# Motivation, NAEP Performance, and Choice of a STEM Major: The Role of Domain-Specific Academic Identity, Self-Efficacy, and Interest: A Synthesis Report

## AIR - NAEP Working Paper 2023-05

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**JULY 2023**

The research contained in this working paper was commissioned by the National Center for Education Statistics (NCES). It was conducted by the American Institutes for Research (AIR) in the framework of the Education Statistics Services Institute Network (ESSIN) Task Order 14: Assessment Division Support (Contract No. ED-IES-12-D-0002/0004) which supports NCES with expert advice and technical assistance on issues related to the National Assessment of Educational Progress (NAEP) and the working paper was completed under a follow-on contract (#91990022C0053). AIR is responsible for any error that this report may contain. Mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

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## NCES support contracts

The analysis for this working paper were completed under Task Order 14 for which AIR is the prime contractor under the Education Statistics Services Institute Network (ESSIN). ESSIN is a network of companies that provided the National Center for Education Statistics (NCES) with expert advice and technical assistance, for example in areas such as statistical methodology; research, analysis and reporting; and survey development. This AIR-NAEP working paper is based on research conducted under the Research, Analysis and Psychometric Support sub-component of ESSIN Task Order 14. The working paper itself was completed under a follow-on contract (#91990022C0053).

William Tirre, a Program Director in the NCES Assessment Division, oversees the Research, Analysis and Psychometric Support sub-component of ESSIN Task Order 14 and its follow-on contract referenced above.

## Suggested citation:

Zhang, J., and Li, M. (2023). *Motivation, NAEP performance, and choice of a STEM major: The Role of Domain-Specific Academic Identity, Self-Efficacy, and Interest: A Synthesis Report*. [AIR-NAEP Working Paper #2023-05]. Washington, DC: American Institutes for Research.

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# Executive summary

Students' academic motivation has been highlighted as one of the most significant and malleable factors that influence their academic behaviors, college major and career choices, and academic performance. The AIR National Assessment of Educational Progress (NAEP) research team has conducted four studies focused on the role of motivation, relating motivation to NAEP achievement in reading, mathematics, and science across different grade levels in three of the studies and exploring its relationship to students' choice of a science, technology, engineering, and mathematics (STEM) major in college in the fourth study.

The current summary report provides a synthesis of these four NAEP motivation studies.

First, the reading motivation study analyzed the 2015 grade 8 NAEP reading data to identify the unique effects of student-level reading motivation and aggregated school-level mean reading motivation on reading achievement.

Second, the science motivation study used 2015 grade 8 NAEP science assessment data to examine whether student-level science motivation measured by science self-efficacy and science interest, and aggregated school-level science motivation are associated with student science achievement. Both studies applied Hierarchical Linear Modeling (HLM) techniques to partition variability in student academic achievement (i.e., reading and science) into within- and between-school components after student- and school-level demographic variables are taken into account.

Third, the mathematics motivation study used the overlap sample of about 3,500 students who participated both in the High School Longitudinal Study of 2009 (HSLS:09) and the 2013 grade 12 NAEP mathematics assessment to investigate whether mathematics motivation (mathematics identity, self-efficacy, and interest) at grades 9 and 11 is related to grade 12 NAEP mathematics performance, simultaneously taking into account grade 9 mathematics achievement, family and school background factors, and grade 11 educational expectations and high school mathematics coursetaking.

The fourth study built on the mathematics motivation study to develop a comprehensive conceptual framework that describes how high school STEM coursetaking, STEM GPA, and STEM motivational beliefs (mathematics identity, science identity, mathematics self-efficacy, and science self-efficacy) are related to students' decision to choose a STEM major at 4-year colleges, taking into consideration student, family, and school background factors. This study used a nationally representative sample of data from HSLS:09 and the 2013 NAEP grade 12 mathematics assessment.

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# Introduction

Students' academic motivation has been highlighted as one of the most significant and malleable factors influencing their academic behavior, major and career choice, and academic achievement. The effects of motivation on achievement are central issues in educational psychology. Research has shown that students' motivation impacts their learning and achievement, taking into consideration cognitive ability as well as other demographic and social characteristics. The AIR National Assessment of Educational Progress (NAEP) research team has conducted four studies relating motivation to NAEP achievement in reading, mathematics, and science across different grade levels in three of the studies as well as its relationship to students' choice of a science, technology, engineering, and mathematics (STEM) major in college in a fourth study.

The current report provides a synthesis of the four NAEP motivation studies. It is organized into four parts: (1) a brief introduction laying out the background and goals of the four motivation studies; (2) a short summary of the theoretical background and recent literature summarizing the effects of motivation on academic achievement; (3) a summary of the findings for each of the four studies; and (4) policy recommendations demonstrated by literature and field practices that help to enhance students' academic motivation and school learning climate.

Three of the motivation studies investigate how students' subject-specific motivation (reading, mathematics, and science) is related to NAEP achievement in the corresponding subject area. The fourth study examines the role of high school students' mathematics and science motivation on their decision to choose a STEM major in college.

The reading motivation study analyzed the 2015 grade 8 NAEP reading data to identify the unique effects of student-level reading motivation and aggregated school-level mean reading motivation on reading achievement. The science motivation study used 2015 grade 8 NAEP science assessment data to examine whether student-level science motivation measured by science self-efficacy and science interest and aggregated school-level science motivation are associated with student science achievement. Both studies applied Hierarchical Linear Modeling (HLM) techniques to partition variability in student academic achievement (i.e., in reading and science) into within- and between-school components after student- and school-level demographic variables were taken into account.

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The fourth study built on the mathematics motivation study to develop a comprehensive conceptual framework that describes how high school STEM coursetaking, STEM GPA, and STEM motivational beliefs (mathematics identity, science identity, mathematics self-efficacy, and science self-efficacy) are related to students' decision to choose a STEM major at a 4-year college, taking into consideration student, family, and school background factors. This study used a national representative sample of the High School Longitudinal Study (HSLS:09) data and 2013 NAEP grade 12 mathematics assessment data.

Overall, the goals of the NAEP motivation series studies are threefold: (1) to provide scientific evidence to support the important role that academic motivation, a malleable factor, plays in students' academic achievement using NAEP data;[1] (2) to understand the role of academic motivation in mediating the relationship between academic achievement and students' sociodemographic characteristics (e.g., sex, race/ethnicity, English learner status) as well as school characteristics; and (3) to provide policy-amenable recommendations and teaching/learning practices to promote students' academic motivation.

For a summary of the four motivation studies (including subject area, grade level, and motivational constructs), please see Table 1. Readers who are interested in learning more about these four studies can see the full study reports at NAEP Data in Focus: Examining the Research | American Institutes for Research (air.org).

**Table 1. An overview of the four NAEP motivation studies**

| Motivation studies | Grade level | Motivation factors |
|---|---|---|
| Mathematics | 9–12th | Math identity; math interest; math self-efficacy |
| Reading | 8th | Reading motivation |
| Science | 8th | Science interest; science self-efficacy |
| STEM major in college | High school–college | Math identity; science identity; math self-efficacy; science self-efficacy |

# Theoretical Background

The set of NAEP motivation studies that examines the role of motivation and its relationship to NAEP performance draws heavily on Bandura's social cognitive theory (SCT) and the expectancy-value theory, developed by Eccles, Wigfield, and their colleagues. These two motivational theories are the most prominent theories of motivation in psychology. Both incorporate students' motivational beliefs, academic behaviors, and social and contextual background into a single model: a model that analyzes reciprocal relationships between motivational beliefs and social contexts to help explain students' academic achievement and high school students' choice of a STEM major in college.

[1] NAEP is the largest nationally representative and continuing assessment of what America's students know and do in different subject areas.

In these two theories, central motivational beliefs include individuals' self-efficacy,[2] identity, and interest. Self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives (Bandura, 1994). It refers to an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments. Such beliefs produce diverse effects through four major processes: cognitive, motivational, affective, and selection. Extensive research has indicated that students with lower academic self-efficacy perform less well on achievement tests and related academic tasks and activities, compared to students with higher levels of self-efficacy (Bassi et al., 2007; Kaya & Bozdag, 2016; Britner, 2008; Bircan & Sungur, 2016; Larry & Wendt, 2021; Lofgran et al., 2015).

Researchers have also demonstrated that students' identity beliefs play a significant role in influencing their academic behaviors, achievement, and career choice (Eccles, 2009; Stets et al., 2017). Individuals' behaviors and decisions (e.g., choosing a STEM major at college) are influenced by their personal and social identities as well, but they also influence the expression of their personal and social identities: that is, there is a reciprocal relationship between the two. Individuals' identity and self-efficacy beliefs also have a reciprocal relationship, where one's identity beliefs influence one's self-efficacy beliefs and one's self-efficacy beliefs in turn influence one's identity beliefs (Bohrnstedt et al., 2020; Brenner et al., 2018). For this reason, students' identity is included in the motivational studies reported below (specifically, mathematics and science identities).

In the NAEP motivation studies, identity takes on a symbolic interactionist perspective in which it is defined as a function of the meaning that persons attach to the roles that they play: roles such as a student, musician, scientist, grandfather, and so on (Stryker & Burke, 2000). It is through identities that we define for ourselves who we are. Following Stone (1962), identities are established when significant others use the same words to describe a person as that person uses for himself or herself. Thus, to be *identified,* claims made for oneself must be legitimated and supported by significant others. For example, a student's mathematics identity is based not only on self-perceived mathematics capabilities and accomplishments, but on the support that this perception is provided by others. One not only sees oneself as being "a math person," but one is also identified by significant others (e.g., teachers, parents, friends) as "a math person." This verification by others is based on significant others witnessing performances that are consistent with the expectations associated with an identity (Felson & Bohrnstedt, 1980; Kepka & Brickman, 1971).

Having an interest in a subject area is also an important motivational construct. Hidi and Renninger (2006) define interest in a discipline (e.g., mathematics, science, reading) as a learner's predisposition to engage and reengage specific disciplinary content over time as well as the psychological state that accompanies this engagement. Under the framework of

[2] Under the expectancy-value theory framework, self-efficacy beliefs are referred to as competence-related beliefs, of which there are two types: ability beliefs and expectancy beliefs (Eccles et al., 1993). *Ability beliefs* are defined as individuals' perceptions of their *current* competence, particularly in a specific domain, such as mathematics or science.

the expectancy-value theory, science interest emphasizes the enjoyment of science; in this regard, the construct is similar to intrinsic motivation in self-determination theory (Ryan & Deci, 2000; Schiefele, 2001). When students intrinsically like science or mathematics, they are more likely to deeply engage in related activities and be more resilient in the face of difficulty while working on assignments (i.e., to feel more self-efficacious).

Not only do social cognitive theory and the expectancy-value theory both consider motivation as an individual characteristic, but they both acknowledge the impact that social context and interpersonal relations have on motivation. Therefore, students' social background, including individual-level and school-level background factors, is included in the framework of all of the NAEP motivational studies. Individual-level background factors include sex, race/ethnicity, socioeconomic status (SES), and English learner (EL) status. School-level background factors include the percentage of students eligible for the National School Lunch Program (NSLP); the percentage of students identified as EL; the percentage of students with Individualized Education Programs (IEPs); the percentage of Black students; and the percentage of Hispanic students.

# Effects of Motivation on Academic Achievement by Student Subgroup

Overall, the significance of motivation to students' academic achievement has been demonstrated in many studies. In recent years, there has been a call to conduct more research studies to examine motivation and achievement at the intersection of students' background characteristics, including gender, race/ethnicity, and socioeconomic status. Students' background characteristics are important because they provide an important context for the development of motivational beliefs and mediate how motivation is associated with academic achievement. The four NAEP motivation studies examined in this paper investigate how the function of subject area motivation in the corresponding area of NAEP achievement varies by students' gender and race/ethnicity.

## Gender, motivation, and academic achievement

Leslie et al. (2015) found that academic disciplines in which there is a belief that success comes from innate abilities are less open to women and underrepresented minorities. More female high school students were enrolled in advanced mathematics and science classes than were their male peers, but they were less likely than male students to report liking these courses. In a study focusing on high-achieving students (Tang & Neber, 2008), gifted girls reported a higher effort goal orientation, but they used more superficial cognitive strategies to learn science more frequently than boys did. Other research shows that girls also believe that gender stereotypes may impact their self-efficacy in doing math and science (Lee et al., 2021).

In contrast to mathematics and science, where male students have been found to perform modestly better than females and have more positive competence, identity beliefs, and subjective values than female students (Eccles et al., 1993; Zhang et al., 2021; Bohrnstedt

et al., 2020), various national and international assessments have found that female students outperform their male peers in reading. Female students also typically have reported more reading motivation than male students (Baker & Wigfield, 1999; Mucherah & Yoder, 2008; Wigfield & Guthrie, 1997) in the areas of curiosity, involvement, and intrinsic value (McGeown, 2015; Durik et al., 2006). Although there appear to be no differences in the motivation level of girls and boys with respect to self-concept as a reader, boys have reported that they value reading less than girls do. When students are more motivated to read, they read more frequently, persist in reading when encountering more challenging text, and perform significantly better than their less motivated peers on measures of reading achievement (Guthrie et al., 1999; Wang & Guthrie, 2004; Wigfield & Guthrie, 1997). A lack of reading motivation for male students at the elementary school age may carry over into middle and high school. Wigfield et al. (2016) also suggested that gender difference findings in reading motivation and reading achievement are likely to be reflections of stereotype expectations—female students are seen as more interested in and positive about reading than male students—and called for more research focusing on improving male students' reading motivation alongside current efforts to promote female students' engagement and involvement in mathematics, science, and engineering.

In general, female students report working harder in school (Lam et al., 2012), showing more homework effort (Trautwein et al., 2006), and placing more personal value on working hard than male students (Heyder & Kessels, 2017). This gender gap in academic effort may explain why female students tend to earn higher grades and higher teacher ratings than male students (DiPrete & Jennings, 2012; Downey & Vogt Yuan, 2005; Lam et al., 2012). Research has also found that males are 1.75 times more likely than females to report they would be unpopular for trying hard in school and 1.50 times more likely to report they would be made fun of for trying hard in school (Workman & Heydar, 2020).

Over the course of schooling, research has indicated that both male and female students' overall self-efficacy beliefs tend to decline, but boys and girls display different patterns of decline across different achievement domains (Wigfield & Eccles, 2000; Wigfield et al., 1997). For example, girls' self-efficacy beliefs toward doing mathematics in the elementary and middle school years decline at a slower rate than boys', leading to a smaller gender-related mathematics achievement gap as students enter higher grade levels. In contrast, male students' competence beliefs and value of reading decline more rapidly than female students' (Jacobs et al., 2002).

## Race/ethnicity, motivation, and academic achievement

Research has shown that students' racial/ethnic background plays a role in shaping their academic motivation. Black students have more positive academic self-concepts, more positive academic self-efficacy, and stronger academic beliefs than White students even when they are doing less well in school in reading and math (Baker & Wigfield, 1999; Graham, 1994; Graham & Taylor, 2002; Kotok, 2017; Zhang et al., 2021). As a consequence, the correlation between reading competency beliefs and reading achievement is lower among African American than among White students (Graham, 1994; Graham & Taylor, 2002). Guthrie et al. (2009)

investigated racial differences in the effects of reading motivation on reading achievement for African American and White students. They found that intrinsic motivation was not significantly related to reading comprehension for African American students but was for White students. Furthermore, Kotok (2017) found a negative relationship between math efficacy and achievement for high-performing Black students. Specifically, Kotok's model revealed that a one-standard-deviation increase in math self-efficacy for high-achieving Black students was associated with a 3.76-point drop in math achievement, controlling for other model variables. Similarly, research also suggests that the relationship between motivation and achievement varies among different race/ethnicity groups. For example, in a study of Asian and Hispanic middle school students living in an urban, socioeconomically disadvantaged area, Unrau and Schlackman (2006) found that intrinsic reading motivation was positively associated with reading achievement for Asian students, but not for Hispanic students Overall, the literature suggests that the relationship between motivation and academic achievement varies across race/ethnicity groups.

Research has also shown that Black and Hispanic students are less likely to see themselves as "a math person or a science person" or as someone fitting into the STEM profession, possibly because they are less likely to be exposed to Black and Hispanic role models working in STEM careers (Ford, 2011; Carlone & Johnson, 2007; Seymour & Hewitt, 1997; Archer et al., 2010). Azmitia et al. (2008) found that minority students were more likely to struggle with having an academic identity, even beyond mathematics. In addition, they found that Black students are more inclined to suffer from negative stereotypes about their mathematics/science achievement than students of other races/ethnicities, with the implication that they are more likely to doubt their mathematical/science competence, which in turn can lead to a disengagement from mathematics tasks and activities.

However, research on self-efficacy beliefs and motivation in middle school science suggests that White students have stronger self-efficacy and achievement beliefs than African American students (Britner & Pajares, 2001). Self-efficacy was the only motivation variable to predict the science achievement of White students, whereas both self-efficacy and self-concept predicted the science achievement of African American students. Relatedly, a longitudinal study of Latino middle school students indicated that self-efficacy was a positive predictor of their school attendance and standardized math achievement scores (Niehaus et al., 2012).

Andersen and Ward (2014) found that high-ability White ninth-graders valued mathematics more than their high-ability Black and Hispanic peers did, indicating that Black and Hispanic students might lack support for their beliefs about the utility of mathematics. Research that studied Black high school students' academic aspirations and motivation found that family educational expectations did not predict Black males' personal determinants of academic success. However, positive peer support was related to their aspiration for and motivation to pursue postsecondary educational opportunities (Cooper, 2015).

Causal attribution about the reasons underlying academic success is also important because academic success influences academic motivation. Recent research shows that African

American students' tendencies to attribute academic success to ability, effort, or their teachers were subject-general, rather than subject-specific (Vuletich et al., 2019). The lack of subject specificity in attribution suggests that when African American students consider what factors influence their school performance, they view academic outcomes as a single achievement domain rather than differentiating among school subjects.

Few studies have examined the patterns of student academic motivation and achievement at the intersection of gender and race/ethnicity. One recent study on math suggested that students' math motivation varied at the intersection of gender and race/ethnicity (Hsieh et al., 2021). Male and female Asian American adolescents had similar math motivational patterns, but many male and female adolescents of other racial/ethnic groups had different patterns. This study strongly suggests that future research on motivation and achievement examine the intersection of gender and race/ethnicity.

## Social context, motivation, and academic achievement

Students' motivational beliefs develop under the influence of various social contexts, including family and school. Therefore, a better understanding of students' motivational beliefs as they relate to academic performance requires a knowledge of family and school contexts.

Parents' educational level and occupational status were shown to be related to their children's reading and other educational outcomes by Yeung et al. (2002). Other studies found that students with high socioeconomic status (SES) are more likely to have higher math scores (Manning & Patterson, 2002; Gregory & Weinstein, 2004) and to participate in and finish advanced mathematics classes (Sciarra, 2010) than are lower SES students. Parents with higher levels of education and higher earnings are also able to provide greater learning opportunities and a more academic environment at home than parents with lower levels of education and lower earnings (Retelsdorf et al., 2011). Castambis (2005) found that parents with high SES had a better understanding of the educational system—for example, how to communicate with teachers and discuss their children's mathematics track—than did low-SES parents (Useem, 1992). Other research has demonstrated parents' role in promoting students' intrinsic academic motivation, such as feelings of competence and control and positive attitudes toward academics (e.g., Gottfried et al., 1994; Grolnick et al., 2009). Overall, family income and parents' education have been shown to be related to students' academic motivation and academic achievement.

Research on parental autonomy support suggests that perceived parental autonomy support predicts later academic achievement via community feeling and student expectations (Froiland & Worrell, 2017). Community feeling, an intrinsic life goal, is positively associated with student expectations, which suggests that motivation to help others and long-term expectations work in concert to promote achievement. Other studies have found that the positive effects of parental autonomy support on achievement are mediated by intrinsic motivation (e.g., Grolnick et al., 1991; Soenens & Vansteenkiste, 2005). In addition, factors such as students' perceived parenting style (e.g., higher levels of parental warmth and support) have also been found to be closely related to students' academic motivation (Rubin, 2017).

School context is also an important factor in understanding student achievement. Freiberg (1999) has argued that the school environment influences student achievement through student attachment, commitment, and involvement, and, most importantly, through schools' resources and academic climate. Perry and McConney (2010) found that school SES was significantly associated with students' academic achievement. Rumberger and Palardy (2005) used data from the National Education Longitudinal Survey of 1988 to examine individual and school effects on achievement growth between grades 8 and 12 in mathematics, science, reading, and history. They found that school-level SES had as much impact on students' achievement as students' individual-level SES, after taking into account other background factors. Other research has found that students who perceive more positive cross-racial interactions, more school support for learning about other cultures, fewer messages about ignoring race, more messages about individual hard work, and less prejudice in teachers and peers felt more connected to those around them and thus find school more inherently enjoyable (Byrd, 2015).

# Summary Findings

In this section, we summarize the findings from the four NAEP motivation studies, focusing on the role of motivation in achievement at the student and school levels. In addition, we highlight how the intersection of students' sex and race/ethnicity mediates the role of motivation in achievement.

## The role of motivation at the student level

The analyses indicated that student **reading, mathematics and science** motivation are all substantially associated with student achievement, taking into account student gender; race/ethnicity; SES, EL, and IEP status; possible interaction effects; and school-level background variables.

- Each unit difference in student **reading motivation and science self-efficacy** on the reading and science motivation scales, both of which ranged from 0 to 3, was associated with about an 11-point difference in NAEP reading and science scores, which is approximately one-third of the scales' standard deviation (SD) units.

- For **science interest**, each unit increase was associated with about a 3-point increase in the NAEP science score (0.10 SD units).

- Similarly, each unit difference in student Grade 11 **mathematics identity** on the mathematics identity scale, which also ranged from 0 to 3, was associated with about a 6-point difference in NAEP mathematics performance, which is approximately 0.19 SD units.

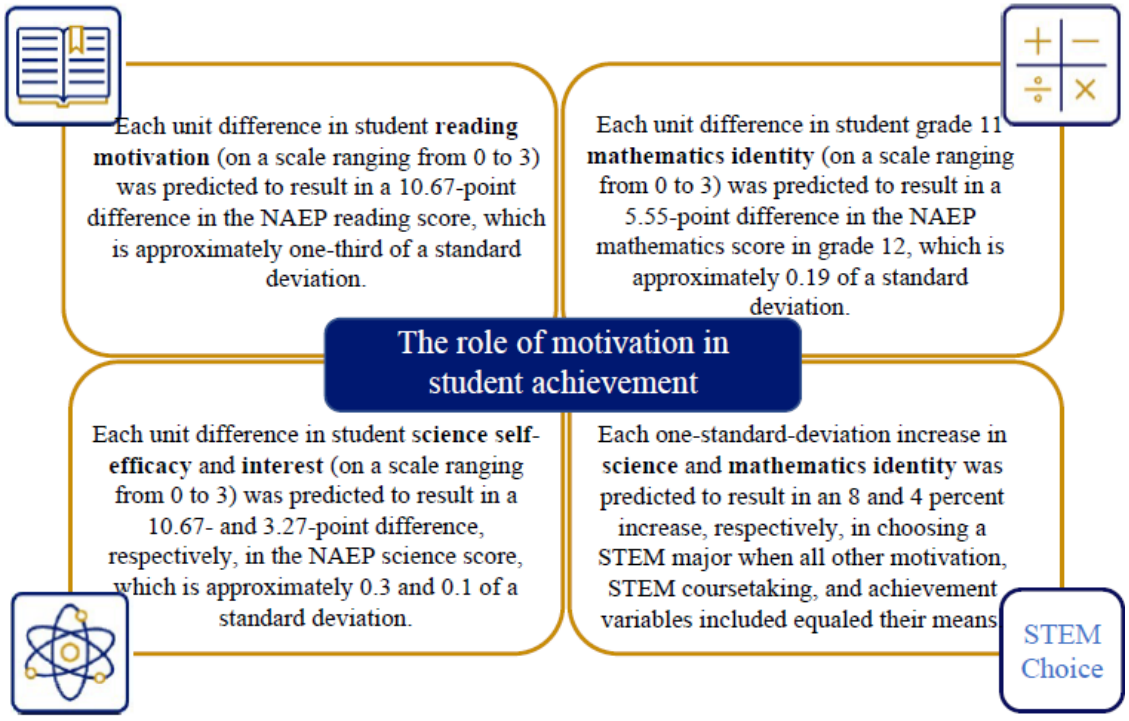
- **Mathematics self-efficacy and interest** were not significantly associated with students' NAEP mathematics achievement when controlling for all other contextual variables.

Students' **science and mathematics identity** were both statistically associated with students' choice of a STEM major.

- Compared to all of the other motivation variables, STEM coursetaking variables, and achievement variables, **science identity and mathematics identity** had the strongest associations with students' choice of a STEM major, with standardized coefficients of 0.24 and 0.13, respectively.
    - For a one-standard-deviation increase in **science identity**, there was an 8 percent increase in the probability of choosing a **STEM major**, when all other variables in the model equaled their means.
    - Similarly, a one-standard-deviation increase in **mathematics identity** corresponded to about a 4 percent increase in choosing a **STEM major** for an otherwise "average" student.
- In contrast, students' **mathematics self-efficacy and science self-efficacy** had small, nonsignificant associations with students' choice of a **STEM major,** controlling for the other variables in the model.

Figure 1 summarizes the role of student motivation in academic achievement by subject.

**Figure 1. The role of student motivation in academic achievement, by subject**




SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09); National Assessment of Educational Progress (NAEP), 2013 Grade 12 Mathematics Assessment; 2015 Grade 8 Reading and Science Assessment.

## The role of motivation at the school level

Another important finding was the unique and substantial effect of school-level mean **reading and science (science self-efficacy)** motivation on school mean **reading and science achievement,** after controlling for school demographic variables, including mean school-level SES, the proportion of racial/ethnic minority students, and the proportion of IEP students.

- The estimated coefficient for school mean motivation suggested that each unit difference in school **mean reading motivation** was associated with a 16.98-point difference in school mean reading achievement, about half of one standard deviation.

- Similarly, a one-unit change in school-level **mean science self-efficacy** was associated with an estimated 12.63-point difference in school-level mean science achievement, which is approximately 40 percent of the standard deviation. However, school-level mean **science self-interest** was not significantly associated with school-level science achievement.

These results highlight a school-level contextual effect as well. That is, the **reading and science** motivation of one's peers in school mattered substantially for overall school-level performance in these subjects. Schools might be able to promote students' academic development not only directly through effective teaching but also indirectly through a school climate that fosters **reading and science** motivation.

The results also showed that the associations between **science interest, self-efficacy, and achievement** varied significantly across schools.

- The positive association between **student science interest and science achievement** was stronger for schools that had more advanced teaching and learning supplies for science instruction, although the size of the effect was not substantial.

- School-level mean **science self-efficacy** had a statistically significant moderating effect on the relationship between **student science self-efficacy and student science achievement**. The effects were higher for schools with a higher level of mean science self-efficacy.

## The role of motivation by sex and race/ethnicity

The studies revealed interesting findings of how the intersection of students' sex and race/ethnicity mediates the role of motivation in achievement.

- The relationship between **science interest and science achievement** was significantly weaker for **female** than for **male students** (-1.98 points), all else being equal.

- Both **reading motivation and mathematics identity** were positively associated with students' reading and mathematics achievement, with similar level of effects regardless of student gender.

- The relationship between **reading motivation and reading achievement** was slightly weaker for **Hispanic students** than for **White students** (-1.33 points) and far weaker for **EL students** than for **non-EL students** (-6.08), all else being equal. By contrast, the relationship between reading motivation and reading achievement was significantly stronger for students with higher SES (0.16; scale ranging from 0 to 16) than for those with lower SES.

- Students' **mathematics identity** was significantly associated with grade 12 **mathematics achievement** for **White and Hispanic students**, but not for **Black students**.

- Students' **mathematics identity** was significantly associated with grade 12 **mathematics achievement** for both **female and male students**.

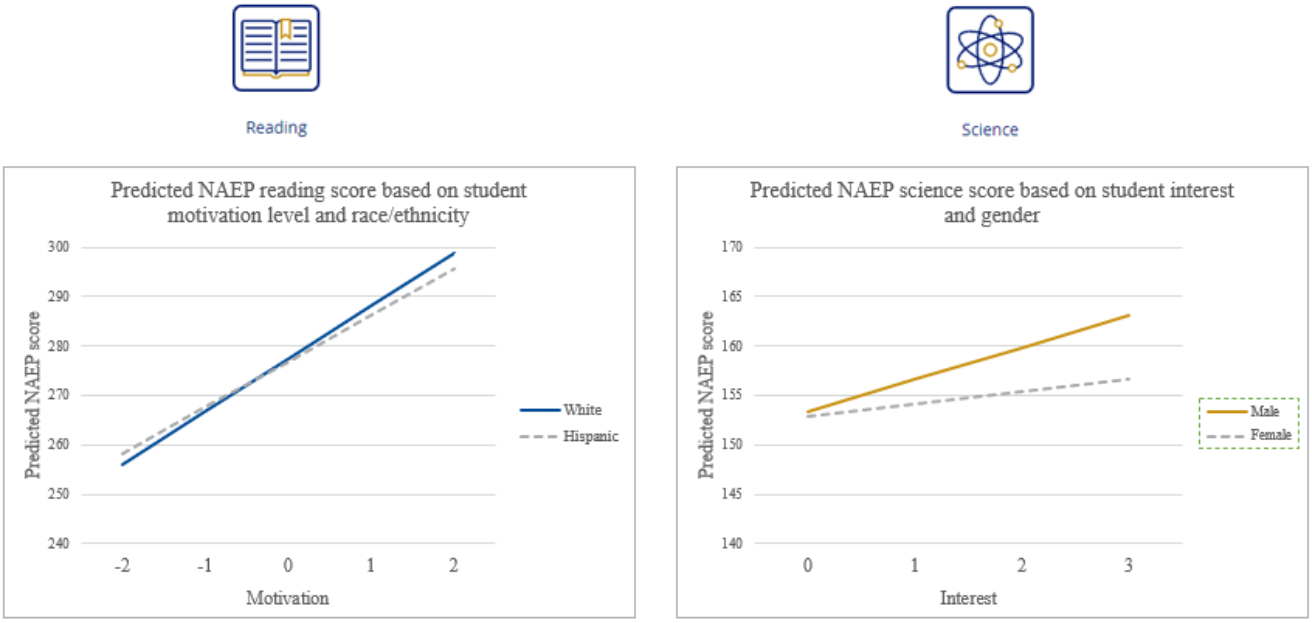
Table 2 and Figure 2 summarize how the role of motivation in student achievement is mediated by students' race/ethnicity and gender.

### Table 2. The level of association between motivation variables and achievement, by gender and race/ethnicity

| Motivation factors | White vs Black | White vs Hispanic | Male vs Female |
|---|---|---|---|
| Mathematics identity | White > Black[1] | No Sig difference | No Sig difference |
| Reading motivation | No Sig difference | White > Hispanic[2] | No Sig difference |
| Science interest | No Sig difference | No Sig difference | Male > Female[3] |

[1] Mathematics identity was significantly associated with the NAEP mathematics performance for White students but not for black students.
[2] The relationship between reading motivation and reading achievement was slightly weaker for Hispanic students than for White students.
[3] The relationship between science interest and science achievement was significantly weaker for female than for male students.
NOTE: No Sig difference refers to no significant difference.
SOURCE: U.S. Department of Education, National Center for Education Statistics, High School Longitudinal Study of 2009 (HSLS:09); National Assessment of Educational Progress (NAEP), 2013 Grade 12 Mathematics Assessment; 2015 Grade 8 Reading and Science Assessment.

**Figure 2. The varied association between student motivation/interest and NAEP scores, by student demographic variables**




SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 Grade 8 Reading and Science Assessment.

# Summary and Policy Implications

The four NAEP motivation studies show there is a statistically significant association between students' reading, mathematics, and science motivation and their academic performance in the corresponding subject. Another important finding of the studies is that there is a unique and substantial association between school-level mean motivation and school academic achievement in the presence of other school demographic variables, such as mean school-level SES, the proportion of racial/ethnic minority students, and the proportion of IEP students. Therefore, it is imperative for policymakers, researchers, and education practitioners to consider, evaluate, and establish effective approaches to foster student motivation and cultivate a positive school climate so as to promote sustained academic engagement and achievement.

Practices that teachers can consider to enhance student motivation include developing a sense of autonomy (e.g., giving students choices about what they read) (Black & Deci, 2000; Ryan & Deci, 2020; Soenens & Vansteenkiste, 2005; Soenens et al., 2015), making learning a social activity (as feeling a sense of connectedness and social belonging is key to students' motivation) (Soenens et al., 2015; Williams & Williams, 2011), building connections to students' experiences (e.g., using what they learn to solve real-life problems) (Williams & Williams, 2011), and having students experience success and increase their sense of self confidence (e.g., by providing explicit and encouraging feedback) (Artino, 2012).

The home environment, life experiences, and opportunities provided by the family, particularly in the early school years, have a powerful, and possibly sustainable impact on students' academic motivation and serve as a foundation for future major or career choices. Practices that parents can consider to enhance motivation include incorporating reading, mathematics, and science practices into daily routines; making sure students are surrounded by learning resources; promoting learning autonomy; and, most importantly, emphasizing the entertainment value of learning rather than the skills aspects (Baker, 2003; Gottfried, 1986; Gottfried et al., 1998; Gottfried et al., 2009; Green et al., 2007).

In addition, to improve student motivation, school systems should reduce the emphasis on extrinsic rewards (e.g., grades, assessments, and performance-based recognition programs) (Epstein & Harackiewicz, 1992; Wery & Thomson, 2014) and increase the emphasis on constructive feedback (O'Brien et al., 2022). Practices that emphasize social comparison and excessive competition among students may lead them to focus on how their performance compares to that of others rather than develop a predisposition to learn for enthusiasm (Butler, 1987; Ames, 1990; Epstein & Harackiewicz, 1992; Retelsdorf et al., 2010; Slavich & Zimbardo, 2012).

School climate can also make a difference in student academic learning and growth. The levers seen as important in improving school climate are principals' leadership (MacNeil et al., 2009; Halverson et al., 2011), teachers' expectations, and interpersonal relationships within and around schools (Maslowski, 2001; Hoy et al., 2006).

Finally, the provision of advanced supplies for science education by schools was found to be associated with student science achievement, and it moderated the role that student interest plays in science achievement. Therefore, schools should not only provide basic teaching and learning supplies (e.g., access to computer labs and computers; access to related magazines and books) for science education, but more advanced teaching and learning supplies as well. This is particularly important for students from underserved groups and communities that lack access to the core elements of a quality education. If schools can provide quality teaching and learning supplies, they can help to ensure educational equity and promote learning for all students and thus mitigate the effect of individual student socioeconomic factors on academic achievement.

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