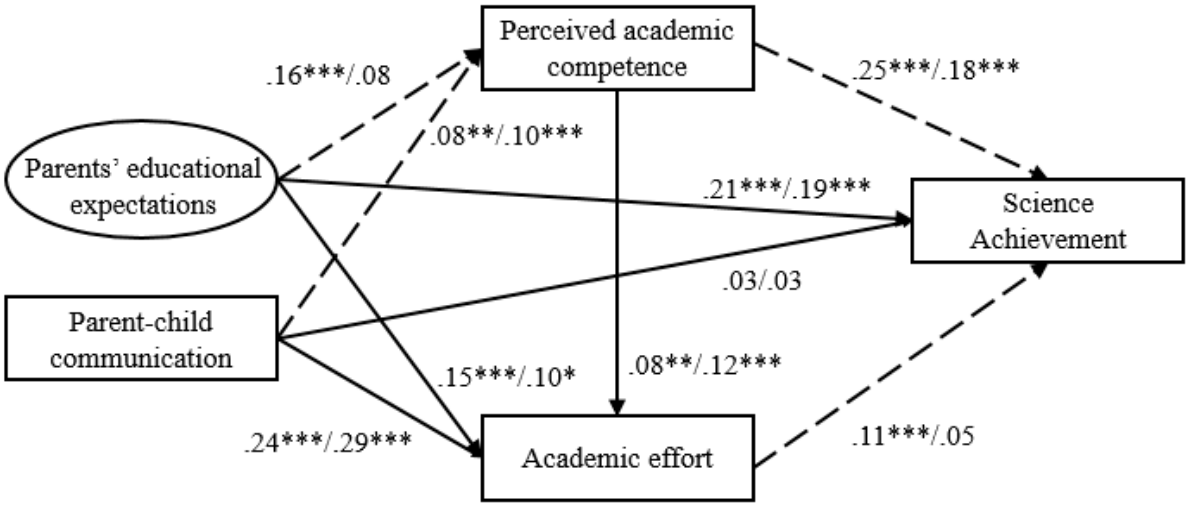

Figure 12. The structural regression model for the direct and indirect associations between parents' educational expectations, parent-child communication, and science achievement across gender groups (Note: Dashed lines indicated significant group differences in the associations among variables. The standardized regression coefficients on the left side of the dash represent the estimates for male students, while the right side of the dash represents the estimates for female students.)

Research question 4. Does child's race or ethnicity moderate the associations between parents' educational expectations, parent-child communication, children's perceived academic competence and academic effort, and their science achievement?

Multi-group analysis also was performed to examine these differences in the structural relations of the model hypothesized. The model was fit first with no constraints to detect whether its structure fit each racial and ethnic group. The unconstrained model had a good fit ($\chi 2$ (16, N =

2, 911) = 17.81, $\chi2/df$= 1.11, p= 0.34, NFI = 0.99, CFI = 1.00, TLI = 1.01, RMSEA = 0.00, 90% CI [0.00, 0.02]), indicating that the model fit for the four racial/ethnic groups. The model then was fit by constraining the factor loadings to be equal across racial/ethnic groups. This model also fit well ($\chi2$ (19, N = 2, 911) = 24.23, $\chi2/df$= 1.28, p= 0.10, NFI = 0.99, CFI = 0.99, TLI = 0.98, RMSEA = 0.00, 95% CI [0.00, 0.02]). Compared to the unconstrained model fit, the $\Delta\chi2$ value indicated that the constrained model fit did not decrease significantly, suggesting an equal measurement across racial/ethnic groups ($\Delta\chi2$ (3, N = 2, 911) = 6.34, $p > 0.05$). The model with equal factor loadings constraints then was fit again by adding equal constraints on the path relations across racial/ethnic groups. Again, the constrained model fit well ($\chi2$ (46, N = 2, 911) = 58.59, $\chi2/df$= 1.27, p= 0.19> .05, NFI = 0.99, CFI = 0.99, TLI = 0.98, RMSEA = 0.01, 95% CI [0.00, 0.02]), and showed no significant decrease in fit indices ($\Delta\chi2$ (27, N = 2,911) = 34.35, $p >$ 0.05), indicating that there was no significant variation in the structural relations across racial/ethnic groups. Thus, it reflected generality in the associations among constructs in the model across Caucasian, African American, Hispanic American, and Asian American groups. Figure 13 shows the standard coefficients across racial/ethnic groups in the model hypothesized. The results indicated that parents' educational expectations were associated positively with children's science achievement across all groups. Parent-child communication was not related significantly to children's science achievement, while their educational expectations were associated positively with children's perceived academic competence and academic effort, as was parent-child communication. Further, children's perceived academic competence was associated positively with academic effort, but not with children's science achievement, and these associations were consistent across different racial/ethnic groups. In summary, this model explained 4% of the variance in children's perceived academic competence, 11.8% of the variance in academic effort, and 21.4% of the variance in science achievement among Caucasian children; 3.0% of the variance in perceived academic competence, 11.2% of the variance in academic effort, and 18.7% of the variance in science achievement among African American children; 5.1% of the variance in children's perceived academic competence, 13.9% of the variance in academic effort, and 22.6% of the variance in science achievement among Hispanic American children, and finally, the model explained 5% of the variance in perceived academic competence, 13.6% of the variance in academic effort, and 31% of the variance in science achievement among Asian American children.

Table 6.

Model Fit Indices and Chi-Square Difference Tests for Moderation Effects

Models	χ^2	*df*	NFI	CFI	TLI	RMSEA	95% CI	$\Delta\chi^2$	Δdf
Model hypothesized	3.32	4	0.99	1.00	1.00	0.00	[0.00, 0.03]		
Moderation effects: Gender									
Unconstrained	8.31	10	0.99	1.00	1.01	0.00	[0.00, 0.02]		
Constrained factor loadings	8.64	11	0.99	1.00	1.01	0.00	[0.00, 0.02]	0.33	1
Constrained structural path	36.27	20	0.98	0.99	0.98	0.02	[0.01, 0.02]	27.63**	9
Moderation effects: Race or Ethnicity									
Unconstrained	17.81	16	0.99	0.99	0.99	0.01	[0.00, 0.02]		
Constrained factor loadings	24.23	19	0.99	0.99	0.98	0.01	[0.00, 0.02]	6.43	3
Constrained structural paths	58.59	46	0.97	0.99	0.98	0.01	[0.00, 0.02]	34.35	27

Note. $^{**}p < 0.01$ (two-tailed tests).

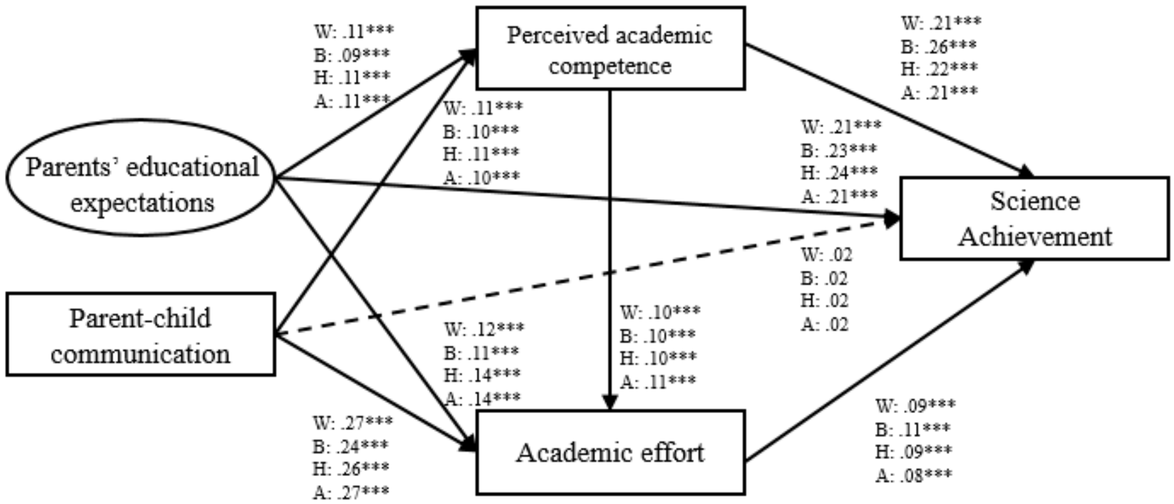

Figure 13. Structural regression model for the direct and indirect associations between parents' educational expectations, parent-child communication, and science achievement across racial/ethnic groups (Note: Solid lines indicate significant associations, while dashed lines indicate nonsignificant associations. "W" represents Caucasian students; "B" represents African American students; "H" represents Hispanic students; "A" represents Asian American students)

Chapter 6. Discussion

Scholars have emphasized the crucial role of parents' educational expectations and parent-child communication in children's academic achievement, in which most research has focused on the subjects of reading (e.g., Davis-Kean, 2005; Gary et al., 2012; Houtenville & Conway, 2008) and math (e.g., Carpenter, 2008; Ing, 2014; Froiland & Davison, 2016; Vukovic et al., 2013). Other studies have stressed that children's perceived academic competence (e.g., Akey, 2006; Bouffard et al., 2003; Yeung et al., 2010) and academic effort (Carbonaro, 2005; Johnson et al., 2001; Stewart, 2008; Yeung, 2011) can be the driving forces in their academic achievement in various subjects. Together, these studies have provided significant insights that specific parental involvement practices, as well as children's academic characteristics, are strong influential factors that contribute to children's academic achievement. However, relatively less research has focused on the way in which parents' educational expectations and parent-child communication, as well as children's perceived academic competence and academic effort, might contribute to children's achievement in the subject area of science. Thus, this study sought to add to our understanding of these issues.

Guided by Bronfenbrenner's ecological model (Bronfenbrenner & Ceci, 1994), the social cultural contexts of parental academic socialization (Tayor et al., 2004), Grolnick and Slowiaczek's (1994) personal dimension of parental involvement framework, attribution theory (Weiner, 1994), and social cognitive theory (Bandura, 1995), this study had three main objectives. First, it assessed the influences of parents' educational expectations and parent-child communication on children's science achievement. It then explained further how parents' educational expectations and parent-child communication contribute to children's science achievement by testing the mediating roles of children's perceived academic competence and their academic effort. Lastly, the study investigated the way in which children's gender and racial/ethnic identity modified the effects on children' science achievement of parents' educational expectations and parent-child communication, as well as children's perceived academic competence and academic effort.

To achieve these objectives, the study used 7th graders in the nationally representative LSAY from 52 public schools in central cities and suburban areas in the United States. The direct and indirect associations between parents' educational expectations, parent-child communication, and children's science achievement via children's perceived academic competence and academic effort were estimated with structural equation modeling. In addressing the issue of the moderating roles of the child's gender and racial/ethnic identity, a multi-group comparison analysis was conducted based on gender and race/ethnicity.

Next, the main findings were discussed and appropriate implications and conclusions were drawn. The findings were summarized in three sections: (1) Effects of parents' educational expectations and parent-child communication on children's science achievement; (2) mediating roles of children's perceived academic competence and academic effort, and (3) the moderating role of gender and race/ethnicity. The following sections provide a detailed discussion of the relevant findings in the study.

Effects of Parents' Educational Expectations and Parent-Child Communication on Children's Science Achievement

Several studies have shown a general positive link between parents' educational expectations and children's science achievement throughout their K-12 education (Byrnes &

Miller, 2007; Froiland et al., 2012). However, during middle school, Sun (2015) observed inconsistent results, in that parents' educational expectations and children's science achievement were not associated significantly. As stated previously, with respect to parent-child communication, few scholars have determined its association with children's science achievement (e.g., McNeal, 1999; Van Voorhis, 2003). However, McNeal (1999) found that this association was significant among Caucasian and African American children, but not among Hispanic and Asian American children. Therefore, the influences of parents' educational expectations and parent-child communication on children's science achievement have not been addressed adequately and clearly to date.

Following Grolnick and Slowizczek's (1994) personal dimension of parental involvement framework, this study examined the role of parents' educational expectations and parent-child communication in children's science achievement. It was hypothesized that the higher parents' educational expectations of their children, the greater those children's science achievement, and similarly, the greater the level of parent-child communication, the greater children's achievement. The results supported the first hypothesis, that greater parental educational expectations tended to be associated with greater science achievement on the part of their children. However, the results showed that parent-child communication was not associated significantly with children's science achievement, which did not support the second hypothesis.

The finding regarding the significant positive association between parents' educational expectations and children's science achievement was consistent with prior research on children in primary and high school (Byrnes & Miller, 2007; Froiland et al., 2012), as well as other investigations conducted on the subjects of reading (e.g., Davis-Kean, 2005; Gary et al., 2012;

Houtenville & Conway, 2008) and mathematics (e.g., Ing, 2014; Vukovic et al., 2013). This study expanded these prior findings to children's science achievement and emphasized the significant role of parents' educational expectations in cultivating children's positive educational development during middle school. This finding was consistent with the ecological model, which suggests that children's educational development is influenced greatly by the proximal context of parent-child interactions. Through the lens of Grolnick and Slowiaczek's (1994) parental involvement framework, parents' educational expectations and parent-child communication are viewed as a type of interaction between parents and children in which parents set an academic goal for their children by showing their educational expectations of them. When children receive and accept the message, they are likely to reach their academic goals and demonstrate high achievement. In this study, when children understood that their parents expected them to do well in science and to earn a college degree in the future, they were likely to perform as anticipated.

With respect to the non-significant association between parent-child communication and children's science achievement, this finding contrasted with those of previous studies that did find a significant association between these variables in reading, math (Houtenville & Conway, 2008; Mireles-Rios & Romo, 2010), and language (e.g., Chinese and English: Chi, 2013). The lack of association between parent-child communication and children's science achievement was somewhat surprising, given that parent-child communication is viewed as direct verbal interactions through which parents share their educational attitudes and values with their children to influence their educational development (Grolnick & Slowiaczek, 1994). Therefore, parent-child communication was expected to be influential in children's academic outcomes, which referred to science achievement in this study.

However, it should be noted that parent-child communication in this study was measured as the frequency with which parents and children conversed about school issues and topics related to science. The findings suggested that the amount of parent-child communication had no influence on children's science learning outcomes. One possible explanation is that other family characteristics, such as parental educational attainment, may explain some of the variance in children's science achievement. Prior studies (Jeynes, 2007; Park, 2008) have suggested that parents with higher levels of education are more likely to convey the significance of education effectively, or have more specialized knowledge related to the subjects their children are studying, such that they can facilitate learning through communication. This study considered parents' educational attainment as a control variable. The effect of parent-child communication on children's science achievement may be diluted when this variable is controlled, and thus, the association between parent-child communication and children's science achievement became non-significant.

Another factor that may explain these results is children's developmental stage. The children in the sample were in the 7th grade, which commonly is considered early adolescence. Children in this developmental stage are more likely to be seeking independence (Finkenauer, Engels, & Meeus, 2002; Laird, Pettit, Dodge, & Bates, 2003) and less likely to engage in communications with, or disclose too much about, their school life to parents, but are more likely to turn to peers instead. Thus, conversations between parents and children may decline while conflicts may increase (Finkenauer et al., 2002; Steinberg & Morris, 2001). Therefore, the observed favorable effect of parent-child communication on children's educational achievement in a child's early years, such as during elementary school (Chi, 2013; Mireles-Rios & Romo, 2010) might become less significant as children reach adolescence.

Overall, the first set of main findings suggested that when children become young adolescents, they are sensitive to their parents' goals and wishes. If parents show clearly that they hope their children will obtain a college education and do well in school, children's school performance is likely to be as expected. However, the degree of direct verbal communication between parents and children about school experiences is not necessarily influential in children's learning outcomes.

The Mediating Roles of Children's Perceived Academic Competence and Academic Effort

In addition to the direct associations, this study explored further whether children's perceived academic competence and academic effort mediated the effects on children's science achievement of parents' educational expectations and parent-child communication. Weiner's (1994) attribution theory suggests that children's learning outcomes can be attributed to their two internal motivations to learn. One is self-evaluation of ability and the other is effort exerted. Bandura's (1995) social cognitive theory suggests that interactions with parents can influence children's internal motivations to learn. Guided by these two theories, this study hypothesized that parents' positive educational expectations and greater levels of parent-child communication contribute to children's science achievement by influencing their perceived academic competence and academic effort invested.

First, the data confirmed the mediating role of children's perceived academic competence. Consistent with prior research that has found parents' educational expectations can promote children's academic achievement in physics (Yeung et al., 2010), math, and English

(Neuenschwander et al., 2007) through children's positive perceived competence, this study found that this mediation path extended to the subject of science. In addition to parents' educational expectations, parent-child communication also promoted children's perceived academic competence, which explained children's science achievement further. Other investigations also have found that other forms of parental involvement, such as parents' greater participation in school events and activities, their positive attitudes about children's school success, and their encouragement of learning, are related to children's greater perceived academic competence, which in turn, contributes to academic achievement (Marchant et al., 2001; Roger et al., 2009). Consistent as well with prior research that has emphasized the mediating role of children's perceived academic competence in the association between parental involvement and academic achievement, the results in this study suggested that parents' educational expectations and parent-child communication are practices that influence children's perceived academic competence, which accounts further for their science achievement.

Second, the study also hypothesized that parents' educational expectations and parent-child communication contribute to children's science achievement by motivating them to engage in academic effort. The data confirmed this hypothesis, and consistent with the attribution and cognitive theories, suggested that parents are influential in their children attributing academic success to effort. When children believe effort is the reason for academic achievement, they tend to increase their level of effort to accomplish academic goals. This finding suggested that positive expectations and a greater level of communication with parents may help children understand the significance of academic effort, and may motivate children to make efforts to learn and perform better in science. Prior investigations have found that academic effort is linked directly to achievement in reading, math, and academic achievement overall (e.g., Moon & Hoffert, 2016; Stewart, 2008; Yeung, 2011). Other scholars have found that the variables of children's own internal motivations, such as learning interest and self-confidence, determined their effort level (Schwinger & Stiensmeier-Pelster, 2012; Trautwein et al., 2009). However, these studies did not examine whether parents can motivate children's academic effort. This study provided evidence that parents' educational expectations, as well as parent-child communication, can contribute to children's academic achievement in science by motivating their academic effort.

Third, in addition to the mediating pathways above, the study hypothesized further that parents' positive educational expectations and greater levels of parent-child communication are associated with children's positive perceived academic competence, which in turn, is related to a greater level of academic effort, and subsequently, a greater level of academic effort is associated with greater science achievement. This sequential mediation pathway was based on attribution theory (Weiner, 1994) and the social cognitive perspective (Bandura, 1995) that explained further the connection between perceived academic competence and academic effort, suggesting that children's beliefs in their academic competence determined their subsequent efforts. Consistent with social cognitive theory, prior research has found that children's internal motivations, such as believing in their competence, are significant predictors of their subsequent effort, which in turn, are associated with academic achievement (Schwinger & Stiensmeier-Pelster, 2012; Trautwein et al., 2009). For example, Trautwein and colleagues (2009) found that students who were confident about their competence in math and English were more likely to invest effort and perform better on math and English tests. Consistent with prior research, the findings in this study supported the positive association between perceived academic competence and academic effort. Further, the study also demonstrated that parents' positive educational expectations and a greater level of parent-child communication were related to children's positive perceptions of their academic competence, which in turn, likely encouraged them to engage in greater levels of academic effort to enhance their science achievement.

The mediating pathways identified suggested overall that children's perceived academic competence and academic effort are crucial internal motivations to learn that translate the effects of parents' educational expectations and parent-child communication into their science achievement.

The Moderating Roles of Gender and Race/Ethnicity

The final objective of this study was to test the moderating roles of the child's gender and race/ethnicity in the influences of parents' educational expectations and parent-child communication on children's perceived academic competence, academic effort, and science achievement. With respect to the moderating role of gender, based on the perspective of the social cultural contexts of parental academic socialization (Taylor et al., 2004), parents may have different educational goals and behaviors that influence their children's academic development, depending on the child's gender. Thus, it was predicted that the associations between parents' educational expectations and parent-child communication, and children's science achievement via their perceived academic competence and academic effort would vary with gender. With the precondition of invariant measurement between the two gender groups, the results indicated that a child's gender modified several association paths. Specifically, the findings revealed that the strength of the association between parents' educational expectations and children's perceived academic competence was stronger for boys, while that of the association between parent-child communication and children's perceived academic competence was stronger for girls. In addition, the study also showed that the strength of the association between children's perceived academic competence and science achievement was stronger for boys. The association between academic effort and science achievement was positive and significant for boys, but non-significant for girls.

These findings are consistent with prior research that has suggested a moderating role of child's gender in parents' practices (Tenenbaum & Leaper, 2003), children's perceived academic competence (Debacker & Nelson, 2000; Pomerantz et al., 2002) and academic effort (Yeung, 2011), and science achievement (Halpen et al., 2011). Prior research has shown especially that, in contrast to girls, parents appear to have a greater expectation that their boys will do well in science and have a science-related job in the future, and they engage their sons in science activities to a greater extent (Tenenbaum & Leaper, 2003). Turning to children's motivation to learn, compared to girls, boys tended to have a higher level of academic competence in science, but invested less academic effort (Debacker & Nelson, 2000; Pomerantz et al., 2002; Yeung, 2011). However, there has not been sufficient research on the issue of the moderating role of child's gender in the influences on children's science achievement of parents' educational expectations, parent-child communication, and children's perceived academic competence and academic effort. The findings in this study suggested that parents' educational expectations were more likely to influence boys' perceived academic competence, while parent-child communication was more likely to affect girls' perceived academic competence. Boys' science achievement may be attributable to their positive perceptions of their science competence and the greater level of academic effort they invest, while for girls, their science achievement enhancement was more likely attributable to their positive perceptions of their competence in science, but not necessarily to academic effort.

In addition to these variations, some association paths between genders were similar. Specifically, the associations between parents' educational expectations, parent-child communication, and children's science achievement did not vary between boys and girls, nor did those between parents' educational expectations, parent-child communication, and academic effort. Prior studies did not test these associations based on child's gender, but focused more on differences in parents' degree of educational expectations (Tenenbaum & Leaper, 2003), children's perceived academic competence in science (Debacker & Nelson, 2000; Pomerantz et al., 2002), academic effort (Yeung, 2011), and science achievement (Jones et al., 2000; Voyer & Voyer, 2014) between genders. The findings of the similarities in the associations demonstrated that a one-unit increase/decrease in parents' educational expectations increased/decreased the level of science achievement for boys and girls to the same degree. Further, parent-child communication did not contribute directly to gender differences in children's science achievement. One unit of parents' educational expectations and parent-child communication motivated the same level of academic effort on the part of both boys and girls.

In addition to the moderator of child's gender, the study also examined that of race/ethnicity. Based on the perspective of the sociocultural contexts of parental academic socialization (Tayor, Clayto, & Rowley, 2004), cultural context should play an influential role in parents' efforts to facilitate their children's academic development. Families from various cultural backgrounds may use different academic socialization strategies to communicate their education values and goals to their offspring (Rogoff, 2003; Suizzo & Soon, 2006). Therefore, this study predicted significant variations in the effect of parents' educational expectations and parent-child communication on children's perceived academic competence, academic effort, and science achievement across racial/ethnic groups (i.e., Caucasian, African American, Hispanic, and Asian American groups). Surprisingly, the study found no significant differences in these associations based on children's race/ethnicity. Consistent with the perspective of sociocultural contexts of parental academic socialization (Tayor, Clayto, & Rowley, 2004), prior research has demonstrated that parents from different cultural backgrounds tend to use different practices based on their own cultural beliefs. For example, parents of Asian origin are more likely to emphasize effort in academic success, while Caucasian parents tend to emphasize ability (Stevenson et al., 1990; Suizzo & Soon, 2006). Other investigations have revealed that some parental practices (e.g., parental academic encouragement and emotional support) may have different effects on children's academic motivation to learn (e.g., children's academic self-efficacy), although these practices were observed universally across different racial/ethnic groups (Suizzo & Soon, 2006; Suizzo et al., 2012). For example, Suizzo and Soon (2006) found that parental academic encouragement and emotional support were associated positively with children's locus of control with respect to academics among Asian American and Caucasian students, but this association was not significant among Hispanics and African Americans. Suizzo et al. (2012) also found that parents' demanding hard work was associated more strongly with African American than with Hispanic children's self-efficacy.

Although prior research has emphasized cultural variations in some parental involvement practices (e.g., variations in level or form), or the effect of certain parental practices on children's motivation to learn, the findings in this study suggested that the effects on children's science achievement of parents' educational expectations, parent-child communication, children's perceived academic competence, and academic effort were invariant across all racial/ethnic groups studied.

Perhaps parents' educational expectations and parent-child communication are common practices that parents of all races/ethnicities tend to use to facilitate and influence children's learning. Because scholars have observed a consistent achievement disparity in the subject of science across children from different racial/ethnic groups, in which Asian American and Caucasian students tend to outperform other ethnic groups (Else-Quest et al., 2013), if the findings in this study are true, it may imply that the relatively low science achievement of some ethnic groups may be attributable instead to parents' low educational expectations or less active parent-child communication, both of which could have negative effects on children's perceived academic competence and engagement in academic effort.

In addition, it should be noted that there are other factors associated with achievement disparity across racial/ethnic groups. However, they are beyond the scope of current study. These factors, according to the literature, include school racial composition (e.g., contemporary research on racial composition have suggested that schools with high concentrations of ethnic minority students tend to maintain or widen the achievement gap) (Ready & Silander, 2011), the opportunities to form interracial friendships and to exposure to cooperative learning activities (Lewis & St. John, 1974; Mattison & Aber, 2007), and equal opportunities to access to social networks (Wells & Crain, 1994). For example, research shows that Black students in desegregated schools may benefit from forming friendship with Whites, which the close ties would afford greater social connectedness that may contribute to achievement gains. Cooperative learning involving small groups of students of varying achievement levels as well as different racial/ethnic groups working on various learning tasks may promote academic achievement for each member (Slavin, 2011). Other scholars observed that Black students benefit from the social networks they established in integrated schools since the networks extend them more educational opportunities and motivate them to take advantage of those opportunities to be successful (Wells et al., 2008). Together, school's racial composition, students' accessible educational resources, and equal opportunities may all somehow contribute to students' achievement disparity across racial/ethnic groups. Additionally, these factors tend to strongly link with students' family background characteristics such as family financial conditions. High minority schools tend to be located in urban areas of concentrated poverty (Quintana & Mahgoub, 2016). It might be challenging and unaffordable for students from these areas to have access to the advanced educational resources such as high qualified science teachers. Therefore, the factors that are associated with achievement disparity across racial/ethnic groups can be complex, rather than simply conclude that some minority parents have low educational expectations or less active communication with their children.

Limitations

The findings in this study must be interpreted cautiously because of several limitations. First, the study analyzed a secondary dataset that was designed and collected by the LSAY research team. The measurements in the study existed already, which limited the ability to explore the concepts underlying the variables this study investigated. Moreover, the limitation attributable to the existing measurements may have resulted in analysis issues that affected the interpretation of the results. For example, parents' educational expectations in this study were measured as a binary variable with low variability. This is likely to cause a ceiling effect, given that the distribution of parents' educational expectations was skewed (Petscher & Logan, 2014). Although there is no statistical test to quantify the ceiling effect, to deal with this potential problem, the binary variable was transformed to a continuous variable by standardizing it and then conducting a normality analysis. No violation of the normal distribution was revealed. In addition, for the variable of parent-child communication, the study measured the frequency of parents and children having conversations about children's school experiences, which represents the amount of parent-child communication. However, the measure may not be able to capture other dimensions of parent-child communication, such as its quality, which may reflect the parent-child relationship. Another example regards the control variables in the study. Although this study controlled family structure and parents' educational attainment, which can be considered as indicators of family SES, other important indicators, such as family income and parents' occupations, cannot be assessed due to information unavailable in the LSAY dataset. These indicators of family SES were necessary to be controlled in the hypothesized model as well.

Second, the measurements of parents' educational expectations, parent-child communication, and children's perceived academic competence and academic effort relied on children's reports, which may cause same-rater bias. Thus, the correlations among these variables could be inflated.

Third, the study used a cross-sectional design to test the associations between parents' educational expectations, parent-child communication, and children's science achievement via children’s perceived academic competence and academic effort. The data on these variables were collected at one time during the fall semester in 1987. The cross-sectional design does not allow researchers to make any inferences about temporal order or draw cause-effect conclusions. Thus, it is not possible to conclude that higher parents’ educational expectations and a greater level of parent-child communication lead to children’s positive perceptions of their academic competence and increase academic effort, which, in turn, lead to children’s increased science achievement. In addition, children's perceived academic competence may be affected by other social contextual factors such as their prior achievement, stereotype threat, and school treatment, which, this study did not consider to control these factors.

Fourth, although the LSAY is a nationally representative sample, the data from these 7th graders were collected in 1987. Thus, the results may be generalizable only to that cohort and may not truly represent 7th graders 30 years later. Therefore, it is necessary to use more current samples to confirm the study findings.

Implications

Despite these limitations, the study has significant implications for young adolescents, parents, and school professionals designing programs to involve parents in children’s science learning. First, the study suggested that parents’ high educational expectations and good parent-child communication are important parental practices that can facilitate middle school students’ science learning and enhance their achievement. Parents’ educational expectations may have a direct effect on children’s science achievement, while the effect of parent-child communication may be indirect. Therefore, education programs for young adolescents in middle school should help increase parents’ awareness of the influential role their expectations and their conversations with their offspring, especially on topics relevant to children's school experiences or science issues, play in their children's education. In addition, efforts should be made to nurture parents' high expectations of their children's science learning and active communication between parents and children, as these forms of parental feedback will have positive effect on children's perceptions of how able they are to learn science, as well as how much effort they need to exert to achieve their academic goals. Effective programs are likely to integrate children's academic characteristics, especially during young adolescence, given that children's internal motivations to learn related to their belief in their competence, as well as their academic effort, play crucial roles in their academic achievement. Therefore, it is necessary to consider the ways in which parents can help their children develop positive perceptions of their competence and motivate them to make their best efforts to learn.

Second, based on the findings, educational programs designed to help young adolescents enhance their science achievement are encouraged to consider the child's gender, as it was found to be an influential factor in the effect of parental involvement practices on children's science learning. Specifically, for boys with low achievement in science, it is suggested that parents set higher educational expectations of their science performance, help them establish positive beliefs in their competence, and emphasize the importance of effort, as boys are more likely to benefit from such practices. For girls, it is suggested to encourage parent-child communication, especially about children's school experiences and science-related topics. Further, through communication, parents are encouraged to help girls develop a positive perception of their competence to learn science, as they may be more likely to benefit from these parental practices.

Third, the study suggested that education programs that target families from diverse cultural backgrounds should encourage parents to set high educational expectations and engage in active parent-child communication, regardless of children's race/ethnicity, as these two practices were shown to be significant in promoting children's internal motivations to learn science.

Conclusion

In summary, considerable research has emphasized parents' educational expectations and parent-child communication because of their significant roles in young adolescents' academic achievement in various subjects. Unfortunately, these two parental involvement practices have not been documented well for the subject of science in middle school children. The findings of this study increase our understanding of the crucial roles of these parental practices in this subject. Further, the study explained that children's internal motivations to learn and perceived academic competence and academic effort were the mechanisms through which parents' educational expectations and parent-child communication contributed to children's science achievement between the genders and across racial/ethnic groups. These findings can inform educational programs designed to help young adolescents learn science by working with their parents from diverse cultural backgrounds. Those educational programs can help such parents become more aware of the importance of having positive educational expectations and active communication with children, and can work with parents to promote children's internal motivations to learn by emphasizing their positive academic competence and academic effort. Successful educational programs also can suggest optimal parental involvement practices that will help parents promote their children's motivation to learn science, while taking into consideration the child's gender and race/ethnicity.

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Ph.D., Human Development and Family Science, Syracuse University, NY, 2018
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PUBLICATIONS

Jung, E., **Zhang, Y**., Huang, W., & Zhang, Y. (2018). Parental health and young adolescents' school functioning in immigrant families: Roles of parental involvement and perceived treatment at school. *Journal of Child and Family Studies. 27*(152), 1-15. doi:10.1007/s10826-018-1032-5

Jung, E., Huang, W., **Zhang, Y**. & Zhang, Y. (2018). Do parents' educational expectations in adolescence predict adult life satisfaction? *Family Relations*. doi: 10.1111/fare.12323

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Ma, Y. & **Zhang, Y.** (2015). Asian American Leadership: A Concise Reference Guide. In D. Nakanishi (Ed.), *Bamboo Ceiling* (pp. 57-59). Mission Bell Media.

CONFERENCE PRESENTATIONS (Selected)

Zhang, Y. (2018). Self-control and empathy: The bridge of parent-child communication and children's perceived peer acceptance. Paper sent to review at the International Association for Relationship Research Conference (IARR), Fort Collins, Colorado. July, 2018. Individual talk.

Zhang, Y. & Jung, E. (2018). Quality matters more than quantity: Parent-child communication and adolescents' academic performance. Paper sent to review at meeting of American Educational Research Association Conference (AERA), New York City, New York. April, 2018.

Zhang, Y. & Jung, E. (2017). Multi-dimensionality of acculturative stress among Chinese international students: What lies behind their struggles? Poster presented at the Falk College Student Research Event, Syracuse University, NY. April, 2017.

Zhang, Y. & Jin, L. (2016). Computer use as a tool in 8th graders' classroom instruction and learning: An exploratory study using TIMSS 2011. Poster presented at the Special Topic Meeting: Technology and Media in Children's Development of the Society for Research in Child Development (SRCD), Irvine, CA. October, 2016.

Jung, E., **Zhang, Y**., Zhang, Y., & Xiao, X. (2016). Future professionals' perceptions of play and intended practices: The moderating role of efficacy beliefs. Paper presented at the annual meeting of American Educational Research Association Conference (AERA), Washington, D. C. April, 2016.

Ma, Y., & **Zhang, Y**. (2015). Stay vs. return: that is a question. Paper presented in the roundtable section of International Migration and Education at the American Sociological Association (ASA) annual meeting, Chicago, IL. August, 2015.

Zhang, Y. & Garcia-Murillo, M. (2014). Can an intervention help to speed the acculturation process? Poster presented at the annual conference & expo of NAFSA, San Diego, CA. May, 2014.

Jung, E., & **Zhang, Y**. (2014). New immigrant children and achievement: The roles of parents, aspiration, gender, and race/ethnicity. Paper presented at the annual meeting of American Educational Research Association Conference, Philadelphia, PA. April, 2014.

Zhang, Y. (2013). Acculturative stress, perceived social support and depression among Chinese international students. Paper presented at the Master's Level Graduate Research Conference, Brockport, NY. April, 2013.

TEACHING EXPERIENCES

- Instructor, Human Sexuality Discussion Groups, Department of Human Development and Family Science, Syracuse University (Fall, 2017)
- Instructor, Research Methods in Human Development, Department of Human Development and Psychology, The State University of New York (SUNY) Oswego (Spring, 2016)
- Teaching Assistant, Department of Human Development and Family Science, Syracuse University (2010-2011; 2013-2015)

- Graduate Assistant, Early Childhood Education experience at preschool classroom, Bernice M. Wright Child Development Laboratory School, Syracuse, NY (2012-2013)

GRANTS

- Dean Edith Smith Endowed Dissertation Grant, Falk College, Syracuse University, 2018
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PROFESSIONAL SERVICES

- Peer reviewer for American Educational Research Association Conference (AERA), Division G- Section 2: Studies of diversity and variation with social context of education, 2016-17
- Trainer in the TA orientation to international teaching assistants as Teaching Mentor in Teaching Mentor Program, Graduate School, Syracuse University, 2017, 2013
- Mentor in Connection Program to serve new coming Chinese international students, Slutzker International Students Center, Syracuse University, 2011

AWARDS

- Winner of Falk College Student Research Celebration, Falk College, Syracuse University, 2017
- Recognition of Scholarly Achievement, Honor Society of Phi Beta Delta, 2017
- Outstanding Graduate Teaching Award, Department of Human Development and Family Science, Syracuse University, 2015
- Alice Sterling Honig Award, Department of Human Development and Family Science, Syracuse University, 2014
- Graduate School Master's Prize, Graduate School, Syracuse University, 2013