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STEM Interest and Achievement in High School Freshmen with ADHD:

Multisystemic Predictors

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Presented to the Graduate and Research Committee

of Lehigh University

in Candidacy for the Degree of

Doctor of Philosophy

in

School Psychology

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Certificate of Approval

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Abstract

The transition from middle to high school can be especially challenging for students with attention-deficit/hyperactivity disorder (ADHD). Also, students with disabilities experience greater barriers when considering careers in science, technology, engineering, and math (STEM) fields. Academic interest and social support may play a critical role in self-regulatory processes and school success in this period. The current study investigated the roles of school-level support, parent support, teacher emotional support, and teacher academic support on math/science interest development and overall high school math/science high school grade point average (GPA) among about 1,730 ninth grade students with ADHD entering high school (70% male). The average age of students was 14.55 (*SD* = .69). A national dataset from the High School Longitudinal Study of 2009 (HSLS:09) was analyzed using structural equation modeling (SEM). It was hypothesized that all types of social support would positively predict math/science interest development and achievement. It was also hypothesized that ninth and 11th grade math/science interest would mediate the relationship between social supports and achievement. Students with ADHD demonstrated unique motivational and achievement patterns. School-level support did not predict any outcome variables, and parent support negatively predicted science interest. Perceived teacher emotional support positively predicted ninth grade interest across domains. Teacher support for deep cognitive engagement positively predicted math GPA, but teacher support for surface cognitive engagement negatively predicted math/science interest. Surprisingly, academic interest emerged as a negative predictor of GPA in both domains. Mediation effects were observed, but potential suppression effects complicated the interpretation of results. The findings highlight the importance of providing developmentally appropriate and individualized supports for increasing interest and achievement in high school students with ADHD.

Chapter I: Introduction and Literature Review

The transition from middle school to high school can be a time of both excitement and unforeseen challenges. The transition period overlaps with the developmental changes from early to late adolescence, characterized by puberty, cognitive development, and changing roles with peers and families. At school, adolescents need to adapt to increased school size, existing peer group expectations, decreased adult support and guidance, and more challenging academic subjects (Wentzel et al., 2019). Adolescents also need to interact with greater numbers of teachers with differing instructional styles (Wentzel et al., 2019). At home, conflict between adolescents and their families increases over issues related to autonomy and control (Eccles et al, 1993). For some adolescents, changes during this period can promote growth and adjustment, but for others, changes can negatively affect self-esteem and increase emotional and behavioral risk (Gutman & Eccles, 2007).

According to stage–environment fit theory (Eccles et al.,1993), some negative changes could be due to a mismatch between the needs of developing adolescents and their changing social environments. The fit between the characteristics of individuals and their social environment influences adolescents' behavior, motivation, and mental health (Eccles et al., 1993). Adolescents are not likely to do well or stay motivated if they are in social environments that do not meet their psychosocial needs. Such decline in motivation will be especially true if the environment is developmentally regressive, or if it provides fewer opportunities for growth compared to their previous environments (Eccles et al., 1993). Therefore, it would be important to consider both adolescents' individual characteristics and environmental changes during their transition to high school. Much attention has been paid to the transition from elementary to middle school because of the relatively dramatic changes in school structure that students face as they leave elementary school (Barber & Olson, 2004). However, students transitioning to high school are exposed to similar risk factors related to middle school transition, such as increased complexity of peer relations, more assignments, decreased teacher support, and a more anonymous student experience.

The first year of high school is especially critical for school success. Whether students were on track at the end of ninth grade in high school is predictive of high school graduation with 80% accuracy, above and beyond test scores (Allensworth, 2013). Being on track is defined here as having sufficient credits to move on to 10th grade and having failed no more than one semester of a core course (Allensworth, 2013). Unfortunately, school performance tends to drop at transition periods, such as elementary to middle or middle to high school (Alspaugh, 1998; Barber & Olsen, 2004). Studies that specifically examined the transition to high school show that students' grades tend to significantly decrease during the transition (Benner, 2011; Roderick, 2003). Also, school engagement declines in the transition as students become less involved in extracurricular activities, have more absences, and experience greater academic demands and hassles, and perceive a decrease in school social support from teachers and principals (Seidman et al. 1996). Further, compared to eighth-grade teachers, ninth-grade teachers rate students as more disruptive and less educationally engaged (Roderick, 2003).

The transition to high school can be even more challenging for students with attention-deficit/hyperactivity disorder (ADHD), a neurodevelopmental disorder defined by impairing levels of inattention, disorganization, and/or hyperactivity-impulsivity (American Psychiatric Association [APA], 2022). Childhood ADHD often persists into adulthood, causing ongoing impairments in social, academic, and occupational functioning (APA, 2022). Adolescents with ADHD tend to earn lower high school grades, require additional support (i.e., tutoring or placement in special classes), are at greater risk for grade retention, and are less likely to attend and complete college (Cherkasova et al., 2022; Kuriyan et al., 2013; Langberg et al., 2011; Molina et al., 2009). Also, it should be noted that school success requires various behavioral skills, including listening to classroom instruction, staying seated in class, completing as well as submitting assignments, and organizing tasks (Raggi & Chronis, 2006). Elevated symptoms of inattention and hyperactivity make it more difficult for students with ADHD to build and maintain such skills. Moreover, students with ADHD tend to have lower academic-related motivation, less enjoyment of learning, and greater reliance on external feedback to evaluate their performance (Carlson et al., 2002; Smith et al., 2020). Such behavioral and motivational challenges may cause students with ADHD to experience significantly more academic difficulties during their transition to high school.

Empirical studies confirm that students with ADHD tend to struggle more during their transition to high school. Di Lonardo Burr et al. (2022) conducted a longitudinal study and found that students with ADHD experience a decline in core subject grades (i.e., mathematics and English) during the transition from middle to high school (i.e., from Grades 8 to 9). In a cross-sectional study by Zendarski et al. (2017), students with ADHD during the first year of high school were less motivated, less connected to peers, and were more likely to be suspended in comparison with state data. Zendarski et al. (2021) also conducted a longitudinal study that examines trajectories of emotional and conduct problems and their association with early high school achievement and engagement for adolescents with ADHD. They found that students with high-persistent trajectories of emotional and conduct problems experienced poorer academic functioning and lower student engagement as they made the transition to high school. The research findings show that students with ADHD, especially those who continue to experience high and persistent emotional and conduct problems, are more likely to experience academic difficulties compared to their peers without ADHD during the transition to high school. As such, researchers and educators must pay additional attention to students with ADHD in the transition to ensure their adjustment and school success.

Fostering academic interest can influence self-regulatory processes and improve school engagement (Harackiewicz, 2016). Although external support from significant others is particularly salient in the early phases of interest development (Hidi & Renninger, 2006; Jungert et al., 2020; Wentzel, 1998), no research has examined interest development in students with ADHD. Also, special attention should be given to fostering interest in science, technology, engineering, and math (STEM) fields in students with disabilities. The number of jobs in the U.S. requiring substantial STEM expertise has grown (National Science Board [NSB], 2018), but students with disabilities experience heightened STEM barriers (Lee, 2011). In addition, many teachers do not view invisible disabilities, such as ADHD, as authentic disabilities and hold a negative stigma toward these students (Hawley, 2013; Lee, 2011). As a result, students with ADHD are often discouraged from considering careers in STEM. As such, researchers should explore the role of schools, parents, and teachers in providing both academic and emotional support in promoting STEM interest in students with ADHD. The current study will inform policy, evidence-based practice, and future research for supporting students with ADHD.

The remainder of the chapter reviews contemporary literature on academic interest and interest development, followed by a discussion of the role of social support and other contextual factors (i.e., parents, teachers, and school) on student interest. Subsequently, the role of interest in students with ADHD is discussed. Lastly, the importance of fostering STEM motivation and achievement in students with disabilities is discussed. The review concludes with a summary and critique of existing literature, followed by a discussion of specific research questions and hypotheses suggested by the review.

Interest as the Key Motivational Variable

Definition of Interest and Theories of Interest

Motivation refers to the process by which goal-directed activities are prompted, energized, and sustained (Schunk et al., 2013). Motivation may manifest itself in various contexts, including at home, at work, and in school. In a school setting, academic motivation influences school performance, persistence, and task choice (Eccles, 2009). There is no single theory that can sufficiently explain all aspects of academic motivation. Rather, many motivational frameworks attempt to explain what energizes students in the classroom, sustains their level of engagement, and helps them achieve their goals. One of the key motivational constructs that has been receiving much attention in the academic context is interest. As a motivational variable, interest refers to the psychological state of engaging or the predisposition to reengage with specific objects, events, or ideas over time (Harackiewicz et al. 2016; Hidi & Renninger, 2006). Most researchers agree that interest is a phenomenon that arises from an individual's interaction with their environment, an idea referred to as the person-object interaction (Krapp et al., 1992; Krapp, 1999). However, different researchers assign varying weights either to the person or to the environment based on their methodological beliefs, theoretical orientations, and research paradigms (Krapp, 1999).

Krapp and colleagues (1992) have identified three conceptualizations of interest, as illustrated in Figure 1. First, interest can be conceptualized as an individual or personal disposition that consists of relatively enduring characteristics or a general orientation to action. Second, interest can be conceptualized as a characteristic of the learning environment (e.g., the interestingness of learning material or text) that can trigger a situation-specific interest in a learner. Finally, interest can be conceptualized as a psychological state that reflects a concrete and actualized form of individual interest. This state of interest is characterized by focused, prolonged, and relatively effortless attention as well as feelings of pleasure. This state arises from the interaction between personal disposition and environmental factors (Hidi & Baird, 1988; Krapp, 2000; Renninger & Wozniak, 1985).

As educational and motivational researchers generally view interest as a psychological state within the person, the rest of this literature review will specifically focus on this conceptualization. Interest, as conceptualized as a psychological state, has several characteristics. First, although the potential for interest lies within the person, the environment can define the direction and development of interest (Hidi & Renninger, 2006). As such, both environmental factors and a person's own efforts, such as self-regulation, can contribute to the development of interest (Hidi & Renninger, 2006). Also, interest is always content-specific (Krapp, 2000; Schiefele, 1991). As Renninger et al. (2002) point out, even students who are highly motivated to achieve generally have interests only in specific content areas and not in others.

Situational versus Individual Interest

Interest can be broadly categorized into two types: situational interest and individual interest (Hidi & Baird, 1988). Situational interest refers to focused attention and affective reaction to environmental stimuli, which may or may not last over time. It is different from automatic arousal or curiosity, a state related to a person perceiving an information gap between what one knows and wants to know (Hidi & Renninger, 2019). Eliciting curiosity by raising uncertainty usually results in a short-term trigger to resolve uncertainty, whereas eliciting situational interest in a specific content area usually creates a more lasting impact and may develop into an individual interest (Hidi & Renninger, 2019). Although curiosity may support further interest development, this occurs only when the learner continues to make a connection to the content even after the knowledge gap is resolved (Hidi & Renninger, 2019). As such, automatic arousal or curiosity is not synonymous with individual interest, and it does not always lead to the development of situational interest.

Empirical studies show that situational interest is likely to increase the level of attention, reading comprehension, recall of information, and readiness for engagement with a specific object or task. In a study by McDaniel et al. (2000), more interesting texts were associated with a more automatic allocation of attention, resulting in less cognitive load for undergraduate students reading these texts. Hidi and Baird (1988) found interest-evoking texts were effective in increasing students' recall of concrete, specific, or personally involving information. Also, situational interest can be triggered by engaging in computer-based activities. Cordova and Lepper (1996) designed educational computer activities designed to teach arithmetical order of operations rules. In the control condition, this material was presented abstractly, but in the experimental conditions, identical material was presented within more meaningful and appealing learning contexts (i.e., contextualization, personalization, and provision of choice). Compared to the default program, the more interesting version of the computer program increased students' enjoyment of math learning and task engagement, the amount they learned in a fixed period, their perceived competence, and levels of student aspiration (i.e., how challenging they desired a future game to be).

Alternatively, individual interest (Renninger & Hidi, 2002), or personal interest (Krapp, 2002; Schraw & Lehman, 2001) refers to a psychological state of interest as well as a relatively enduring predisposition to seek out and reengage in specific activities or content. The terms ‘individual interest’ and ‘personal interest’ are used interchangeably in the interest literature (e.g., Krapp, 2002; Rotgan & Schmidt, 2017; Schraw & Lehman, 2001; Tsai et al, 2008; see Renninger, 2000 for an alternative opinion). Well-developed individual interest in a subject matter is characterized by attention, memory, flow-like engagement, and strong positive feelings for that given subject, which enables focused work (Renninger & Hidi, 2002). Instructional conditions that include group work, puzzles, and computer-based activities have been found to trigger situational interest (Hidi & Renninger, 2006). Also, instructional conditions that provide opportunities for interaction with peers and/or experts and offer challenges can facilitate the development of individual interest (Hidi & Renninger, 2006).

Overall, empirical research has shown that individual interest increases attention, recognition, and recall (e.g., Renninger &Wozniak, 1985). Individual interest also increases persistence, effort expenditure, and levels of learning. For example, Fulmer and Frijters (2011) found that individual interest can buffer against negative motivational and emotional outcomes when students are presented with a very challenging reading task. Students who read a text that they rated to be most personally interesting reported greater interest and enjoyment for the activity, reported fewer attributions for the difficulty to any causes, and were more likely to persist when given the option to stop reading. Further, individual interest can predict self-regulation above and beyond self-efficacy and grade goals (Lee et al., 2014). These findings illustrate how individual interest can have an overarching and lasting positive effect on student learning and engagement.

Situational interest and individual interest are often considered to be distinctive, and empirical research supports the distinction. Mitchell (1993) examined the structure of situational interest in the context of high school mathematics classrooms and identified two general and distinctive scales (i.e., situational and individual interest) and five subscales related to situational interest. However, Mitchell argues that in an educational context, a teacher's ultimate goal would be triggering situational interest in students and then fostering the situational interest into more lasting personal interest over time.

Four-Phase Model of Interest Development

Although many researchers have proposed different models of interest development, the most widely discussed model is the four-phase model of interest development proposed by Hidi and Renninger (2006). The model describes phases of situational and individual interest in terms of both affective and cognitive processes. The premise of the model is that situational interest is a basis for an emerging individual interest and subsequently well-developed individual interest. In other words, interest development occurs on a continuum. Furthermore, the four-phase model has been empirically examined in various academic domains and across age groups, such as computer science learning in adolescents (Lakanen & Isomöttönen, 2018), science learning in elementary school students (Rotgans & Schmidt, 2017), and across STEM contexts in middle school students (Staus et al., 2019).

Phase 1: Triggered Situational Interest. Triggered situational interest refers to a psychological state caused by short-term changes in affective and cognitive processing (Hidi & Baird, 1988; Mitchell, 1993). Triggered situational interest is the first stage of interest development, and it allows the learner to attend to content. Triggered interest can be sparked by environmental stimuli, such as texts that include surprising information, character identification, personal relevance, and intensity (Hidi & Renninger, 2006). It is typically supported by extrinsic factors that are introduced by other people or changes in the environment (Hidi & Renniger, 2019). Situational interest can be triggered by instructional practices and learning environments that include group work, puzzles, and computer programs with specific features (e.g., Cordova & Lepper, 1996; Hidi & Baird, 1988). Although feelings may be either positive or negative at this stage, any negative feelings need to subside for interest to develop (Hidi & Renninger, 2019).

Phase 2: Maintained Situational Interest. Maintained situational interest refers to a psychological state that involves focused attention and persistence over time (Hidi & Renninger, 2006). Situational interest that has been triggered is held and sustained through the meaningfulness of tasks and personal involvement (Hidi & Renninger, 2006). Maintained situational interest prompts a learner to reengage with a task or content. As with triggered situational interest, it is typically supported by external factors, such as other people, instructional design, or changes in the environment. Other people can support the maintenance of situational interest by helping learners recognize the usefulness of what they are learning (e.g., Harackiewicz et al. 2016). Furthermore, hands-on activities, software, games, group work, and the meaningfulness of tasks can contribute to the maintenance of situational interest (e.g., Mitchell 1993; Swarat et al. 2012). Also, at this stage feelings about the content tend to be positive, and encouragement to continue in a task or activity can help the maintenance of interest (Hidi & Renninger, 2006).

Phase 3: Emerging Individual Interest. Emerging, or less well-developed, individual interest refers to a psychological state of interest as well as the beginning phases of a more enduring predisposition to engage and/or reengage with a particular task or content (Hidi & Renninger, 2006). It is characterized by positive feelings, stored knowledge, and personal value (Hidi & Renninger, 2006. 2019; Renninger & Wozniak, 1985). At this phase, learners start to independently seek out additional information to deepen their knowledge of the content (Hidi & Renninger, 2019). Although emerging individual interest is typically self-generated, it still requires some level of external support (Hidi & Renninger; 2006). Social and instructional support from peers, teachers, and parents can contribute to emerging individual interest. In a study by Azevedo (2006), providing challenges and opportunities to explore contributed to sustained interest and sustained engagement in computer-based scientific image processing activities. Also, Nolen et al. (2007) found that providing ways to see reading as an opportunity for enjoyment and learning, framing learning specific tasks as a game, and building in opportunities for social interaction around books, increased young children's interest in reading and writing. Further, encouragement from others can help learners to maintain their emerging individual interest (Hidi & Renninger, 2006, 2019).

Phase 4: Well-developed Individual Interest. Well-developed individual interest refers to the psychological state of interest as well as a relatively stable disposition to reengage with a particular task or content over time (Hidi & Renninger, 2006). Well-developed interest is characterized by more stored knowledge, value, and positive feelings for a particular content compared to that of emerging individual interest (Hidi & Renninger, 2006). Well-developed individual interest is typically self-generated. Learners with well-developed interest is voluntarily search for information, formulate and address their own questions, and identify links with other relevant content (Hidi & Renninger, 2006, 2019). Well-developed individual interest also makes it easier for learners to self-regulate their learning (Hidi & Renninger, 2019; Lee et al., 2014; Sansone & Thoman, 2005). Multiple environmental and instructional factors can contribute to well-developed individual interest. Research has shown that providing opportunities that include interaction with others (e.g., peers) and challenges that leads to knowledge building promote well-developed individual interest (Hidi& Renninger, 2006). Project-based learning, which requires learners to solve complex and authentic problems, also contributes to well-developed individual interest (Blumenfeld et al., 1991). Alternatively, when support from the learning environment is lacking, interest can fall off, go dormant, or disappear (Bergin, 1999).

It should be noted that students' interest in school subjects tends to decrease over time. This phenomenon is observed as early as the first year of elementary school, and it has also been widely reported in secondary school students (Hidi et al., 2004). Moreover, such declines in student interest have been most prominent in STEM fields, especially for female students in these subjects (Hidi et al., 2004; Hoffmann, 2002). The declines in academic interest over time could be due to both students' cognitive development (Bandura 1997; Wigfield, 1994) as well as a lack of environmental support for fostering student interest (Hidi et al., 2004; Hoffmann, 2002; Renninger & Hidi, 2002). According to Bandura (1997), individual interest emerges from one's sense of self-efficacy, or individuals' beliefs about how well they will do on upcoming tasks. Wigfield (1994) also notes that although young children's competence and task-value beliefs are likely to be relatively independent of each other, as children get older, they begin to attach more value to activities in which they do well. As such, it is likely that ninth grade students who face the increased academic demands of high school may demonstrate a decrease in interest over time, especially in STEM-related domains. During this time, the role of teachers, parents, and school culture would be especially important in reversing or buffering the developmental trajectory of academic interest in older students.

Multisystemic Contributors to Interest Development

The four-phase model of interest development (Hidi & Renninger, 2006) emphasizes the importance of external factors, including exposure to stimuli, the meaningfulness of learning materials, and interaction with others who provide feedback and encouragement. External factors are especially salient in the early phases of interest development (Hidi & Renninger, 2006; Jungert et al., 2020; Wentzel, 1998). Adults who interact with an individual on a regular basis, such as teachers and parents, can play a crucial role in manipulating the learning environment for the individual and providing ongoing support for interest development. This support, in turn, would influence the formation and maintenance of the individual's values and interest.

Ecological Systems Theory and Social Support

According to Wentzel et al.'s (1999) socialization models of development, socializers influence children via a least two general mechanisms. First, ongoing social interactions with socializers teach children about themselves and what they need to do to become accepted and competent member of their social worlds. In the process, children develop a set of values and standards for behavior and goals. Wentzel and colleagues (1999) point out that children can also develop many of these beliefs and goals through observational learning (Bandura, 1986). Second, the qualities of children's social relationships can influence motivation. When children's relationships with adults are nurturing and supportive, they are more likely to adopt and internalize the expectations and goals that are valued by those adults, but such internalization is less likely to occur when the relationships are harsh and critical (Wentzel et al., 1999).

Academic motivation in the form of interest and achievement goals is one likely mediator that links social influences to academic achievement (Wentzel, 1988). As such, academic motivation and achievement should be understood within not only specific learning contexts but also the broader social and psychological settings (Song et al., 2015). According to Bronfenbrenner's ecological systems theory (1977), a child's development is an ongoing process based on reciprocal interactions among concentric systems surrounding the child. Specifically, Bronfenbrenner (1977, 1986) proposes five subsystems that are interconnected: the microsystem, mesosystem, exosystem, macrosystem, and chronosystem. The innermost level, microsystem, consists of relations between children and their immediate surroundings, such as the child's relationship with family members and teachers. Next, the mesosystem consists of connections among two or more microsystems, such as the relationships between parents and teachers in schools. The exosystem refers to distal social structures that have an indirect effect on the child, such as neighborhood, media, and governmental agencies. The macrosystem refers to the overarching institutional patterns of the culture or subculture, such as the economic, social, educational, legal, and political systems. The chronosystem refers to changes over time not only within the person but also in the environment, such as socio-historical circumstances (Bronfenbrenner, 1986).

All systems impact children's development and functioning, but the innermost two systems, microsystem and mesosystem, can directly influence academic motivation, interest, and achievement in students. Schools are unique in that they can serve as both a microsystem and a mesosystem for students (Ayers et al., 2012). At the microsystemic level, school serves as a community in which students participate directly and interact with others; at the mesosystemic level, the school serves to bring together microsystems such as teachers, peers, families, and neighborhood influences (Ayers et al., 2012). As such, this study will examine both microsystemic (i.e., parent and teacher support) and mesosystemic (i.e., school-level support) contributors to student interest development and achievement that can facilitate school success for high school students with ADHD.

Perceived versus Direct Social Support

Most research on socialization experience effects on academic outcomes has focused on students' perceptions of interpersonal relations. According to Wentzel (1999), the focus on students’ perceptions is based on an underlying assumption that individuals construct beliefs about themselves and their social worlds as they experience and interact with others. Numerous studies have shown significant relations between students' perceptions of support from adult socializers (e.g., parents and teachers) and positive aspects of student motivation, including academic interest and goal pursuit (Wentzel, 1999). Such findings support the importance of considering students’ self-beliefs and their interpretation of surrounding environments. However, the processes that explain links between students' perceptions of social experiences and motivation are not well understood. Wentzel (1999) suggests that perceptions of support from parents and teachers might simply be a proxy for students' interpretations of effective parenting or instructional styles at home or in the classroom.

According to Eccles and Wigfield’s (2020) situated expectancy-value theory, socialization occurs at both distal and proximal levels. In their model of parents’ socialization of motivation, parent and family characteristics as well as child characteristics are distal and direct contributors to child motivation, such as child’s beliefs, values, goals, performance, and subsequent task or activity choice. Parent, family, and child characteristics can also influence parents’ general (e.g., gender-role stereotypes, efficacy beliefs, and general and specific values) and child-specific beliefs (e.g.., expectations of child’s achievement, perceptions of child’s abilities, perceptions of the value of various skills for child, perceptions of child’s interest, and specific socialization goals). Parental beliefs, in turn, may influence more proximal factors like family socioemotional climate and general child rearing style, parents’ modeling behaviors, and parents’ activity-specific behaviors. Parents’ activity-specific behaviors include teaching strategies; career guidance, encouragement of various activities; provision of tools, toys, and opportunities to learn various skills; training of specific values, and causal attributions for child’s behavior and outcomes. Finally, parental child rearing style and activity-specific behaviors influences child outcomes.

Eccles and Wigfield (2020) posit that social influence flows from distal to proximal factors in the model of parents' socialization of motivation, but they also stressed the dynamic and iterative nature of the model over time. For example, parents' general child rearing style, role modeling, and activity-specific behaviors can influence a child's values, goals, and choices, which can, in turn, influence parents' general beliefs and child-specific beliefs over time. Also, the model of parents' socialization of motivation can be applied to teachers as well. Although most studies have heavily relied on measures of student-reported measures of perceived social support on student motivation, the situated expectancy-value theory suggests that more specific and direct support from socializers (e.g., role modeling behaviors and various activity-specific behaviors) should also be explored. Further, data from multiple informants, rather than solely relying on students' self-reports, would provide a more comprehensive picture of the multifaceted relationship between social support, academic motivation, and achievement.

Academic versus Social Support

Although consensus exists that social support is a positive contributor to positive student outcomes, the exact function of perceived social support remains unclear. According to Song et al. (2015) and Wentzel et al. (2010), existing research has largely overlooked the multidimensionality of social support and individual differences. They argue that social support from particular social agents and specific types of social support may have greater influence on adolescent development. However, most studies do not examine multiple sources and types of support within the same investigation (Wentzel et al., 2010).

To address this issue, Wentzel et al. (2010) examined the influence of five dimensions of perceived social support from teachers and peers (i.e., expectations for positive social behaviors, expectations for academic engagement, provisions of help, perceived safety, and emotional support) on general interest in classroom activities and social goal pursuit among middle school students. They found that students' general interest was significantly predicted by four all types of hypothesized perceived teacher support (i.e., teacher academic expectations, safety from teachers, teacher help, and teacher emotional support) as well as three types of perceived peer support (i.e., peer academic expectation, peer help, and peer emotional support). Whereas perceived safety from teachers was a significant predictor of student interest, perceived safety from peers was not. Alternatively, students' social goal pursuit was significantly predicted by perceived safety from both teachers and peers, teacher emotional support, and peer expectations for social behaviors. The results demonstrate how the impact of multiple supports on students' academic and social motivation may differ as a function of source of support.

Song et al. (2015) further explored the multidimensionality of social support on academic and motivational outcomes using longitudinal data following Korean middle school students from Grade 7 to 9. Although Wentzel et al.'s (2010) study only examined the role of classroom social support from teachers and peers, Song and colleagues also included social support from parents. Song et al. argued that parents also serve as primary social agents who influence the development and learning of adolescents. In addition, Song and colleagues also distinguished support that is mainly academic in nature (e.g., providing study tips) from support that is mainly emotional in nature (e.g., providing empathy and encouragement), hypothesizing that academic support and emotional support will play different roles depending on the source of the social supports.

Song et al. (2015) found that parents were the strongest source of perceived support for adolescents. Parental emotional support was most beneficial, predicting adaptive achievement goals, lower test anxiety, and higher academic achievement. However, parental academic support functioned as a double-edged sword. Parental academic support predicted not only adaptive achievement goals but also higher test anxiety. Alternatively, teacher emotional support was not as effective as that from parents in predicting adolescent motivation or achievement. Nevertheless, teacher academic support predicted adaptive achievement goals and higher achievement. Lastly, peer support, which was measured as a unitary construct based largely on emotional support items, worked as a buffer against maladaptive motivation and anxiety for adolescents. Song et al.'s findings highlight the importance of examining not only the sources of social support but also the types of social support.

Research by to Wentzel et al. (2010) and Song et al. (2015) provides much insight on the importance of considering the multidimensionality of social supports. Even when social supports come from the same social agent, different types of supports (e.g., academic versus emotional support) can play differential roles on adolescents' academic motivation and achievement. However, the influences of multisystemic social supports specifically on student interest development need further exploration. Brief literature review of roles of different social agents in interest development is presented below.

Role of Teachers in Interest Development

Educators can play a supportive role in determining whether and how students develop their interest in a subject matter (Lipstein & Renninger, 2006). However, if educators do not provide students with opportunities to connect ideas or respect their ideas, students' interest may decline (Lipstein & Renninger, 2006). In a study by Wentzel (1998), perceived teacher support, as measured by subscales of social and academic support, was a positive predictor of students' general academic interest in school (e.g., "I really enjoy being at school.") as well as interest in class for each academic subject (e.g., English, science, social studies, and mathematics). Teacher support in terms of classroom management can also impact student interest. For example, Kunter and colleagues (2007) found students' perceptions of rule clarity (i.e., whether they feel they understand what is expected of them) and teacher monitoring (i.e., whether they feel that teacher monitors students' actions and is alert to any behavioral problems or learning difficulties) positively predicted math-related interest. Furthermore, educators can and should support students to feel positive about their efforts to learn to promote student interest. Feelings towards a subject matter can predict enjoyment in learning and positive learning outcomes (Renninger & Hidi, 2002; Pekrun et al., 2002).

Role of Parents in Interest Development

Parents are role models for their children's eventual interests, educational values, and choices (Jacobs & Eccles, 2000; Jacobs & Harvey, 2005). As such, parental support can be a powerful factor in students' development and maintenance of interest. Wentzel (1998) found that perceived parent support also indirectly predicted students' interest in school, by way of negative relations with emotional distress. It should be noted that in Wentzel's study (1998), perceived parent support was measured by a family cohesion scale, which contains social support items and not academic support items. George and Kaplan (1998) found that parental involvement has significant direct as well as indirect effects on eighth grade students' science attitudes (via science activities and library/museum visits). They also found that science activities have a significant direct effect on science attitudes. Such findings suggest the importance of parental involvement and support in promoting student motivation and interest.

Role of School Support in Interest Development

Although many studies have examined the role of teachers and parents on students' interest development at the microsystemic level, the role of schools in shaping students' motivation has often been overlooked (Maehr & Midgley, 1991). According to Robinson (2023), classrooms frequently act as delivery mechanisms of or reactions to broader systems, such as schools, communities, policies, and sociohistorical systems, which all contribute to an overall motivational climate. A school is a place where families, teachers, school staff, and administrators have ongoing interactions that impact individual students at the mesosystemic level. Also, a school is where federal-, state-, and local-level educational policies are implemented and enforced, serving as a connecting point for educational mesosystems and ecosystems.

Teachers alone cannot carry the burden of significant school change to enhance student motivation and achievement (Maehr & Midgley, 1991). Even if teachers try to implement changes at the classroom level to increase students' academic motivation, such efforts may not be as effective or sustainable without addressing the broader school system (Maehr & Midgley, 1991). For example, a classroom teacher may attempt to make learning intrinsically meaningful and interesting by providing students with appropriate challenges and opportunities to explore (Azevedo, 2006). However, if the building principal and school leadership team do not provide the teacher with sufficient financial and human resources or even penalize the teacher for such attempts, any positive school-level changes will be discouraged. As such, the immediate and proximal influences of teachers and parents along with the indirect influences of school level support and policies on student motivation should be investigated.

Interest and School Achievement

Numerous studies have shown that individual or subject matter interest and school achievement (i.e., grades, standardized tests) are positively associated. Nevertheless, there has been an ongoing debate on the strength and the nature of the relationship. Schiefele et al. (1992) conducted a meta-analysis to examine the relationship between interest and achievement, and they found that on average, across subject areas, school types and age groups, the level of subject interest accounts for about 10% of observed achievement variance. The relationship between subject interest and achievement was stronger in male students than in female students. However, Schiefele and colleagues acknowledge that the strength of the relationship between interest and achievement cannot be fully evaluated without considering other predictors, such as an individual's ability. Nevertheless, other researchers argue that ability and interest independently predict achievement (e.g., Schiefele & Csikszentmihalyi, 1995).

Furthermore, the expectancy-value model of achievement motivation (e.g., Eccles, 2009; Wigfield & Eccles, 2002) suggests that task values, such as interest, maybe a better predictor of academic choices than of achievement outcomes. In a longitudinal study by Köller et al. (2001), math interest did not predict math achievement from Grade 7 to Grade 10, although it did predict more advanced course selection at the end of Grade 10. The results seem to support the argument that interest is a stronger predictor of academic choices than achievement. However, students' math interest at the end of Grade 10 had a direct and an indirect effect (via course selection) on achievement in Grade 12, suggesting that age and developmental stage may moderate the relationship. As such, the relationship between interest and achievement should be further investigated in various samples and contexts.

Academic Interest in Students with ADHD

Many researchers have empirically investigated the development of academic interest (e.g., Harackiewicz et al., 2000; Linnenbrink-Garcia et al., 2013; Mitchell, 1993). However, no studies have examined academic interest development specifically among students with ADHD. The internalization of environmentally triggered situational interest into longer-term individual interest may be harder for students with ADHD, given their deficits in self-regulation of affect-motivation-arousal and their tendency to rely on external feedback. According to Sansone and Thoman's (2005) model of self-regulation, if an experience is interesting and personally involving, individuals will continue to perform the activity. If it is uninteresting, individuals consider whether there are sufficient extrinsic reasons to perform the activity. If not, individuals will quit. If there are sufficient reasons to continue, individuals have two choices: 1) They can continue to perform the uninteresting activity as is, holding on for as long as they can until they reach the goal; or 2) individuals can actively change how they perform the task, using strategies to make performance more interesting. For students with ADHD, persisting in an uninteresting task, even if there are sufficient extrinsic reasons, may be more challenging.

Unfortunately, students with ADHD tend to have lower academic-related motivation compared to their peers (Carlson et al., 2002; Smith et al., 2020). Also, students with ADHD show less enjoyment of learning and more reliance on external feedback than internal standards to evaluate performance (Carlson et al., 2002). Lower levels of motivation among students with ADHD could be due to deficits in executive functioning. According to the executive functioning theory of ADHD (Barkley, 1997), individuals with ADHD have difficulties with self-regulation of affect-motivation-arousal, or the ability to regulate one's motivational states or drives to engage in and accomplish goal-directed behavior. Typically developing children may learn to induce more positive emotional and motivational states when they are angered, frustrated, disappointed, saddened, anxious, or bored, by taking self-directed actions such as self-comforting and self-reinforcement (Barkley 1997). Alternatively, students with ADHD may have difficulty effectively utilizing self-directed strategies that help them to pursue long-term goals. Deficits in self-regulation of affect-motivation-arousal, in turn, may decrease classroom engagement and achievement in students with ADHD.

Although external support from significant others is particularly critical in the early phases of interest development (Hidi & Renninger, 2006; Jungert et al., 2020; Wentzel, 1998), no empirical study has examined the role of social support on interest development in students with ADHD. Also, an individual's development is directly and indirectly affected by multiple layers of proximal and distal social interactions (Bronfenbrenner, 1977, 1986). As such, the development of academic interest in students with ADHD should be examined not in only specific learning and achievement contexts but also in broader ecological systems, including family, teacher, and school-level factors.

Fostering STEM Interest in High School Students with Disabilities

Lastly, special attention should be given to fostering interest in science, technology, engineering, and math (STEM) fields in high school students with disabilities. The number of jobs in the U.S. requiring substantial STEM expertise has grown by nearly 34% (National Science Board [NSB], 2018). However, students with disabilities experience greater STEM barriers in high school compared to their peers without disabilities, such as a lack of role models in STEM professions; reduced teacher and parental expectations; presumptions of inability; and teachers' lack of skill and experience in including and engaging students with disabilities (Hawley et al., 2013). In addition, many teachers do not view invisible disabilities, such as ADHD, as authentic disabilities, and see students with invisible disabilities as lazy or incapable

(Hawley, 2013; Lee, 2011). As a result, students with ADHD are often discouraged from considering careers in STEM (Lee, 2011). As such, the role of parents and teachers in providing both academic and emotional support in fostering STEM interest in this population should be examined.

Purpose of Current Study

The current study examined the relationships between school-level support, parent support, teacher support, student interest in mathematics and science, and student achievement among students with ADHD entering high school (see Figures 2 and 3). Data were from a longitudinal field study that included student self-reports, school administrator reports, and parent reports.

Research Questions and Hypotheses

Research Question 1 (RQ1)

Does school-level support for students' STEM interest development in ninth grade predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ1

School-level support for students' STEM interest development in ninth grade will positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD.

Research Question 2 (RQ2)

Does parental support for students' STEM interest development in ninth grade predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ2

Parental support for students' STEM interest development in ninth grade will positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD.

Research Question 3 (RQ3)

Does perceived ninth grade math/science teacher emotional support predict ninth grade math/science interest, 11th grade math/science, and overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ3

Perceived ninth grade math/science teacher emotional support will positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD.

Research Question 4 (RQ4)

Does ninth grade math/science teacher academic support predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ4

Ninth grade math/science teacher academic support will positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD.

Research Question 5 (RQ5)

Does ninth grade math/science interest predict overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ5

Ninth grade math/science interest will positively predict overall high school math/science GPA for students with ADHD.

Research Question 6 (RQ6)

Does ninth grade math/science interest mediate the relationship between different types of social support (school-level support, parental support, and teacher emotional and teacher academic support) provided to students in ninth grade and overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ6

Ninth grade math/science interest will mediate the relationship between different types of social support and overall high school math/science GPA in students with ADHD.

Research Question 7 (RQ7)

Does 11th grade math/science interest predict overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ7

11th grade math/science interest will positively predict overall high school math/science GPA in students with ADHD.

Research Question 8 (RQ8)

Does 11th grade math/science interest mediate the relationship between different types of social support provided to students in ninth grade and overall high school math/science GPA in students with ADHD?

Hypothesized Results for RQ8

11th grade math/science interest will mediate the relationship between different types of social support and overall high school math/science GPA in students with ADHD.

Research Question 9 (RQ9)

Does ninth grade math/science interest predict 11th grade math/science interest in students with ADHD (RQ 9.1)? Does ninth grade math/science interest and 11th grade math/science interest sequentially mediate the relationship between different types of social support provided to students in ninth grade and overall high school math/science GPA in students with ADHD? (RQ 9.2)?

Hypothesized Results for RQ9

Ninth grade math/science interest will positively predict 11th grade math/science interest in students with ADHD (RQ 9.1)? Further, ninth grade math/science interest and 11th grade math/science interest sequentially mediate the relationship between different types of social support provided to students in ninth grade and overall high school math/science GPA in students with ADHD (RQ 9.2).

Chapter II: Methods

Samples

This study used restricted data from the High School Longitudinal Study of 2009 (HSLS:09), the fifth study undertaken by the National Center for Education Statistics (NCES) as part of its Secondary Longitudinal Studies Program. HSLS:09 recruited a nationally representative sample of ninth graders across the United States (Ingels et al., 2011; 2015). The restricted-use HSLS:09 dataset allows researchers to link school- and student-level variables. The access to restricted HSLS:09 data was approved under the license of the Principal Project Officer (PPO) at Lehigh University who oversees the day-to-day operations involving the use of subject data and is responsible for liaising with the IES Data Security Office.

The baseline data were collected in the fall of 2009 from adolescents in ninth grade in 944 schools through a stratified, two-stage random sample design with primary sampling units defined as schools (Ingels et al., 2011). About 27 students per school were randomly selected from school enrollment rosters, and 25,206 of the selected students were determined to be eligible for the base-year assessment (Ingels et al., 2011). Follow-up surveys and additional data collection occurred in 2012, 2013, and 2016. In the base year (fall 2009), surveys were also administered to parents, teachers, school counselors, and school administrators, but in the first follow-up (spring 2012), teacher surveys were omitted. Also, students' academic interest was only measured at two time points (2009 and 2012). Given limited high school data points in student and teacher surveys and the current study's focus on the transition to high school period, only the fall 2009 baseline data from student, parent, teacher, and school administer surveys, the spring 2012 first follow-up data from the student survey, and the high school transcript data (collected in 2013 post-high school graduation) were utilized. It is important that the teacher data are meant only to supply contextual information for students' classrooms, while the student remains the unit of analysis (NCES, 2018). The HSLS:09 research team emphasizes how the teacher sample is not representative of teachers in the school and that the HSLS:09 does not provide data for a standalone analysis sample of teachers. Instead, the HSLS:09 permits specific teacher characteristics and practices to be related directly to the learning context and educational outcomes of sampled students.

When students were in ninth grade, parents were asked, "Has a doctor, health care provider, teacher, or school official ever told you that your child has attention deficit disorder or attention deficit hyperactive disorder, that is, ADD or ADHD?" with responses coded 1 (*yes*) or 0 (*no*). Of the 25,206 initial eligible baseline sample, about 9,530 had missing data, resulting in about 15,680 students with and without ADHD (the number of sample members was rounded to the nearest 10 to protect respondent privacy). The overall baseline student sample consisted of about 1,730 ninth grade students with ADHD (70% male) and about 13,950 ninth grade students without ADHD (48% male). Only students with ADHD were included in the analytic sample.

Constructs and Measures

All measures used in the HSLS:09 dataset demonstrated adequate reliability and validity as indicated in the user manual (Ingles et al., 2011). However, existing student-level and school-level composite measures provided by NCES were not appropriate for the proposed observed and latent constructs. As such, all latent variables in this study were re-created by selecting individual survey items based on theoretical literature, and psychometric properties were explored in the current study. The frequency was reported for all observed discrete predictor variables, and the coefficient of reliability was calculated for all latent continuous variables.

In the current study, social supports were measured using either student-perceived social support measures or socializer-reported social support measures depending on the available survey items. Specifically, only math/science teacher emotional supports were measured using student-reported items of perceived social support. School-level STEM support, parent STEM support, math/science teacher academic support were directly measured using school administrator-, teacher-, or parent-reported items of direct social support. It would have been optimal to measure both student-reported perceived social support and socializer-reported social support for all support constructs. As students subjectively interpret their experiences, social support as perceived by students and actual social support provided by social agents are likely to have different levels of influence on student outcomes. The term "actual social support" is used here for convenience to distinguish between student perception and socializer perception of social support; Socializer-reports of social support provided to students is also socializer's perception of support provision, and they are not objective measures that can be readily observed. However, due to the limitation of using an existing large dataset, such discrepancies could not be examined in the current study.

Ninth Grade School-level STEM Support

An observed variable of school-level support for students' STEM interest development was measured using 10 binary items in the 2009 baseline school administrator questionnaire. School administrators were asked, "Does your school do any of the following to raise high school students' interest and achievement in math or science? (check all that apply)" with responses coded as 1 (*yes*) or 0 (*no*). The statements included: "Hold school-wide math or science fairs, workshops, or competitions," "Partner with community colleges or universities that offer math or science summer programs or camps for high school students," "Sponsor a math or science after-school program," "Pair students with mentors in math or science," "Bring in guest speakers to talk to students about math or science," "Take students on math- or science-relevant field trips such as to a city aquarium or planetarium," "Tell students about regional or state math or science contests, math or science web sites and blogs, or other math or science programs online or in your community, such as a 21st Century Community Learning Center program or Girls Incorporated Operation SMA," "Partner with Mathematics Engineering Science Achievement (MESA) or a similar enrichment-model program in your community or state that provides math or science academic development activities and services to students," "Require teacher professional development in how students learn math or science," and "Require teacher professional development in increasing student interest in math or science." The responses were summed, and a higher score represents more support.

Ninth Grade Parent STEM Support

An observed variable of parent-reported STEM support was created using six binary item-level indicators in the 2009 baseline parent questionnaire. Parents were asked, "During the last 12 months, which of the following activities have you or another family member done with your 9th-grader? Check all that apply," with response s coded as 1 (*yes*) or 0 (*no*). The statements included, "Visited a zoo, planetarium, natural history museum, transportation museum, or a similar museum," "Worked or played on a computer together," "Built or fixed something such as a vehicle or appliance," "Attended a school science fair," and "Helped your 9th-grader with a school science fair project," and "Discussed a program or article about math, science, or technology." The responses were summed, and a higher score represents more support.

Ninth Grade Math/Science Perceived Teacher Emotional Support

A latent variable of student-reported perceived emotional teacher support from ninth grade math/science teachers was measured using seven item-level indicators in the 2009 baseline student questionnaire. Students rated how much they agree or disagree with the following statements about their math/science teacher on a four-point Likert scale (1= *Strongly agree*, 2=*Agree*, 3=*Disagree*, 4=*Strongly disagree*): "Values and listens to students' ideas," "Treats students with respect," "Treats every student fairly," "Thinks all students can be successful," "Thinks mistakes OK if students learn," "Treats some kids better than others (reverse-coded)," and "Treats males/females differently (reverse-coded)." Higher values represent greater perceived support.

Ninth Grade Math Teacher Academic Support

A latent variable of math teacher-reported academic support was measured using 14 items in the 2009 baseline teacher questionnaire. Math teachers were asked, "Think about the full duration of this [fall 2009 math course]. How much emphasis are you placing on each of the following objectives?" Math teachers rated using a 3-point Likert scale (2= *No emphasis*; 3= *Moderate emphasis*; 4 = *Heavy emphasis*). The objectives included: "Increasing students' interest in mathematics," "Teaching students mathematical concepts," "Teaching students mathematical algorithms or procedures," "Developing computational skills," "Developing problem-solving skills," "Teaching students to reason mathematically," "Teaching students how mathematics ideas connect with one another," "Preparing students for further study in mathematics," "Teaching students the logical structure of mathematics," "Teaching students about the history and nature of mathematics," "Teaching students to explain ideas in mathematics effectively," and "Teaching students how to apply mathematics in business and industry," " Teaching students to perform computations with speed and accuracy"; and "Preparing students for standardized tests." Higher scores represent greater support.

Ninth Grade Science Teacher Academic Support

A latent variable of science teacher-reported academic support was measured using 11 items in the 2009 baseline teacher questionnaire. Science teachers were asked, "Think about the full duration of this [fall 2009 science course]. How much emphasis are you placing on each of the following objectives?" Science teachers rated using a 3-point Likert scale (2= *No emphasis*; 3= *Moderate emphasis*; 4 = *Heavy emphasis*). The objectives included: "Increasing students' interest in science," "Teaching students basic science concepts," "Teaching students important terms and facts of science," "Teaching students science process or inquiry skills," "Preparing students for further study in science," "Teaching students to evaluate arguments based on scientific evidence," "Teaching students how to communicate ideas in science effectively," "Teaching students about the applications of science in business and industry," "Teaching students about the relationship between science, technology, and society," "Teaching students about the history and nature of science," and "Preparing students for standardized tests." Higher scores represented greater support.

Ninth and 11th Grade Student Math Interest

A latent variable of math interest was measured with three item-level indicators assessing ninth and 11th graders' interest in their math course. In the fall 2009 baseline student survey and in the spring 2012 first follow-up survey, students were asked, "How much do you agree or disagree with the following statements about your [fall 2009/spring 2012 math course title]?" Students rated to what degree they agreed with the following statements on a four-point Likert scale (1= *Strongly agree*, 2= *Agree*, 3= *Disagree*, 4 = *Strongly disagree*): "You are enjoying this class very much," "You think this class is a waste of your time (reverse-coded)," and "You think this class is boring (reverse coded)." Higher values represent a greater interest in math.

Ninth and 11th Grade Student Science Interest

A latent variable of science interest was measured with three items assessing ninth and 11th graders' interest in their science course. In the fall 2009 baseline student survey and in the spring 2012 first follow-up survey, students were asked, "How much do you agree or disagree with the following statements about your [fall 2009/spring 2012 science course title]?" Students rated to what degree they agreed with the following statements on a four-point Likert scale (1= *Strongly agree*, 2=*Agree*, 3=*Disagree*, 4=*Strongly disagree*): "You are enjoying this class very much," "You think this class is a waste of your time (reverse-coded)," and "You think this class is boring (reverse coded)." Higher values represent a greater interest in science.

Overall High School Math/Science GPA

Math GPA is the cumulative GPA across all high school years in classes that begin with code 02 according to the School Codes for the Exchange of Data (SCED), and science GPA is the cumulative GPA across all high school years in classes that begin with code 04 according to the SCED (Bradby et al., 2007). Overall high school GPA data were collected in 2013 post-high school graduation.

Data Collection

A detailed description of the HSLS:09 data collection process is provided in the base year technical manual (Ingles et al., 2011). In the base year of HSLS:09, students were sampled through a two-stage process. First, stratified random sampling and school recruitment resulted in the identification of 1,889 eligible base-year schools. Of these eligible schools, a total of 944 schools participated in the study, resulting in a 5.5% weighted school response rate. The target population at the school level was defined as regular public schools, including public charter schools, and private schools in the 50 United States and the District of Columbia, that provided instruction in both ninth and eleventh grades.

The target population of students included all ninth-grade students who attended study-eligible schools in the fall 2009 term. All students who met the target population definition were deemed eligible for the study. Students who were unable to participate directly in the study due to language barriers or severe disabilities were retained in the sample, and contextual data were sought for them. Their ability to complete the study instruments was reassessed in the subsequent follow-ups. In the second stage of sampling, about 27 students per school were randomly selected from school enrollment rosters, and 25,206 of the selected students were determined to be eligible for the base-year assessment. Of the 25,206 base-year sample members, 25,184 were eligible for the first follow-up in spring 2012 (22 were deceased or ineligible); 25,168 were eligible for the 2013 Update (a cumulative total of 38 were deceased or ineligible); and 25,167 were eligible for the high school transcript data collection in 2013 (a cumulative total of 39 were deceased or ineligible). Of the 25,167 transcripts requested, 21,928 were received, resulting in 88% weighted school response rate (Ingles et al., 2015).

In the current study, the student was the unit of analysis (Ingles et al., 2011). Data at the school, classroom, or home level were attached to the student record as contextual data. Several contextual respondent populations were sampled. The school's head administrator was asked to complete a school administrator questionnaire at the base year, and mathematics and science teachers of ninth graders enrolled in the subject were asked to complete a teacher questionnaire. The final source of contextual data was the parent. The parent was self-selected, using the criterion that the responding parent should be the one most knowledgeable about the ninth grader's current situation.

Although HSLS: 09 has a nested structure (i.e., the outcome variables of student math/science interest were measured at the individual level, and the key explanatory variables of teacher support were measured at the classroom level), no student-teacher link variable was provided in the HSLS:09 data. This prevented the utilization of hierarchical linear modeling to examine the relationship between variables at the student and classroom levels in a nested design. Also, only about 27 students per school were randomly selected from each of the 944 participating schools, and the number of ninth grade students with ADHD at each school was very small. Overall, 38% of schools had fewer than two students with ADHD, and 65% of schools had fewer than three students with ADHD. The limited ADHD sample size at the school level prevented the utilization of hierarchical linear modeling to examine the relationship between variables at the student and school levels in a nested design.

Human Subjects and Data Protection

Lehigh University's IRB approved this human subjects research. The HSLS:09 restricted-use data provide school information, most of which had to be suppressed on the public-use dataset, along with more student-level variables with less alteration or suppression. Although the HSLS:09 restricted data set does not contain any identifiable information about individual participants, school-level identifying information could potentially be used to trace the data back to participants. In accordance with the guidelines provided by IES Data Security Office, data were stored in a password-protected external hard drive that was stored in a secure, locked cabinet drawer and was only accessed from a private room at Lehigh University. The local computer used to access the hard drive containing the data was disconnected from the Internet and all other networks conforming to the IES data security requirements.

Data Analysis Plan

All data analyses were conducted using SPSS version 26.0 and AMOS version 28 (Arbuckle, 2021) via full information maximum likelihood (FIML). FIML is a direct model-based method for estimating parameters in the presence of missing data. The FIML approach computes a casewise likelihood function with observed variables for each case, and it is considered one of the best practices for missing data management in the field of psychology (Enders & Bandalos, 2009; Schlomer et al., 2010). Alternatively, it should be noted that the use of FIML approach in AMOS creates several limitations because AMOS does not have a method, such as listwise or pairwise deletion, to calculate the observed covariance matrix in the presence of missing data (IBM, 2018). First, AMOS does not produce modification indexes when there is missing data. As such, modification indexes were not utilized to improve the model fit when examining the measurement and structural models for this study. Second, AMOS does not allow parametric bootstrapping when there is missing data. Therefore, the bootstrap confidence intervals (CIs) for indirect effects are not provided with FIML method in AMOS. As such, Sobel tests (Sobel, 1982) were used to test mediation effects instead of the bootstrapping method (Hayes, 2009) in the current study, although the latter is gaining wide popularity as it does not require the assumption of normal distribution (Hayes, 2009; Preacher et al., 2007). An alternative method would be calculating and saving a covariance matrix in SPSS and entering that matrix as input data to AMOS. However, this method was not used because the advantages of the FIML approach to missing data would be lost (IBM, 2018).

In addition, the current study did not utilize sampling weights despite the use of large national dataset. Although the HSLS:09 dataset provides weights that researchers can apply to assure estimates made from the data are representative of the study population, this study utilized a subsample of students with ADHD. Communication with the study director of the HSLS:09 (E. Christopher, personal communication, March 21, 2023) confirmed that a set of weights available by diagnosis is not available, as this was not part of the sample design. Given above considerations, analyses were conducted in the following sequence.

First, descriptive statistics were checked to understand the characteristics of the sample, including assigned sex, school type, race, ethnicity, parents' level of education, and household income. Central tendency and variation (e.g., means and standard deviations) statistics, bivariate correlations, and univariate and multivariate normality of the continuous variables also were checked to ensure these data meet assumptions of normality and homogeneity of variance.

Second, a structural equation modeling (SEM) analysis was used to investigate the relationships among school-level support, teacher support, parent STEM support, ninth grade math/science interest, and high school GPA in math/science. Direct effects, indirect effects, and multiple mediation effects were tested. A bias-corrected bootstrapping procedure with 5,000 samples was used.

In the first step, a confirmatory factor analysis (CFA) was conducted to test the factor structure of proposed latent variables (i.e., ninth grade math/science teacher emotional support; ninth grade math/science teacher academic support; ninth and 11th grade student math interest; ninth and 11th grade student science interest). CFA assumes each observed variable to be a distinct indicator of an underlying latent construct. Several indices were used to assess model fit, including the chi-square test, root mean square error of approximation (RMSEA), Tucker– Lewis

Index (TLI), and comparative fit index (CFI). Ideally, the chi-square test will be nonsignificant (Martens, 2005). However, the chi-square test is influenced by sample size. When samples are large, as it is the case in the current study, small differences between the fitted and sample covariance matrices may yield a statistically significant test result (Martens, 2005). Therefore, additional fit indices with fit criteria specified a priori were used in conjunction with the chi-square test to determine acceptability of model fit (Weston & Gore, 2006). Criteria for good model fit were specified as RMSEA values of .08 or less (Browne & Cudeck, 1993) and CFI and TLI values of .90 or higher (Hu & Bentler, 1995).

In the second step, two separate models for the domains of math and science were examined. Hu and Bentler's (1999) criteria for *a priori* good fit cutoff values were used to assess model fit. Standardized estimates of each proposed structural path also were examined for statistical significance, magnitude, and direction.

To answer the proposed research questions, the significance of direct and indirect effects was examined. First, to test whether school-level support for STEM interest development in ninth grade predicts ninth grade math/science interest, 11th grade math/science interest and overall high school math/science GPA in students with ADHD (*RQ1*), direct paths from school-level support in ninth grade to ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA were examined separately. Second, to test whether parental support for students' STEM interest development in ninth grade predicts ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD (*RQ2*), direct paths from parental support in ninth grade to ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA were examined separately. Third, to test whether ninth grade math/science teacher emotional support predicts ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD (*RQ3*), directs path from math/science teacher emotional support to ninth grade math/science interest, 11th grade math/science interest, and the overall high school math/science GPA were examined separately. Fourth, to test whether ninth grade teacher academic support predicts ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD (*RQ4*), direct paths from teacher academic support to ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA were examined separately.

Fifth, to test whether ninth grade baseline interest predicts overall high school math/science GPA(*RQ5*), the direct path from ninth grade math/science interest to overall high school math/science GPA were examined. Sixth, to test whether ninth grade math/science interest mediates the relationship between different types of social support provided to students in ninth grade and overall high school math/science GPA in students with ADHD (*RQ6*), the indirect paths between different types of social support and overall high school math/science GPA for students with ADHD (via ninth grade math/science interest) were examined.

Seventh, to test whether 11th grade baseline interest predicts overall high school math/science GPA(*RQ7*), the direct path from 11th grade math/science interest to overall high school math/science GPA was examined. Eighth, to test whether 11th grade math/science interest mediates the relationship between different types of social support and overall high school math/science GPA in students with ADHD (*RQ8*), the indirect paths between different types of social support and overall high school math/science GPA for students with ADHD (via 11th grade math/science interest) were examined.

Next, to test whether ninth grade math/science interest predicts 11th grade math/science interest in students with ADHD (*RQ 9.1*), the direct path from ninth grade math/science interest to 11th grade math/science interest was examined. Finally, to test whether ninth grade and 11th grade math/science interest sequentially mediate the relationship between different types of social support and overall high school math/science GPA for students with ADHD (*RQ 9.2*), the indirect paths between different types of social support and overall high school math/science GPA for students with ADHD (via ninth grade and 11th grade math/science interest) were examined.

Chapter III: Results

Descriptive Statistics and Correlations

Descriptive statistics for demographic information are listed in Tables 1 through 4. Table 1 reports the frequency of students with and without ADHD in the HSLS:09 national sample of 25,206. Table 2 reports the demographic characteristics of the study sample of students with ADHD ($N \approx$ 1,730). It should be noted that the HSLS:09 data provides the sample member's birth year and month but not the exact day (X1STDOB). Also, the HSLS:09 provides the month and year the sample member responded to the base year student interview but not the exact day (X1SQDATE). Therefore, an estimated age was calculated by subtracting X1STDOB from X1TESTDATE. Table 3 provides information on the relationship between the Parent Questionnaire respondent and the study sample member. Table 4 provides family characteristics, including total family income from all sources 2008, poverty indicator, and highest level of parents' education.

Next, frequency statistics were reported for the two observed discrete predictor variables: Ninth Grade School STEM Support and Ninth Grade Parent STEM Support. Ninth Grade School STEM Support was measured by the base year School Administrator Questionnaire items. Ninth Grade Parent STEM Support was measured by the base year Parent Questionnaire items. The questionnaire items served as a checklist of discrete school or home practices rather than to describe intended underlying concepts. As such, only the frequency information was reported (see Table 6). Correlations and descriptive statistics (i.e., mean, standard deviation, skewness, and kurtosis) for all other study variables are presented in Tables 6 though 8. Curran et al. (1996) state skewness should be between 2 and +2 and kurtosis should be between 7 and +7 to meet the assumption of normality. In this study sample, skewness values for all variables fell within the range of -2 to 2, and kurtosis values fell within the range of -7 to 7, indicating no significant concerns regarding univariate normality. Bivariate normality was also checked by examining the scatterplots, and no obvious concerns were found. Another widely used indicator of multivariate normality is Mardia's coefficient; however, this index was not determined because the AMOS program does not produce Mardia's coefficients when there are any missing data.

Math Measurement Models

Math Measurement Models per Construct

At this stage, CFA for each construct with individual items as indicators was performed. Error covariances were allowed between items for the same construct when the content or wording of the respective items justified the covariance, as described below. Stevens (1992) suggests using a factor loading cut-off of 0.4, irrespective of sample size, for interpretative purposes. Alternatively, Comrey and Lee (1992) suggest cut-offs ranging from 0.32 (poor), 0.45 (fair), 0.55 (good), 0.63 (very good), or 0.71 (excellent). As the scales included in this study have not been previously validated, the more stringent cut-off of .45 was used as a reference point.

Ninth Grade Math Teacher Academic Support. The initial model for Math Teacher Academic Support, without any error covariances, demonstrated a poor fit to data, $\chi^2(77, N = 1{,}730) = 939.24$, $p < .001$, CMIN/DF = 12.198; CFI = .777; TLI = .695; RMSEA = .080 (90% CI [.076, .085]). Complete results from these preliminary CFA can be found in Figure 4. All unconstrained regression weights in the model were significant at $p < .001$.

Out of the original 14 items, four items did not meet the $\lambda \geq .45$ cut-off criterion: M1COMPUTE ($\lambda = .43$), M1COMPSKILLS ($\lambda = .40$), M1ALGORITHM ($\lambda = .39$), M1TEST ($\lambda = .23$), and M1CONCEPTS ($\lambda = .42$). Closer examination of the content and wording of the items with low factor loadings revealed M1COMPUTE, M1COMPSKILLS, M1ALGORITHM, M1TEST, and M1CONCEPTS reflected math teacher's heavy emphasis on surface level cognitive engagement characterized by rote memorization.

Teacher academic support that focuses mainly on retention of information is conceptually distinctive from teacher academic support that focuses on meaningful learning. Cognitive engagement can be distinguished into surface and deep levels (Greene, 2015; Mayer, 2002). The surface or shallow level of cognitive engagement focuses on retention of information and rote learning, in which students use strategies such as rehearsal and memorization (Greene, 2015; Mayer, 2002). Alternatively, the deep level of cognitive engagement focuses on meaningful learning and transfer of information to performance, in which students use strategies such as exemplifying, inferring, comparing, organizing, and integrating information (Greene, 2015; Mayer, 2002). Therefore, as an alternative to a unitary first-level model of Ninth Grade Math Teacher Academic Support, the construct domain was divided into two separate constructs: Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement and Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement.

Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement. The newly proposed latent construct of Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement was defined by nine item-level indicators (see Figure 5). The initial model, without any error covariances, demonstrated improved but still unacceptable fit to data, $\chi^2(27, N = 1{,}730) = 364.79$, $p < .001$, $CMIN/DF = 13.511$; $CFI = .877$; $TLI = 795$; $RMSEA = .085$ (90% CI [.077, .093]). All unconstrained regression weights in the model were significant at $p < .001$. Indicators showed fair to excellent factor loadings, ranging from .47 to .74.

To improve the model fit, the content or wording of the items was reviewed to allow error covariances between items for the same construct. After a close examination, M1PROBLEM and M1REASON (r = .41); M1REASON and M1LOGIC (r = .16); and M1REASON and M1IDEAS (r = .15) were allowed to covary. The modified model showed a significantly improved fit, $\chi^2(24, N = 1{,}730) = 203.82$, $p < .001$, CMIN/DF = 8.493; CFI = 934; TLI = .877; RMSEA = .066 (90% CI [.058, .074]). All unconstrained regression weights in the model were significant at $p < .001$. All indicators showed fair to excellent factor loadings, ranging from .49 to .72.

Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement. The newly proposed latent construct of Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement was defined by five item-level indicators. The initial model, without any error covariances, demonstrated acceptable to poor fit to data, $\chi^2(5, N = 1{,}730) = 65.86$, $p < .001$, CMIN/DF = 13.173; CFI = .900; TLI = 699; RMSEA = .084 (90% CI [.067, .103]). CFI met the *a priori* cut-off criteria, but TLI and RMSEA suggested a poor fit. All unconstrained regression weights in the model were significant at $p < .001$. Indicators showed a wide range of factor loadings, ranging from .27 to .74. Although M1CONCEPTS ($\lambda = .27$) M1TEST ($\lambda = .32$) did not meet the cut-off of $\lambda \geq .45$ for a good fit, the items were retained at this point based on theoretical and conceptual consistency.

Next, to improve the model fit, the content or wording of the items was reviewed to allow error covariances. Error values for M1COMPSKILLS and M1 COMPUTE (r = .42) were allowed to covary. The modified model showed a significantly improved fit, $\chi^2(4, N = 1{,}730) = 19.87$, $p < .001$, CMIN/DF = 4.967; CFI = .974; TLI = .902; RMSEA = .048 (90% CI [.028, .070]). All unconstrained regression weights in the model were significant at $p < .001$. Indicators showed improved factor loadings, ranging from .36 to .62 (see Figure 6).

The results from the initial confirmatory factor analysis showed that teacher-reported math teacher academic support is a not a unidimensional construct. Instead, two separate models of Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement and Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement provided better explanation of the data.

Ninth Grade Perceived Math Teacher Emotional Support. The initial model for Ninth Grade Perceived Math Teacher Emotional Support, without any error covariances, demonstrated poor fit to data, $\chi^2(14, N = 1{,}730) = 421.94$, $p < .001$, CMIN/DF = 30.138; CFI = .915; TLI = .829; RMSEA = .130 (90% CI [.119, .141]). Although CFI showed a good fit, TLI and RMSEA did not meet the criteria for an acceptable fit. All unconstrained regression weights in the model were significant at $p < .001$. All indicators showed fair to excellent factor loadings, ranging from .47 to .88.

To further improve the model fit, the content and wording of the items were reviewed to allow error covariances between items for the same construct. A closer examination of the items revealed that two sets of reverse-coded items were worded similarly. As such, errors for S1MTCHTREAT and S1MTCHMFDIFF were allowed to covary ($r = .48$, $p < .001$). The modified model showed significantly improved fit, $\chi^2(13, N = 1{,}730) = 80.96$, $p < .001$, CMIN/DF = 6.228; CFI = .986; TLI = .969; RMSEA = .055 (90% CI [.044, .067]). All unconstrained regression weights in the model were significant at $p < .001$. All indicators showed fair to excellent factor loadings, ranging from .44 to .88. The results from the confirmatory factor analysis verify that student-reported perceived math teacher emotional support is a nonhierarchical and unidimensional construct (see Figure 7).

Ninth and 11th Grade Math Interest. The correlated model for ninth and 11th grade math interest, without any error covariances, demonstrated good fit to data, $\chi^2(8, N= 1{,}730) = 89.05$, $p <.001$, CMIN/DF = 11.131; CFI = .970; TLI = .920; RMSEA = .077 (90% CI [.063, .091]). All unconstrained regression weights in the model were significant at $p < .001$. The correlation between Ninth Grade Math Interest and 11th Grade Math Interest was also significant at $p <$ 001, with an estimate of .40. All indicators showed excellent factor loadings, ranging from .64 to .88. Also, student-reported ninth and 11th grade student math interest, measured over time, were moderately correlated ($r = .40$).

To further improve the model fit, the content or wording of the items was reviewed to allow error covariances between items for the same construct. A closer examination of the items revealed that two sets of reverse-coded items were worded similarly. As such, errors for S1MWASTE ["9th grader thinks fall 2009 math course is a waste of time"] and S1MBORING ("9th grader thinks fall 2009 math course is boring") were allowed to covary ($r = .36$), and errors for S2MWASTE ["11th grader thinks spring 2012 math course is a waste of time"] and S2MBORING ("11th grader thinks spring 2009 math course is boring") were allowed to covary ($r = .31$). The modified model showed an improved fit, $\chi^2(6, N= 1{,}730) =66.50$, $p <.001$, CMIN/DF = 11.083 CFI = .977; TLI = .921; RMSEA = .076 (90% CI [.060, .093]). All unconstrained regression weights in the model were significant at $p <.001$. All indicators showed fair to excellent factor loadings, ranging from .55 to .82. Also, student-reported ninth and 11th grade student math interest, measured over time, were again moderately correlated ($r = .46$). The results from the confirmatory factor analysis verify that student-reported math interest in ninth grade and 11th grade are nonhierarchical and unidimensional constructs that are correlated with one another (see Figure 8).

Math Full Measurement Model

Next, a full measurement model in math with all exogeneous and endogenous variables, including the outcome variable of math GPA, was examined. The full measurement model showed an excellent fit, $\chi^2(373, N = 1{,}730) = 1033.93$, $p < .001$, CMIN/DF = 2.772; CFI = .944; TLI = .930; RMSEA = .032 (90% CI [.030, .034]).

Math Full Structural Equation Model

A full SEM model in math with all exogeneous and endogenous variables was examined (see Figure 9). The full SEM model showed an excellent fit, χ^2 (373, $N = 1{,}730$) = 1033.934, $p < .001$, CMIN/DF = 2.772; CFI = .944; TLI = .930; RMSEA = .032 (90% CI [.030, .034]). The factor loadings for all indicators and the statistical significance of regression weights are presented in Table 9.

Direct Effects

Ninth Grade School-Level Support did not predict Ninth Grade Math Interest, 11th Grade Math Interest, or Math GPA with statistical significance. Parental Support did not predict Ninth Grade Math Interest, 11th Grade Math Interest, or Math GPA with statistical significance. Ninth Grade Perceived Math Teacher Emotional Support positively predicted Ninth Grade Math Interest ($\beta = .55$, $p < .001$), but it negatively predicted 11th Grade Math Interest ($\beta = -.14$, $p < .001$). The negative relationship between Perceived Math Teacher Emotional Support and 11th Grade Math Interest should be interpreted with caution. The bivariate correlation between the two variables was positive and statistically significant ($r = .12$, $p < .001$; see Table 7). As such, the sign reversal could be due to the suppression effect. A suppressor variable is a third variable that increases the regression coefficient between the independent variable and dependent variable by its inclusion in a regression equation (Conger, 1974). The inclusion of other predictor variables in a model may have caused the coefficient in the model to reverse sign due to a suppression effect (see Krus & Wilkinson, 1986).

As Ninth Grade Math Teacher Academic Support construct was further divided to two different constructs, the predictability of two types of teacher support on endogenous variables was examined separately. Math Teacher Academic Support for Deep Cognitive Engagement did not predict Ninth Grade or 11th Grade Math Interest with statistical significance, but it positively predicted Math GPA ($\beta = .19$, $p = .021$). Alternatively, Math Teacher Academic Support for Surface Cognitive Engagement did not predict Ninth Grade Math Interest with statistical significance, but it negatively predicted 11th Grade math interest ($\beta = - .27$, $p = .014$). It did not predict Math GPA with statistical significance.

Contrary to hypotheses, both Ninth Grade Math Interest ($\beta = -.20$, $p < .001$) and 11th Grade Math Interest ($\beta = -.20$, $p < .001$) negatively predicted Math GPA. Finally, Ninth Grade Math Interest positively predicted 11th Grade Interest ($\beta = .59$ $p < .001$).

Indirect Effects

To test whether Ninth and 11th Grade Math Interest mediated the relationship between different types of social support and Math GPA, the indirect paths between different types of social support and overall high school math GPA for students with ADHD (via ninth grade math interest) were examined. Sobel tests (Sobel, 1982) were conducted for paths that were statistically significant at $p < .05$.

The classical "causal steps approach" for mediation testing, as described by Baron and Kenny (1986); entails the following steps: 1) Test whether X and Y are significantly associated (the *c* path); 2) Test whether X and M (the mediator variable) are significantly associated (the *a* path); 3) Test whether M and Y are significantly associated after controlling for X (the *b* path);

and 4) Compare the direct of effect of X (the *c′* path--predicting Y from X after controlling for M) to the total effect of X (the *c* path from Step 1). If *c′* is closer to zero than *c*, and non-significant, the researcher can conclude that M completely mediates the association between X and Y. Alternatively, if *c′* is still significant, the researcher concludes that M is only a partial mediator of X's influence on Y. According to this classical approach, X and Y must be significantly associated (the *c* path). However, there is relatively large consensus among statisticians that it is legitimate to conclude that M mediates the association between X and Y even if the total effect (*c'*) is not significant, and that the total effect should not be used as "gatekeeper" for tests of mediation (e.g., Hayes, 2009; Shrout & Bolger, 2002). Zhao et al. (2010) also suggest that meditation without the significant total effect is a type of viable mediation model. As such, mediation effects were tested even when only *a* and *b* paths are significant. All significance tests were two-tailed.

First, the mediating role of Ninth Grade Math Interest (M1) between Math Teacher Emotional Support (X) and Math GPA (Y) was examined. The mediation was statistically significant, $Z = -3.58$ ($SE = .05$), $p < .001$. Next, the mediating role of 11th Grade Math Interest (M2) between Math Teacher Emotional Support (X) and GPA (Y) was examined. The mediation was statistically significant, $Z = 3.23$ ($SE = .02$), $p = .001$. However, the interpretation of the indirect effect maybe difficult due to the potential suppression effect in the path between X and M2. Finally, the serial mediation effect of Ninth Grade Math Interest (M1) and 11th Grade Math Interest (M2) between X and Y was tested. The serial mediation was also statistically significant, $Z = -4.01$($SE = .02$), $p < .001$. Again, the results of this serial mediation should also be interpreted with caution due to the potential suppression effect.

Second, the mediating role of Ninth Grade Math Interest (M1) between Math Teacher Academic Support for Deep Cognitive Engagement (X) and Math GPA (Y) was not examined because the path between the X and M1 (*a*) was not statistically significant, which violates the basic premise of mediation. Similarly, the mediating role of 11th Grade Math Interest (M2) between Math Teacher Academic Support for Deep Cognitive Engagement (X) and Math GPA (Y) was also not examined because the path between the X and M2 (*a*) was not statistically significant.

Third, the mediating role of Ninth Grade Math Interest (M1) between Math Teacher Academic Support for Surface Cognitive Engagement (X) and Math GPA (Y) was not examined because the path between the X and M2 (*a*) was not statistically significant. Alternatively, the mediating role of 11th Grade Math Interest (M) between Math Teacher Academic Support for Surface Cognitive Engagement (X) and Math GPA (Y) was examined. The mediation was statistically significant, $Z = 2.16$ ($SE = .12$), $p = .031$.

Science Measurement Models

Science Measurement Models per Construct

CFAs for each construct with individual items as indicators was performed in the domain of science. The same procedures used in the domain of math were applied here.

Ninth Grade Science Teacher Academic Support. The initial model for Science Teacher Academic Support, without any error covariances, demonstrated a poor fit to data, $\chi^2(44, N = 1{,}730) = 596.39$, $p < .001$, CMIN/DF = 13.554; CFI = .764; TLI = .646; RMSEA = .085 (90% CI [.079, .091]). Complete results from the preliminary CFA can be found in Figure 10. All unconstrained regression weights in the model were significant at $p < .001$.

Out of the original 11 items, three items did not meet the cut-off criteria of $\lambda \geq .45$: N1TEST ($\lambda = .19$), N1TERMS ($\lambda = .36$), and N1CONCEPTS ($\lambda = .32$). As was the case for math, items with low factor loadings reflected science teacher's heavy emphasis on instructional strategies that focused on promoting surface or shallow cognitive engagement. Therefore, as an alternative to a unitary first-level model of Science Teacher Academic Support, the construct domain was divided into two separate constructs: Science Teacher Academic Support for Deep Cognitive Engagement and Science Teacher Academic Support for Surface Cognitive Engagement. The model of Science Teacher Academic Support for Deep Cognitive Engagement could be defined by eight item-level indicators. However, an independent model of Science Teacher Academic Support for Surface Cognitive Engagement could not be defined by three item-level indicators because the model was saturated with zero degrees of freedom. As such, a correlated model consisting of the two distinct but related factors was created, and a CFA was conducted to test the factor structure.

Correlated Model of Ninth Grade Science Teacher Academic Support for Deep and Surface Cognitive Engagement. The initial correlated model of Ninth Grade Science Teacher Academic Support for Deep and Surface Cognitive Engagement (see Figure 11), without any error covariances, demonstrated improved but unacceptable fit to data, $\chi^2(43, N = 1{,}730) = 476.518$, $p < .001$, *CMIN/DF* = 11.082, *CFI* = .815; *TLI* = 715; *RMSEA* = .076 (90% CI [.070, .083]). All unconstrained regression weights in the model were significant at $p < .001$. Indicators showed fair to excellent factor loadings, ranging from .47 to .74, except for one item, N1TEST ($\lambda = .39$). Science Teacher Academic Support for Deep Cognitive Engagement and Science Teacher Academic Support for Surface Cognitive Engagement were moderately correlated with statistical significance ($r = .48$, $p < .001$).

To improve the model fit, the content or wording of the items was reviewed to allow error covariances between items for the same construct. For the Science Teacher Academic Teacher Academic Support for Deep Cognitive Engagement factor, error terms between N1SKILLS and N1EVIDENCE (*r* = .14), N1EVIDENCE and N1IDEAS (*r* =.11), N1BUSINESS and N1SOCIETY (.51), and N1SOCIETY and N1HISTORY (*r* = .14) were allowed to covary. For the Science Teacher Academic Instructional Academic Support factor, error terms between N1TERMS and N1TEST (*r* = .20) were allowed to covary. The modified model showed a significantly improved fit, χ^2(38, *N* = 1,730) =193.51, *p* <.001, CMIN/DF = 5.092; CFI = 933; TLI = .884; RMSEA = .049 (90% CI [.042, .056]). All unconstrained regression weights in the model were significant at *p* <.001. Indicators showed fair to excellent standardized factor loadings, ranging from .50 to .63, except for N1TEST (λ = .26) (see Figure 12). Although N1TEST continued to show showed a poor factor loading for the latent variable of Science Teacher Academic Support for Surface Cognitive Engagement, the item was retained based on conceptual and theoretical basis.

Ninth Grade Perceived Science Teacher Emotional Support. The CFA model for Perceived Science Teacher Emotional Support, without any error covariances, demonstrated a good fit to data, χ^2(14, *N* = 1,730) = 379.72, *p* <.001, CMIN/DF =27.123; CFI = .924; TLI = .848; RMSEA = .123 (90% CI [.112, .134]). Although CFI showed a good fit, TLI and RMSEA did not meet the criteria for acceptable fit. All unconstrained regression weights in the model were significant at *p* <.001. Indicators showed fair factor loadings, ranging from .43 to .90.

To further improve the model fit, the content and wording of the items were reviewed to allow error covariances between items. As it was in the domain of math, two sets of reverse-coded items were worded similarly. As such, errors for S1STCHTREAT and S1STCHMFDIFF were allowed to covary (r = .47, p < .001). The modified model showed an excellent fit, χ^2(13, N = 1,730) =73.39, p <.001, CMIN/DF = 5.646; CFI = .987; TLI = .973; RMSEA = .052 (90% CI [.041, .064]). All unconstrained regression weights in the model were significant at p <.001. Indicators showed fair to excellent factor loadings, ranging from .41 to .91. The results from the confirmatory factor analysis verify that student-perceived science teacher emotional support is a nonhierarchical and unidimensional construct (see Figure 13).

Ninth and 11th Grade Science Interest. The correlated model for ninth and 11th grade science interest, without any error covariances, demonstrated good fit to data, χ^2(8, N = 1,730) = 28.76, p <.001, CMIN/DF = 3.595; CFI = .993; TLI = .980; RMSEA = .039 (90% CI [.024, .054]). All unconstrained regression weights in the model were significant at p < .001. All indicators showed excellent factor loadings, ranging from .64 to .89. Also, Ninth Grade Science Interest and 11th Grade Science Interest showed a small correlation, r = .26, p < 001. The results from the confirmatory factor analysis verify that student-reported science interest in ninth grade and 11th grade are nonhierarchical and unidimensional constructs that are correlated to one another.

In the domain of math, covarying errors for S1MWASTE and S1MBORING, as well as errors for S2MWASTE and S2MBORING significantly improved the model fit for student math interest. However, in the domain of science, covarying errors for S1SWASTE and S1SBORING (r = .26, p = .01), as well as errors for S2SWASTE and S2SBORING (r = .36, p = .06) reduced the model fit, χ^2 (6, N = 1,730) = 24.990, p <.001, CMIN/DF = 4.165; CFI = .993; TLI = .976; RMSEA = .043 (90% CI [.026, .061]). As such, the unmodified original model was retained (see Figure 14).

Science Full Measurement Model

Next, a full measurement model in science with all exogeneous and endogenous variables, including the outcome variable of Science GPA, was examined. The full measurement model showed an excellent fit, χ^2 (293, N = 1,730) = 679.11, p <.001, CMIN/DF = 2.318; CFI = .963; TLI = .953; RMSEA = .028 (90% CI [.025, .030]).

Science Full Structural Equation Model

Next, a full SEM model in science with all exogeneous and endogenous variables was examined (see Figure 15). The SEM model showed an acceptable fit, χ^2(293, N = 1,730) = 679.11, p <.001, CMIN/DF = 2.318; CFI = .963; TLI = .953; RMSEA = .028 (90% CI [.025, .030]). The factor loadings for all indicators and the statistical significance of regression weights are presented in Table 10.

Direct Effects

Ninth Grade School-Level Support did not predict any of the outcome variables. Ninth Grade Parent STEM Support negatively predicted 11th Grade Science Interest with statistical significance (β = - .07, p = .020), but it did not predict Science GPA. Ninth grade Perceived Science Teacher Emotional Support positively predicted Ninth Grade Science Interest (β = .55, p < .001), but it did not predict 11th Grade Science Interest or Science GPA. Although the path between Science Teacher Emotional Support and 11th Grade Science Interest was statistically nonsignificant, it should be noted the bivariate correlation between the two variables was positive and statistically significant (r = .14, p < .001; see Table 8). As such, the sign reversal could be due to a suppression effect.

Ninth Grade Science Teacher Academic Support for Deep Cognitive Engagement did not predict any of the outcome variables. Alternatively, Ninth Grade Science Teacher Academic

Support for Surface Cognitive Engagement negatively predicted Ninth Grade Science interest with statistical significance ($\beta = -.20$, $p = .004$) but not 11th grade science interest. Also, Ninth Grade Science Teacher Academic Support for Surface Cognitive Engagement did not predict Science GPA with statistical significance.

Next, Ninth Grade Science Interest positively predicted 11th Grade Science Interest ($\beta = .29$, $p < .001$). As was the case for math, both Ninth ($\beta = -.10$, $p = .032$) and 11th Grade Science Interest ($\beta = -.10$, $p = .002$) negatively predicted Science GPA.

Indirect Effects

Mediation effects were examined for paths that were statistically significant at $p < .05$. First, the mediating role of 11th Grade Science Interest (M) between Ninth Grade Parent Support and Science GPA was examined. 11th Grade Science interest did not significantly mediate the relationship.

Second, the mediating role of Ninth Grade Science Interest (M1) between Ninth Grade Science Teacher Emotional Support and Science GPA was examined. Ninth Grade Science Interest significantly mediated the relationship, $Z = -2.58$ (SE =.04), $p = .010$. The mediating role of 11th Grade Science Interest (M2) between Science Teacher Emotional Support and Science GPA was not examined, as the path between X and M2 was not significant in the model. Also, the interpretation of the indirect effect maybe difficult due to the potential suppression effect in the path between X and M2. Finally, the serial mediation effect of Ninth Grade Science Interest (M1) and 11th Grade Science Interest (M2) between Science Teacher Emotional Support and Science GPA was tested. The serial mediation was statistically significant, $Z = -2.92$ (SE =.01), $p = .003$. Again, the results of this serial mediation should also be interpreted with caution due to the potential suppression effect.

Third, the mediating role of Ninth Grade Science Interest (M1) between Ninth Grade Science Teacher Academic Support for Surface Cognitive Engagement and Science GPA was examined. Ninth Grade Science Interest did not statistically significantly mediate the relationship. Next, the mediating role of 11th Grade Science Interest (M2) between Science Teacher Academic Support for Surface Cognitive Engagement and Science GPA was examined. 11th Grade Science Interest did not statistically significantly mediate the relationship. Finally, the serial mediation effect of Ninth Grade Science Interest (M1) and 11th Grade Science Interest (M2) between X and Y was tested. The serial mediation was statistically significant, $Z = 2.07$ ($SE = .01$), $p = .038$.

Discussion

Multiple socioecological factors and individual characteristics can impact students' academic motivation and performance. Ongoing microsystemic interactions with socializers, including family members and teachers, can directly influence students' values and attitudes toward learning. Further, school-level policies can indirectly impact student learning at a mesosystemic level. Moreover, the strength and role of social support on students' academic motivation and achievement may vary depending on a student's level of development as well as changes in the environment and social expectations. As a student transitions from middle school to high school, they undergo developmental changes from early to late adolescence, characterized by puberty, cognitive development, and social-emotional maturation (Branje 2018; Gutman & Eccles, 2007). Finally, the patterns of academic motivation and achievement may look different in students with ADHD, who are characterized by impairing levels of inattention, disorganization, and/or hyperactivity-impulsivity (APA, 2022).

The current study had two main purposes. First, the study attempted to ascertain the role of different sources and types of social support on math/science interest development and achievement among students with ADHD in their transition to high school. Second, this research tested whether students' ninth grade and 11^{th} grade math and science interest mediate the relationship between different types of social support and domain-specific academic achievement.

Ninth Grade School-Level Support on Math/Science Interest and Achievement

It was hypothesized that school-level support for increasing students' STEM interest development during the transition to high school would positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science

GPA in students with ADHD (*RQ1*). This hypothesis was not supported. School-level support for STEM interest development did not predict any of the student outcome variables in both math and science. The results suggest that broader school-level support may not directly impact math/science interest or achievement in high school students with ADHD.

The unexpected results could also be due to how the school support construct was defined and measured. School STEM Support was measured by 10 binary *yes/no* items from the base year School Administrator Questionnaire items. It was a screener for school administrators to check off school-level practices rather than a validated dimensional scale to measure an underlying construct. To better understand how school-level support may impact students' academic interest and achievement in math and science, taking a dimensional rather than categorical approach may be more useful and informative. Future studies may wish to develop and validate a measure of school-level academic support that will allow examination of psychometric properties.

Parental-Level Support on Math/Science Interest and Achievement

It was hypothesized that parental STEM support in ninth grade would positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD *(RQ2)*. This hypothesis was not supported. In math, parental STEM support did not predict students' ninth grade math interest, 11^{th} grade math interest, or overall high school math GPA. In science, parental STEM support negatively predicted 11^{th} grade science interest, and it did not predict overall high school science GPA. The results suggest that parental STEM support does not foster academic interest and achievement in high school students with ADHD. The results also suggest that parental STEM support may even be undermining students' academic interest, depending on the subject domain.

The unexpected negative relationship between parental STEM support and science interest could be due to students occupying a unique developmental stage. During the transition period, adolescents and their families experience increased conflict as adolescents strive to gain more autonomy and control (Branje, 2018). Also, the importance of peer relationships increases during this period. During the high school transition, adolescents expand their social networks by moving into larger schools with older peers and new same-age classmates (Benner, 2011). As such, adolescents may not wish to engage in STEM-related activities with their parents, such as going to a planetarium together, working on a school science fair project together, and discussing a STEM-related program or article. There may also be more developmentally appropriate parent support actions for this age group, such as having open and ongoing parent-adolescent discussions of STEM careers. Such discussions should be autonomy-supportive, as adolescents' biological and cognitive development facilitates a shift from a vertical parent-adolescent relationship towards a more horizontal relationship characterized by egalitarianism and reciprocal interactions (Branje, 2018).

Moreover, the changes in parent-adolescent relations may be more pronounced in families with adolescents with ADHD. Many children and adolescents with ADHD have comorbid disruptive behavior disorders, such as oppositional defiant disorder (ODD) or conduct disorder (CD) (Becker & Fogleman, 2020). Further, teenagers with comorbid ADHD/ODD and their parents report significantly more parent-teen conflicts, greater anger during those conflicts, and poorer parent-teen communication compared to their control group families (Edwards et al., 2001; Wiener, 2020). As such, the negative relationship between parental support and students' academic interest may be understood from both developmental and psychopathological perspectives.

Another limitation is that Ninth Grade Parent STEM Support was measured by binary *yes/no* items from the base year Parent Questionnaire items. As was the case for the School-level STEM Support measure, Ninth Grade Parent STEM Support was a checklist for parents to report on family practices, rather than a validated scale that attempts to measure an underlying unitary construct in a dimensional fashion (i.e., degree of support or activity frequency). To better understand how parental support may impact students' academic interest and achievement in math and science, future studies may wish to develop and validate a dimensional measure.

Teacher Emotional Support on Math/Science Interest and Achievement

It was hypothesized that perceived ninth grade math/science teacher emotional support would positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD *(RQ3)*. This hypothesis was partially supported.

Across math and science, perceived ninth grade teacher emotional support predicted students' ninth grade subject interest with a large effect size. The findings highlight the importance of the emotional connection between students and their science teachers and feelings of classroom emotional safety in shaping early science interest as students make the transition to high school. Unexpectedly, perceived math teacher emotional support negatively predicted students' 11th grade math interest after controlling for ninth grade math interest. The originally positive and statistically significant bivariate relationship became negative when an array of other variables was included in the final Math SEM Model. Also, although the bivariate correlation between science teacher emotional support and 11th-grade science interest was positive and statistically significant, the relationship was no longer statistically significant when other variables were included in the final Science SEM Model. Such reversal of valence or nullification of statistically significant relationships possibly suggests suppression effects.

According to Burkholder and Harlow (2003), suppression is recognizable when the direction of the beta weight changes for a predictor in the presence of a second predictor. The change in sign results in a weight that is inconsistent with the original correlation between predictor and outcome measures. A longitudinal design is susceptible to the suppression effect, which is likely to occur in the presence of multicollinearity, or when several variables are highly correlated with each other (Burkholder & Harlow, 2003; Shrestha, 2020). Suppression effects are likely be observed when same-construct predictors are in included with a model, particularly when the constructs are stable in nature and do not exhibit mean change over time (Burkholder & Harlow, 2003). Adding redundant variables into a model can decreases weighted validity, or the product of the regression weight and zero order validity (Conger, 1974). This results in either an increase in the absolute size of the regression weights, negative contributions to variance, or mixed changes in weights depending on complex relationships among variables included in the model (Conger, 1974).

In the present study, the repeated measurement of students' academic interest may have contributed to multicollinearity and subsequent suppression. Ninth grade and 11th grade math interest were same-construct predictors that were included in the math SEM model. Also, ninth grade and 11th grade science interest were same-construct predictors that were included in the science SEM model. The same-construct predictors were included in respective models to examine students' development of academic interest over time in math and science domains. However, interest as a psychological state not only arises from modifiable environmental factors but also is based on relatively stable personal dispositions (Hidi & Baird, 1988; Krapp, 2000;

Renninger & Wozniak, 1985). As such, student's academic interest in math and science may not change much between students' freshmen and junior years of high school. Adding a redundant variable (e.g., 11th grade math/science variable) may have created multicollinearity and caused suppression effects in each model.

Identifying where the multicollinearity occurs often requires model re-specification. For example, Burkholder and Harlow (2003) broke down their original longitudinal crossed-lagged model and created two separate cross-lagged models, each containing either Time 1 values or Time 3 values for their behavioral constructs. Of the two competing models, they chose the model that indicated more significant paths and that was more consistent with the originally proposed theoretical model. However, the purpose of the current study was to examine the complex multisystemic relationships among different sources and types of social support on student interest development and achievement over time. Examining only one source or type of social support or including only one time point of interest measurement would not provide a comprehensive picture of student motivation. Accordingly, I decided to keep the original math/science models instead of creating multiple competing models. As multicollinearity and suppression could not be resolved, the findings should be interpreted with caution. In summary, results suggest that math/science teacher emotional support, in isolation, is likely a powerful and positive predictor of student math/science interest.

Teacher Academic Support on Math/Science Interest and Achievement

It was originally hypothesized that ninth grade math/science teacher academic support, as a unitary construct, would positively predict ninth grade math/science interest, 11th grade math/science interest, and overall high school math/science GPA in students with ADHD (*RQ4)*.

Although a single construct of teacher academic support was originally proposed, CFA analyses revealed that teacher academic support is better explained by two distinctive but correlated factors across math and science domains. Also, closer examination of the teacher academic support items supported the current cognitive engagement literature. According to Greene (2015) and Mayer (2002), cognitive engagement can be categorized into either surface or shallow cognitive engagement and deep or active cognitive engagement. Surface cognitive engagement involves lower levels of processing that focuses on retaining knowledge, whereas deep cognitive engagement involves higher levels of cognitive processing that focuses on transferring the knowledge gained to solve problems (Mayer, 2002). Based on both psychometric examination and theoretical background, Ninth Grade Math/Science Teacher Academic Support was divided into two factors: Math Teacher Academic Support for Deep Cognitive Engagement and Math Teacher Academic Support for Surface Cognitive Engagement. Teacher support that focuses more on students' deep cognitive engagement predicted more adaptive student outcomes than teacher support that focuses more on providing support for surface cognitive engagement.

Teacher Academic Support for Deep Cognitive Engagement

In math, ninth grade math teachers' academic support for deep cognitive engagement did not predict students' ninth- and 11th grade math interest, but it directly and positively predicted overall high school math GPA. In science, ninth grade science teachers' academic support for deep cognitive engagement predicted neither student interest nor overall high school science GPA. The lack of a positive relationship between math/science teacher academic support for deep cognitive engagement and students' math/science interest is counterintuitive. Other moderating variables may impact the relationship between teachers' academic support for deep cognitive engagement and students' academic interest, such as perceived student self-efficacy.

Even if teachers try to promote math/science interest development in students, if students believe that they are not competent in math/science, students' academic interest may not increase. According to Wigfield (1994), as children get older, they begin to attach more value to activities in which they do well. Stated differently, older students may devalue activities in which they struggle. As such, even if ninth grade math/science teachers try to promote interest development, their efforts may not significantly impact the developmental trajectory of academic interest in older students, who have become keenly aware of math/science competency by social comparison.

Also, it is possible that teacher academic support for deep cognitive engagement would be a better predictor of more direct and proximal student outcomes, such as students' use of deeper cognitive strategies in math/science classrooms, rather than students' math/science interest. Nevertheless, the results suggest that teacher support for deeper cognitive engagement can directly and positively predict long-term academic achievement, specifically in the math domain.

Teacher Academic Support for Surface Cognitive Engagement

In both math and science, ninth grade teacher's academic support for surface cognitive engagement negatively predicted students' academic interest. The findings suggest that teacher support that focuses too much on surface or shallow learning (e.g., teaching students basic math/science concepts; teaching students math algorithms or procedures; developing students' computational skills; and preparing students for standardized tests) may undermine math/science interest in high school students with ADHD. Classroom environments that primarily focus on lower-level cognitive processing, such as repetition and rehearsal, may lead students to become bored and less interested in math and science. According to the control-value theory (Goetz &

Hall, 2014; Pekrun, 2006), features of learning environments (e.g., quality of instruction, induction of values, autonomy support, goal structures, expectancies of significant others, and feedback) deliver information related to students' perceptions of controllability and academic values. Students' perceptions of personal control and value-related achievement activities and outcomes represent one of the most important cognitive antecedents of boredom in achievement settings (Goetz & Hall, 2014). As such, in a classroom where teachers mainly focus on students' rote learning of facts, students with ADHD may struggle more than their peers to stay cognitively and behaviorally engaged in classroom activities, feel sense of agency, and develop personal interest in math/science because they cannot effectively control their boredom.

It may also be the case that teachers are providing greater support that focuses on rote memorization and rehearsing to students with ADHD who are already experiencing challenges in math and science. Moreover, students with ADHD who have been struggling in the subject areas throughout their childhood may exhibit less interest in math and science. Teachers may need to keep a careful balance between emphasizing memorization of facts and promoting elaboration and organization of ideas to optimize classroom engagement and learning in students with ADHD.

Further, teachers' emphasis on providing math/science knowledge and skills did not directly predict math/science achievement in high school students with ADHD. Teacher academic support for surface cognitive engagement could have been perceived as achievement pressure from teachers in high school students with ADHD. Achievement pressure refers to the excessive demands imposed by significant others, such as parents and teachers, on students to perform at high levels (Song et al., 2015). Teacher academic pressure has shown to increase test anxiety but not achievement in typically developing middle school students (Song et al., 2015).

The findings of the current study suggest that teachers may need to provide more individualized, intensive, and multifaceted academic supports for students with ADHD. Taking a typical “one-size-fits-all” instructional approach may not be sufficient to address challenges experienced by students with ADHD within math and science classrooms.

Math/Science Interest as Predictors of High School Achievement

It was hypothesized that ninth grade math/science interest would positively predict overall high school math/science GPA for students with ADHD *(RQ5)*. It was also hypothesized that 11th grade math/science interest would positively predict overall high school math/science GPA in students with ADHD *(RQ7)*. The hypotheses were not supported across domains. Students’ ninth grade and 11th grade math/science interest were negatively associated with overall high school math/science GPA. The findings directly contradict the expectation that higher interest in a subject area would lead to better academic performance.

The unexpected findings may reflect the unique characteristics of students with ADHD. Children and adolescents with ADHD have difficulties with executive functioning, which leads to difficulties inhibiting impulses, planning, and estimating time (APA, 2022; Boyer et al., 2015). Also, individuals with ADHD may “hyperfocus” on events that trigger their interest, making it difficult for them to shift their attention to other events (Ozel-Kizil et al., 2016). Heightened interest in math or science may lead students with ADHD to hyperfocus on minute details or exciting aspects of math or science that may distract them from overall performance in these subject areas.

Heightened interest may distract students from completing tasks that require multi-step procedures and sustained attention that are crucial for overall classroom performance. A prominent example of an academic task that requires multi-step procedures and sustained attention is homework completion. Completing homework requires multiple steps: 1) recording the assignment correctly, 2) bringing home the needed material, 3) planning when and how to do the assignment, 4) managing after-school time, 5) completing the assignment correctly, 6) bringing the assignment back to school, and 7) turning in the assignment on time (Langberg et al., 2016). Indeed, De Vries et al. (2023) found that teens with ADHD had significantly more problems with homework completion and homework management compared to their typically developing peers.

Academic interest alone may not be powerful enough for students with ADHD to regulate their emotions, inhibit their impulses, and shift their attention from less-important tasks to more important tasks. Further, heightened academic interest may even be maladaptive for overall achievement in high school students with ADHD by distracting students from long-term goals. These distracting interests may cause students with ADHD to struggle more with planning, time managing, and completing academic tasks.

It is also important to note how academic interest was measured in the current study. Student academic interest in each domain was measured with three items, including one regular-coded item ("You are enjoying this class very much,") and two reverse-coded items ("You think this class is a waste of your time," and "You think this class is boring"). As such, student academic interest variables in this study largely measured how students perceived a class to be "not boring and pointless." Given that math/science teachers' academic support for surface cognitive engagement negatively predicted students' academic interest, another explanation is possible for the unexpected negative relationship between students' academic interest and achievement. It is possible that the classes in which students had greater academic interest, or felt "less boring and pointless," were more challenging classes that require deeper cognitive processing, as opposed to easier classes that only require shallow and rote processing. Therefore, students with ADHD who took more challenging and cognitively classes may have obtained lower GPA. However, the current study did not examine the relative impact of different levels of math and science classes on academic interest and outcomes, which is one of the limitations which will be discussed further in a subsequent section.

Ninth Grade Academic Interest as Predictors of 11th Grade Academic Interest

It was also hypothesized that students' ninth grade math/science interest measured at the fall of freshmen year would positively predict 11th grade math/science interest in students with ADHD (*RQ 9.1*). The hypothesis was fully supported. In both math and science, ninth grade academic interest positively predicted 11th grade academic interest. The results show how academic interest in math and science remain relatively stable throughout high school years. In the four-phase model of interest development proposed by Hidi and Renninger (2006), the last step of interest development is well-developed individual interest. Well-developed individual interest is characterized by a relatively stable disposition to reengage with a particular task or content over time. Thus, the findings of the present study show that well-developed individual interest is stable across high school years in students with ADHD.

Mediational Analysis

The study employed mediation analysis to understand how different types of social support and student math/science interest might influence Math GPA. First, it was hypothesized that ninth grade math/science interest would mediate the relationship between different types of social support provided in ninth grade and overall high school math/science GPA in students with ADHD *(RQ6).* In math, ninth grade math interest mediated the relationship between perceived science teacher emotional support and overall high school math GPA. The indirect effect was negative because teacher emotional support positively predicted ninth grade math interest, whereas ninth grade math interest negatively predicted science GPA. Similar patterns emerged in science. Ninth grade science interest mediated the relationship between perceived science teacher emotional support and overall high school science GPA. The indirect effect was negative because teacher emotional support positively predicted ninth grade science interest, whereas ninth grade science interest negatively predicted science GPA. The results show that greater teacher emotional support may promote higher math/science interest in ninth grade students, but the heightened math/science interest in ninth grade may negatively impact long-term math/science achievement. The negative mediation of ninth grade subject interest again highlights the unique characteristics of students with ADHD and the importance of providing individualized instruction and support in classrooms, particularly with respect to organizational skills that promote focus on academic instruction and assignments.

Next, it was hypothesized that 11^{th} grade math/science interest would mediate the relationship between different types of social support and overall high school math/science GPA *(RQ8*). It was also hypothesized that ninth grade math/science interest and 11^{th} grade math/science interest would sequentially mediate the relationship between different types of social support and overall high school math/science GPA in students with ADHD (RQ 9.2). As described previously, due to the potential suppression effects in the structural paths between social support variables and 11th grade interest variables, the results could not be accurately interpreted at this time.

Theoretical and Clinical Implications

Fostering academic interest may influence self-regulatory processes and improve school engagement in students during their transition to high school. Also, the development of academic interest does not occur in a vacuum but through a complex interplay of environmental and social factors. The current study explored the contributions of different sources and types of social support on academic interest and STEM achievement in students with ADHD as they transition to high school. The findings shed light on the unique characteristics of students with ADHD. The findings also highlight the challenges students with ADHD may face as they transition from early to late adolescence and adjust to changing social and academic expectations as high school freshmen.

Based on previous investigations regarding social supports, academic interest, and achievement that have been conducted with typically developing children and adolescents, it was expected that different types of social support provided to incoming high students with ADHD would positively predict students' math/science subject interest over time as well as achievement. Alternately, some of the findings were counterintuitive and surprising. School-level STEM support did not promote STEM interest or achievement across domains, and parent STEM support predicted lower academic interest. Also, the findings show the importance of considering both the sources and types of social support. Not all teacher-support was facilitative in increasing student's subject interest and achievement or improving student outcomes. The results show that perceived teacher emotional support may play a crucial role in increasing math/science interest. Alternately, teacher academic support for deep cognitive engagement may play a more important role in improving student achievement than directly increasing academic interest. Finally, teacher academic support for surface cognitive engagement may even undermine math/science interest in students with ADHD. Again, teachers' overemphasis on rote memorization and repetition may cause students to feel lack of control, reduce value in math/science, and increase boredom in classrooms. Also, students with ADHD are likely to be already academically struggling and have lower interest in the subject due to those struggles.

The present study calls for a need for more individualized and intensive instructional support for this student population. Also, heightened subject-specific interest may even be deleterious to academic achievement in high school students with ADHD. The results highlight the importance of taking a more balanced approach for teachers in providing support for both deep and surface cognitive engagement for students with ADHD. Moreover, teachers can implement strategies for enhancing executive function skills to help students with ADHD focus on instruction and assignments (e.g., organizational skills training). This will help students with ADHD to check themselves and re-focus to top priority tasks even when they are excited and immersed in the subject area. With individualized support and help, heightened academic interest could become a strength, and not a deficit, for students with ADHD.

Strengths of the Current Study

One strength of the current study is the utilization of a longitudinal national dataset. The HSLS:09 dataset follows ninth graders from their high school entrance to postgraduation. As such, the study was able to analyze data for high school students with ADHD across schools in the U.S. Further, the dataset allowed the examination of changes in students' math/science interest at two important time points (i.e., the fall of freshman year and the spring of junior year) and provided overall high school math/science GPA post high school graduation. Also, the current study used a multi-informant approach, including student self-reports, school administrator reports, and parent reports. This allowed the examination of the nature and impact of multisystemic social supports on student interest and achievement in math and science.

Another strength of the current study is that it specifically focused on high school students with ADHD. Although there is abundant research on interest development in general student samples, no prior study has examined interest development in students with ADHD. Also, it is one of the few studies that examined academic achievement in high school students with ADHD, as most studies in the field of ADHD focus on academic achievement in younger children.

Limitations of the Current Study

One limitation of this study is that the student sample in this study is not nationally representative. The HSLS:09 study team recruited a nationally representative sample of ninth graders (Ingels et al., 2011; 2015). Also, the HSLS:09 team utilized weighted response rates to correct any imbalances between the survey sample and the population caused by school response rates and student attrition. However, the present study used a subsample of students with ADHD. Sampling weights for this subsample were not utilized, as the HSLS:09 did not provide a set of weights for students with ADHD diagnosis is not available. As such, the present study could not determine whether the ADHD subsample was nationally representative.

Second, the researcher had no control over what measures and items were contained in the dataset because the current research used secondary data. Thus, some of the proposed research constructs were not adequately represented by the choice of instruments. Although most measurement tools in the social and behavioral sciences have gone through a careful development and validation process, the measures in the current study have been either created or modified because the HSLS:09 data did not provide existing measures that adequately reflected many of the research constructs. Therefore, this study was exploratory in nature, and reliability and validity of the measures needs further examination.

For example, the HSLS:09 data provided an existing composite scale of students' math and science interest, but some inputs to this scale included items that did not accurately reflect Hidi and Renninger's (2006) definition of academic interest (e.g., an item asked students' rating of favorite school subject out of all courses offered). Such items were deleted, and new latent variables of math/science interest were created based on remaining items. However, although the newly created latent variables of math/science interest showed adequate fit to the data, they did not fully reflect Hidi and Renninger's (2006) original definition of academic interest. Most of the available items needed to be reverse-coded, the academic interest variable in this study better captured how students perceived a class to be "not boring and pointless" rather than cognitively and motivationally "interesting". Future studies should use previously validated scales of interest development scales that better capture academic interest as a cognitive and motivational construct, such as the Interest Development Scale (IDS; Boeder et al., 2020) to ensure better content validity, or evidence that the content of the items reflects the construct of interest (Kazdin, 2022).

Similarly, the teacher support constructs also call for further examination. The current study demonstrated that teacher academic support construct can be psychometrically better explained by two newly created separate constructs of teacher support for deep cognitive engagement and teacher support for surface cognitive engagement. However, one of the inputs to science/math teacher academic support for deep cognitive engagement (i.e., how much do ninth grade math/science teachers put emphasis on increasing students' interest in math/science) does not accurately capture the theoretical definition of deep cognitive engagement despite its adequate factor loadings. According to Mayer (2002), deep cognitive processing focuses on meaningful learning and learning by creating, and it requires higher-level strategies, such as exemplifying, classifying, inferring, and comparing, and organizing. As such, teachers' academic support for deep cognitive engagement should reflect promotion of such active cognitive strategies. Whereas other items support this definition of deep cognitive engagement, the item regarding teacher support for increasing students' math/science interest may undermine the overall content validity. Across all latent measures that were either created or re-created for this study, further scale validation examination should be conducted.

Another limitation of this study is how the ADHD sample was selected. First, the ADHD student sample was selected based on parent-report of provider diagnosis of ADHD. The parent-report of an ADHD diagnosis was not validated against medical records or clinical evaluation. However, a recent study by Cree et al. (2023) showed that parent report of provider diagnosis of ADHD demonstrates high reliability and validity. Second, the parent-report of provider diagnosis of ADHD does not provide information on different presentations of ADHD. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5-TR) lists three presentations of ADHD: Predominantly Inattentive, Hyperactive-Impulsive, and Combined (APA, 2022). Students with one presentation may show different patterns of interest development and achievement in response to different source and types of social support. Future studies could utilize datasets that distinguishes between different ADHD presentations.

Furthermore, the current study was not a true longitudinal study, although it attempted to follow students with ADHD from their first year in high school to graduation. Longitudinal studies should capture at least three waves of data so that the data can show linear and nonlinear trends that occur over time (Cosco et al., 2017). However, the HSLS:09 team collected data on students' math and science interest at only two time points. Also, school-level, parent-level, and teacher-level data were only collected in the fall of ninth grade. Repeated assessment of contextual data would have allowed for analyses that provided a better understanding of student interest development over time.

Lastly, the current study did not examine the relative impact of different math and science classes on academic interest and outcomes. According to the 2017–2018 data from National Teacher and Principal Survey (NTPS), 40% of public high schools in the United States used ability grouping, also known as tracking, as a method to organize classes or students (Standing & Lewis, 2021). One problem with academic tracking is that students from minoritized backgrounds are more likely to be placed in lower tracks, even when their standardized test scores are equal or even better to than their peers (Edosomwan & Williams, 2024; Flores, 2007). This suggests potential bias playing a role in tracking decisions. Further, teachers often have lower expectations of their students in low tracks, which reduces student engagement and classroom performance (Edosomwan & Williams, 2024).

Given that teachers hold a negative stigma towards students with invisible disabilities and have lower expectations for such students (Hawley, 2013; Lee, 2011), it is possible that students with ADHD are more likely to be placed in low STEM tracks than their typically developing peers and receive less support in classrooms. Also, as discussed previously, the negative relationship between student academic interest and achievement maybe better understood with additional information on course taking. Future studies should examine the impact of specific classes to better understand academic motivation and achievement among students with ADHD.

Future Directions for Research

First, further research is needed to explore the nuances of relationships among constructs and develop targeted interventions to support math and science interest development and achievement in students with ADHD. Student academic interest alone may not directly improve, or could even undermine, academic achievement in high school students with ADHD. This calls for interventions that can directly help students with executive functioning. Skills-based interventions that teach organization and planning skills to help with homework completion, such as Homework, Organization, and Planning Skills (HOPS) intervention (Langberg, 2011), may help improve academic achievement in students with ADHD. Future studies may wish to examine whether targeted executive functioning interventions may buffer the negative impact of heightened subject interest on achievement in high school students with ADHD.

Second, the role of peers in academic interest development and achievement was not explored in the present study because the HSLS:09 dataset did not include relevant peer measures. The importance of peer relationships increases in adolescence (Benner, 2011). Also, the transition to high school requires adolescents to seek out new friends and peer groups. As such, adolescents may perceive social supports coming from peers as more salient than social supports provided by adults. Thus, academic values and beliefs may be influenced by social desirability during the transition to high school and throughout the high school years. For example, students may want to do well in school, but when faced with the choice of either doing their homework or hanging out with friends, they may choose to the latter, which provides a more immediate social reward (Benner, 2011). Peer influence can also be adaptive to academic engagement and learning. In a study by Wentzel et al (2010), peer expectations for academic performance and provisions of per emotional support, in combination with teacher supports, positively predicted student interest in classroom activities. Future studies may explore the impact of peer relationship on academic values, beliefs, and behaviors in high school students with ADHD.

Third, future studies could examine additional variables such as students' self-efficacy and expectancy for success. Researchers of the expectancy-value framework (e.g., Eccles, 2009; Wigfield & Eccles, 2002) suggest that task values (i.e., intrinsic value or interest, utility value, and attainment value) are often a better predictor of academic choices, whereas students' self-efficacy and expectancy for success are often a better predictor of achievement. Also, Jiang et al. (2020) used the HSLS:09 data and found that both math/science task values and self-concept of ability at the beginning of high school were positively associated with high school STEM GPA as well as STEM course taking throughout high school, which in turn predicted adolescents' decision to choose a STEM major in college. As such, including self-efficacy or self-concept of ability measures may provide a more comprehensive understanding of academic motivation and achievement in high school students with ADHD.

In addition, future studies could develop dimensional measures for assessing school-level STEM interest support and parental STEM-support for students' STEM interested development. Development and validation of dimensional measures of school-level and parental STEM support will allow the research community to better understand how complex interplay of ecosystems may impact high school students' STEM-related academic motivation and achievement.

Furthermore, in the current study only students with ADHD were included in the analytic sample based on parent-report of provider diagnosis of ADHD. This selection may have resulted in selection bias, which occurs when study participants differ systematically from non-study participants (Schneider et al., 2007). DuPaul (2020) points out that the diagnostic assessment of students suspected of ADHD typically involves subjective ratings from clinicians, parents, and teachers, which may be influenced by an array of factors, such as student and adult race, student sex, family socioeconomic status, adult role, and context. Future studies could control for student and family background (e.g., student age, student sex assigned at birth, student race, parents' level of education, and family income), teacher background (e.g., sex, race, certification type, years of experience, level of education), and school background (e.g., median income, percentage below the federal poverty level, and racial distribution) to prevent such bias.

Finally, future studies could conduct multigroup analysis to compare students with ADHD and those without ADHD. This study showed unexpected motivational patterns, which could be due to the unique characteristics of students with ADHD. Students with ADHD tend to have lower academic-related motivation, less enjoyment of learning, and greater reliance on external feedback to evaluate their performance compared to those without ADHD (Carlson et al., 2002; Smith et al., 2020). As such, the next step is to match students with and without ADHD and compare the group differences in motivational patterns.

Clinical Implications and Conclusions

Students with ADHD experience more academic struggles than their typically developing peers during their transition from middle to high school. Academic interest has shown to facilitate self-regulation in typically developing children and adolescents (Hidi & Renninger, 2019; Lee et al., 2014; Sansone & Thoman, 2005). However, the role of academic interest has not been fully explored in children and adolescents with ADHD. Also, social supports from significant others can influence interest development (Hidi & Renninger, 2006; Jungert et al., 2020; Wentzel, 1998). As such, the present study investigated the role of different social supports on academic interest and achievement in high students with ADHD in their transition to high school. Also, students with disabilities often experience greater barriers when considering STEM fields (Hawley, 2013; Lee, 2011). Therefore, this study specifically focused on the role of STEM-related social supports on student interest and achievement in math and science.

The results of current study highlight the distinctive characteristics of high school students with ADHD. Adolescents' relationships with their parents shift greatly during their transition to high school. Also, students with ADHD often have co-occurring symptoms of ODD and CD (Jensen et al., 2001). As such, educators, caregivers, and researchers should be mindful that adult support may not always be facilitative in promoting academic interest and achievement. Also, although extant interest research conducted in general student samples have shown generally positive relationships between academic interest and achievement, this was not the case in high school students with ADHD. The negative relationship between math/science interest and overall high school math/science GPA shows how promoting academic interest alone is not sufficient in increasing achievement in classrooms for students with disabilities such as ADHD.

Moreover, the current findings show that not all supports are equal. Even if the source of social support is the same, the types of social support may play different roles. For example, each of the three types of teacher support (i.e., emotional support, academic support for deep cognitive engagement, and academic support for surface cognitive engagement) differentially predicted student math/science interest and achievement. The positive relationship between perceived teacher emotional support and students' math and science interest highlights the importance of making classrooms an emotionally safe place. The negative relationship between teacher academic support for surface cognitive engagement and student math/science interest shows how over-emphasizing performance, without providing emotional and motivational support, may be interpreted by students as academic pressure. Lastly, there was a positive relationship between teacher academic support for deep cognitive engagement and overall high school subject GPA in math but not in science. The results suggest that the impacts of social supports may vary depending on the subject domain.

Parents may need to understand that high school students with ADHD are actively seeking independence and personal agency. Teachers many need to provide a more balanced social support, consisting of emotional support that can help adolescents feel safe and treated fairly; academic support that can directly teach skills and knowledge; and academic support that can encourage students to actively connect ideas discussed in class and apply the knowledge to real-life situations. Moreover, teachers should continue to promote students' subject interest and help students connect interests with meaningful classroom activities and assignments. Although heightened math and science interest negatively predicted overall high school math and science GPA, school success should not be defined by achievement alone. Heightened math and science interest may predict other positive outcomes that are not measured in the current study, such as number of STEM courses taken in high school and decisions to choose a STEM major in college. In addition, school districts and state-and federal-level agencies may revisit curriculum and the evaluation process. In rapidly changing world, STEM education should reflect the society's need for creativity and innovation.

Lastly, the current findings are based on data collected between 2009-2012. Nevertheless, the results provide insights that are relevant in understanding academic motivation and achievement of current population of high school students with ADHD as the academic and motivational difficulties faced by this population remain relevant. Students experienced academic, social, and behavioral challenges during the Coronavirus disease (COVID-19) pandemic, which may have adversely impacted their academic motivation and achievement. Sibley et al. (2021) surveyed problems experienced by adolescents and young adults with ADHD during the COVID-19 pandemic, when youths experienced abrupt transition from in-person to online learning. Both adolescents and young adults with ADHD and their parents reported that social isolation, difficulties engaging in online learning, motivation problems, and boredom were top problems that were exacerbated during the pandemic. Sibley and colleagues pointed out that such problems increase risk for major depression and school dropout, calling for interventions that aim to increase social interaction, academic motivation, and behavioral activation among adolescents and young adults with ADHD. Although COVID-19 has shifted from pandemic to endemic and schools have been normalized, classroom engagement and sustained academic motivation continues to be a challenge among students with ADHD (Zendarski et al., 2017). The findings from current study also supports how social supports from significant others can impact school engagement and academic motivation among students with ADHD.

In conclusion, the current study shows the importance of providing individualized support and interventions for students with ADHD. Students with ADHD may not exactly "fit the mold," which can leave educators, caregivers, and researchers feeling puzzled. Therefore, taking a strength-based approach, rather than a deficit-based approach, is crucial for understanding and supporting students with ADHD. According to the basic tenets of neurodiversity movement, people experience and interact with the world around them in many ways, and there is no one "right" way of thinking, learning, and behaving (Baumer & Frueh, 2021). National agencies, community, schools, and families should embrace neurodiversity and provide supports that meet each student's needs.

Providing individualized instruction for students has been viewed as an idealistic but often unattainable goal in public schools due to limited financial and human resources. Teachers need both material (e.g., incentives for staff development opportunities, professional development funds, and extra planning time) and psychological (e.g. school administrators who are supportive and encourage individualized instruction) supports to effectively differentiate instruction (Bondie et al., 2019). Also, specifically for students with ADHD, individualized support provided though Individualized Education Programs and 504 Plans often consist of interventions and accommodations that lack empirical evidence (Spiel et al., 2014; Lovett & Nelson, 2021).

Fortunately, the advancement of artificial intelligence (AI) may allow teachers provide more effective individualized instructions to individual students with and without ADHD. According to Coppin (2004), AI is defined as “the ability of machines to adapt to new situations, deal with emerging situations, solve problems, answer questions, device plans, and perform various other functions that require some level of intelligence typically evident in human beings” (p.4). There are two types of AI: traditional AI and generative AI (Marr, 2023). Traditional AI refers to systems designed to respond to a particular set of inputs, and generative AI refers to a form of AI that goes a step further to create new data based on training data (Marr, 2023).

Khazanchi and Khazanchi (2024) argue that generative AI, such as Chat GPT, can revolutionize education. Advanced machine learning algorithms can capture individual students' learning patterns, preferences, and strengths, which can then be used customize the educational materials (Khazanchi & Khazanchi, 2024). For teachers, generative AI chatbots can serve as teaching assistant and instructional planning resources when creating learning plans, test or quiz questions, assessment rubrics, questions for class discussions, and student’s assignments. For students, chatbots can support creative thinking and provide customized step-by-step directions for completing a complex learning activity (Trust et al., 2023). This personalization can not only improve students' engagement but also provide tailored feedback and coaching to teachers (Khazanchi & Khazanchi, 2024). Although legal, ethical, and socially responsible use of AI technology in education calls for ongoing discussions (Trust et al., 2023), AI may allow educators to provide personalized instruction for students with ADHD as well as to create a more inclusive learning environment for all students.

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Table 1

Frequency of the HSLS:09 National Sample of Students with and without ADHD

Variable	Sample (N = 25,206)	
Parent-Reported ADHD Diagnosis in Base Year	N	Total %
No ADHD	13,950	55.35
ADHD	1,730	6.96
Unit non-response	8,210	32.58
Missing	1,310	5.21

Note. HSLS = High School Longitudinal Study of 2009. ADHD = attention-deficit/hyperactivity disorder. Number of sample members rounded to the nearest 10 to protect respondent privacy. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data File.

Table 2

Student Demographic Information

Variable	Sample ($N \approx$1,730)	
	N	Total %
Student Race/Ethnicity		
White	1,120	65%
Biracial/Multiracial	190	10.9%
Hispanic		
Hispanic, race specified	180	10.6%
Hispanic, no race specified	10	0.5%
Black or African American	170	9.5%
Asian	40	2.1%
Native American Indian or Alaskan Native	20	1%
Native Hawaiian or Other Pacific Islander	10	0.3%
Missing	#	#
Student Sex		
Male	1,220	70.3%
Female	510	29.7%
Estimated Student Age		
12	#	#
13	10	0.3%
14	870	50.3%
15	620	35.7%
16	120	7.1%
17	10	0.6%
19	#	#
Missing	100	5.8%

= Rounds to zero.

Note. Number of sample members rounded to the nearest 10 to protect respondent privacy. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data File.

Table 3

Parent-Child Relationship Information

Variable	Sample ($N \approx$ 1,730)	
	N	Total %
Whether Parent questionnaire respondent is Parent 1		
Parent questionnaire respondent is neither P1 nor P2	#	#
Parent questionnaire respondent is P1	1,730	99.9%
Parent 1's Relationship to 9th grader		
Biological mother	1,240	71.4%
Biological father	250	14.2%
Adoptive mother	10	5.7%
Adoptive father	30	1.4%
Stepmother	20	1.3%
Stepfather	20	1.0%
Foster mother	10	0.5%
Foster father	#	#
Female partner of parent or guardian	#	#
Grandmother	40	2.5%
Grandfather	#	#
Other female relative	10	0.6%
Other male relative	#	#
Other female guardian	10	0.5%
Other male guardian	10	0.3%

= Rounds to zero.

Note. Number of sample members rounded to the nearest 10 to protect respondent privacy. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data File.

Table 4

Family Demographic Information

Variable	Sample (*N* ≈ 1,730)	
	N	Total %
Total family income from all sources 2008		
Family income less than or equal to $15,000	190	10.8%
Family income > $15,000 and <= $35,000	350	20.4%
Family income > $35,000 and <= $55,000	300	17.5%
Family income > $55,000 and <= $75,000	270	15.5%
Family income > $75,000 and <= $95,000	150	8.6%
Family income > $95,000 and <= $115,000	140	8.2%
Family income > $115,000 and <= $135,000	90	5.1%
Family income > $135,000 and <= $155,000	80	4.5%
Family income > $155,000 and <=$175,000	40	2.2%
Family income > $175,000 and <= $195,000	20	1.2%
Family income > $195,000 and <= $215,000	40	2.0%
Family income > $215,000 and <= $235,000	#	#
Family income > $235,000	70	3.8%
Missing	#	#
Poverty indicator (relative to 100% of Census poverty threshold)		
At or above poverty threshold	1,410	81.7%
Below poverty threshold	320	18.2%
Missing	#	#
Parents'/guardians' highest level of education		
Less than high school	80	4.7%
High school diploma or GED	700	40.7%
Associate's degree	290	16.8%
Bachelor's degree	360	20.8%
Master's degree	210	11.8%
Educational Specialist diploma	10	0.3%
PhD/MD/Law/other high level professional degree	80	4.9%

Note. GED = General Education Program. Number of sample members rounded to the nearest 10 to protect respondent privacy. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data File.

Table 5

Frequency of Observed Binary Predictor Variables for Math and Science Domains

Variable	*N* ≈ 1,730		*N*	*Percent*	*Valid Percent*
Ninth Grade School STEM Support					
Holds math or science fairs/workshops/competitions	Valid	No	950	54.97	62.65
		Yes	570	32.77	37.35
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.10	
		Total	210	12.25	
	Total		1,730	100	
Partners w/ college/university that offers math/science summer program	Valid	No	790	45.61	51.98
		Yes	730	42.14	48.02
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total	No	1,730	100	
Sponsors a math or science after-school program	Valid	No	740	42.89	48.88
		Yes	780	44.86	51.12
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total		1,730	100	
Pairs students with mentors in math or science	Valid	No	980	56.82	64.76
		Yes	540	30.92	35.24
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	

		Total	210	12.25	
	Total		1,730	100	
Brings in guest speakers to talk about math or science	Valid	No	600	34.74	39.6
		Yes	920	53.01	60.4
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total		1,730	100	
Takes students on math- or science-relevant field trips	Valid	No	550	31.91	36.36
		Yes	970	55.84	63.64
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total		1,730	100	
Tells students about math/science contests/websites/blogs/other programs	Valid	No	430	24.74	28.19
		Yes	1,090	63.01	71.81
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total		1,730	100	
Partners with MESA or a similar enrichment-model program	Valid	No	1210	69.71	79.45
		Yes	310	18.03	20.55
		Total	1,520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total		1,730	100	
Requires teacher prof development in how students learn math/science	Valid	No	630	36.65	41.77
		Yes	880	51.1	58.23
		Total	1,520	87.75	100

	Missing	Missing	140	8.15	
		Unit non-response	80	4.1	
		Total	210	12.25	
	Total		1,730	100	
Requires teacher prof development in increasing interest in math/science	Valid	No	910	52.37	59.68
		Yes	610	35.38	40.32
		Total	1520	87.75	100
	Missing	Missing	140	8.15	
		Unit non-response	70	4.1	
		Total	210	12.25	
	Total		1,730	100	
Ninth Grade Parent STEM Support					
Went to science or engineering museum with 9th grader in last year	Valid	No	860	49.83	50.38
		Yes	850	49.08	49.62
		Total	1,710	98.9	100
	Missing	Missing	20	1.1	
	Total	Total	1,730	100	
Worked or played on computer with 9th grader in last year	Valid	No	220	12.66	12.8
		Yes	1,490	86.24	87.2
		Total	1,710	98.9	100
	Missing	Missing	20	1.1	
	Total		1,730	100	
Built or fixed something with 9th grader in last year	Valid	No	790	45.72	46.23
		Yes	920	53.18	53.77
		Total	1,710	98.9	100
	Missing	Missing	20	1.1	
	Total		1,730	100	
Attended a school science fair with 9th grader in last year	Valid	No	1,460	84.51	85.45
		Yes	250	14.39	14.55
		Total	1,710	98.9	100
	Missing	Missing	20	1.1	
	Total		1,730	100	
	Valid	No	1,080	62.49	63.18

Helped 9th grader with a school science fair project in last year		Yes	630	36.42	36.82
		Total	1,710	98.9	100
	Missing	Missing	20	1.1	
	Total		1,730	100	
Discussed STEM program or article with 9th grader in last year	Valid	No	560	32.08	32.44
		Yes	1,160	66.82	67.56
		Total	1,710	98.9	100
	Missing	Missing	20	1.1	
	Total		1,730	100	

Note. Number of sample members rounded to the nearest 10 to protect respondent privacy. Detail may not sum to totals because of rounding.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data Files.

Table 6

Descriptive Statistics for All Study Variables

Variable	*N*	Min	Max	*M*	*SD*	Skewness	Kurtosis
9th Grade School STEM Support	1,520	0	10	4.87	2.37	0.16	-0.43
9th Grade Parent STEM Support	1,710	0	6	3.10	1.42	-0.07	-0.47
9th Grade Math Teacher Academic Support- Deep	1,010	9	36	28.68	4.10	-0.67	0.71
9th Grade Math Teacher Academic Support- Surface	1,010	5	20	16.76	2.20	-0.61	0.87
9th Grade Math Teacher Emotional Support	1,420	2	28	12.79	3.98	0.39	0.15
9th Grade Student Math Interest	1,420	1	12	6.63	2.22	0.37	-0.25
11th Grade Student Math Interest	1,410	1	12	7.26	2.34	0.15	-0.50
Overall Math GPA	1,560	0	4	1.95	0.89	-0.07	-0.50
9th Grade Science Teacher Academic Support- Deep	880	11	32	25.44	3.69	-0.31	0.22
9th Grade Math Teacher Academic Support- Surface	880	4	12	10.21	1.47	-0.68	0.24
9th Grade Science Teacher Emotional Support	1,280	1	28	12.57	4.01	0.51	0.62
9th Grade Student Science Interest	1,290	1	12	6.29	2.25	0.39	-0.22
11th Grade Student Science Interest	1,400	1	12	6.48	2.29	0.44	-0.15
Overall Science GPA	1,550	0	4	1.99	0.90	-0.13	-0.39

Note. STEM = Science, technology, engineering, and mathematics; 9th Grade Math/Science Teacher Academic Support- Deep = Ninth Grade Math/Science Teacher Academic Support for Deep Cognitive Engagement; 9th Grade Math/Science Teacher Academic Support - Surface = Ninth Grade Math/Science Teacher Academic Support for Surface Cognitive Engagement; GPA = Grade point average. Number of sample members rounded to the nearest 10 to protect respondent privacy. Detail may not sum to totals because of rounding. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Table 7

Bivariate Correlation for Predictor and Outcome Variables in Math

	1	2	3	4	5	6	7	8
1. School STEM Support	--							
2. Parent STEM Support	-.04	--						
3. Math Teacher Academic Support- Deep	.03	.00	--					
4. Math Teacher Academic Support- Surface	-.04	-.03	**.50*****	--				
5. Math Teacher Emotional Support	-.04	-.03	-.04	-.03	--			
6. Ninth Grade Student Math Interest	-.03	-.02	-.04	-.01	**.45*****	--		
7. 11th Grade Student Math Interest	.01	-.03	-.07	**-.08***	**.12*****	**.34*****	--	
8. Overall High School Math GPA	-.02	**.06***	**.10****	.00	**-.06***	**-.21*****	**-.21*****	--

* $p < .05$. ** $p < .01$. *** $p < .001$. Statistically significant coefficients are in bold.

Note: STEM = Science, technology, engineering, and mathematics; 9th Grade Math Teacher Academic Support- Deep = Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement; 9th Grade Math Teacher Academic Support - Surface = Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement; GPA = Grade point average.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Table 8

Bivariate Correlation for Predictor and Outcome Variables in Science

	1	2	3	4	5	6	7	8
1. School STEM Support	--							
2. Parent STEM Support	-.04	--						
3. Science Teacher Academic Support- Deep	**.10****	**.08***	--					
4. Science Teacher Academic Support- Surface	**.07***	.02	**.35*****	--				
5. Science Teacher Emotional Support	-.05	-.01	**-.09***	-.04	--			
6. Ninth Grade Student Science Interest	-.05	-.05	**-.10****	**-.13*****	**.50*****	--		
7. 11th Grade Student Science Interest	-.03	**-.08****	-.04	.00	**.14*****	**.22*****	--	
8. Overall High School Science GPA	-.01	**.06***	.02	-.03	-.04	**-.10*****	**-.13*****	--

* $p < .05$. ** $p < .01$. *** $p < .001$. Statistically significant coefficients are in bold.

Note: STEM = Science, technology, engineering, and mathematics; 9th Grade Science Teacher Academic Support- Deep = Ninth Grade Math/Science Teacher Academic Support for Deep Cognitive Engagement; 9th Grade Science Teacher Academic Support - Surface = Ninth Grade Science Teacher Academic Support for Surface Cognitive Engagement; GPA = Grade point average.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Table 9

Standardized Estimates from Math SEM Model

			Estimate	*p*
9GR_MAT_INT	**<---**	**MAT_TCHR__EMO**	**.55**	***
9GR_MAT_INT	**<---**	**SCH_SUPPORT_COM**	**-.01**	**.785**
9GR_MAT_INT	**<---**	**MAT_TCHR_ACA_DEEP**	**-.08**	**.342**
9GR_MAT_INT	**<---**	**MAT_TCHR_ACA_SURFACE**	**.09**	**.372**
9GR_MAT_INT	**<---**	**PAR_SUPPORT_COM**	**.00**	**.886**
11GR_MAT_INT	**<---**	**9GR_MAT_INT**	**.59**	***
11GR_MAT_INT	**<---**	**SCH_SUPPORT_COM**	**.00**	**.996**
11GR_MAT_INT	**<---**	**PAR_SUPPORT_COM**	**-.04**	**.188**
11GR_MAT_INT	**<---**	**MAT_TCHR__EMO**	**-.21**	***
11GR_MAT_INT	**<---**	**MAT_TCHR_ACA_DEEP**	**.13**	**.158**
11GR_MAT_INT	**<---**	**MAT_TCHR_ACA_SURFACE**	**-.27**	**.014**
MathT_Emo7_S1MTCHMFDIFF_R	<---	MAT_TCHR__EMO	.45	***
MathT_Emo6_S1MTCHTREAT_R	<---	MAT_TCHR__EMO	.52	***
MathT_Emo5_S1MTCHMISTKE	<---	MAT_TCHR__EMO	.60	***
MathT_Emo4_S1MTCHCONF	<---	MAT_TCHR__EMO	.70	***
MathT_Emo3_S1MTCHFAIR	<---	MAT_TCHR__EMO	.86	***
MathT_Emo2_S1MTCHRESPCT	<---	MAT_TCHR__EMO	.88	***
MathT_Emo1_S1MTCHVALUES	<---	MAT_TCHR__EMO	.80	
G9MathINT1	<---	9GR_MAT_INT	.80	***
G9MathINT2	<---	9GR_MAT_INT	.58	***
G9MathINT3	<---	9GR_MAT_INT	.69	
G11MathINT1	<---	11GR_MAT_INT	.80	***
G11MathINT2	<---	11GR_MAT_INT	.57	***
G11MathINT3	<---	11GR_MAT_INT	.76	
X3TGPAMAT	**<---**	**SCH_SUPPORT_COM**	**-.03**	**.295**
X3TGPAMAT	**<---**	**PAR_SUPPORT_COM**	**.04**	**.089**
X3TGPAMAT	**<---**	**MAT_TCHR__EMO**	**.07**	**.075**
X3TGPAMAT	**<---**	**9GR_MAT_INT**	**-.20**	***
X3TGPAMAT	**<---**	**11GR_MAT_INT**	**-.20**	***
MathT_Aca12_M1BUSINESS	<---	MAT_TCHR_ACA_DEEP	.49	***
MathT_Aca11_M1EXPLAIN	<---	MAT_TCHR_ACA_DEEP	.67	***
MathT_Aca10_M1HISTORY	<---	MAT_TCHR_ACA_DEEP	.63	***
MathT_Aca9_M1LOGIC	<---	MAT_TCHR_ACA_DEEP	.67	***
MathT_Aca8_M1PREPARE	<---	MAT_TCHR_ACA_DEEP	.50	***
MathT_Aca7_M1IDEAS	<---	MAT_TCHR_ACA_DEEP	.71	***
MathT_Aca6_M1REASON	<---	MAT_TCHR_ACA_DEEP	.60	***
MathT_Aca5_M1PROBLEM	<---	MAT_TCHR_ACA_DEEP	.56	***

MathT_Aca1_M1INTEREST	<---	MAT_TCHR_ACA_DEEP	.53	
MathT_Aca13_M1COMPUTE	<---	MAT_TCHR_ACA_SURFACE	.51	***
MathT_Aca4_M1COMPSKILLS	<---	MAT_TCHR_ACA_SURFACE	.49	***
MathT_Aca3_M1ALGORITHM	<---	MAT_TCHR_ACA_SURFACE	.52	***
MathT_Aca2_M1CONCEPTS	<---	MAT_TCHR_ACA_SURFACE	.46	
MathT_Aca14_M1TEST	<---	MAT_TCHR_ACA_SURFACE	.32	***
X3TGPAMAT	**<---**	**MAT_TCHR_ACA_DEEP**	**.19**	**.021**
X3TGPAMAT	**<---**	**MAT_TCHR_ACA_SURFACE**	**-.15**	**.109**

*** $p < .001$. Structural paths are in bold.

Note: SCH_SUPPORT_COM = School STEM Support; PAR_SUPPORT_COM = Parent STEM Support; MAT_TCHR_ACA_SURFACE = Math Teacher Academic Support for Surface Cognitive Engagement; MAT_TCHR_ACA_DEEP = Math Teacher Academic Support for Deep Cognitive Engagement; MAT_TCHR__EMO = Perceived Math Teacher Emotional Support; 9GR_MAT_INT= Ninth Grade Student Math Interest; 11GR_MAT_INT= 11th Grade Student Math Interest; X3TGPAMAT= Overall High School Math GPA. Abbreviations for item-level indicators (unbolded) are defined in Appendix C.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Table 10

Standardized Estimates from Science SEM Model

			Estimat	*p*
9GR_SCI_INT	**<---**	**SCH_SUPPORT_COM**	**-.02**	**.467**
9GR_SCI_INT	**<---**	**PAR_SUPPORT_COM**	**-.06**	**.051**
9GR_SCI_INT	**<---**	**SCI_TCHR__EMO**	**.55**	***
9GR_SCI_INT	**<---**	**SCI_TCHR_ACA_DEEP**	**.04**	**.540**
9GR_SCI_INT	**<---**	**SCI_TCHR_ACA_SURFACE**	**-.20**	**.004**
11GR_SCI_INT	**<---**	**9GR_SCI_INT**	**.29**	***
11GR_SCI_INT	**<---**	**SCH_SUPPORT_COM**	**-.02**	**.471**
11GR_SCI_INT	**<---**	**PAR_SUPPORT_COM**	**-.07**	**.020**
11GR_SCI_INT	**<---**	**SCI_TCHR__EMO**	**-.02**	**.635**
11GR_SCI_INT	**<---**	**SCI_TCHR_ACA_DEEP**	**-.06**	**.332**
11GR_SCI_INT	**<---**	**SCI_TCHR_ACA_SURFACE**	**.15**	**.060**
SciT_Emo7_S1STCHMFDIFF_R	<---	SCI_TCHR__EMO	.42	***
SciT_Emo6_S1STCHTREAT_R	<---	SCI_TCHR__EMO	.49	***
SciT_Emo5_S1STCHMISTKE	<---	SCI_TCHR__EMO	.65	***
SciT_Emo4_S1STCHCONF	<---	SCI_TCHR__EMO	.77	***
SciT_Emo3_S1STCHFAIR	<---	SCI_TCHR__EMO	.86	***
SciT_Emo2_S1STCHRESPCT	<---	SCI_TCHR__EMO	.91	***
SciT_Emo1_S1STCHVALUES	<---	SCI_TCHR__EMO	.81	
G9SciINT1	<---	9GR_SCI_INT	.76	***
G9SciINT2	<---	9GR_SCI_INT	.76	***
G9SciINT3	<---	9GR_SCI_INT	.82	
G11SciINT1	<---	11GR_SCI_INT	.64	***
G11SciINT2	<---	11GR_SCI_INT	.74	***
G11SciINT3	<---	11GR_SCI_INT	.88	
X3TGPASCI	**<---**	**SCH_SUPPORT_COM**	**-.02**	**.585**
X3TGPASCI	**<---**	**PAR_SUPPORT_COM**	**.04**	**.104**
X3TGPASCI	**<---**	**SCI_TCHR__EMO**	**.06**	**.131**
X3TGPASCI	**<---**	**9GR_SCI_INT**	**-.12**	**.010**
X3TGPASCI	**<---**	**11GR_SCI_INT**	**-.11**	***
SciT_Aca10_N1HISTORY	<---	SCI_TCHR_ACA_DEEP	.51	***
SciT_Aca9_N1SOCIETY	<---	SCI_TCHR_ACA_DEEP	.53	***
SciT_Aca8_N1BUSINESS	<---	SCI_TCHR_ACA_DEEP	.53	***
SciT_Aca7_N1IDEAS	<---	SCI_TCHR_ACA_DEEP	.62	***
SciT_Aca6_N1EVIDENCE	<---	SCI_TCHR_ACA_DEEP	.65	***
SciT_Aca1_N1INTEREST	<---	SCI_TCHR_ACA_DEEP	.57	
SciT_Aca11_N1TEST	<---	SCI_TCHR_ACA_SURFACE	.26	***
SciT_Aca3_N1TERMS	<---	SCI_TCHR_ACA_SURFACE	.63	***
SciT_Aca2_N1CONCEPTS	<---	SCI_TCHR_ACA_SURFACE	.54	
SciT_Aca5_N1PREPARE	<---	SCI_TCHR_ACA_DEEP	.63	***
SciT_Aca4_N1SKILLS	<---	SCI_TCHR_ACA_DEEP	.59	***
X3TGPASCI	**<---**	**SCI_TCHR_ACA_SURFACE**	**-.03**	**.632**

X3TGPASCI	**<---**	**SCI_TCHR_ACA_DEEP**	**.04**	**.491**

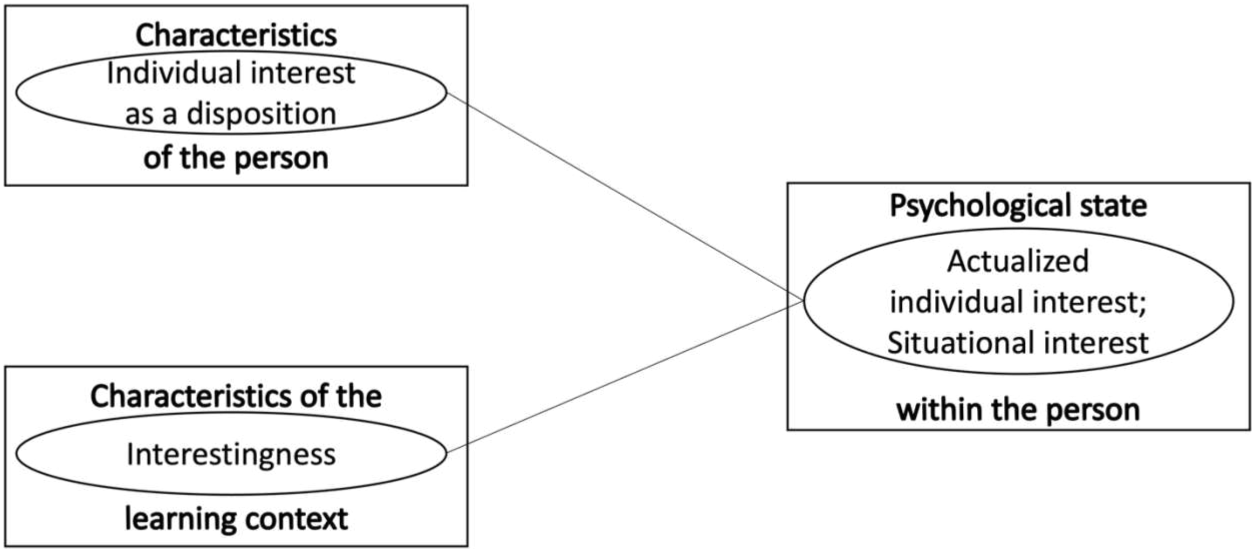
*** *p* <.001. Structural paths are in bold.

Note: SCH_SUPPORT_COM = School STEM Support; PAR_SUPPORT_COM = Parent STEM Support; SCI_TCHR_ACA_SURFACE = Science Teacher Academic Support for Surface Cognitive Engagement; SCI_TCHR_ACA_DEEP = Science Teacher Academic Support for Deep Cognitive Engagement; SCI_TCHR__EMO = Perceived Science Teacher Emotional Support; 9GR_SCI_INT = Ninth Grade Student Science Interest; 11GR_SCI_INT = 11th Grade Student Science Interest; X3TGPASCI = Science GPA. Abbreviations for item-level indicators (unbolded) are defined in Appendix D.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Figure 1

Three Approaches to Interest Research (Krapp, 1999)



Note: Reprinted from "Interest, motivation and learning: An educational-psychological perspective," by K.A. Krapp, 1999, *European Journal of Psychology of Education, 14*(1), 23–40. Copyright 2012 by Springer Nature. Reprinted with permission.

Figure 2

Proposed Model of Multisystemic Predictors of Math Interest and Achievement

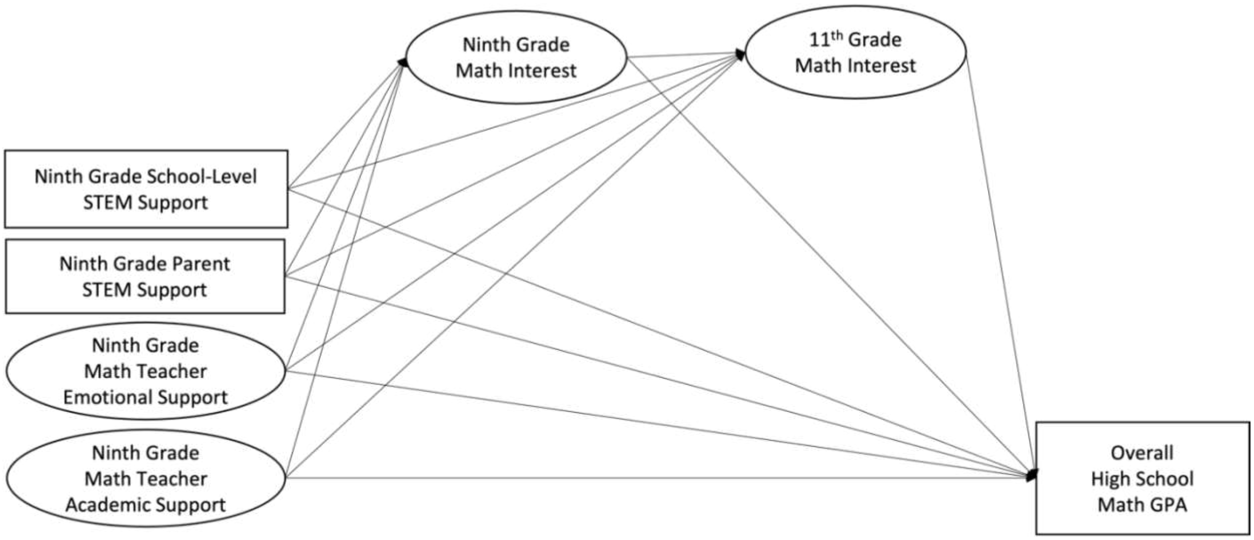


Figure 3

Proposed Model of Multisystemic Predictors of Science Interest and Achievement

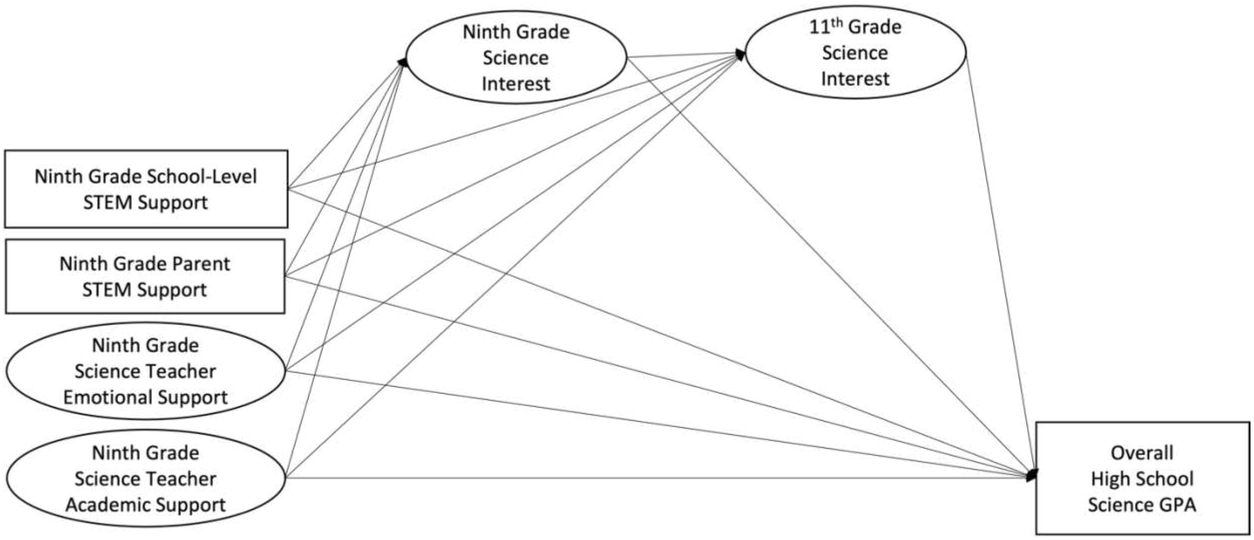
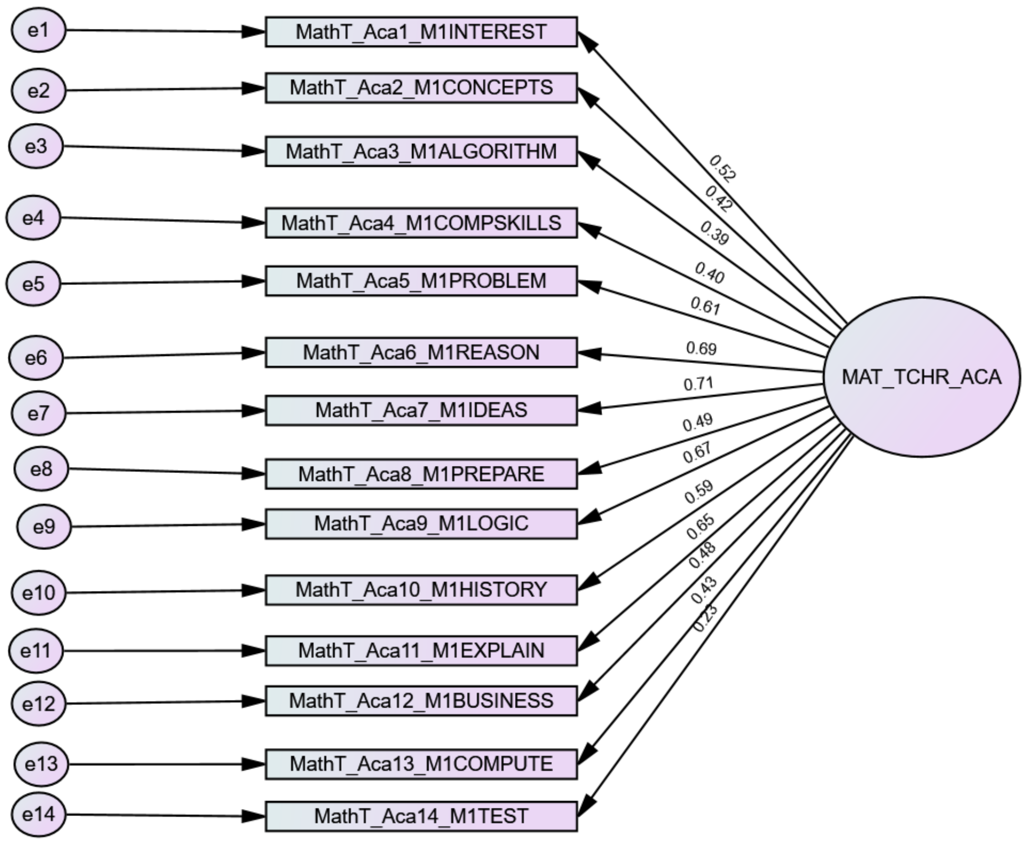


Figure 4

Ninth Grade Math Teacher Academic Support Factor

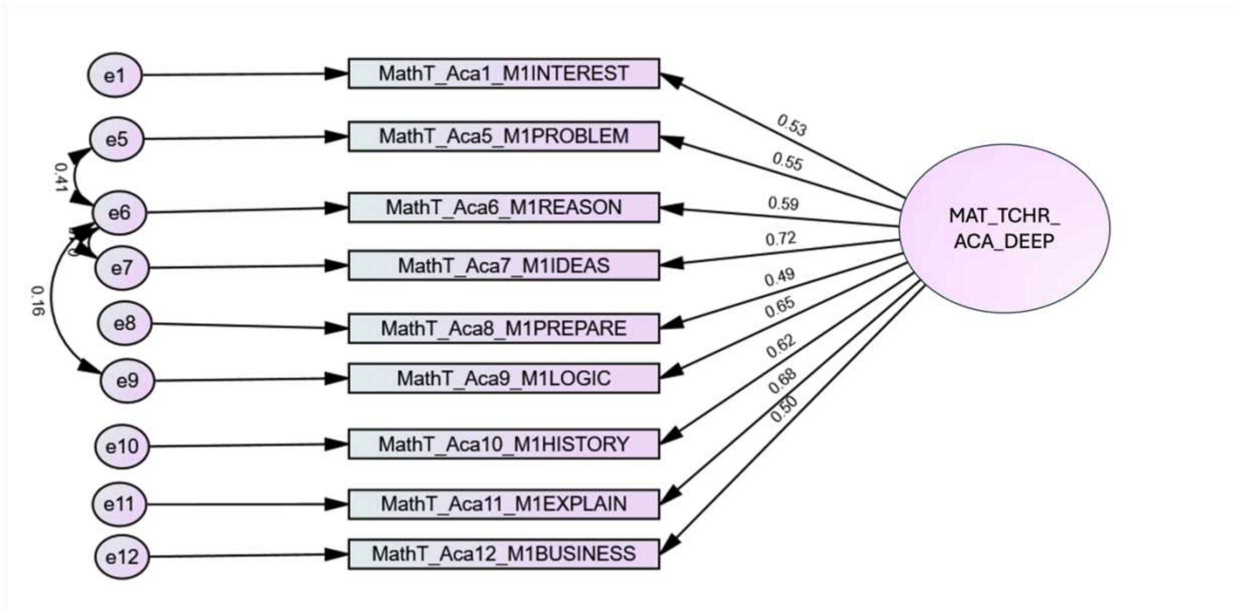


Note: All paths are significant at $p < .001$. MAT_TCHR_ACA= Math Teacher Academic Support.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data Files.

Figure 5

Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement Factor

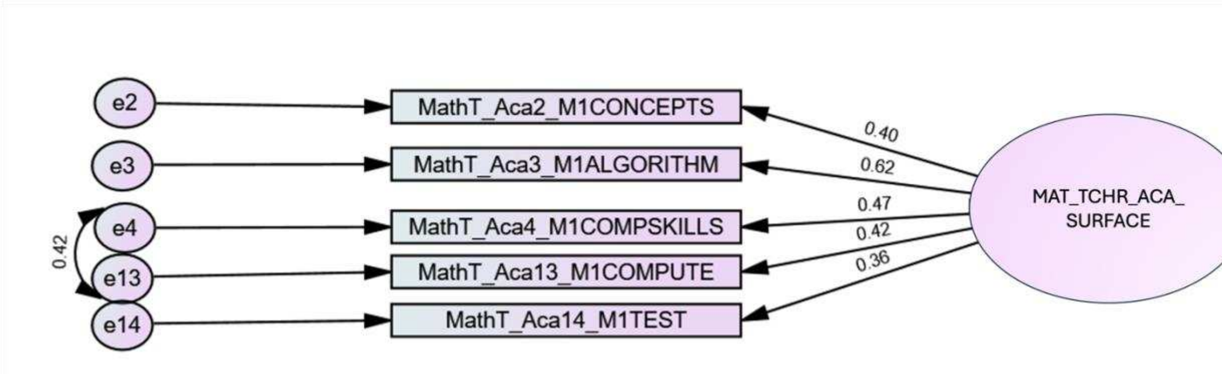


Note: All paths are significant at $p < .001$. MAT_TCHR_ACA_DEEP = Math Teacher Academic Support for Deep Cognitive Engagement

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data Files.

Figure 6

Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement Factor

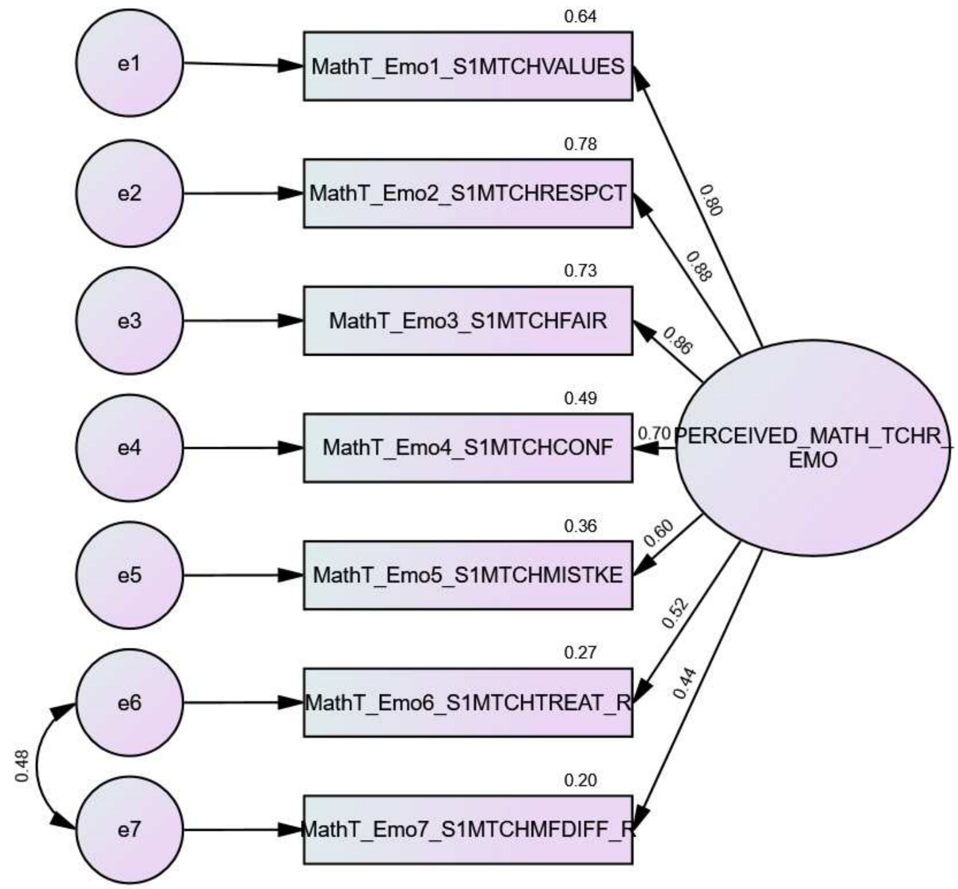


Note: All paths are significant at $p < .001$. MAT_TCHR_ACA_SURFACE= Math Teacher Academic Support for Surface Cognitive Engagement

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data Files.

Figure 7

Ninth Grade Perceived Math Teacher Emotional Support Factor

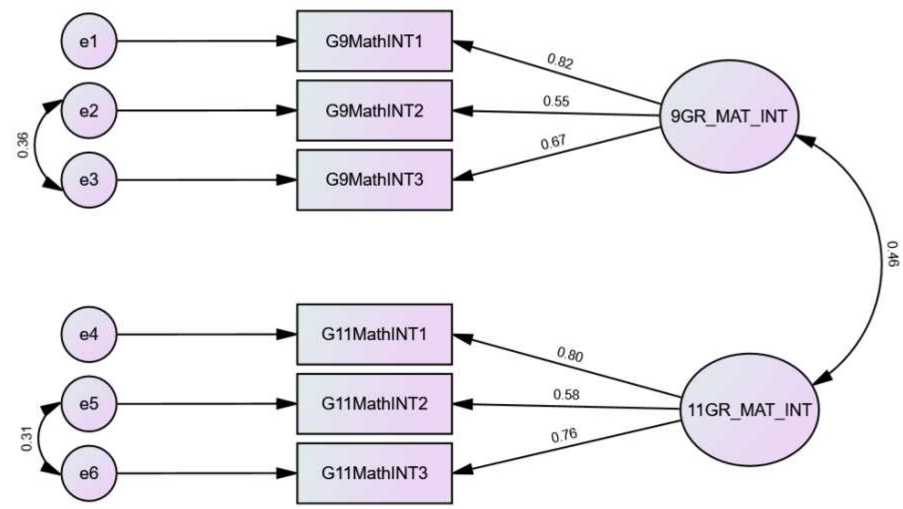


Note: MAT_TCHR__EMO = Math Teacher Emotional Support. All paths are significant at *p* < .001.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data Files.

Figure 8

Correlated Ninth Grade and 11th Grade Math Interest Model

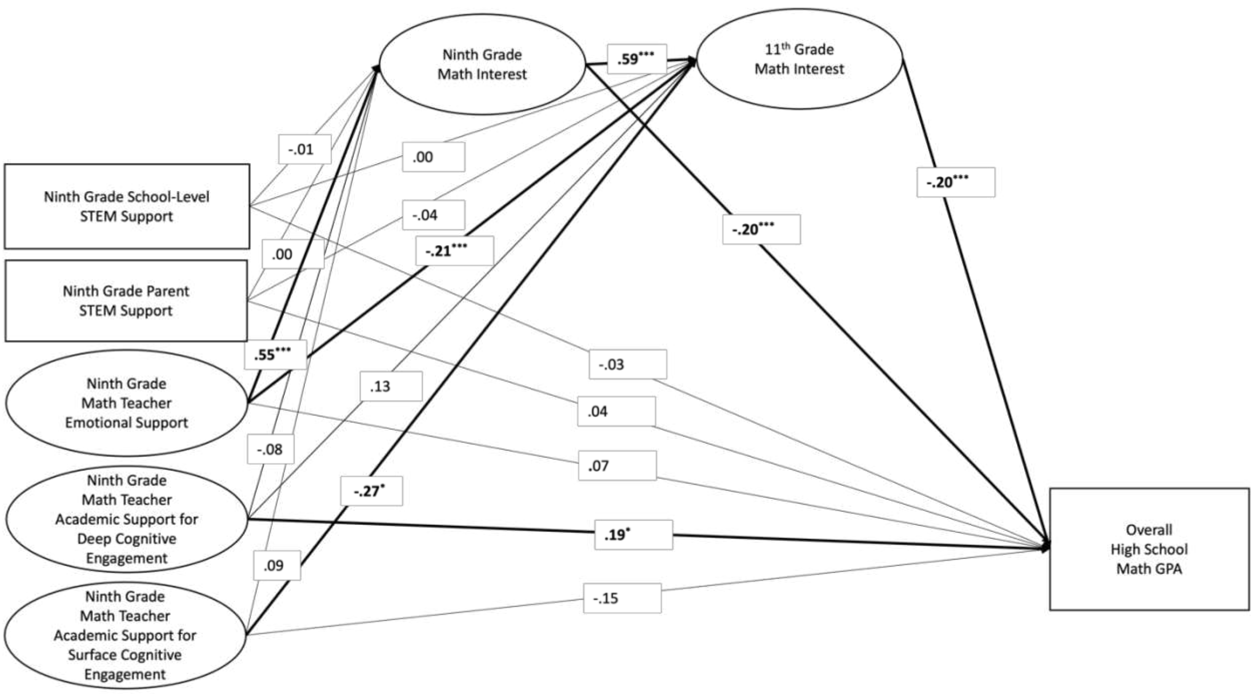


Note: 9GR_MAT_INT= Ninth Grade Student Math Interest; 11GR_MAT_INT= 11th Grade Student Math Interest. All paths are significant at $p < .001$.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) and First Follow-up (2012) Restricted-Use Data Files.

Figure 9

Full Math Structural Equation Model

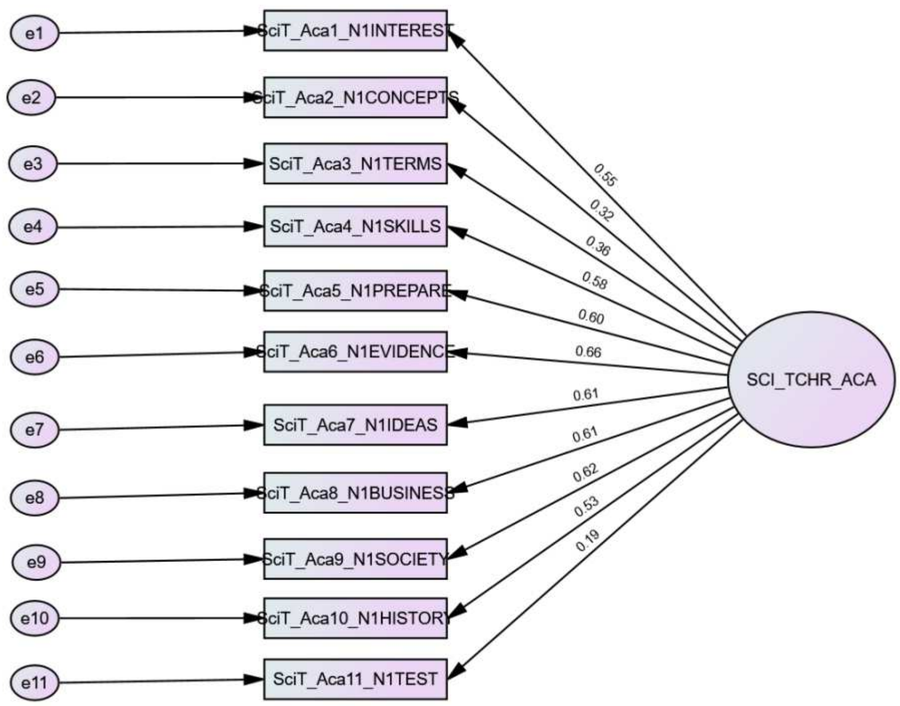


Note: Statistically significant paths are shown in bold. * $p < .05$. ** $p < .01$. *** $p < .001$.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Figure 10

Ninth Grade Science Teacher Academic Support Factor

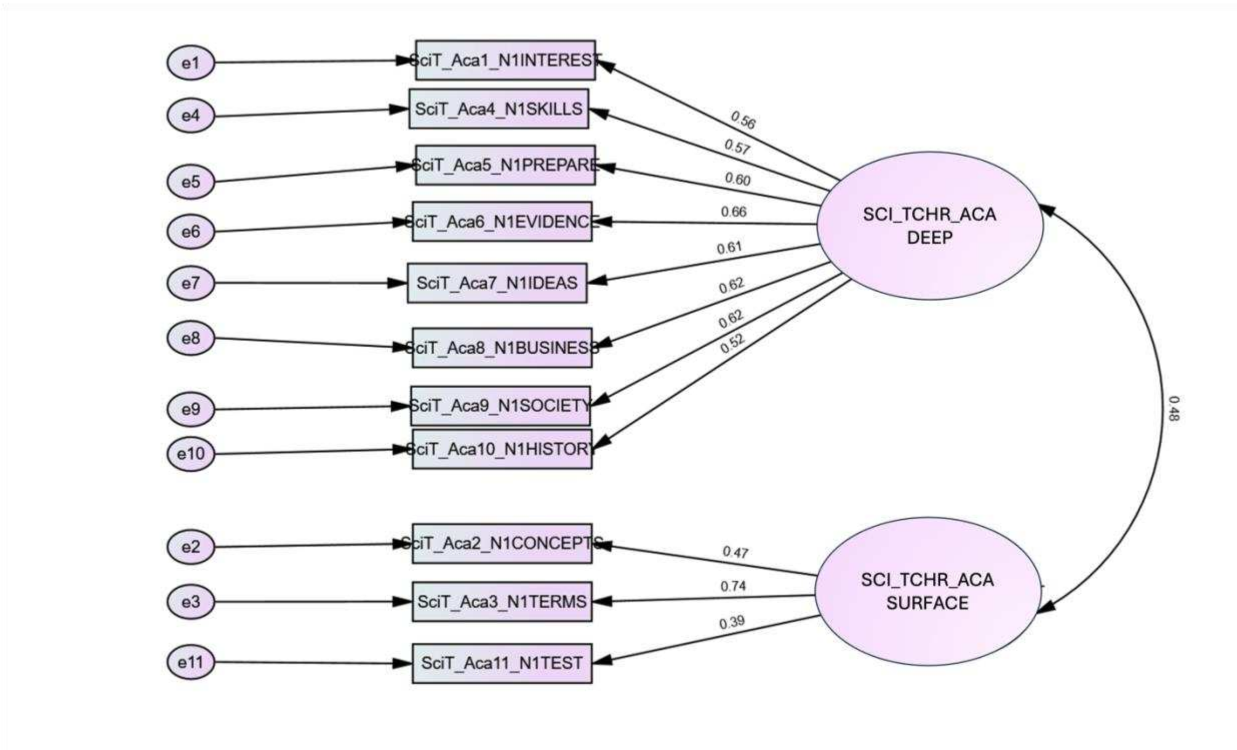


Note: All paths are significant at $p < .001$. SCI_TCHR_ACA= Science Teacher Academic Support.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data File.

Figure 11

Correlated Model of Ninth Grade Science Teacher Academic Support for Deep and Surface Cognitive Engagement

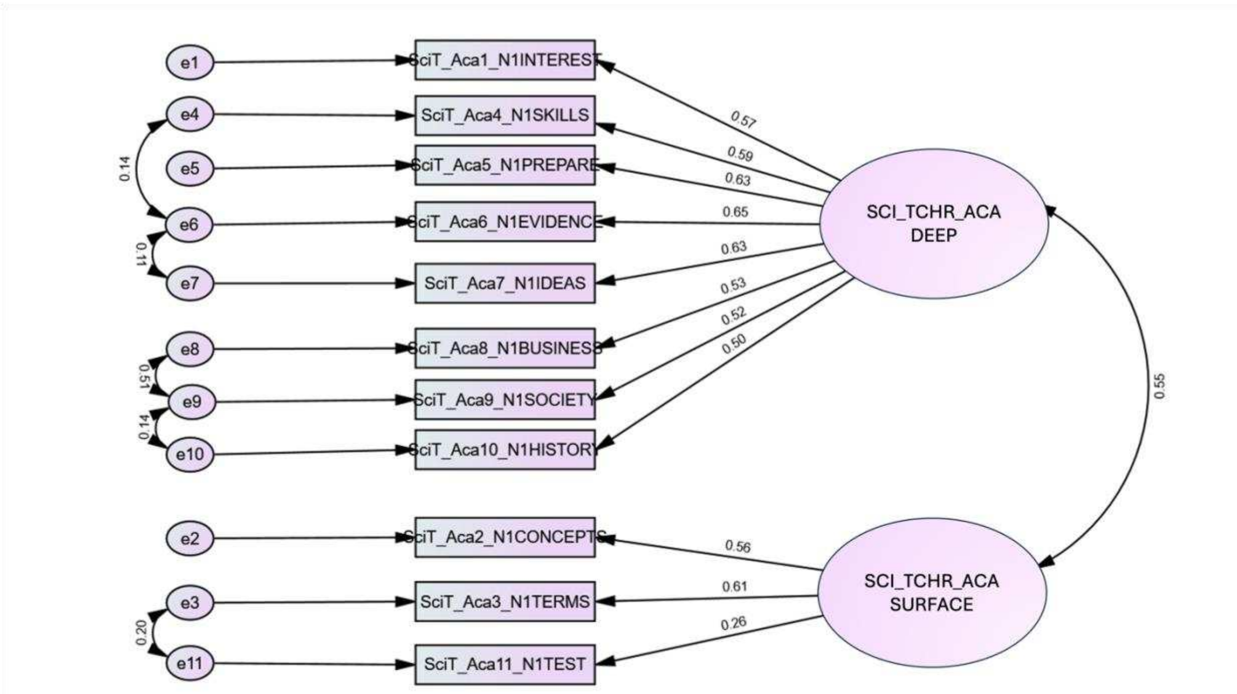


Note: All paths are significant at $p < .001$. SCI_TCHR_ACA_DEEP = Science Teacher Academic Support for Deep Cognitive Engagement. SCI_TCHR_ACA_SURFACE= SCI Teacher Academic Support for Surface Cognitive Engagement

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09), Base-Year (2009) Restricted-Use Data File.

Figure 12

Correlated Model of Ninth Grade Science Teacher Academic Support for Deep and Surface Cognitive Engagement (Revised)

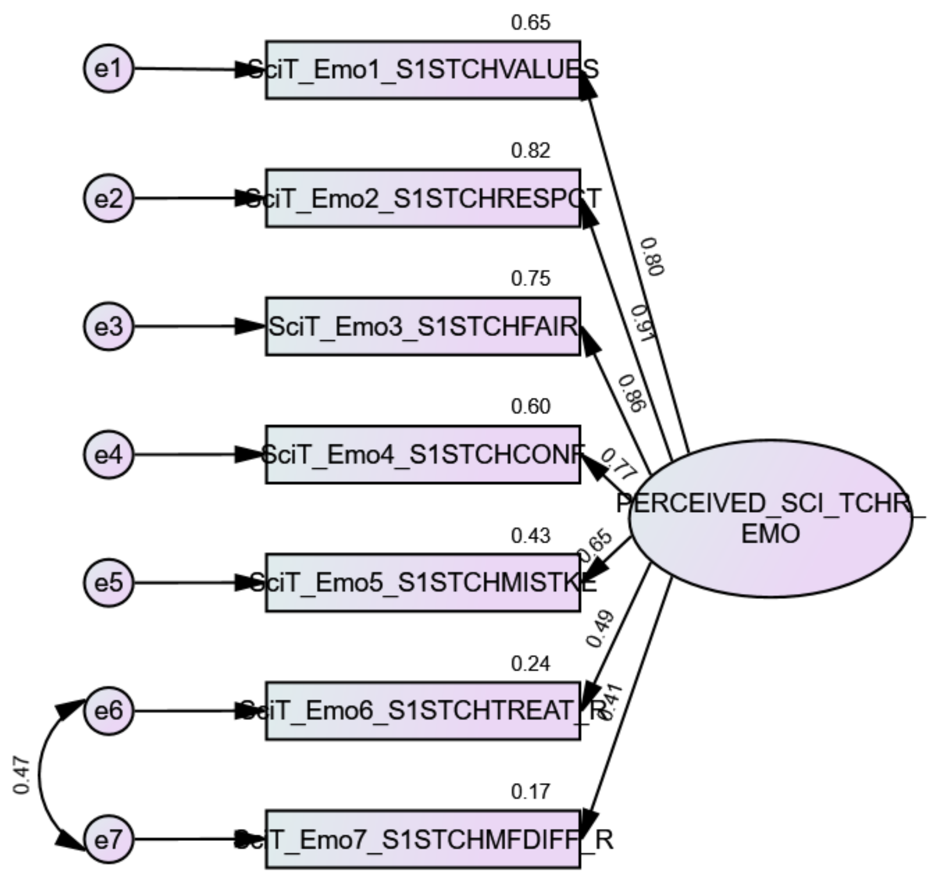


Note: All paths are significant at $p < .001$. SCI_TCHR_ACA_DEEP = Science Teacher Academic Support for Deep Cognitive Engagement. SCI_TCHR_ACA_SURFACE= SCI Teacher Academic Support for Surface Cognitive Engagement

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009) Restricted-Use Data File.

Figure 13

Ninth Grade Perceived Science Teacher Emotional Support Factor

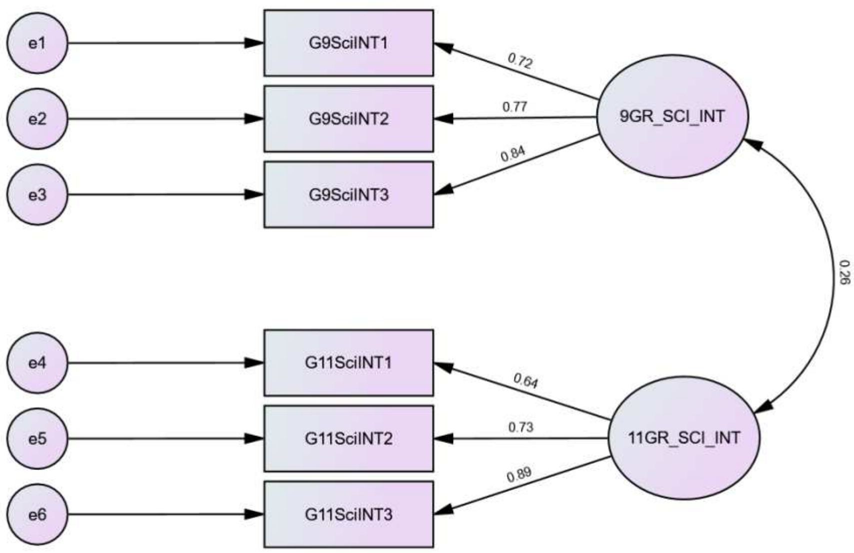


Note: All paths are significant at $p < .001$.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009) Restricted-Use Data File.

Figure 14

Correlated Ninth Grade and 11th Grade Science Interest Model

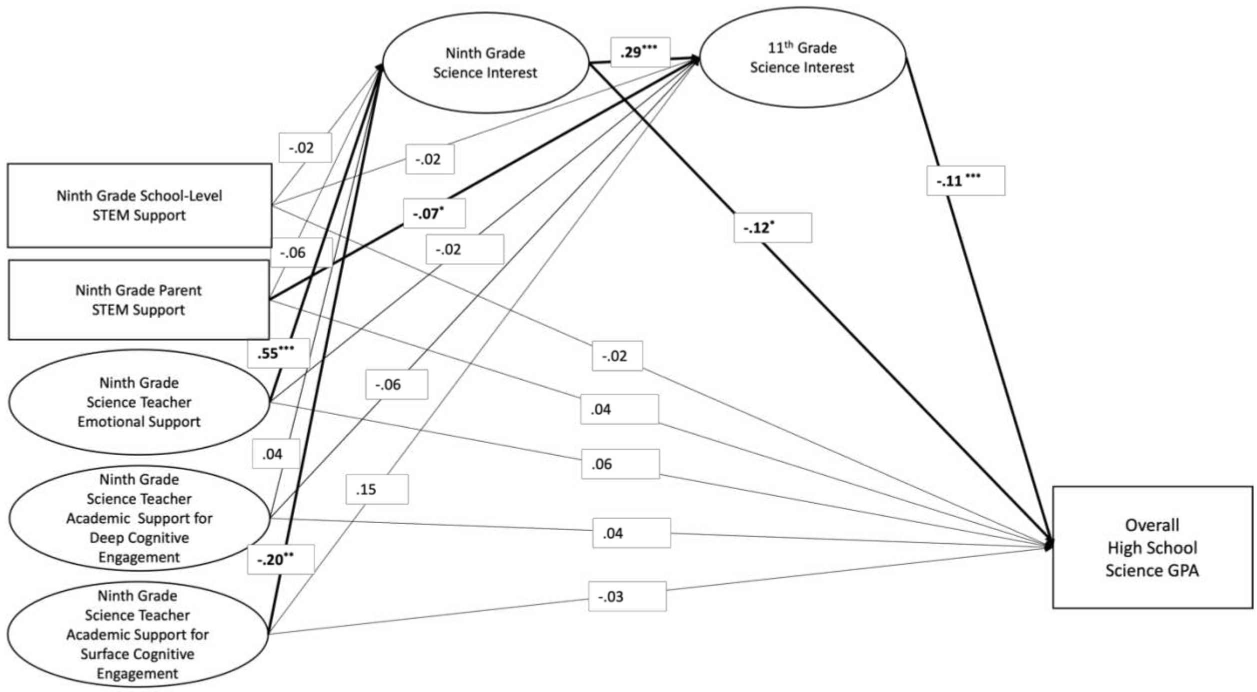


Note: All paths are significant at $p < .001$.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009) and First Follow-up (2012) Restricted-Use Data Files.

Figure 15.

Full Science Structural Equation Model



Note: Statistically significant paths are shown in bold. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09) Base-Year (2009), First Follow-up (2012), and 2013 Update and High School Transcripts Restricted-Use Data Files.

Appendix A

Ninth Grade School-level STEM Support (Base Year Administrator Questionnaire)

** Does your school do any of the following to raise high school students' interest and achievement in math or science? (check all that apply;* 0 =No; 1= Yes; -8 = Unit non-response; -9 = Missing)

1. A1MTHSCIFAIR
    - Hold school-wide math or science fairs, workshops, or competitions.
2. A1MSSUMMER
    - Partner with college or university that offers math or science summer programs or camps.
3. A1MSAFTERSCH
    - Sponsor a math or science after-school program.
4. A1MSMENTOR
    - Pair students with mentors in math or science.
5. A1MSSPEAKER
    - Bring in guest speakers to talk about math or science.
6. A1MSFLDTRIP
    - Take students on math- or science-relevant field trips such as to a city aquarium or planetarium.
7. A1MSPRGMS
    - Tell students about regional or state math or science contests, math or science web sites and blogs, or other math or science programs online or in your community, such as a 21st Century Community Learning Center program or Girls Incorporated Operation SMA.
8. A1MESA (* Variable suppressed with -5 values on the public use file)
    - Partner with Mathematics Engineering Science Achievement (MESA) or a similar enrichment-model program in your community or state that provides math or science academic development activities and services to students.
9. A1MSPDLEARN
    - Require teacher prof development in how students learn math or science.
10. A1MSPDINTRST
    - Requires teacher prof development in increasing student interest in math/science.

Appendix B

Ninth Grade Parent STEM Support (Base Year Parent Questionnaire)
* *During the last 12 months, which of the following activities have you or another family member done with [your 9th-grader]? (Check all that apply;.* 0 =No; 1= Yes; -8 Unit non-response; -9 Missing)

- Note: Question/response wording was customized in the survey instrument such that the sample member's name appeared in place of "your 9th-grader".

1. P1MUSEUM
   - Visited a zoo, planetarium, natural history museum, transportation museum, or a similar museum.
2. P1COMPUTER
   - Worked or played on a computer together.
3. P1FIXED
   - Built or fixed something such as a vehicle or appliance.
4. P1SCIFAIR
   - Attended a school science fair.
5. P1SCIPROJ
   - Helped [your 9th-grader] with a school science fair project.
6. P1STEMDISC
   - Discussed a program or article about math, science, or technology.

Appendix C

Ninth Grade Math Teacher Academic Support (Base Year Math Teacher Questionnaire)

** Think about the full duration of this [fall 2009 math course]. How much emphasis are you placing on each of the following objectives?*

- 1 = No emphasis; 2 = Minimal Emphasis; 3 = Moderate Emphasis; 4 = Heavy Emphasis
- Note: Question wording was customized in the survey instrument such that the actual name of the fall 2009 math course taught by the teacher respondent was used in place of 'fall 2009 math course'.
- Comment: "No emphasis" recoded as "No emphasis or minimal emphasis" on the public use file.

Ninth Grade Math Teacher Academic Support for Deep Cognitive Engagement

1. M1INTEREST
   - Increasing students' interest in math
2. M1PROBLEM
   - Developing students' problem solving skills.
3. M1REASON
   - Teaching students to reason mathematically.
4. M1IDEAS
   - Teaching students how mathematics ideas connect with one another
5. M1PREPARE
   - Preparing students for further study in mathematics
6. M1LOGIC
   - Teaching students the logical structure of mathematics
7. M1HISTORY
   - Teaching students about the history and nature of mathematics
8. M1EXPLAIN
   - Teaching students to explain ideas in mathematics effectively
9. M1BUSINESS
   - Teaching students how to apply mathematics in business and industry

Ninth Grade Math Teacher Academic Support for Surface Cognitive Engagement

1. M1CONCEPTS
   - Teaching students math concepts
2. M1ALGORITHM
   - Teaching students math algorithms or procedures
3. M1COMPSKILLS
   - Developing students' computational skills
4. M1COMPUTE
   - Teaching students to perform computations with speed and accuracy
5. M1TEST
   - Preparing students for standardized tests

Appendix D

Ninth Grade Science Teacher Academic Support (Base Year Science Teacher Questionnaire)

* Think about the full duration of this [fall 2009 science course]. How much emphasis are you placing on each of the following objectives? (1 = No emphasis; 2 = Minimal Emphasis; 3 = Moderate Emphasis; 4 = Heavy Emphasis)

- Note: Question wording was customized in the survey instrument such that the actual name of the fall 2009 math course taught by the teacher respondent was used in place of 'fall 2009 science course'.
- Comment: "No emphasis" recoded as "No emphasis or minimal emphasis" on the public use file.

Ninth Grade Science Teacher Academic Support for Deep Cognitive Engagement

1. N1INTEREST
   - Increasing students' interest in science
2. N1SKILLS
   - Teaching students science process or inquiry skills
3. N1PREPARE
   - Preparing students for further study in science
4. N1EVIDENCE
   - Teaching students to evaluate arguments based on scientific evidence
5. N1IDEAS
   - Teaching students how to communicate ideas in science effectively
6. N1BUSINESS
   - Teaching students about the applications of science in business and industry
7. N1SOCIETY
   - Teaching students about the relationship between science, technology, and society
8. N1HISTORY
   - Teaching students about the history and nature of science

Ninth Grade Science Teacher Academic Support for Surface Cognitive Engagement

1. N1CONCEPTS
   - Teaching students basic science concepts
2. N1TERMS
   - Teaching students important terms and facts of science
3. N1TEST
   - Preparing students for standardized tests

Appendix E

Ninth Grade Math Perceived Teacher Emotional Support (Base Year Student Questionnaire Items)

** How much do you agree or disagree with the following statements about [your math teacher]? Remember, none of your teachers or your principal will see any of the answers you provide. Your math teacher...*

- 1= Strongly agree; 2 = Agree; 3 = Disagree; 4= Strongly disagree; -7 = Item legitimate skip/NA; -8 = Unit non-response; -9= Missing
- Note: Question wording was customized in the survey instrument such that the name of the respondent's math teacher (if available) was displayed in place of "your math teacher."

1. S1MTCHVALUES
    - [9th grader's fall 2009 math teacher] values/listens to students' ideas.
2. S1MTCHRESPCT
    - [9th grader's fall 2009 math teacher] treats students with respect.
3. S1MTCHFAIR
    - [9th grader's fall 2009 math teacher] treats every student fairly.
4. S1MTCHCONF
    - [9th grader's fall 2009 math teacher] thinks every student can be successful.
5. S1MTCHMISTKE
    - [9th grader's fall 2009 math teacher] thinks mistakes are okay as long as all students learn.
6. S1MTCHTREAT
    - [9th grader's fall 2009 math teacher] treats some kids better than other kids. (R)
7. S1MTCHMFDIFF
    - [9th grader's fall 2009 math teacher] treats males and females differently. (R)

Appendix F

Ninth Grade Science Perceived Teacher Emotional Support (Base Year Student Questionnaire Items)

** How much do you agree or disagree with the following statements about [your science teacher]? Remember, none of your teachers or your principal will see any of the answers you provide. Your math teacher...*

- 1= Strongly agree; 2 = Agree; 3 = Disagree; 4= Strongly disagree; -7 = Item legitimate skip/NA; -8 = Unit non-response; -9= Missing
- Note: Question wording was customized in the survey instrument such that the name of the respondent's math teacher (if available) was displayed in place of "your science teacher."

1. S1STCHVALUES
    - [9th grader's fall 2009 science teacher] values and listens to students' ideas.
2. S1STCHRESPCT
    - [9th grader's fall 2009 science teacher] treats students with respect.
3. S1STCHFAIR
    - [9th grader's fall 2009 science teacher] treats every student fairly.
4. S1STCHCONF
    - [9th grader's fall 2009 science teacher] thinks all student can be successful.
5. S1STCHMISTKE
    - [9th grader's fall 2009 science teacher] thinks mistakes are okay as long as all students learn.
6. S1STCHTREAT
    - [9th grader's fall 2009 science teacher] treats some kids better than other kids. (R)
7. S1STCHMFDIFF
    - [9th grader's fall 2009 science teacher] treats males and females differently. (R)

Appendix G

Ninth Grade Student Math Interest

1. S1MENJOYING
    - S1 C06A 9th grader is enjoying fall 2009 math course very much
2. S1MWASTE
    - S1 C06B 9th grader thinks fall 2009 math course is a waste of time (R)
3. S1MBORING
    - S1 C06C 9th grader thinks fall 2009 math course is boring (R)

11th Grade Student Math Interest

1. S2MENJOYING
    - S2 C06A 11th grader is enjoying spring 2012 math course very much
2. S2MWASTE
    - S2 C06B 11th grader thinks spring 2012 math course is a waste of time (R)
3. S2MBORING
    - S2 C06C 11th grader thinks spring 2012 math course is boring (R)

Ninth Student Science Interest

1. S1SENJOYING
    a. S1 D06A 9th grader is enjoying fall 2009 science course very much
2. S1SWASTE
    a. S1 D06B 9th grader thinks fall 2009 science course is a waste of time (R)
3. S1SBORING
    a. S1 D06C 9th grader thinks fall 2009 science course is boring (R)

11th Grade Student Science Interest

1. S2SENJOYING
    a. S2 D06A 11th grader is enjoying spring 2012 science course very much
2. S2SWASTE
    a. S2 D06B 11th grader thinks spring 2012 science course is a waste of time (R)
3. S2SBORING
    a. S2 D06C 11th grader thinks spring 2012 science course is boring (R)

Appendix H

Overall High School Math/Science GPA

- X3TGPAMAT
  - X3 GPA: mathematics
  - HS Transcript student level composites
- X3TGPASCI
  - X3 GPA: science
  - HS Transcript student level composites

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EDUCATION

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APA-Approved Internship
Jul 2023– June 2024

Multidisciplinary Pediatric Feeding Program
Emory University School of Medicine/ Children's Healthcare of Atlanta/ Marcus Autism Center, Atlanta, GA
Major Rotation
Primary Supervisors: Emily Kate Rubio, PhD, BCBA; Valerie Volkert, PhD, BCBA-D; and Kristin Hathaway, PhD, BCBA
Assessment Supervisors: Addam Wawrzonek, PhD, BCBA; and Taylor Davidson, PsyD.

- Provided assessment for avoidant/restrictive food intake disorder (ARFID) to make general recommendations for further evaluations.
- Worked in a multidisciplinary team, including nurse practitioners, dietitians, speech therapists, occupational therapists, and social workers to evaluate the factors contributing to feeding problems and develop individualized treatment plans.
- Provided intensive feeding sessions to children with ARFID and comorbid developmental and medical diagnoses.
- Supported and trained caregivers to implement procedures.

Pre-doctoral Intern
APA-Approved Internship
August 2023– June 2024

Research Units in Behavioral Intervention (RUBI) Program
Emory University School of Medicine/ Children's Healthcare of Atlanta/ Marcus Autism Center, Atlanta, GA
Minor Rotation
Supervisor: Mindy Scheithauer, PhD, BCBA-D; and Alexis Pavlov, PhD, BCBA-D

- Provided outpatient behavioral parent training to decrease challenging behaviors in children with autism spectrum disorder (ASD) between the ages of 3-10.
- Provided caregivers with evidence-based strategies to prevent, manage, and reduce occurrences of problem behaviors of mild to moderate severity while promoting skill development.
- Supported caregivers and problem-solved barriers to treatment.

Psychology Extern Pediatric Psychology
Jul 2022– May 2023

Division of Endocrinology
Children's Hospital of Philadelphia (CHOP), Philadelphia, PA
Supervisor: Leela Morrow, PsyD

- Conducted diagnostic intake and risk assessment for pediatric patients with various endocrine conditions, including hyperinsulinism, Turner Syndrome, Klinefelter Syndrome, congenital adrenal hyperplasia (CAH), and other and differences in sex development (DSD).
- Provided consultation for patients and their families coping with a new diagnosis.
- Provided cognitive behavioral therapy (CBT) to pediatric patients to mitigate medical trauma and needle phobia.
- Provided behavioral consultation to increase medical adherence.

- Offered psychoeducation to patients and families about the relationship between endocrine conditions and mood/emotions.
- Worked with a multidisciplinary care team, including endocrinologists, neuropsychologists, nurse practitioners, dieticians, social workers, and child life specialists to provide optimal care for patients with endocrine conditions.

Psychology Extern
Integrated Primary Care
Jul 2021– May 2023

Sleep Well! Sleep Intervention in Urban Primary Care
Children's Hospital of Philadelphia (CHOP), Philadelphia, PA
Supervisor: Ariel Williamson, PhD, DBSM

- Virtually implemented a brief, manualized intervention for early childhood sleep problems.
- Assessed sleep problems and identified family-centered goals.
- Provide behavioral sleep treatment strategies, such as following a consistent bedtime routine, graduated extinction, and bedtime fading.
- Provide psychoeducation on sleep health and hygiene.
- Document sessions in the patient's electronic medical chart (EPIC) to integrate care with medical providers.

Psychology Extern
Integrated Primary Care
Aug 2021– May 2022

Star Wellness KidsCare, Bethlehem, PA
Supervisor: Jennifer Brisbane, PsyD

- Provided short-term, solution-focused consultation (i.e., intake interviews, psychotherapy, and psychoeducation) for emotional, behavioral, and/or social needs of pediatric patients in a federally qualified health center (FQHC).
- Collaborated with pediatricians, nurse practitioners, physician assistants, and social workers to address complex needs of patient populations.
- Facilitated referrals for long-term and/or specialty mental health services.

Psychology Extern
Pediatric Neuropsychology
Aug 2020 – Jun 2021

Concussion/Mild Traumatic Brain Injury (mTBI) Clinic
Nemours Children's Health, Wilmington, DE
Supervisor: Gregory Witkin, PhD, ABPP-CN

- Conducted clinical interviews to assess symptoms of concussion/mTBI.
- Administered neuropsychological assessments with children and adolescents with concussion/mTBI.
- Provided consultation on return-to-school/return-to-play.

Graduate Assistant/ Academic Coach
Aug 2019 – Aug 2020

Disability Student Services (DSS)
Lehigh University, Bethlehem, PA
Supervisors: Maria S. Zullo, Assistant Dean of Students; Michelle S. Koch, Associate Director of DSS, Ed.S., LPC; Michell Conrad, Ed.S.

- Reviewed documentation of college students diagnosed with specific learning disabilities, ADHD, and/or chronic health conditions.
- Assisted high school to college transition.
- Provided weekly one-to-one coaching meetings to maximize student academic success.
- Assisted students in requesting and receiving necessary accommodations.

Practicum Student
School Psychology
Sep 2021- June 2022

Simon Butler Elementary School, Chalfont, PA
Supervisor: Julia Szarko, PhD, NCSP

- Administered psychoeducational assessments and rating scales.
- Conducted direct behavioral observations.
- Progress monitored student performance and evaluated the effectiveness of academic and behavior instruction or interventions.
- Collaborated with parents and the school team to develop and modify Individualized Education Programs (IEPs) and 504 Plans

Practicum Student
School Psychology
Jan 2020 – June 2021

George D. Steckel Elementary School, Whitehall, PA
Supervisor: Karen Christ, EdS., NCSP

- Administered psychoeducational assessment and rating scales.
- Wrote evaluation and re-evaluation reports.
- Participated in both in-person and virtual IEP and multidisciplinary team meetings during the COVID-19 pandemic.

Practicum Student
School Psychology
Sep 2019 – Dec 2019

Calypso Elementary School & William Penn Elementary School, Bethlehem, PA
Supervisor: Elyse Lubell, PhD
Conducted direct observations and psychoeducational evaluations (cognitive, achievement, behavioral, and academic assessments)

- Conducted direct observations to compare students' behaviors to their peers.
- Collaborated with teachers, parents, and learning support teachers within the conjoint behavioral consultation (CBC)

framework to develop and implement behavior interventions.

Practicum Experience
School Psychology
Sep 2018 – Dec 2018

Broughal Middle School, Bethlehem, PA
- Worked as a behavioral consultant within the school district.
- Conducted functional behavioral assessments (FBAs) and utilized applied behavioral analysis (ABA) principles to develop an intervention plan for decreasing out-of-seat behavior for a student with intellectual disability.

RESEARCH/ PROFESSIONAL EXPERIENCES

Research Assistant & Interventionist
Aug 2020 – Aug 2022

Project PEAK
(Promoting Engagement with ADHD Pre Kindergarteners)
Institute of Education Sciences (IES).
Lehigh University, Bethlehem, PA
Principle investigators: George DuPaul, PhD & Lee Kern, PhD.
- Worked as an interventionist for a 10-week face-to-face behavioral parent training (BPT) program.
- Worked as an interventionist for a 10-week online BPT program,
- Assisted the development of online intervention modules.
- Recruited research participants and conducted phone screens and diagnostic interviews for eligibility determination.
- Administered cognitive and achievement assessments for children ages 3-5 and wrote evaluation reports.

Research Volunteer
Aug 2019 – Aug 2020

Collaborative Research Opportunity (CORE) Internal Grant
(Immersive Virtual Reality to Support Effective Intervention for Individuals with Disabilities: Promoting Maintenance and Generalization)
Lehigh University, Bethlehem, PA
Principle investigators: George DuPaul, PhD & Lee Kern, PhD.
- Administered eligibility assessment children ages 3-5 with or at risk for ADHD.
- Assisted the implementation of the BPT.

Graduate Assistant
Aug 2020 – Aug 2022

College of Education Research Office
Lehigh University, Bethlehem, PA
- Assisted the Associate Dean for Research in various research-related activities across programs (i.e., counseling psychology, educational leadership, instructional technology, school psychology, and special education).
- Created Section 508 compliant and accessible documents.
- Maintained faculty and student research websites.
- Assisted publication of the COE Research & Scholarship Newsletters.

Assistant Researcher
Jun 2015 – Dec 2015

Office of International Relations & Cooperation
Korean Educational Development Institute (KEDI), Seoul, Korea

- Coordinated the 2015 Korea-OECD International Seminar [Theme: Implications of Teaching and Learning International Survey (TALIS) 2013 for Asia-Pacific].
- Assisted the publication of *KEDI Journal of Educational Policy (KJEP).*
- Assisted the publication of Korean translation of OECD TALIS reports.

Research Assistant
Mar 2013 – Jun 2015

Brain and Motivation Research Institute (*b*MRI)
Korea University, Seoul, Korea

- Designing and conducting research on motivation and emotion using various methods, including experiments, surveys & *f*MRI.
- Coordinated the 2014 *b*MRI Symposium on Motivation (Theme: Motivation and Engagement in Context: School, Family, and Peers).

Program Assistant
May 2012 – Dec 2012

Publication and Public Relations Unit
UNESCO Asia-Pacific Centre of Education for International Understanding (APCEIU), Seoul, Korea

- Assisted the publication of *SangSaeng*, an English magazine that discusses issues, methods, and experiences in the field of education for international understanding (EIU).

AWARDS & GRANTS

Mar 2024	**Division 53 Diversity Travel Award** Society for Clinical Child and Adolescent Psychology (SCCAP) American Psychological Association (APA). Awarded: $300.00
Apr 2022	**Division 53 Innovative Research Graduate Student Poster Award** Society of Clinical Child and Adolescent Psychology (SCCAP) American Psychological Association (APA). Awarded: $200.00
Feb 2023	**Diversity Committee Student Research Grant** College of Education, Lehigh University. Awarded: $500.00
Nov 2020	**Diversity Committee Student Research Grant** College of Education, Lehigh University. Awarded: $400.00
Mar 2021	**“Go Beyond!” Dr. Edward S. Shapiro Memorial Fund Award** College of Education, Lehigh University. Awarded: $350.
Jan 2021	**School Psychology Review (SPR) Student Editorial Board Service Award**
2019-2024	**Dean's Endowed Student Travel Scholarship**, Lehigh University (awarded six times)

2019-2023	**Graduate Student Senate (GSS) Travel Grant**, Lehigh University (awarded four times)
2013-2014	**BK21(Brain Korea 21) Scholarship** National Foundation of Korea (NRF) & Korea University
2007-2010	**Dean's List**, Ewha Womans [sic] University (awarded four times)
2009-2010	**Student Exchange Grant** Japan Student Services Organization (JASSO)

PUBLICATIONS

Oram, R., Daffner-Deming, M., **Ahn, J. H.,** Rogers, M., & DuPaul, G. (2023). Basic Psychological Needs of Undergraduate Students with and without High ADHD Symptomatology. Canadian Journal of Educational and Social Studies, 3(1), 17–28. https://doi.org/10.53103/cjess.v3i1.94

Ahn, J.H. (December 2022). Response to P.A. Zirkel (ed.) You be the judge #23: Child find and eligibility under the IDEA. *Communiqué, 51*(4), pp. 18-20.

DuPaul, G.J., Chunta, A.M, & **Ahn, J.H.** (2022). Parenting children with externalizing behavior and ADHD. In J. M. Smith and A.S. Morris (Eds.), *Handbook of Parenting: Interdisciplinary Research and Application.* Cambridge University Press.

CONFERENCE PRESENTATIONS

Ahn, J.H. & Fritz, S. P. (2024, August 8-10). *Where the Pipeline Ends: Mental Health Access Disparity for Youth with Diabetes* [Poster accepted]. APA Annual Convention, Seattle, WA.

Ahn, J.H., DuPaul, G.J., Dever, B.V., & Fu, Q. (2024, February 14-17). *STEM Interest and Achievement in High School Freshmen with ADHD* [Paper presentation]. National Association of School Psychologist (NASP) Annual Convention, New Orleans, LA.

Nelson, AK., Lam, J.T.Y., **Ahn, J.H.**, Dever, B.V., Kern, L., & DuPaul, G.J. (2023, November 16-19). *Influence of Sleep on Parenting Stress in Young Children who are At-risk for ADHD* [Poster presentation]. ABCT Annual Convention, Seattle, WA.

Ahn, J.H., Morrow, L., McKnight, H., De Leon-Crutchlow, D.D., Stewart, N., & Asbury, K. (2023, April 13-14). *Hyperinsulinism and developmental/behavioral problems: Early screening results in outpatient specialty clinic* [Poster presentation]. Hyperinsulinism-Novel Genes, Drugs and Guidelines. Philadelphia, PA.

Ahn, J.H., Morrow, L., McKnight, H., De Leon-Crutchlow, D.D., Stewart, N., & Asbury, K. (2023, March 30-April 1). *Hyperinsulinism and developmental/behavioral problems: Early screening results in outpatient specialty clinic* [Poster presentation]. Annual Conference of the Society of Pediatric Psychology (SPPAC), Chicago, IL.

Nelson, A.K., **Ahn, J.H.,** DuPaul, G.J. & Evans, S. (2023, February 7-10). *Executive functioning as mediator between daytime sleepiness and academic performance* [Poster presentation]. National Association of School Psychologist (NASP) Annual Convention, Denver, CO.

Ahn, J.H., Jung, H. J. & DuPaul, G.J. (2022, Aug 4 – Aug 7). *Psychosocial impact of Covid-19 and discrimination on Asian American youths and families* [Poster presentation]. APA Annual Convention, Minneapolis, MN (*Recipient of Innovative Research Poster Award, Division 53 of APA)

Nelson, A.K., **Ahn, J.H.,** DuPaul, G.J. & Evans, S. (2022, April 7-9). *The role of anxiety and depression symptomology in predicting excessive daytime sleepiness for adolescents with* ADHD [Poster presentation]. Annual Conference of the Society of Pediatric Psychology (SPPAC), Phoenix, AZ

Ahn, J. H., Gross, Y., Jung, H. J. & DuPaul, G.J. (2022, February 15–18). *Rendered invisible: Mental health needs of Asian American students* [Paper presentation]. NASP Annual Convention, Boston, MA. (*Recipient of the Lehigh College of Education Diversity Committee Student Research Award)

Ahn, J.H., Comis, M.P., DuPaul, G.J., Hughes, T.L., & Graves, S. L. (2022, February 15–18). *Virtual classroom management for teachers and parents* [Practitioner conversation]. NASP Annual Convention, Boston, MA.

Comis, M.P., **Ahn, J.H.,** Hughes, T.L., Graves, S.L., & DuPaul, G.J. (2022, February 15–18). *How school psychologists can increase cultural awareness during virtual learning.* [Practitioner conversation]. NASP Annual Convention, Boston, MA.

Chunta, A.M., **Ahn, J.H.**, Clarke, M.S., and Chen, R. (2022, February 15–18). *Supporting caregivers of children at risk for ADHD through optimism training* [Practitioner conversation]. NASP Annual Convention, Boston, MA.

Nelson, A.K., **Ahn, J.H.**, DuPaul, G.J., & Kern, L. (2021, November 18-21). *Screen time During the COVID-19 Pandemic: Implications for pre-adolescent sleep functioning* [Poster presentation]. ABCT Annual Convention, New Orleans, LA.

Nelson, A.K., **Ahn, J.H.**, DuPaul, G.J., & Kern, L. (2021, August 12-14). *BPT for children with ADHD on parent stress: Moderating role of child sleep problems* [Poster presentation]. APA Annual Convention, San Diego, CA.

Ahn, J.H. & DuPaul, G.J. (2021, February 23–26). *Academic self-efficacy miscalibration in high school students with ADHD* [Paper presentation]. NASP Annual Convention, Virtual.

Ahn, J. H., Chunta, A.M., DuPaul, G.J., & Kern, L. (2020, November 17-22). *The impact of behavioral and optimistic parenting training and immersive virtual reality on parental affiliate stigma* [Poster presentation]. ABCT Annual Convention, Virtual.

Ahn, J. H. & DuPaul, G. J. (2020, August 6-9). *Digital media use, ADHD symptoms, and parental monitoring in pre-adolescents* [Poster presentation]. APA Annual Convention, Virtual.

Ahn, J. H., Younis, D., & Dever, B. V. (2020, February 18-21). *Cost as mediator between performance goals and risk* [Paper presentation]. NASP Annual Convention, Baltimore, MD.

Ahn, J. H. & DuPaul, G. J. (2019, November 19-22). *ADHD symptoms as predictors of TBI risk in children* [Poster presentation]. ABCT Annual Convention, Atlanta, GA.

Ahn, J. H., Han, H. W., Lee, H. J., & Kim, S. (2014, June 27-28). *Relationship between interest and academic achievement in science: Based on PISA 2006* [Poster presentation]. Annual meeting of Korean Educational Research Association (KERA), Seoul, Korea.

Song, J., Woo, Y., Reeve, J., Bong, M., & **Ahn, J. H.** (2014, April 3-7). *The role of different forms of cognitive engagement as a mediator between motivation and* achievement [Poster presentation]. Annual meeting of the American Educational Research Association (AERA), Philadelphia, PA.

PROFESSIONAL DEVELOPMENT WORKSHOPS

Ahn, J. H. (2021, April 18). Multi-tiered System of Supports (*MTSS) for Neuropsychologists* [Presentation at the neuropsychology didactics seminar]. Nemours Children's Health, Wilmington, DE.

TRAINING & SKILLS

Aug 2023	**Basic Life Support (CPR & AED) Program** American Heart Association
Jul 2023	**ADOS-2 Advanced Clinical Workshop** Modules 1, 2, 3, 4 and Toddler Marcus Autism Center Summer Symposium, Atlanta, GA
Aug 2023	**Marcus Autism Center Crisis Prevention Program (MCPP)** Tier 3: Advanced Skills Training–crisis prevention, de-escalation, post-crisis management strategies and full training on personal protective procedures Marcus Autism Center, Atlanta, GA
Jun 2023	**Unified Protocol for Transdiagnostic Treatment of Emotional Disorders in Children and Adolescents (UP-C/A)** Live Webinar by Child and Adolescent Mood and Anxiety Treatment (CAMAT) Program, University of Miami
Feb 2022	**Disaster Mental Health Services: Introduction** Certificate of Completion Disaster Cycle Services, American Red Cross
Jan 2022	**Essentials of CBT, Certificate of Completion** Beck Institute for Cognitive Behavior Therapy
Nov 2020	**Pennsylvania Student Assistance (SAP) Program K-12 Training** Caron Foundation & Pennsylvania Network for Student Assistance Services (PNSAS)
Sep 2020	**Mandated Reporter Training** Pennsylvania Department of Education
Oct 2020	**Teacher's Suicide Awareness and Prevention Training** Lehigh University, Counseling and Psychological Services
Jan 2020	**Cognitive Behavioral Intervention for Trauma in Schools** (**CBITS**) **Provider Basic Training Course Certification** 3C Institute, Durham, NC - School-based group intervention for 5- 12th grade students exposed to stressful and traumatic events.
May 2019	**Bounce Back Provider Training Course Certification** 3C Institute, Durham, NC - School-based group intervention for elementary school students exposed to stressful and traumatic events.
Aug 2011	**Teaching Certificate, Secondary School** (Subject: English) Ministry of Education, Korea

TEACHING EXPERIENCE

Jan 2022 – May 2022 Teaching Assistant to Dr. George DuPaul, Lehigh University
- *Research Methods* (Graduate course)

Sep 2014 – Dec 2014 Teaching Assistant to Dr. Mimi Bong, Korea University
- *Theories of Learning and Instruction* (Undergraduate course)
- *Motivational Science* (Graduate course)

Sep 2013 – Dec 2013 Teaching Assistant to Dr. Sung-il Kim, Korea University
- *Mind, Brain, & Education* (Undergraduate course)
- *Psychological Approach to Education* (Graduate course)

Mar 2016 – Feb 2017 English Teacher, Ewha-Kumnan Middle School, Seoul, Korea
- Taught 8th and 9th graders in intermediate & low-achievement level classrooms

May 2011 Pre-service Teacher, Yongran Girls' Middle School, Seoul, Korea

SERVICES/LEADERSHIP ROLES

Jul 2023- Present Society of Clinical Child & Adolescent Psychology (SCCCAP) Mentorship Program, Student Mentor

Mar 2023 Student Ambassador, Society of Pediatric Psychology Annual Conference (SPPAC)

Apr 2021 – May 2022 Network of Campus Representative (NCR), Society of Pediatric Psychology (SPP)

Sep 2021 – Sept 2022 Student Journal Club Member, Journal of Pediatric Psychology (JPP)

Jul 2020 – July 2022 Student Ambassador, Association for Behavioral and Cognitive Therapies (ABCT)

Jun 2020 – Jun 2023 Student Editorial Board Member, School Psychology Review (SPR)

Aug 2019 – Aug 2021 President, Lehigh University Korean Students & Scholar's Association (LUKSSA)

Aug 2018 – Aug 2019 Vice President, LUKSSA

ACADEMIC ASSOCIATIONS

American Psychological Association (APA), Student Affiliate
- Division 16, School Psychology
- Division 53, Society of Clinical Child and Adolescent Psychology (SCCAP)
- Division 54, Society of Pediatric Psychology (SPP)

National Association of School Psychologists (NASP), Graduate Student Member
Association for Behavioral and Cognitive Therapies (ABCT), Student Member