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Massachusetts *Linking Experiences & Pathways (M-LEAP)* Research Project Final Report

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TABLE OF CONTENTS

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Irene F. Goodman *and* Karen Gareis

EXECUTIVE SUMMARY

The Massachusetts Linking Experiences and Pathways (M-LEAP) research project was a three-year longitudinal study by Goodman Research Group, Inc. (GRG). M-LEAP investigated the factors that influence elementary and middle school students' interests and aspirations in Science, Technology, Engineering, and Math (STEM) fields. The study focused primarily on gender differences with an eye towards better understanding how girls' and boys' science beliefs, experiences, and aspirations (SBEAs) differ and develop from third grade through middle school.

INTELLECTUAL MERIT

The intellectual merit of M-LEAP is that it focused on a younger population than had previously been studied and used a prospective, longitudinal design to ask 3rd-8th grade students directly about their SBEAs. M-LEAP also made contributions to research on the Eccles Expectancy-Value Model of Achievement-Related Choices, the theoretical model guiding our study. Furthermore, it sought to fill in a gap in the literature by exploring the relationship between early science experiences and elementary and middle school students' career aspirations (see Exhibit 1). Finally, M-LEAP's scope was broader than most research that has addressed this issue, as it collected data on students' out-of-school activities as well as in-school subjects and skills. It also incorporated data from parents, teachers, and science specialists, as well as web-based information about the schools, districts, and communities in which they are located.

METHODS

We collected data from 1,576 unique students, 690 unique parents, and 138 unique teachers in eight K-8 schools in Massachusetts, representing a range in terms of geography, urbanicity, and socioeconomic status. Each spring between 2011 and 2013, 3^{rd}-8^{th} grade students were surveyed, as were their parents and teachers. In addition, in late spring each year, we conducted follow-up interviews with a subset of the sample — approximately 100 students.

Three primary student outcomes were investigated: (1) how good students thought they were at various school subjects and skills (science, math, computers, reading/ELA, and teamwork) and how well they expected to do in them (Self-Efficacy, SE), (2) how useful and interesting they thought the subjects/skills were (Subjective Task Value, STV), and (3) the kind of job students aspired to have when they grow up (i.e. STEM job or not).

RESEARCH RESULTS

M-LEAP used both descriptive and univariate analyses, and then, based on those results, used a statistical technique called hierarchical linear modeling (HLM). HLM analyses showed that students' SE and STV beliefs are tightly linked, that children are heavily influenced by the value that they perceive adults assign to particular subjects, and that participating in more out-of-school STEM activities is linked to higher STV. Furthermore, parents' holding boy-favoring stereotypes about STEM subjects was found to be detrimental to girls' feelings of ability and their expectations for academic success in these areas.

Our results yield evidence of a link between the following and students aspiring to a STEM job:

- A student's science self-efficacy
- A student's math subjective task value
- A student's favorite subject being a STEM subject
- A student frequently participating in out-of-school STEM activities
- A child perceiving that her/his parent values math
- A parent believing that her/his child has strong science abilities

BROADER IMPACTS

The broader impact of this work is in its implications for potential interventions for and by formal and informal educators, parents, media purveyors, and STEM industry that are geared towards attracting more students, especially girls, to STEM careers. These domains of influence are interconnected. Some of our primary recommendations are that:

- Parents encourage their children to succeed in STEM subjects at a young age, emphasize the importance of doing well in these subject areas and skills, and limit their own gender stereotype beliefs.
- Elementary and middle school teachers reinforce these positive messages amongst their students, and tailor science, math, and technology learning to be hands-on and collaborative.
- All stakeholders encourage students to participate in STEM-related out-of-school activities and get parents involved.
- Children should be provided with opportunities to interact in person with STEM professionals to enrich their understanding of STEM jobs and what it takes to attain them.
- Media purveyors provide positive, non-stereotyped messages encouraging girls regarding the pursuit of STEM subjects, realistic explanations about what it takes to go into various STEM careers, and portrayals of real women — as role models — working in these careers.

CHAPTER 1: INTRODUCTION

Many adults still cite an elementary or middle school teacher as the reason they love history, science, math, or English literature. Moreover, a number of adults working in science fields attribute their career choices to teachers they had or to pivotal experiences as a child. However, we rarely hear young students tell us why they love specific subjects, and when we do, it has been difficult to determine whether these responses will change significantly over time. What are students' science-related beliefs, experiences, and aspirations (SBEAs) in elementary and middle school? What happens in the intervening years between then and when they start seriously considering their options in high school and college and begin in careers?

The research project described in this final report is named ***Massachusetts Linking Experiences and Pathways*** (***M-LEAP***). The M-LEAP project has been a three-year longitudinal study designed by Goodman Research Group, Inc. (GRG) to investigate the factors that influence students during late elementary and middle school to pursue or retreat from STEM areas and career aspirations. Funded by the National Science Foundation's Division of Gender in Science and Engineering (NSF GSE), we have focused primarily on the gender differences in these factors with an eye toward better understanding how girls' and boys' SBEAs differ and develop at a young age. If we can identify variables in childhood that affect 8th grade science career aspirations, then perhaps we can better understand the factors underlying the gender gap in science career attainment in adulthood. The ultimate aim of our study is to advance knowledge about attracting girls and young women into science careers.

The project's name reflects the longitudinal nature of our study and the fact that we are interested in how early experiences are linked to later experiences that lead down various academic and career paths. For practical purposes, we conducted the study solely within Massachusetts, focusing on students, their parents, and teachers in eight schools — one school in each of eight districts across the state.

THE GENESIS OF THE M-LEAP PROJECT

GRG has a strong interest in researching the area of girls' interest in and achievement in science, technology, engineering, and mathematics (STEM) fields. Our interest has been grounded in four main areas connected to the work of GRG.

1. Many of the programs we have evaluated over the past 24 years have aimed to address the underrepresentation of girls and women in science and engineering pursuits.

2. The findings from our large-scale study of retention and persistence of undergraduate women in engineering highlighted the need for support and cultivation of interest in young women's formative years (Goodman et al., 2002).

3. A steady stream of reports emerging over the last decade has documented a clear gender disparity still remains in the proportion of male and female students who intend to continue their scientific studies at a more advanced level or pursue a science career, despite the variety of interventions to address this issue.

4. A number of studies by Jacquelynne Eccles and her colleagues have investigated achievement-related choices using the Expectancy-Value (E-V) framework, which had particular relevance for our work.

Evaluations of Programs to Encourage Science Participation among Girls

GRG is a research firm that specializes in program evaluation, with a specialty in evaluating informal science education programs. Over more than two decades, a number of our clients have developed and implemented programs designed to encourage youth — some focused particularly or solely on girls — to be more engaged in science or engineering, either in school or out of school (or both), and to consider taking science classes and working toward a career in a science or engineering field. GRG has evaluated **FIRST**'s *LEGO League* and *FIRST Robotics*, as well as in-school supplementary curriculum, such as **SAE International**'s (formerly Society of Automotive Engineers) *A World in Motion.* Just a few examples of female-focused programs or projects GRG has evaluated are:

- A formative and summative evaluation of the **National Academy of Engineering's** *Engineering Equity Extension Services (EEES)*, a comprehensive research-based consultative and peer mentoring infrastructure that supports enhanced gender equity in engineering education in the U.S.

- A summative evaluation of *Seek Out Science (SOS)*, the outreach campaign that accompanied *Discovering Women*, the **PBS** series about six contemporary women scientists that aired in 1995. GRG conducted a research study — employing pre- and post-project testing — of upper elementary and middle school students' attitudes about science and scientists and, more specifically, about women in careers and in science.

- A formative, process, and summative evaluation of the *Dan River Information Technology Academy (DRITA)* for the **Institute for Advanced Learning and Research (IALR)**. DRITA implemented programs that helped students of color, including girls, develop information technology (IT) skills and provided experience with various STEM fields, both as a means of encouraging students to study and pursue careers in the STEM fields. GRG collected data over the three project years from youth participants and their families, DRITA instructors, and key staff members at participating organizations and externship sites.

- An evaluation of early programs for ***Science Club for Girls***, started in Cambridge, MA in several of the city's schools. This afterschool program provides girl-specific programming by connecting girls in grades K-12 with female mentor-scientists through free science and engineering programs.

- An evaluation of *Girls Communicating Career Connections (GC3)*, **EDC** grantee, **NSF GSE/COM** funder. The GC3 projects' media series — short video segments produced by middle school girls — was designed to capture the inquiry-based learning experiences of girls as they investigated what it means to be a scientist or engineer. The project materials also included a companion educator website and supporting materials for formal and informal educators.

- Evaluations of independently funded ***Sally Ride Science*** programs, which have focused on the informal realm outside of school, such as science clubs for girls, engineering design camps, computer science summer projects, and Sally Ride Science's national toy design challenge.

- Evaluation of the **Girls Get Connected Collaborative *Technology at the Crossroads*** Project, funded by NSF-ITEST. The project designed and adapted and then implemented a comprehensive set of STEM curriculum modules that sought to give middle and high school students firsthand experience using various technologies that would enable them to solve real problems, while simultaneously encouraging them to pursue further study in the STEM fields.

Many of these projects have been shown to be effective in terms of short-term goals, such as knowledge gain and enhancement of attitudes toward STEM. The primary variable shown to have an effect has been program dosage, with more participation associated with more positive attitudes and knowledge. However, since many of these kinds of projects have had grant funding, many have operated for only a few years (typically three to five). Some are able to be sustained or institutionalized, while others cease to exist once federal funding ends. Moreover, evaluations have only been tied to federal funding and thus have not been able to investigate longer-term outcomes for program participants, such as STEM course-taking in high school or other predictors of selecting a STEM major in college.

Building on GRG's WECE Study

From 1998-2001, GRG conducted the **Women's Experiences in College Engineering (WECE)** Project study, funded by NSF and the Alfred P. Sloan Foundation. The idea for WECE grew out of a desire by the Sloan Foundation to evaluate the Women in Engineering programs it was funding on a number of college campuses. Because of the fluidity of many of these programs, we decided with the Sloan program officer that it was more prudent to conduct a research study of women in engineering support activities on college campuses beyond what the Sloan Foundation had funded. We applied for NSF funding to cover most of our research costs, with a contribution by Sloan. Over 20,000 engineering undergraduate women at 53 U.S. institutions of higher education participated in the survey at least once during the three years of annual data collection. WECE became the first cross-institutional, longitudinal quasi-experimental study of aspects of women's educational experiences — both institutional and personal factors — that were critical to their retention in undergraduate engineering majors (Goodman et al., 2002).

Particularly relevant to the M-LEAP research, WECE results showed that enrichment programs, informal activities, and exposure during pre-college and earlier years encouraged young women to pursue engineering majors. Their participation in support activities during college was vital to these undergraduates, who needed to feel they were part of a larger community in engineering. Women who frequently took advantage of a variety of social and support activities and resources were more likely to stay in the major than were women who did not participate.

On average, the women who stayed had higher grades in their engineering-related courses than those who left. Nonetheless, two-thirds of those who quit had engineering grade averages of A or B in a previous year, suggesting that many students left despite their ability to do the academic work. Even those who were doing well academically often were discouraged by the academic and social climate. Students who held positive views of the climate in their department and their classrooms were most likely to stay in the field. Leavers often cited factors such as workload, competition, and discouraging faculty and peers.

We found that young women who stayed in engineering majors had parents who had encouraged them to pursue an engineering degree and who were sources of encouragement in every year of college. Pre-college exposure was key in encouraging students. In fact, a large percentage of students reported having a parent who was an engineer or scientist; nearly one-third of respondents had a father who was an engineer and nearly half of respondents' mothers, and more than half of fathers, worked in a STEM field.

We outlined a number of specific recommendations for supporting women in undergraduate engineering, such as support measures during the critical first few academic terms, strategies for making the academic climate more welcoming and providing a sense of community, and professional development (PD) to help faculty and administrators be more sensitive to women's self-confidence. We also summarized possible ways to expose young women to engineering concepts, what engineers do, and necessary skills:

- Expand enrichment activities in pre-college informal education settings and expose girls to engineering at the elementary and middle school level.
- Foster greater implementation of universities' outreach initiatives that teach girls and their teachers and school guidance counselors about engineering.
- Continue to mount and expand outreach initiatives within the engineering profession (e.g., National Engineering Week, Introduce a Girl to Engineering Day, etc.).
- Solicit sponsorship by foundations and other organizations of an ongoing media campaign over the next decade to help the public better understand what engineers do.

Links in the Science Pathway

As we moved into the mid-2000s, there were still headlines that recruitment of women into science and engineering fields was quite low, despite a number of intervention programs, and we continued to wonder how elementary school experiences affected girls' interests. At the time of our NSF proposal, evidence existed for significant gender disparities at *many* education and career points along the science pathway (e.g., Clewell & Campbell, 2002; Freeman, 2004; Handlesman et al., 2005; Jacobs et al., 1998; Land of Plenty Commission Report, 2000; National Science Board, 2003; NSF, 2003, 2004; Tai et al., 2006).

However, there had been a dearth of research on early science experiences earlier than middle school and, in particular, on gender differences therein. Some studies from the 1980s and 1990s had also examined gender differences in out-of-school (OOS) influences (e.g., Farenga & Joyce, 1997; Greenfield, 1997), but we were unable to find rigorous research that examined how experiences earlier than middle school affect successive links in the science pathway and how these relationships differ by gender.

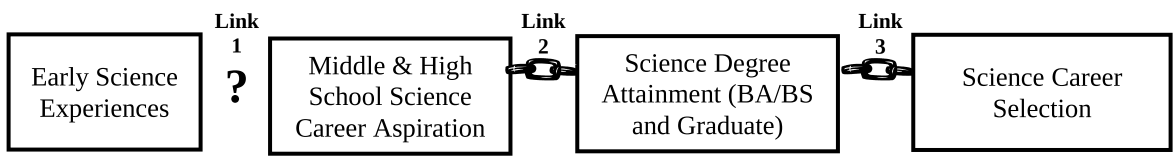
A major source of inspiration for the M-LEAP study was the work of Xie and Shauman (2005), which used 17 nationally representative data sets to conduct statistical analyses of gender differences at various career stages from middle school onwards. We believed we could contribute to the field if we could explore prospectively and longitudinally some of the antecedents to what Xie and Shauman, and others, had found regarding the strong association between career aspirations during middle and high school and college and later life outcomes related to science career attainment.

Their research contributed greatly to what we have termed “Links in the Science Pathway” (see Exhibit 1-1), which is a representation of the trajectory toward attaining a science career and the various links of understanding that connect each critical moment or experience. These links represent the insights contained within the existing body of research that allow us to explain gender differences in the STEM workforce by connecting them with earlier life experiences. The links are described in the Literature Review in the next chapter.

Therefore, we decided to focus on understanding Link 1, which connects early science experiences with career aspirations during middle and high school, as shown in Exhibit 1-1. We have framed our research to study how early in- and out-of-school SBEAs in grades 3-8 were related to gender-based differences in science achievement-related choices. Thus, M-LEAP asks two related overarching questions:

1. What factors contribute to the development of science career choice at a young age?
2. Are experiences prior to 8th grade related to later life outcomes associated with science career attainment?

Exhibit 1-1: The Missing Link in What is Known about Science Pathways



Building on Eccles’ Expectancy-Value (E-V) Model

As a guiding framework for measuring the impact of SBEAs, our research employed the Eccles Expectancy-Value (E-V) Model of Achievement-Related Choices (Eccles [Parsons] et al., 1983); Eccles, 2005). This model seeks to explain individuals’ achievement-related choices (e.g., what courses to enroll in and what career to choose) as a factor of their ratings on various psychological constructs such as self-efficacy (SE) and subjective task value (STV). These constructs correspond to expectations for success in making those choices, and the perceived level of value of the chosen outcome; in other words, the E-V model theorizes that individuals are motivated to make these decisions based on how positive and valuable they expect the outcomes to be. The E-V Model is explained more fully in Chapter 2’s Literature Review.

MAJOR RESEARCH QUESTIONS

The research questions for the M-LEAP study are:

1. What SBEAs do children have between 3rd and 8th grade? How do they differ by gender?

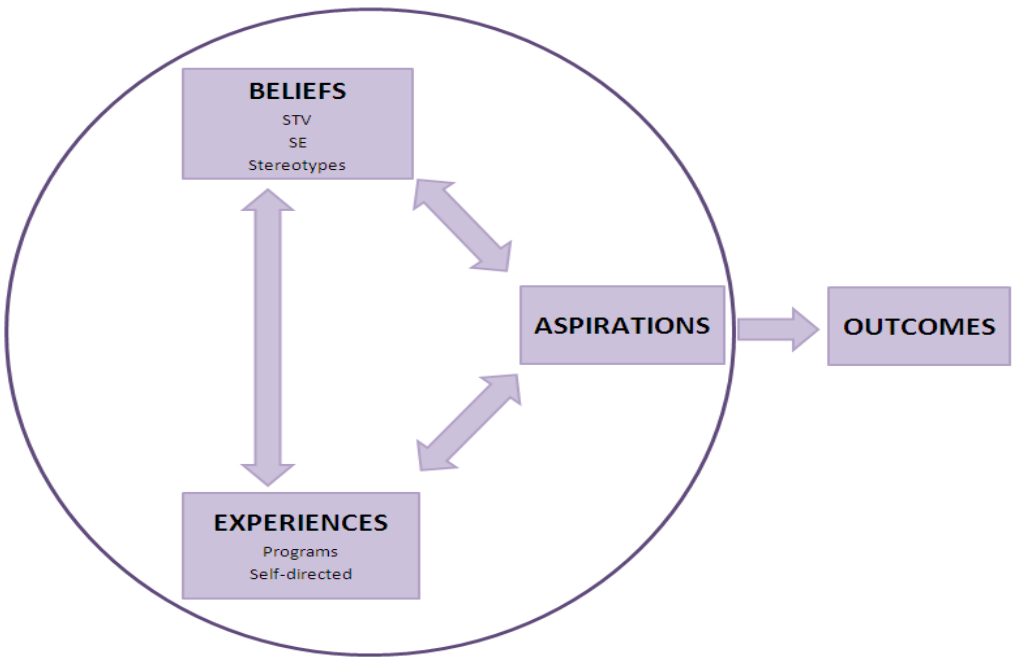
2. How are SBEAs related to each other, and are there gender-based differences?

3. How do SBEAs change over time? How are these early SBEAs associated with 8th grade achievement-related choices? How do these relationships differ by gender?

We hypothesized that boys have significantly more science experiences outside of school than girls and that boys outpace girls in 8th grade SBEAs. Previous research has established that, by 8th grade, girls are less interested in science than when they were younger and less interested than are boys of the same age (e.g., Hill, Corbet, & St. Rose, 2010).We also theorized that students who have a richer and more positive set of experiences in and beliefs about science at a young age will hold higher SE and STV beliefs, and thus will be more likely to hold science career aspirations as they get older.

M-LEAP's theorized relationship between SBEAs, the Eccles constructs of SE/STV beliefs, and science career aspirations is illustrated in Exhibit 1-2. The arrows represent direct association and influence. As shown in Exhibit 1-2, we do not conceive the relationships to be one-directional; while experiences such as engaging in science-related activities outside of school or receiving strong parental support in science may contribute to enhanced SE/STV beliefs, for example, these beliefs may also reinforce students' interests and experience-seeking. Further, aspirations both affect and are affected by beliefs and experiences. The short-term outcome variable is science career aspiration, while the longer-term outcome is pursuit of science-related high school coursework, then college majors and degrees, and continuation into the STEM workforce.

Exhibit 1-2: M-LEAP's Schema



M-LEAP'S POTENTIAL CONTRIBUTIONS TO THE FIELD

Prospectively documenting the role of early science experiences at a point in the pathway often omitted from models of gender and science career-choice development

Two strong features of the current study are its focus on a population younger than has been previously been studied and its prospective rather than retrospective nature. First, by conducting a rigorous examination of children's experiences during this early developmental time point, we sought to add a missing link to the chain of understanding within the science career-selection pathway. As discussed in the Literature Review, each step in the science pathway presents a powerful area of intervention and guidance. If we can better understand the factors that influence young students' progression toward aspiring to a STEM career at this crucial time, then we may not only be able to better explain the persisting gender gap in STEM career fields, but also perhaps identify new approaches to closing it.

Secondly, we wanted to take a prospective approach, rather than a retrospective one. While retrospective research with scientists has cited associations between early science experience and later career aspirations, as well as the importance of OOS science experiences in inspiring interest in science and careers (Roe, 1952; Friedman & Quinn, 2006; McCreedy & Dierking, 2013), we sought to answer these questions using input in "real time."

Further illumination of Eccles' E-V Model

Past research guided by the E-V model has established relationships between children's competence beliefs and subjective task values in domains including sports (male-typed domain), language arts (female-typed domain), and math (either similar or slightly more male-typed domain) (Jacobs, 2002). While the model is well tested among slightly older children, far fewer studies have tracked task value and competence beliefs among elementary school-aged children, despite the fact that research has established that children's valuing of experiences in different domains develops early (Jacobs, 2002; Wigfield et al., 2006). M-LEAP has sought to extend work grounded in the E-V Model, focusing on elementary school-aged children and exploring the domain of science in more depth.

Inclusion of a range of both in-school and out-of-school experiences

While the benefits of formal and informal education in science have been investigated separately, no study at the time of our proposal had examined the combined influence of both formal and informal science experiences of students, with input from parents, teachers, and community science education providers. We believe it is important to provide a more complete picture of students' early science experiences, their perceived value of those experiences, and subsequent achievement-related choices related to science aspirations. The investigation of media experiences through survey and interview questions, especially, sets it apart from numerous other studies that have sought to use the E-V framework to explain gender differences in STEM career aspirations, where media influences may not even be mentioned (e.g., see Wang & Degol, 2013).

Making these contributions through the first years of an ongoing longitudinal study that incorporates multiple informants and mixed methods

National longitudinal studies on early childhood (e.g., through middle school) have not typically focused on the variety of experiences (with an emphasis on science) that we included in our research. For example, the Early Childhood Longitudinal Study (e.g., 2004, 2009, 2012) concerns children's health, early care, and early school experiences. It does include one measure completed by science teachers, but that measure focuses on teachers' perceptions of students' skills in the science classroom. In order to understand a broad range of school and OOS experiences and how these experiences may be associated with science career aspirations longitudinally, we gathered data from a variety of sources (e.g., children, teachers, parents, and school- and district-level science coordinators). We saw M-LEAP as being the first phase of an ongoing study. In fact, with an additional NSF grant awarded to GRG in late 2013, we will continue our research with a subset of students and families.

CHAPTER 2: LITERATURE REVIEW

The prevalence of women in STEM-related areas of study and occupations has been a topic of significant interest among researchers, policy-makers, and everyday citizens in the United States for some time. Although the gap between men and women earning undergraduate degrees in some areas of science and engineering has closed significantly over the last few decades (NCSES, 2013), there continues to be a disconnect between the educational and professional realms in terms of the rate at which women are studying science versus going on to pursue a science-related career. Recent evidence suggests that women continue to be underrepresented in nearly every professional STEM discipline, and have actually become less present in certain areas, as can be seen in the decline in the prevalence of women in computer science occupations since 1990 (Landivar, 2013).

This literature review presents research that existed at the time of our proposal in 2009, as well as more recent studies that have since been published. First, we wanted to ensure that the statistics and data presented here are relevant and current, as well as indicative of the realities of the STEM workforce at the time when this research was initiated. Second, advancements made since our proposal in the E-V literature and science career decision motivational theory are cited in order to acknowledge research developments that influenced our thinking over the course of the study. While our methods, by and large, did not change over the three years, our thinking was influenced in terms of the broader context of the implications and recommendations stemming from our work.

The literature review is organized as follows:

- A brief overview of the issue of gender disparities in elementary to post-secondary school-aged students' decisions to pursue science careers, with figures on the number of U.S. women pursuing scientific studies with the intention of working in a scientific field from secondary school onwards and the prevalence of women in science-related occupations, with the connections between early childhood experiences with science and the eventual decision to pursue a career in science
- Research on Eccles' E-V Model
- Research on Science Identity Theory
- Research on domains of influence — family, school, and non-school
- Results of previous programs and interventions to encourage girls and women in STEM

GENDER DISPARITIES IN STEM STUDIES AND CAREERS

Notable progress has been made in the undergraduate realm over the past 40 years in terms of the proportion of STEM degrees awarded to women. In 1970, women made up 28% of all U.S. bachelors' recipients in science and engineering degree fields, with 0.8% of degrees in engineering being awarded to women; by 2010 those numbers had risen to 50.3% and 18.4%, respectively. At the graduate level, women earned 40.9% of doctoral degrees awarded in science and engineering in 2010, although only 23.1% of doctoral degrees in engineering, specifically, went to women. Meanwhile, the proportion of bachelors' recipients in biological and agricultural sciences who are women rose from 24.1% to 57.8% over the same period (NCSES, 2013).

These data suggest that women and men are closer to being equally represented in undergraduate and graduate STEM programs than they were in the past, but dramatic differences persist in some areas. Related research suggests that both genders continue to have disparate experiences and challenges when it comes to persisting in STEM in college and beyond (e.g., Goodman et al., 2002).

Recent figures published by the U.S. Department of Education in a report titled *Gender Equity in Education* suggest these enrollment disparities are smaller in high school compared to post-secondary institutions, but also have not disappeared entirely. Girls enroll in biology and chemistry courses at equal or higher rates than do boys, but are underrepresented in high school physics. They are enrolled in rigorous high school math courses — such as geometry, algebra, and calculus — at the same rate as boys, and they outnumber boys in enrollment in Advanced Placement science; however, they are underrepresented in AP mathematics. In examining earlier grades, this report shows that a greater percentage of girls than boys take Algebra 1 in 7th or 8th grade (U.S. Department of Education, 2012).

These gaps in enrollment do not necessarily reflect gaps in performance. Research has documented that boys and girls perform about as well as one another in STEM areas at all levels of education, although small gender differences do persist in some cases. Girls pass Algebra 1 in 7th and 8th grade at a higher rate than do boys (U.S. Department of Education, 2012) and perform as well on standardized math tests as do boys, on average (Hyde et al., 2008); however, they do earn lower scores on the mathematics section of the ACT and SAT (Hill, Corbet, & St. Rose, 2010). It is important to note that prior academic achievement does not play a significant role in explaining the gender gap in entering STEM majors (Riegle-Crumb et al., 2012), and that the gender gap in math achievement, at least, is now "too small to explain any substantial portion of the gender segregation in STEM fields or occupations" (Mann & DiPrete, 2011, p. 1522). A report from the American Association of University Women (AAUW) observes that girls express lower interest in math or science careers than boys do, despite having similar achievement scores in these areas (Hill, Corbet, & St. Rose, 2010).

Other researchers have shown that high-achieving men and women surveyed in 12th grade and then interviewed again at age 33 entered STEM fields at differing rates if they were capable in both mathematical and verbal tasks versus just gifted at math. Those who exhibited high abilities in both areas entered STEM careers at a lower rate than those who were only capable in math. Because this group included more women than men, the researchers suggest that women and men enter STEM careers at disproportionate rates because women have more career options than men, given their breadth of abilities (Wang, Eccles, & Kenny, 2013). This stirring finding underscores the emerging consensus that prevailing stereotypes regarding girls' and boys' abilities in STEM areas are misguided and that differing ability across genders is not a credible explanation of gender gaps in STEM higher education or beyond.

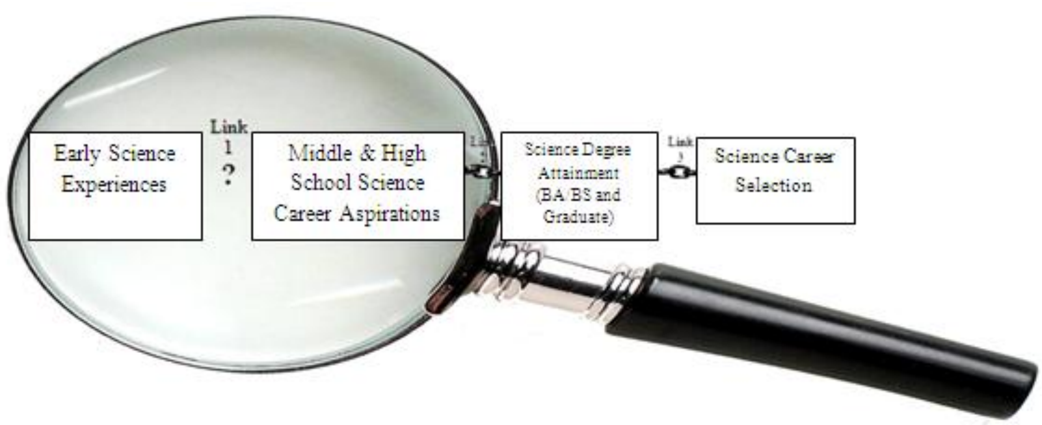
Many of these developments in enrollment and achievement are indicative of progress, but we do not intend to suggest that they reflect a state of equity among men and women in STEM education, nor that these changes have necessarily translated into a STEM workforce with equal representation of men and women. In fact, while progress is being made in secondary and post-secondary education, the needle has slowed recently in terms of a growing presence of women in the STEM workforce itself. According to a 2011 U.S. Department of Commerce Report, women hold nearly half of all jobs in the United States, but hold less than 25% of STEM jobs (Beede et al., 2011). There has been a dropoff in recent years in the proportion of women in the computer industry, and evidence suggests that much of the growth seen in the female STEM workforce is the result of women who entered the workforce between the 1970s and 1990s, where younger generations may not following the same trends (Landivar, 2013). Even though they hold the same degrees as men, women who earn their post-secondary degree in a STEM area are still less likely to work in a STEM occupation (Beede et al., 2011; Landivar, 2013).

LINKS IN THE SCIENCE PATHWAY

While there is clearly a balance between the extrinsic and intrinsic factors that drive whether or not individuals hold a STEM job, it is the decision to pursue a career in science — and the factors influencing this choice — that is of central interest to the M-LEAP study. The decision made during secondary school to pursue a STEM career is a strong predictor of whether or not students actually pursue a STEM degree (Tai et al., 2006), which in turn is predictive or whether or not they work in a STEM profession (Xie & Shauman, 2005). Despite the implications of this growing body of research for studying science career choice development at an early age, our review of the literature suggests that the emergence of science career aspirations as a result of early science experiences has not been examined in a truly comprehensive manner to date. Thus, M-LEAP focuses on two related questions: (1) “What factors related to behaviors, experiences, and aspirations contribute to the development of science career choice at a young age?” and (2) “Are experiences prior to 8th grade related to later life outcomes associated with science career attainment?”

The decision to pursue a science career is considered to be the result of a dynamic set of developmental changes, experiences, and events. As described in the Introduction (see Exhibit 1-1), considering the progression toward a science career as a series of steps along the pathway with connecting chains of understanding representing the knowledge and insights gained by existing research, ultimate science career selection can be linked back to various earlier steps in the pathway. Gender disparities have been documented at all these points (Clewell & Campbell, 2002; Freeman, 2004; Handlesman et al., 2005; Jacobs et al., 1998; Land of Plenty Commission Report, 2000; National Science Board, 2003; NSF 2003, 2004; Tai et al., 2006). In this section, we describe the known links in understanding at each step in the pathway.

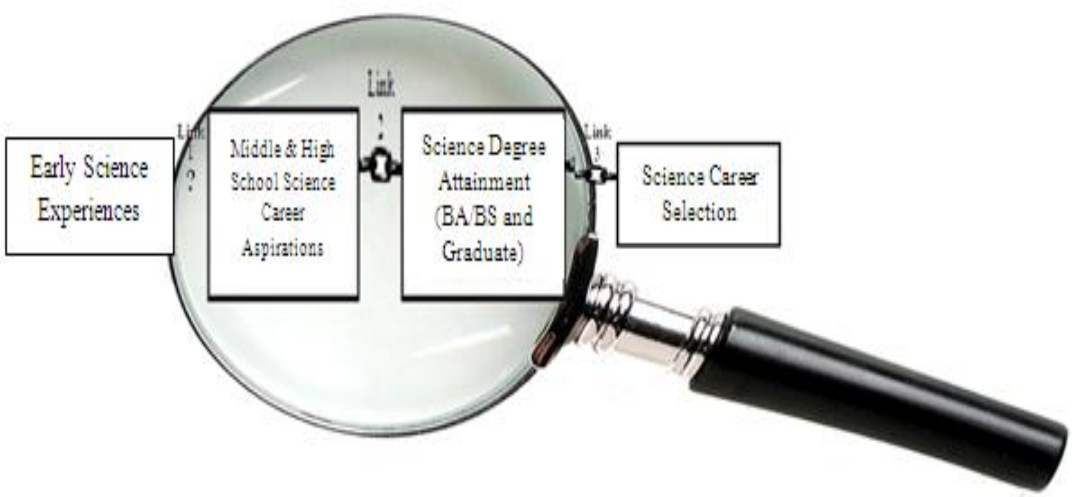
Link 1: The Missing Link in Research



The M-LEAP study was designed to address the missing link in the chain of understanding between students’ early science experiences and their middle and high school career aspirations. Unlike similar studies on the development of science career aspiration throughout students’ lives, the M-LEAP study prospectively examines the role of science experiences in elementary grades. The prospective nature of our research makes it unique to the research in this area, whereas most studies of early childhood influences are retrospective (see Roe, 1952; McCreedy & Dierking, 2013). Moreover, the elementary years are omitted from models of gender and science career choice development, despite signs from retrospective studies indicating that experiences during early childhood may have a significant impact on students' career aspirations when entering high school and beyond. Researchers have argued that in order to attract students to the sciences, closer attention must be paid to children's earlier experiences with science in elementary and middle school (Jacobs et al., 2002).

While the E-V model is well-tested among slightly older children, far fewer studies have tracked psychological constructs that could relate to science career choice development, such as task value and competence beliefs, among elementary school-aged children. This is despite the fact that research has established that children's valuing of experience in different domains develops early (Jacobs et al., 2002; Wigfield, Byrnes, & Eccles, 2006). Furthermore, elementary school has been shown to be the time point at which children's ratings of their academic competence begin to match cognitive performance (Chapman & Tunmer, 2003; Guay, Marsh, & Boivin, 2003; Wigfield et al., 1997). In other words, students begin to be able to accurately assess how good they are at school by the time they are in elementary school. Other studies have shown that students' math self-concepts are active and influenced by gender stereotypes as early as ages 6-10 (Cvencek, Meltzoff, & Greenwald, 2011). This suggests that children's perceptions of themselves in relation to school subjects develop at a very young age.

Link 2: From 8th Grade Aspirations to College Majors

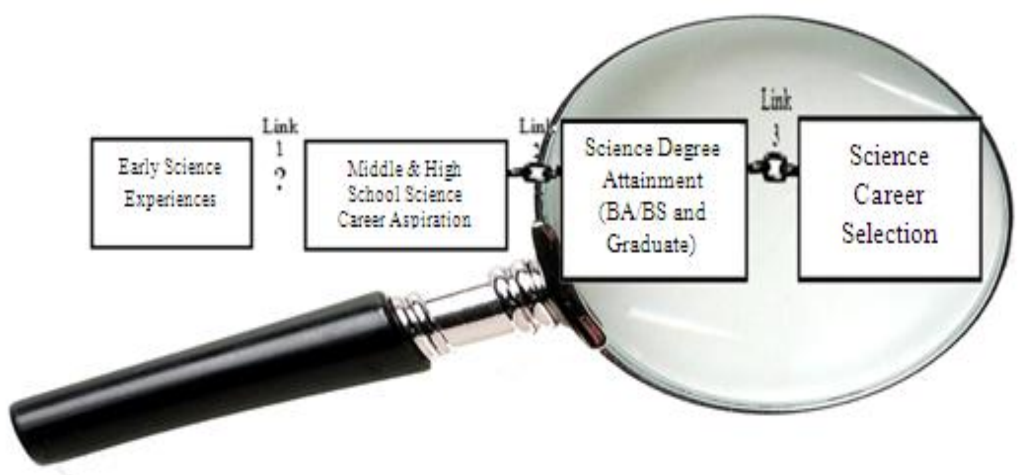


Research has documented Link 2: a relationship between 8th grade science career aspirations and future attainment of college science degrees (Tai et al., 2006). These researchers found that 8th graders who expected to graduate with a degree in science were actually more likely to graduate with a bachelor's degree in a science field. Tai's study co-varied for gender and ethnicity but did not report any gender effects. Other studies have found gender differences in science-related choices (in and out of school) and career aspirations of students in grades 8-12 (Jacobs et al., 1998; Trusty et al., 2000; Watt, 2005). While 8th grade typically represents mid-adolescence, it is fairly well accepted that the developmental period preceding this time (e.g., Link 1) typically represents one of great physical, socioemotional, and cognitive changes in children (see Wigfield, Byrnes, & Eccles, 2006 for a review). Thus, Link 1 provides another potential area of research, which M-LEAP has sought to address.

By 8th grade, girls and boys have different beliefs and aspirations regarding the pursuit of science, including future education and career options. In the most comprehensive examination of the underrepresentation of women in science that had been published at the time of M-LEAP's inception, Xie and Shauman (2005) used 17 nationally representative data sets to conduct statistical analyses of gender differences at various career stages. Although they studied the career trajectory of female scientists from middle school onward, their seminal lifecourse model does not address earlier experiences in science.

Further, scientists frequently cite early-age experiences alongside those from high school and college when reflecting on what drove them to pursue a career in science. In a retrospective study of 726 scientists in Australia and New Zealand, Venville et al. (2013) observed that just over half of respondents said they realized they were interested in studying science by the time they were 15 years old. That figure jumped to nearly 90% by the time they were 17. A recent NSF-funded study on young girls' afterschool programs showed that informal learning experiences, like in-school experiences, were powerful motivators in promoting interest and engagement in science over participants' lifetimes, as well as predicting pursuing a science career in some cases (McCreedy & Dierking, 2013). Findings such as these underscore the opportunity for a prospective study of early-age experiences to yield insights into the ways that future scientists progress along the science career choice development pipeline.

Link 3: From College Major to Workforce Selection



Research has documented Link 3 between college science degrees and science career selection, (e.g., Xie & Shauman, 2005). Char (1999) conducted a retrospective study of 25 years of Dartmouth alumnae who had majored in a science-related field. She found that 80% of respondents' current or most recent job was in a STEM-related field. Those students who entered college intending to pursue a degree in a science-related field tended follow through with those majors (Char, 1999).

Others have found gender gaps in science careers related to gender differences in obtaining a post-secondary science degree. For example, surveys of incoming freshmen showed that twice as many males (29%) as females (15%) planned to major in a STEM field in 2006 (Hill, Corbet, & St. Rose, 2010).

THE EXPECTANCY-VALUE MODEL OF ACHIEVEMENT-RELATED CHOICES

The M-LEAP study is grounded in the Eccles E-V Model of Achievement-Related Choices (Eccles [Parsons] et al., 1983; Eccles, 2005). The E-V Model has evolved and been re-interpreted regularly since it was first developed by Dr. Jacquelynne Eccles of the University of Michigan School of Education and her colleagues (Eccles [Parsons] et al., 1983). This theoretical model is based on the recognition that individuals consider achievement-related choices — about course selection, degrees to pursue, and careers — based on the subjective value they place on those choices, the outcomes they predict will result from those choices, and their beliefs about their own proficiency in various domains. It has been used as a framework for understanding the motivational differences between genders in academic and career aspirations and achievement in numerous studies over the past 30 years.

Components of the E-V Model

The E-V model incorporates three primary modules: a psychological component, a biological component, and a socialization component. This basic combination of components encompasses the competence beliefs, values, goals, and interests of individuals with regard to achievement-related decisions, as well as the biological, social, and environmental factors that influence these beliefs (Wang & Degol, 2013). Our focus has been on the psychological and social factors present in 3rd-8th graders. The four major constructs of the model are defined in Exhibit 1-3.

Exhibit 1-3: Major Constructs of the E-V Model

Construct	Definition	Example
Subjective Task Value (STV)	The potential cost of investing time in one activity versus another	Perceived utility of science relative to other subjects
Predicted Outcomes	The relationship of an activity to short-term and long-term goals	Perceived relationship of science class activities to long-term goals
Competency Beliefs	One’s expectations for success and self-efficacy (SE), or beliefs about own ability	Perceived ability in science class
Social Structure	One’s cultural and environmental milieu	Perceived roles based on family demographics, gender, and socioeconomic status

For M-LEAP, we decided to focus primarily on the constructs of SE, STV, and the gender and family role components of social structure. SE includes individuals’ competency and ability beliefs, as well as their expectations for success within a given domain in the future. STV includes students’ beliefs about the utility and interest of science and other school subjects. In other words, our operationalization of STV measures how interesting those courses are to students and how useful they are generally perceived to be. Additional subconstructs within STV not directly measured here include cost and attainment value (see Wang & Degol, 2013).

Numerous studies have confirmed the relevance of SE and STV beliefs in evaluating individuals' attitudes and behaviors toward STEM areas. Research grounded in the E-V Model, including studies of children as young as 1st grade, supports the theory that the subjective values that individuals associate with particular tasks or choices are more significant than the absolute attributes or values of those choices. Likewise, individuals' perceptions of their ability in various domains are more important than their actual ability or prior achievement (Eccles, 2005; Eccles et al., 1993; Jacobs et al., 2002; Wigfield & Eccles, 2000). Thus, individuals — including young children — are intrinsically motivated to pursue activities that they think they are good in and which are valuable to them personally, rather than activities that are objectively understood to be valuable and interesting.

Gender differences in achievement-related choices often play a central role in studies that employ the E-V framework. This framework helps to explain gender discrepancies in girls' and boys' attitudes and beliefs toward school subjects by "[integrating] research on the ways in which individuals, their parents, teachers, peers, and the broader culture together influence academic choices and outcomes" (Priess & Hyde, 2008, p. 27). In doing so, it combines an inward focus on the interest level, task value, and expectations for success that students associate with various academic disciplines (the psychological component), and an external focus on the ways that these beliefs may be influenced by the perceptions and behaviors of others (the socialization component). For example, the E-V model allows for students' expectations for success within an academic domain to be influenced by their perception of their parents' expectations for them.

The E-V Model has been applied in numerous studies on students' attitudes toward school subjects (for an overview, see Meece, Glienke, & Burg, 2006). Many of these studies have focused on gender differences and the development of attitudes over time. Gender gaps in competency and value beliefs among boys and girls have been seen as early as early elementary school (Eccles et al., 1993) and have been shown to shrink or remain the same as students reach high school, depending on the subject area in question (Jacobs et al., 2002). Wigfield et al. (1997) found that students' self-ratings of competence in various elementary and middle school subjects were related to evaluations of their ability as assessed by parents and teachers, and that students' ratings begin to converge with those of adults over time, noting that this relationship already begins to stabilize by 1st and 2nd grade. These and similar studies confirm that it is possible to apply the E-V framework in studies of relatively young individuals, including elementary and middle school students.

Another relevant aspect of the E-V framework is that it theorizes that students hold differential beliefs about various school subjects. For example, Eccles et al. (1993) found that young children can distinguish between their ability levels in different areas, such as math and reading. Jacobs et al. (2002) found that the competency and task value beliefs that students hold toward school subjects tend to be domain specific rather than global, meaning that students' beliefs about how good they are and how useful the material is vary by school subject. This finding is fundamental to our research, as we seek to isolate students' attitudes toward science studies and careers, specifically.

SE and STV beliefs have been shown to be important predictors of students' achievement and persistence in STEM areas. Science SE beliefs have been shown to be predictive of both engagement and achievement in science-related activities inside and outside the classroom for high school students (Britner & Pajares, 2006). Similar effects are seen among middle school students, where science SE predicts achievement in science classes (Britner & Pajares, 2001). As discussed in Meece, Glienke, and Burg (2006), several studies have shown that course enrollment patterns and participation rates may be predicted by the value judgments that students make of various STEM areas. For example, students who value math more highly are more likely to enroll in optional mathematics courses (Feather, 1988).

Students' SE and STV beliefs at a young age are predictive of later life outcomes, such as course enrollment. Eccles, Vida, & Barber (2004) found that 6th grade students' academic ability self-concepts were strongly predictive of their attending college two years after high school. Other studies have shown that interest in math and science at a young age is predictive of enrollment in high school math and science courses (Wang & Degol, 2013). Self-concepts and intrinsic values measured in grade 10 are predictive of course enrollment in grade 12 (Nagy et al., 2007). As theorized by the E-V framework, SE and STV beliefs have been shown to be better predictors of later life outcomes than absolute outcomes, like students' actual performance in school (Simpkins, Davis-Kean, & Eccles, 2006). In their prospective study of 272 11- to 15-year-old students, Bandura et al. (2001) conclude that "[children's] perceived efficacy rather than their actual academic achievement is the key determinant of their perceived occupational self-efficacy and preferred choice of work-life" (p. 187).

The relationship between SE and STV beliefs and later life outcomes could manifest through several mechanisms (Eccles, 2005a). For example, students with low SE in science and mathematics at a young age may be less likely to take the necessary classes in high school and college that would allow them to pursue a career in a related field (Zeldin & Pajares, 2000). Research has shown that advanced courses in math and science electives serve as "gatekeepers" for STEM occupations (Dorsen, Carlson, & Goodyear, 2006, p. 8).

SCIENCE IDENTITY THEORY

While the theoretical basis for the M-LEAP study is firmly grounded in the E-V Model, our study is also supported by a more recent, parallel, body of research in science identity development. In the context of the present study, science identity is defined as "who we think we must be to engage in science" (Barton, 1998), "the sense of who students are, what they believe they are capable of, and what they want to do and become in regard to science" (Brickhouse & Potter, 2001), and "the degree to which [students] perceive themselves to be the right type of person for [science]" (Hazari et al., 2010). As with the E-V framework, science identity theory is robust in that it allows for development to be influenced by both internal and external factors, such as the perceptions of others.

Science identity has been shown to be a very good predictor of retention and career pursuit in science (Hazari et al., 2010). When asked to reflect on their early years, scientists have been observed to cite science identity development, such as overcoming gender stereotypes, alongside expectancy-value factors, like ability and interest, as being important in their decision to pursue a science career (Venville et al., 2013; McCreedy & Dierking, 2013). This theory motivated several of the items asked in the third year of data collection, when we revised our student interview protocol to include several questions on the ways in which students perceived themselves relative to science and other areas (i.e., whether or not they saw themselves as a "science person", or any other particular kind of student).

DOMAINS OF INFLUENCE

The M-LEAP study has focused primarily on SBEAs that children have between grades 3-8. In this study, we define science-related experiences as the kinds and frequency of science activities in which children participate, both in and out of school; the common scientific materials they experience; and the people with whom they share these experiences. Aspirations include college and career goals related to science, and interests include students' interest in studying and learning about science in school, as well as engaging with it informally through such activities as games and visiting informal learning institutions. SBEAs are affected by family, school, and OOS influences and experiences. This section presents relevant research on the ways each of these areas of influence have been shown to affect individuals' attitudes toward science, as well as academic and career outcomes.

For the purposes of this review, we have grouped the potentially influencing variables that we investigated into the following categories: Family Influences, In-School Influences, and Out-of-School Activities and Media Influences. These categorizations were made in alignment with our interpretation of previous E-V research, such as the review done by Wang & Degol (2013), and existing categorization schemes in social psychology. Below, we present research done in each of these areas that highlights the connection between students' academic and career aspirations and their SBEAs, as mediated by the E-V framework. Given our research questions, we focus primarily on studies that discuss how boys' and girls' attitudes and behaviors are affected differently by changes within each of these domains.

Family Influences

Discussions of early-childhood SBEAs often revolve around the impact parents' attitudes and behaviors have on their children. Studies have shown that the attitudinal constructs that make up the E-V framework can be highly influenced by students' perceptions of their parents' attitudes toward various school subjects — which in turn may be influenced by gender stereotypes — as well as additional parental factors such as their profession and educational background. Prior research underscores the importance of considering parents' perspectives in understanding and contextualizing children's experiences (Jacobs & Bleeker, 2004). In presenting this review, we highlight not only the connection between parental beliefs and student beliefs in terms of SE and STV, but also introduce some of the factors that have been shown to influence parents' beliefs, such as gender stereotypes. For a review of the mechanisms by which parental attitudes may influence children's beliefs, behaviors, and achievement, see Jacobs and Bleeker (2004).

Parental attitudes are important predictors of children's competence beliefs, which are an important component of SE beliefs. Wigfield et al. (1997) found that students' self-reported ability ratings are related to ratings given by their parents, and that while parents' ratings remained relatively stable over the course of a 3-year longitudinal study, students' ratings began to converge with those of adults and stabilize as early as 1st and 2nd grade.

Much of the research demonstrating the relationship between student and parental attitudes has shown that parental attitudes about children's abilities may be influenced by gender stereotypes. Tiedemann (2000) studied the relationship between parents' gender stereotypes and elementary school-aged children's self-reported abilities in mathematics, and found that parents' beliefs about their children's abilities were influenced by gender stereotypes that they held, and that children's self-perceived abilities were related to the ability levels that their parents assigned them. Thus, students' competence beliefs were related to parents' beliefs, and parents' beliefs served as a conduit for gender stereotypes. Similar results have been documented elsewhere (Priess & Hyde, 2008; Frome & Eccles, 1998; Jacobs & Eccles, 1985).

Eccles, Parsons, Adler, and Kackzala (1982) found that parents of daughters did not believe that their children were as capable at mathematics as did parents of sons. Rudasill et al. (under review) surveyed 500 gifted 5th-11th grade students and their parents and discovered that this same gender stereotype held true for parents' perceptions of their children's abilities in science, although they also found that parents perceive daughters to be more capable in humanities; boys and girls did not differ in their self-reported ability levels in these areas except for a positive bias in humanities on the part of girls.

Parents' beliefs and behaviors may influence their children's value judgments when it comes to being interested in and endorsing the importance of science, which are two crucial components of STV. Increased parental involvement in students' science studies has been shown to be associated with increased science task value as well as improved performance among elementary school-aged children (Senler & Sungur, 2009). Unfortunately, these parental beliefs may also be influenced by gender stereotypes. Parents of sons think that it is more important for their children to take advanced math courses (Eccles [Parsons] et al., 1982). They also talk with their sons about science more frequently and at a more sophisticated level than parents of daughters (Priess & Hyde, 2008; Crowley, Callanan, Tenenbaum, & Allen, 2001; Tenenbaum, Snow, Roach, & Kurland, 2005).

Children are not only able to pick up on these perceptions and behaviors, but they can also be influenced dramatically by them. They may hold differing SE and STv beliefs and alter their academic and career decisions as a result. One study showed that "parents' beliefs were more directly related to children's self-concepts and expectancies than were the children's past performances in math" (Eccles Parsons, Adler, & Kackzala, 1982, p. 310). Rudasill et al. (under review) found that parents' beliefs about their children's academic abilities were strongly associated with their children's beliefs, and warned, based on their findings of gender stereotypes on the part of parents, that "[parents] may be steering their children toward careers according to these gender stereotypes" (Rudasill & Callahan, 2007).

Studies have shown that students' perceptions of their parents' attitudes and beliefs toward school subjects can also influence various aspects of their academic achievement, such as their personal achievement aims. For example, Friedel et al. (2007) found that children's goals in school can be predicted by their perceptions of their parents' goals for them. Findings from this study and others like it suggest that students who perceive their parents as having high goals for them in terms of understanding and mastery of academic material will set similar goals for themselves and engage in fewer self-handicapping and help-avoidance behaviors. Achievement is also strongly related to parental socioeconomic status, and it has been theorized that parental achievement aims for their children act as a mediating variable in this relationship (Wang & Degol, 2013).

This research influenced our study by making it clear that the relationship between parents and children is an important one to consider when investigating what factors influence young students' science career aspirations and decisions. As a result, we included several questions about parents on the Student Survey, and administered an independent survey to parents about their attitudes and beliefs, as well.

In-School Influences

Students' attitudes and expectations about various academic areas are inextricably linked with their experiences in school, including their relationships with teachers, classroom experiences, and interactions with peers. Studies have established a strong connection between these school and classroom factors and student attitudes toward science (Osborne, Simon, & Collins, 2003).

Our focus on certain in-school experiences was motivated by research suggesting that students' SE and STV beliefs are shaped by their SBEAs in and around the classroom. These, in turn are related to the careers that students choose. Research has suggested that in-school science learning plays a role in future science interest, and beliefs about self-competence (Turner, Bernt, & Percora, 2002). Legewie and DiPrete (2012) found that attending a high school where girls' engagement in science and math is supported and encouraged leads to a substantially higher probability of their graduating with a bachelor's degree in a STEM area. We seek to extend this research and the work summarized below by investigating how students' in- and out-of-school experiences, beliefs about science, and parents' and teachers' beliefs are related to their career aspirations.

Teachers are undoubtedly an important influence on children's attitudes toward certain areas and school more generally (for a review of relevant research, see Osborne, Simon, & Collins, 2003; Wang & Degol, 2013). As such, it is important to consider how teachers' beliefs, attitudes, and behaviors toward science and their students may affect young learners' SE and STV beliefs as a precursor to investigating how these beliefs influence science career decisions, especially where students are treated differentially along gender lines.

Numerous studies confirm that the quality and style of teaching influences student attitude toward science, as well as course enrollment decisions (Osborne, Simon, & Collins, 2003). In their investigation of effective science teachers, Woolnough (1994) surveyed more than 1,000 U.K. students, as well as teachers and administrators, and discovered that quality of teaching was a major determinant of whether or not students continue to take science classes after the age of 16. While we did not investigate the quality of instruction as part of the M-LEAP study, this line of research underscores the relationship between teacher behaviors and student achievement-related choices.

Another line of research investigates the role that teachers' own confidence in their proficiency with regard to content knowledge and instruction plays in shaping students' opinions and beliefs. This is important because teachers' attitudes can influence their students' attitudes toward the area (Gunderson et al., 2012). For example, teachers' math SE ratings have been shown to be positively related to the attitudes of their students (Midgley et al., 1989). Beilock et al. (2010) observed a gender discrepancy in this relationship. They found that girls whose female teachers expressed high math anxiety declined in math performance over the school year, but that boys did not show a similar decline. We also asked teachers about their own self-ratings of proficiency in science as a part of this study.

As with parents, an important area of research in the realm of teacher-student relationships is gender stereotyping. Interviews with and observational studies of teachers in science classrooms suggest that while some teachers may believe that the days of gender stereotyping in STEM fields are firmly in the past, male and female students continue to be treated differently when it comes to in-classroom exchanges, with boys receiving more attention than girls (Shumow & Schmidt, 2012). Similarly, teachers may gender stereotype when they assess how capable their students are in mathematics by underrating females and overrating males, and by setting different expectations for each sex (Li, 1999). As was the case with parents, studies have shown that teacher stereotypes and attitudes can influence students' own stereotypes (Gunderson et al., 2012).

The present study sought to build on this previous research. We investigated how teacher attitudes may shape students' SE and STV beliefs, and in turn influence their achievement-related decisions and science career aspirations. Teachers were asked about their own gender stereotype beliefs, and rated their students in terms of ability and interest in STEM areas.

While our examination of in-school factors focused primarily on teachers, it is important to note that numerous other factors play a role. As discussed in the following section, which briefly introduces some of the recent efforts geared toward encouraging young students to decide to pursue science careers, schools are an important source of career planning information for young people. Numerous studies on STEM career choice development have called for improvements in career counseling in schools (Dorsen, Carlson, & Goodyear, 2006). The reason for this is that career counseling is an important opportunity for students to learn about certain career options and begin to formulate plans for working in a particular field. While we did not interview or survey career counselors as part of this study because they are generally not present in elementary and middle schools, this perspective is important to keep in mind as one considers the myriad ways in which in-school experiences influence children's career aspirations.

Out-of-School (OOS) Activities and Media Influences

In addition to parental influences, there are numerous other science-related experiences aimed at children outside the school context that may influence young students' career aspirations at the end of middle school. These media and activities include books, television, museums, hobbies, clubs, websites, and family vacations. Several of these activities and media influences are typically categorized as informal educational opportunities that take place outside the classroom and often outside of school (OOS). Here, we present a brief overview of some of the relevant literature that informed our decision to include OOS activities among the SBEAs we investigated in our study.

To fully understand children's science learning, it is important to look not only at in-school but OOS learning as both have profound effects on children's achievement in school and SE beliefs (Eshach, 2007). Support for the importance of informal experiences can be found in the National Science Education Standards (National Research Council, 1996), which state that museums and science centers "can contribute greatly to the understanding of science and encourage students to further their interests outside of school" (p. 45).

Engagement in OOS science-related activities is not only an important predictor of academic achievement and persistence, as well as career choice, but is also understudied (Simpkins, Davis-Kean, & Eccles, 2006). Retrospective research with scientists has cited associations between early science experiences and later career aspirations, as well as the importance of OOS science experiences in inspiring interest in science careers (Roe, 1952; Friedman & Quinn, 2006). Further, as discussed in the Introduction, numerous recent initiatives and programs designed to attract more students to STEM areas have focused on this informal realm, albeit with mixed results.

Especially relevant to this study are findings linking informal learning programs to long-term impacts on female students, in particular. In a recent, NSF-funded study published by the Franklin Institute Science Museum, researchers conducted a retrospective analysis of several afterschool programs that the study participants (all women) had attended between five and 25 years ago. They found that these afterschool programs had positively impacted participants' views and attitudes toward STEM. Participants expressed detailed memories of trips and other experiences, as well as experiments and activities they had participated in. A high percentage of the sample had gone on to obtain a STEM degree in college, and subsequently pursued a career in a STEM field (McCreedy & Dierking, 2013). Other research has shown that participating in OOS science and math activities in middle school is related to positive subjective valuation of and self-concept development in science and math, as well as persistence in enrolling in these areas in high school and graduation with a STEM-related degree (Simpkins, Davis-Kean, & Eccles, 2006; Afterschool Alliance, 2011).

In one of the few relevant prospective studies, Farenga and Joyce (1999) found a correlation between high-ability 9- to 13-year-old boys' informal physical science experiences and their intentions to study physical science courses. Similarly, they found a correlation between informal life science experiences of high-ability 9- to 13-year-old girls and their intentions to take life science courses.

Media is another relevant category of informal learning and OOS experience, but it is very difficult to define and evaluate its impact on students' SE, STV, and career aspirations in isolation because of the diversity of programing and formats that science-related media adopts. Further, they are challenging to evaluate longitudinally, and especially unwieldy because often different media cover the same material in different ways (Bell et al., 2009). Nevertheless, media are becoming an increasingly important part of students' and adults' learning experiences alike and have been shown to have a powerful influence on people's relationship with science. Some researchers have suggested that these activities play a particularly strong role at a young age because of the increased amount of free time that younger students have (Venville et al., 2013).

RESULTS OF PREVIOUS PROGRAMS AND INTERVENTIONS

In the final section of this literature review, we present some recent research conducted on organized formal and informal interventions seeking to promote girls' participation in science, both as an area of study and as a career. We briefly highlight evaluations of afterschool programs, camps, and clubs in order to identify ways in which research on the E-V Model has been successfully applied.

One of the most common forms of intervention in this area is the afterschool program. Examples include *For Inspiration and Recognition of Science and Technology* (FIRST), which is a national robotics program open to K-12 students and *Science Club for Girls* (SCFG), which introduces 8th-12th grade girls in Massachusetts to STEM professionals and facilitates science activities and field trips. Referring to these and a broad range of before-school, afterschool, and summertime programs, the Afterschool Alliance found that programs that focus on STEM have been shown to have positive outcomes including "improved attitudes towards STEM fields and careers," "increased STEM knowledge and skills," and a "higher likelihood of graduation and pursuing a STEM career" (Afterschool Alliance, 2011, p. 2). A commonly cited outcome of these programs is increased confidence in one's abilities and competence in science. In the context of the E-V framework, the implication is that many of these programs succeed by promoting students' SE in science and other areas. They also used engaging approaches to promote interest (Afterschool Alliance, 2011), an important component of STV.

As discussed above, a recently published NSF-funded study on girls-only afterschool programs revealed several ways in which informal learning experiences at a young age may influence students' attitudes toward and aspirations about science. While several of the key outcomes they investigated through their interviews of adult women were not necessarily predicated upon the E-V framework we use in our research, the researchers discovered that 67% of their 159 respondents mentioned that their informal learning experience had changed their attitude toward and perception of STEM areas in some way. Many expressed a belief that the informal learning had given them an increased level of confidence and interest in STEM areas (McCreedy & Dierking, 2013), both of which are directly related to SE and STV.

Research has also been carried out on interventions that include parents. As discussed above, parental influences are incredibly important in shaping students' SE and STV beliefs in science, as well as in influencing key outcomes such as enrollment in science courses and pursuit of a science career (Wang & Degol, 2013). Despite this, interventions geared toward parents have been somewhat rare. In one unique experimental study of an intervention aimed at parents that employed the E-V framework, researchers were able to show that simply highlighting the utility value of STEM courses for parents through brochures and websites was associated with an average one-semester increment in the number of mathematics and science courses teens took in high school and positively related to the teens' perceptions of the utility of these areas (Harackiewicz et al., 2012).

These and similar studies reveal the powerful impact that manipulation of the kinds of SBEAs that we chose to investigate in our study can have on girls. While most interventions to date have been geared to students (Harackiewicz et al, 2012), it is was our hope in the formulation of this research study that it would yield broad policy and practice recommendations for implementation in multiple arenas due to our holistic approach in considering both in-school and OOS factors, including parents, that help shape students' opinions, aspirations, and goals with regard to science.

CHAPTER 3: METHODS

This chapter begins with a brief presentation of the methodological design used in the M-LEAP study. It is followed by a description of the sampling procedure used in selecting the school districts and schools that took part in the M-LEAP study. Finally, we introduce the instruments we developed, our response rates for each instrument by year and school, and the procedures for administering these instruments.

RESEARCH DESIGN

Design elements such as sample selection, measures, and longitudinal data collection are introduced here at a high level, and covered in further detail in subsequent sections. As with any large-scale longitudinal research study, certain elements were revised during the course of the study, and we have tried to make note of these changes where applicable, especially those that reflect a modification of our original NSF proposal.

The M-LEAP study collected longitudinal data from 3rd-8th grade students and their parents and teachers over a three-year period from 2010-2013. To accomplish this, we employed a longitudinal design in which students in grades 3-6 during Wave 1 were followed for three years, until they were in grades 5-8.

Eight districts were included in each year of the study, with one school per district. While we had originally envisioned selecting only four or five districts, increasing the number of districts allowed us to expand the geographic representation of our sample by including schools from across the state of Massachusetts, so that we had schools in urban, suburban, and rural areas. The diversity of the involved districts allowed us to examine gender as a factor in relating the underrepresentation of women in STEM careers to a broad array of childhood experiences, as well as diverse race/ethnicity.

We only selected schools in Massachusetts that included grades from K-8. Practicaly, this increased our chances of successfully tracking students across elementary and middle school grades, rather than following them into new middle schools and attempting to forge working relationships with administrators at additional schools. Given our systematic and purposive sampling plan, described in greater detail below, we determined that limiting sampling to K-8 schools would not compromise external validity. The goal of our sampling plan was to maximize diversity while achieving a sample that is representative of the state on a number of demographic characteristics. Because there are 98 K-8 schools in Massachusetts, we were able to accomplish this goal.

With each school, we used a population approach when sampling students. This involved collecting data from all students in a grade, rather than only a sample from each grade. As with the K-8 school approach, we determined this was the simplest way to effectively track students from year to year, enabling us to capture cohorts of students even as classrooms broke up and spread across different classrooms each year. A population approach also allows for the inclusion of new or transfer students each year, helping counteract attrition. Students were assigned unique ID numbers, allowing us to follow them from year to year.

We followed students for up to three years. During Wave 1 of data collection, all students in grades 3-6 at each school were invited to participate. In Wave 2, students were in grades 4-7, and in Wave 3, they were in grades 5-8.

The study design was primarily quantitative. The primary instrument was the student survey, with two researchers administering paper surveys annually in each participating classroom. To triangulate the data, we also administered annual parent/guardian surveys and teacher surveys using a mixed mode of paper and online surveys. Parents answered questions about themselves as well as about all their children in the eligible grade range that year. We attempted to collect data from both parents (if applicable) rather than relying on the perception of only one parent about the educational and career aspirations and expectations they held for their child. Teachers answered a brief set of questions about themselves as well as about each participating student they taught that year. Further details for each of these instruments are described below.

We also collected qualitative data, primarily from students in the form of interviews. Based on their Wave 1 survey responses, a subset of up to 16 students per school, stratified on their interest in and engagement with STEM areas (high and low), were selected for brief, 10- to 20-minute, one-on-one interviews. The purpose was to gain a richer picture of students' beliefs, in- and out-of-school experiences, and aspirations. As with the larger sample of surveyed students, we sought where possible to follow at least a portion of the interview sample from year to year to observe change versus stability over time in interest and engagement.

In Wave 3, we changed our interview strategy to include the following categories: (1) students who scored high on STEM only on that year's survey, (2) those who were high across the board (across all the content areas) on that year's survey, and (3) those who gained or lost engagement with STEM areas compared to previous years' surveys. Further, this change was accompanied by alterations to the interview protocol that sought to deepen our understanding of the factors that might explain those changes. As discussed below in the Instruments section, this modification was influenced by emerging research on science identity theory.

Finally, in order to gain a more global perspective on students' early childhood experiences with science, we collected contextual information on in- and out-of-school opportunities in each of the sampled communities from a variety of sources, including interviews with district subject matter specialists and web and database searches.

SAMPLE OF DISTRICTS AND SCHOOLS

As noted above, we took a rigorous and systematic approach to obtaining our sample to achieve a diverse sample representative of Massachusetts. Initially, we ranked all cities and towns in Massachusetts (N = 351) in deciles along two criteria: median household income and median single-family home sales price as of November 2008. Municipalities in the highest and lowest decile were eliminated from the sampling frame, leaving 248 eligible school districts. We then limited the sample to include only K-8 schools, leaving 98 eligible schools.

Next, we selected schools based on geographic spread (e.g., different regions of the state), demographic characteristics (percentages low-income, free/reduced-price school lunch, first language not English/limited English proficiency, and special education, along with racial and ethnic composition), and MCAS (Massachusetts Comprehensive Assessment System) scores.

In Massachusetts, K-8 schools are not evenly distributed geographically; they are more concentrated in large, urban districts in the eastern part of the state, while they are more scattered in rural areas in

Western Massachusetts and on the Cape and Islands. To the greatest extent possible, however, we recruited a geographically diverse sample. Letters of inquiry were sent to principals of 24 geographically dispersed public K-8 schools. We contacted principals directly to explain the study, highlighting the opportunity for the school to participate in important research as well as other benefits, including a stipend of $2,000 per year and a report showing aggregated school-level and studywide results. We wanted to avoid focusing too heavily on our interest in gender and science, so we framed the study as an exploration of students' interests in 21st century skills and careers.

We achieved our target sample size of eight schools; three are urban, three are suburban, and two are rural or semi-rural. Four schools are in Eastern Massachusetts, with one each in Central, Northern, and Western Massachusetts and one Cape and Islands school. One school dropped out after the first year and was replaced in Waves 2 and 3 by a school with similar demographic characteristics.

To protect the anonymity of the schools, students, school and district personnel, and parents who were a part of this study, we have given pseudonyms to each of the participating schools and communities.

SAMPLE OF STUDENTS WITHIN THE EIGHT SCHOOLS

The M-LEAP schools and their region and urbanicity are shown in Exhibit 1-4, along with the population and distribution by grade level of 3rd-8th grade students. (Response rates are presented later in the chapter.)

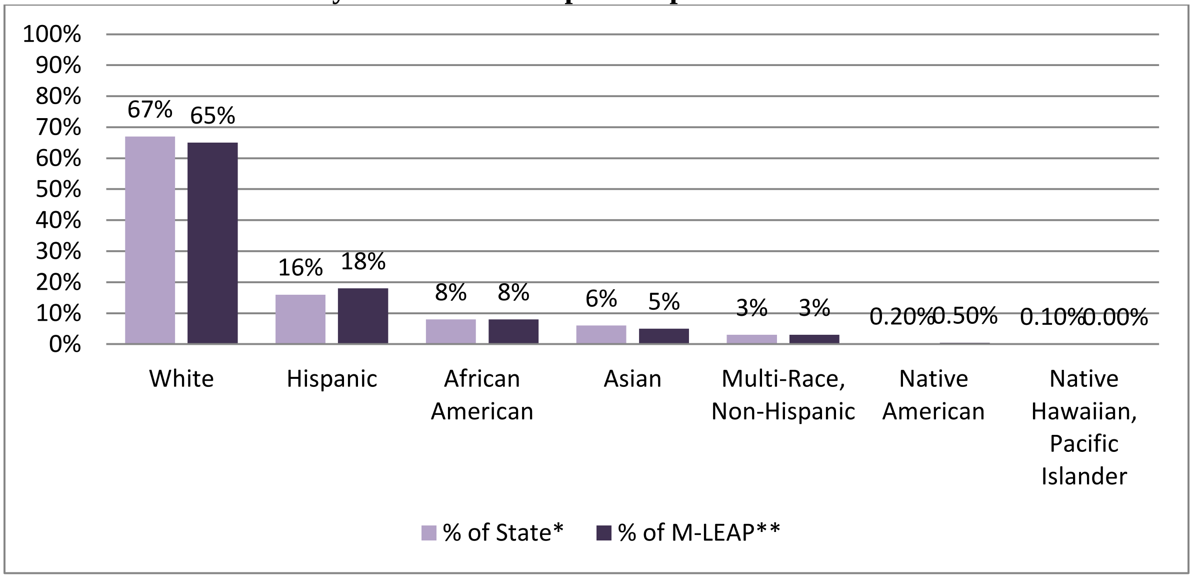
Exhibit 1-4: Total Population of Students in M-LEAP Schools, 2012-2013 School Year (Wave 3)

				Population size in each grade					
M-LEAP SCHOOLS	**Region**	**Urbanicity**	**Grades 3-8**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**
Pseudonym			N	N	N	N	N	N	N
Heybridge[a]	Eastern MA	Urban	353	70	67	68	55	50	43
Prescott	Eastern MA	Suburban	559	98	95	84	107	92	83
Girton	Eastern MA	Urban	292	47	41	45	60	49	50
Marigold[b]	Northern MA	Suburban	791	146	123	128	136	134	124
Davison	Central MA	Suburban	384	58	59	62	75	65	65
Beaufort	Western MA	Rural	96	18	12	23	12	9	22
Pace	Eastern MA	Urban	242	43	41	48	34	43	33
Winship	Eastern MA	Urban	587	78	97	76	130	101	105
Allentown	Cape & Islands	Rural	208	35	33	36	39	34	31
TOTAL			**3512**	**593**	**568**	**570**	**648**	**577**	**556**

[a]Heybridge joined in Waves 2 and 3 as a replacement for Marigold.
[b]Marigold dropped out after Wave 1 and was replaced in Waves 2 and 3 by Heybridge.

Our sample of students is diverse in terms of race and ethnicity. As shown in Exhibit 1-5, it is representative of the Massachusetts student population as a whole, with the exception that the M-LEAP sample slightly overrepresents Hispanic students and, correspondingly, slightly underrepresents White students.

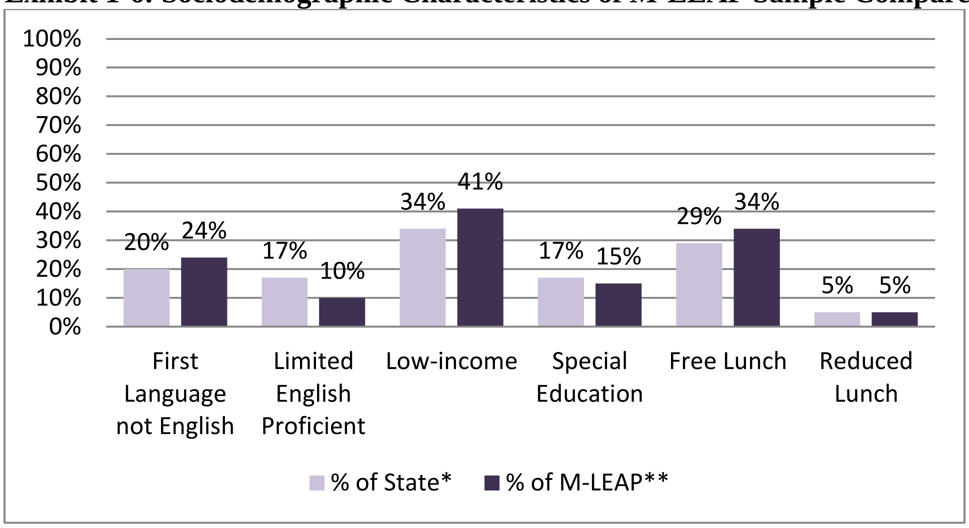
Exhibit 1-5: Race/Ethnicity of M-LEAP Sample Compared to State



*MA DOE Public school data, 2011-12 school year
**M-LEAP schools data, 2012-13 school year (*N* = 1,327)

In terms of other sociodemographic variables, the M-LEAP sample slightly overrepresents both students whose first language is not English and low-income students, also evidenced by the higher percentage in our sample who qualified for free lunch, as shown in Exhibit 1-6.

Exhibit 1-6: Sociodemographic Characteristics of M-LEAP Sample Compared to State



*MA DOE Public school data, 2011-12 school year
**M-LEAP schools data ranging from 2010-12 school year

INSTRUMENTS

Based on a review of the literature and consultation with our team of formal and informal STEM advisors, we developed five instruments for students, parents, teachers, and science coordinators:

surveys for students, parents, and teachers and interview protocols for students and district-level science specialists. Each of the instruments is described in further detail below. These measures are primarily grounded in the Eccles E-V Model (Eccles [Parsons] et al., 1983; Eccles, 2005), but also include additional questions related to other areas of interest, such as OOS activities. Because the M-LEAP study was presented to participants as a study on 21st century skills — and not about STEM areas specifically — each measure incorporated questions on five 21st century skill-related subject areas and skills: reading/ELA, math, science, computers, and teamwork.

After developing the measures, we piloted the student survey at two schools not participating in our study then revised it and conducted a second round of piloting. At each step, we obtained feedback from our advisors and consultants, including local public school teachers. We also had several different teachers review the teacher survey, including one at a very diverse school and another specializing in special education.

Because of the unusual diversity of our sample, we had some unique considerations in developing measures. Student surveys had to be understandable and appropriate across grades 3-8 as well as across a range of literacy levels and cultural values. Parents were also widely diverse in terms of literacy levels, first language, and cultural values, so we used clear, straightforward language. We also had parent surveys translated into Spanish, Portuguese, and Haitian Creole to accommodate parents for whom these are native languages.

Student Survey

The primary data collection instrument was the student survey (see Appendix A). The bulk of the survey assesses student beliefs, experiences, and aspirations regarding various school subjects. As noted above, we focused on five: reading/ELA, math, science, computers, and teamwork. We shortened the measure used by Eccles into six items per area assessing SE (i.e., ability self-concept and expectations for success) and STV (i.e., interest and utility value). We added three additional items on OOS experiences, academic plans, and career aspirations in the five areas as further indicators of STV. Based on Eccles' theoretical constructs, we also asked about identification with parents, beliefs about parent attitudes toward different 21st century subject areas, and beliefs about boys' versus girls' aptitudes for different subjects and skills.

We also added a section on OOS STEM activities, including frequency of participation in these activities, enjoyment of these activities, and with whom they participated in the activities, including reading, watching television, playing games, doing hands-on activities, participating in clubs or programs, and visiting places to learn about STEM topics. We had initially intended to collect very detailed information about these activities from parents and guardians, but in light of the likely poorer response rates from parents than from students, we chose to simplify the questions so students could answer them, minimizing the problem of missing data on this important construct.

- In addition to the piloting described above, we further refined the student instrument during larger-scale survey administration. During Wave 1, we found the survey section about OOS STEM activities was quite lengthy and cumbersome, leading to student test fatigue. We conducted descriptive and psychometric analyses on the Wave 1 student survey data to determine which items performed best: Descriptive statistics on mean, range, distribution, and missing responses were used to determine whether there was adequate variability in responses and whether any items appeared to be confusing to students.

- Cronbach's alphas assessed the internal consistency of related items, or how well each item hung together with the rest.
- Correlational analyses measured the strength of the relationship of OOS STEM items to items that were theoretically related; for example, attitudes toward different school subjects.

Consequently, we were able to shorten that section of the survey while retaining the best-performing items starting in Wave 2. Based on these analyses, we revised the OOS STEM activities items as follows:

- We changed two of the six activities (playing computer games, participating in clubs or programs) to yes/no questions because there was inadequate variability in responses to the frequency items. For these items, we deleted the enjoyment and co-participant items.
- For the remaining activities, we deleted the enjoyment items because responses were highly redundant with frequency responses, and frequency responses were more strongly correlated with theoretically related items.
- We rearranged items, moving yes/no questions to the beginning and grouping items by type of question (e.g., frequency, co-participants) rather than by type of activity.
- These changes reduced this section of the survey from four pages to one and a half and shortened survey administration by 10+ minutes.

No additional revisions of note were made to the student survey following Wave 2, so the same instrument was carried forward and used in Wave 3.

Student Interview

We developed an open-ended interview protocol to collect richer information from a subsample of surveyed students on some of the key constructs of the E-V model, including the interest, attainment, and utility values of different school areas and the positive and negative aspects of different activity choices as well as the opportunity costs of those choices. The same interview protocol was used in Waves 1 and 2 of data collection.

Prior to Wave 3, we revised the interview protocol to better examine the causes of change over time. A key focus was using the results of Wave 1-3 surveys to inform deeper, more probing questions about why students' beliefs, expectations, and aspirations might have developed as they did. Interviewers presented student interviewees with their prior survey responses and asked them to reflect on why their beliefs about certain school areas changed or stayed the same.

In addition to those relevant to the E/V framework, new questions were added that were inspired by emerging research on science identity theory. These included items like, "Has anyone ever told you that you are especially good at a certain school subject?" seeking to tease out factors relevant to student self-identity.

Finally, we added questions probing more deeply into the influences on students' job aspirations, including whether they had a role model with that job, knew what is involved in the job, or knew what types of classes and education are required to obtain the job. The revised Wave 3 student interview protocol is in Appendix B.

Parent Survey

The parent survey was parallel to the student survey in that it asked substantively similar questions to the student survey; however, the primary focus was on their child(ren)'s BEAs regarding various school areas. There were also a few questions about the parents' own beliefs. All items were intentionally worded similarly to allow for comparisons between parent and student responses (see Appendix C). As noted above, parent surveys were translated into Spanish, Portuguese, and Haitian Creole based on the demographics of the M-LEAP schools. The English version of the parent survey included instructions in all three other languages for parents to request a translated survey.

Teacher Survey

The primary task for teachers was to rate each of their students' interest and aptitude in the five areas. For older students who had separate classes for different subjects, the subject teacher rated students only in the subject they taught, as well as in computers and teamwork (e.g., science teachers rated students on science, computers, and teamwork; English teachers rated students on reading/ELA, computers, and teamwork). The survey also asked teachers about their own knowledge and enjoyment of the different subjects and their beliefs about boys' versus girls' aptitudes for different subjects (see Appendix D).

Science Specialist Interview

The Principal Investigator conducted semi-structured interviews with 13 school science specialists (or lead science teachers) and district-level science coordinators (see Appendix E) representing seven of the eight schools. These interviews provided context for the formal science offerings within each school district, as well as informal science offerings in the community. Coordinators shared information on types of curriculum used, PD for teachers in STEM subjects, relationships with local informal science institutions (ISIs), and types of informal STEM activities in which students from their school engaged outside of regular school hours, either at their school or in a community setting. These data were used to create the school/community vignettes in Chapter 4, which precede the Results in Chapters 5 and 6.

Community Scans

Data collected from students, parents, and science coordinators gave us a sense of what kinds of OOS STEM activities students participated in. As a complement to this, we wanted to make sure we understood what was *available* in the community, not just what was *accessed* by students. Thus, the research team also conducted web-based community scans collecting information on a wide range of informal, OOS science programmatic offerings available to students within the eight communities. Data from the community scans are integrated into the school vignettes.

PROCEDURES

Due to the diversity of the eight schools and school districts in our sample, the M-LEAP research team developed extensive procedures driven by the unique requirements for research set by each participating district. Each year, we met with the eight principals to iron out logistics and set dates for data collection. We developed tracking forms, which we used to collect information about the numbers of students and teachers per grade level for each school as well as other information necessary for planning.

The M-LEAP project team members conducted in-person training for all GRG staff and field researchers prior to Wave 1 data collection, with annual training and updates for both new and veteran researchers assisting the project.

Our grant award was 1 March 2010 and Wave 1 of data collection took place between February and July 2011 due to the extensive lead time needed to recruit the schools, develop the instruments, have the instruments translated, obtain final IRB approval, and set up data collection. Therefore, Wave 1 data collection occurred in Grant Year 2, Wave 2 data collection spilled over into Grant Year 3, and Wave 3 data collection and analysis continued for several months after the end of the grant period.

To have comparable data across waves, we collected data at the same time each year, with the Wave 1 data collection extending a few extra months:

- Grant Year 1 (03/01/10-02/28/): Wave 1 (grades 3-6): 02/11-07/11
- Grant Year 2 (03/01/11-02/29/12): Wave 2 (grades 4-7): 02/12-05/12
- Grant Year 3 (03/01/12-02/28/13): Wave 3 (grades 5-8): 02/13-05/13

Survey Data Collection

Student survey data collection took place over nine weeks in Wave 1 and over six weeks in Waves 2 and 3. To avoid interfering with the MCAS, the biannual Massachusetts statewide test administered in March and May, we aimed to collect data in schools in February or early March each year.

Wave1 Data Collection (Spring 2011)

For each school, we set up a date and an alternate date. In Wave 1, several winter storms affected data collection both in terms of needing to reschedule for snow days and in high levels of absenteeism due to inclement weather. In Wave 1, due to multiple postponements, we ran up against the May administration of MCAS; therefore, Wave 1 data collection took longer than in the subsequent waves.

We offered incentives at multiple institutional levels within schools to boost the parental consent return rate. Principals chose between individual and/or classroom-level incentives. The individual incentive was a colorful stick eraser for each child whose parent returned a completed form. The classroom incentive was pizza parties for the rooms with the greatest consent return rates.

In addition, we attended several parent events at schools with low return rates to inform parents about the study, and at one school, we used school telephones to make calls to parents. In virtually every instance, when parents were given the forms and the study explained to them directly in person or by phone, they consented for their children to participate.

Each school requested that surveys be administered slightly differently. In most cases, all classrooms in one or two grade levels took the survey at the same time in their regular classrooms. (At schools with looping, we surveyed students from the two grades together.) At two schools,[1] because parental consent rates were very low, those students with parental consent were taken from their classrooms to the cafeteria or the auditorium to take the survey. Because our Wave 1 sample included 3rd-6th graders, the researchers recited each question and response anchor on the survey orally, as students read along, in order to maximize comprehension.

In Wave 1, parent and teacher survey administration occurred later in the spring. We maximized parental response rates by allowing them to choose the most convenient method — online or paper — for completing the survey. Principals sent reminders in the formats they had found to be most effective (e.g., emails, newsletters, and mass calling systems such as ConnectED). We provided sample scripts to the principals for each type of communication.

Obtaining responses from teachers and parents proved a challenge during Wave 1. We sent multiple postcard and email reminders to parents and teachers as well as sending new copies of the surveys. Response rates from both groups were somewhat lower than we had hoped, so we continued to solicit and accept parent and teacher surveys beyond the end of the school year.

Wave 2 Data Collection (Spring 2012)

One school dropped out of our study after Wave 1 due to internal school issues. It had been the largest participating school, but was also one of the two schools described above with unusually low parent consent rates. For Wave 2, we recruited a replacement school similar to the dropout school in its urbanicity, SES, and geographic location; this school remained in the study in Wave 3. Fortunately, our chosen analytical technique, hierarchical linear modeling (HLM), can accommodate the missing Wave 1 data at the replacement school.[2] Similarly, HLM leverages all the data that are available, even when students, parents, and/or teachers miss one or more waves of data collection.

Based on our Wave 1 experience, we streamlined and refined our Wave 2 and 3 data collection procedures. Importantly, we obtained IRB approval of passive rather than active parental consent procedures. Thus, parents received a letter explaining the study, but did not need to take action unless they wanted to opt their child out. Six schools used the passive consent process in Waves 2 and 3. One large urban school was not permitted by their district to use passive consent procedures, which led to continued low consent return rates for this school. A second school also required active consent, but this school had very high consent return rates in all three waves.

To raise the visibility of the research study, we distributed tokens of appreciation prior to Wave 2 data collection. All students and teachers in grades 4-7 at each school received a pencil with the M-LEAP logo and a magnet picture frame with M-LEAP and GRG logos and contact information. Pencils and magnets were bundled for each classroom, accompanied by a note for the teacher explaining our upcoming data collection procedures. These small gifts proved quite popular, with magnets on display

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[1] One of these schools dropped out of the study after Wave 1.
[2] Note that data from the dropout school were not included in any of our analyses due to the extremely low student participation rate, indicating a strong likelihood of bias in that sample.
[3] This was related to the very low student participation rate. The few parents who actually returned a consent form for their children to take the survey were correspondingly likely to also fill out the parent
[2] Note that data from the dropout school were not included in any of our analyses due to the extremely low student participation rate, indicating a strong likelihood of bias in that sample.

on lockers and in classrooms. Along with the gifts, teachers also received parental consent forms to send home in student backpacks.

In seven of the eight schools, student surveys were administered in February 2012. These schools were quite cooperative in reminding teachers and parents of the study via emails and automated telephone messages. For the eighth school, which was the urban active-consent school, we planned survey administration for March in order to allow more time to gather parent consent forms.

One of the streamlining mechanisms in Wave 2 was to roll out all three surveys — student, teacher, and parent — at once, bringing all materials to the school on their administration date. We collected all completed student surveys and as many completed teacher surveys as possible before leaving the school, leaving postage-paid return envelopes for teachers who needed more time. We also distributed parent surveys and return envelopes to be sent home in student backpacks. This streamlined procedure was designed to minimize the burden on the schools and result in better adult response rates, particularly from teachers, who would not be burdened with surveys at the always-busy end of the school year. This procedure also minimized postage costs as well as staff and field researcher hours.

As with Wave 1, the researchers administering the survey during Wave 2 recited each item and response anchor orally to grades 4, 5, and 6 to maximize student comprehension; 7th graders read the surveys to themselves.

Wave 3 Data Collection (Spring 2013)

While we made enormous strides in streamlining and refining data collection procedures in Wave 2, we continued to refine our procedures for Wave 3. We asked principals for data collection dates earlier in the school year to increase efficiency as well as allow sufficient time to follow up with non-responsive teachers and parents. We also used a more efficient and streamlined process for ordering, preparing, and packing materials.

In Wave 3, we stepped up our efforts to gain parental permission for student participation at the two active-consent schools. In November 2012, we made a presentation to the faculty at the large active-consent urban school to enlist support for the study. We also distributed consent forms directly to parents rather than relying on students to bring them home, and we distributed the forms much earlier than in the past two years, allowing more time for redistributions and reminders.

In Wave 3, because the students were in middle and upper-middle grades, survey administration did not require verbatim reading of the entire survey. Instead, in grades 5-6, one researcher read some questions aloud in order to pace the students, while a second researcher circulated to answer student questions. In grades 7-8, students self-administered the survey, with one researcher circulating to answer questions.

Student Interview Data Collection

In-person student interviews took place toward the end of each school year. Students were selected for interview based on their survey responses. During Waves 1 and 2, we selected four students in each grade level: one boy and one girl with very positive attitudes toward STEM subjects (science, math, and computers) and one boy and one girl with very negative attitudes toward STEM areas. This allowed for up to 16 interviews per school.

For Wave 3 data collection, we modified our recruitment strategy for the student interviews, targeting a slightly different subsample of students and allowing for up to 20 interviews per school. As with Waves 1 and 2, student survey responses informed interviewee selection. However, rather than selecting students with positive or negative attitudes toward STEM areas, we selected students from three target groups, as described earlier:

1. Those who sustained highly positive attitudes toward STEM areas across at least two years of data collection ("high-STEM"),
2. Those who sustained high self-ratings across the board in all areas ("high in all subjects"), and
3. Those who exhibited change over time in attitudes toward STEM areas, especially those who gained or became more positive ("STEM changers").

Selected students in each of these three groups were distributed as evenly as possible by gender and grade, with preference given to older students, and, where possible, those who had been interviewed during at least one previous wave of data collection.

In all three waves, pairs of researchers spent a half-day at each school conducting interviews. In the smallest school, which only had one classroom per grade level, there were not enough students to fill each of the four required slots described above, so only 11 interviews were conducted in Waves 1 and 2. In other schools, we were unable to reach the maximum of 16 interviews due to student absences. In a few cases in Wave 1, parents were unreachable, so we could not obtain their consent for the interview.

RESPONSE RATES AND TRENDS OVER THE THREE YEARS

In this section, we present the response rates for students (survey and interview), parents, and teachers. We also briefly comment on some of the trends in response rates and relate them to the procedural adjustments discussed above.

Student Survey Response Rates

As described above, active parental consent was required for all schools during Wave 1, and thus the overall response rate of 40% across the eight schools is not surprising. Once we were able to use passive parental consent in six of the eight schools, response rates rose to 62% in Wave 2 and 73% in Wave 3 (see Exhibit 1-7). Also contributing to the increase in overall response rate was that the Wave 1 dropout school (Marigold) had the lowest response rate (28%), while the school that replaced it (Heybridge) had one of the highest response rates (83% in Waves 2 and 3).

Research team strategies also contributed to increased student response rates in Waves 2 and 3, including:

- Visiting most schools to drop off materials and pick up class rosters,
- Attempting to communicate regularly with administrators, and

- Offering goodwill gestures (e.g., bringing pens, pencils, and magnets; providing administrative staff with coffee gift cards) to obtain principal, staff, teacher, and student buy-in.

Exhibit 1-7: Response Rates for the Student Survey, by School and Year

School Pseudonym	Wave 1			Wave 2			Wave 3		
	Student Surveys	Students in Grades 3-6	Response Rate	Student Surveys	Students in Grades 4-7	Response Rate	Student Surveys	Students in Grades 5-8	Response Rate
Heybridge	–	–	–	178	215	83%	179	216	83%
Prescott	141	366	39%	258	375	69%	309	366	84%
Girton	76	185	41%	153	174	88%	140	204	69%
Marigold	148	524	28%	–	–	–	–	–	–
Davison	105	246	43%	196	258	76%	218	267	82%
Beaufort	50	71	70%	63	68	93%	47	66	71%
Pace	81	173	47%	133	171	78%	129	158	82%
Winship	113	330	34%	78	407	19%	172	412	42%
Allentown	101	147	69%	68	144	47%	133	140	95%
All Schools	**815**	**2042**	**40%**	**1127**	**1812**	**62%**	**1327**	**1829**	**73%**

Student Interviews

In Wave 1, we interviewed 96 students, and in Wave 2, we interviewed 109. In Wave 3, we interviewed 137 students, which was not surprising given our increased target of 20 students per school, rather than 16. The number of interviews conducted per year per school is shown in Exhibit 1-8.

Exhibit 1-8: Number of Student Interviews by Year and School

School Pseudonym	Student Interviews, Wave 1 (N)	Student Interviews, Wave 2 (N)	Student Interviews, Wave 3 (N)	Interviewed at Waves 1 and 2 (N)	Interviewed at Waves 2 and 3 (N)	Interviewed at Waves 1 and 3 (N)	Interviewed at Waves 1, 2 and 3 (N)
Heybridge	–	15	17	0	4	0	0
Prescott	14	16	18	6	1	1	2
Girton	14	15	18	10	0	0	4
Marigold	15	–	–	–	–	–	–
Davison	14	9	18	7	0	2	0
Beaufort	11	9	11	7	1	0	0
Pace	15	16	17	8	4	0	1
Winship	13	13	21	4	2	0	0
Allentown	15	16	17	0	4	0	0
All Schools	**96**	**109**	**137**	**42**	**16**	**3**	**7**

Parent Survey Response Rates

In order not to bias the parent sample in favor of those with regular online access, we distributed paper surveys as well as asking principals to distribute the link to an online version. The overwhelming majority of parent surveys were completed on paper. Parent response rate was calculated by dividing the number of parent surveys by the number of corresponding student surveys (see Exhibit 1-9).

In Wave 1, the parent response rate was 67% (it included the large school that dropped out and that had a fairly high parent response rate[3]). In Wave 2, parent response decreased to 36%, which we attributed at least partly to passive parental consent: the number of students participating increased sharply due to passive consent procedures, while the number of parents completing surveys did not necessarily rise commensurately. We followed school practice and sent surveys and reminders to parents via student backpacks rather than mailing them home. For Wave 3, we mailed parents multiple surveys and reminders via U.S. post rather than sending them in student backpacks in order to boost response rates; unfortunately, parent response rates dropped yet again to 23%, influenced heavily by passive consent and by the very low response rate for one of our active consent schools.

Exhibit 1-9: Response Rates for the Parent Survey, by School and Year

	Wave 1				Wave 2				Wave 3			
School Pseudonym	**Parent 1**	**Parent 2**	**Student Surveys**	**Response Rate**	**Parent 1**	**Parent 2**	**Student Surveys**	**Response Rate**	**Parent 1**	**Parent 2**	**Student Surveys**	**Response Rate**
Heybridge	–	–	–	–	55	14	171	31%	29	7	179	16%
Prescott	87	30	141	62%	99	39	258	38%	77	38	309	25%
Girton	48	17	76	63%	25	9	153	16%	28	11	140	20%
Marigold	104	9	148	70%	–	–	–	–	–	–	–	–
Davison	98	28	105	93%	99	29	196	50%	56	28	218	26%
Beaufort	41	5	50	82%	19	8	30	63%	18	8	47	38%
Pace	61	21	81	75%	41	17	133	31%	38	14	129	29%
Winship	46	9	113	41%	12	2	78	15%	16	4	172	9%
Allentown	63	11	101	62%	53	18	68	78%	40	19	133	30%
All Schools	**548**	**130**	**815**	**67%**	**403**	**136**	**1127**	**36%**	**302**	**129**	**1327**	**23%**

RR = Parent survey from at least one parent
Note: For the purposes of calculating response rates, we only include the first parent to rate the student. Some students were rated by two parents, but we cannot assume that every student has two parents available to complete a survey.

[3] This was related to the very low student participation rate. The few parents who actually returned a consent form for their children to take the survey were correspondingly likely to also fill out the parent survey.

In Wave 1, 29% of parents who completed a survey did so for more than one student. In Wave 2, this figure was 25%, and in Wave 3, it was 19%. In most cases, Parent 1 was a mother and Parent 2 was a father.

Teacher Response Rates

At each wave, teachers received a $40 stipend in appreciation for their filling out the survey and student rating form. Response rates for teachers increased substantially from Wave 1 (59%) to Wave 2 (78%) because at Wave 2, teachers were asked to complete surveys and rating forms while we were administering the student survey in their classrooms; at least half did so. The response rate for teachers in Wave 3 dropped somewhat to 64% due to a 28% response rate at the largest school in our sample, Winship. Response rates across all three years are shown in Exhibit 1-10.

Exhibit 1-10: Response Rates for the Teacher Survey, by School and Year

	Wave 1			Wave 2			Wave 3		
School Pseudonym	**Teacher Surveys**	**Teachers, Grades 3-6**	**Response Rate**	**Teacher Surveys**	**Teachers, Grades 4-7**	**Response Rate**	**Teacher Surveys**	**Teachers, grades 5-8**	**Response Rate**
Heybridge	–	–	–	10	11	91%	5	5	100%
Prescott	11	16	69%	13	17	76%	10	13	77%
Girton	9	13	69%	8	8	100%	5	7	71%
Marigold	9	25	36%	–	–	–	–	–	–
Davison	7	12	58%	12	12	100%	11	12	92%
Beaufort	5	6	83%	5	7	71%	3	5	60%
Pace	6	7	86%	11	13	85%	7	8	88%
Winship	11	22	50%	9	20	45%	8	29	28%
Allentown	7	9	78%	7	8	88%	7	8	88%
All Schools	**65**	**110**	**59%**	**75**	**96**	**78%**	**56**	**87**	**64%**

DATA ANALYSIS PLAN

The design of this study is an accelerated longitudinal design. We initially sampled students in grades 3-6 and followed this cohort in Waves 2 and 3 until the original 3rd graders had reached 5th grade and the original 6th graders had reached 8th grade, as shown in Exhibit 1-11 below.

Exhibit 1-11: M-LEAP Cohort Grades Included in Each Wave

	Wave 1	Wave 2	Wave 3
3rd graders	✓		
4th graders	✓	✓	
5th graders	✓	✓	✓
6th graders	✓	✓	✓
7th graders		✓	✓
8th graders			✓

Thus, there were three years' worth of data from 5th and 6th graders and two years' worth from 4th and 7th graders. The "extra" students in the middle grades allow us to estimate the trajectories of students with greater precision. Our modeling strategy (described below) also allows us to estimate a continuous trajectory from 3rd to 8th grade even though no students in the study participated across that entire range of grades.

HLM Models

Our analytic model is a longitudinal growth model using multilevel modeling (MLM, also known as hierarchical linear modeling, or HLM). This approach, derived from MLM, initially developed to study individuals clustered within groups, views time points as clustered within individuals. Thus, it is flexible and accommodates all individuals regardless of the number of time points available for any given individual. Because each individual is given a best-fitting trajectory for the time points actually observed, no individual need be observed on all time points, in this case grades.

Our models use grade to represent time, so, for example, all 4th to 5th grade trajectories are treated as aligned and equivalent. On the other hand, we include in our model a variable representing cohort, or the age at which students entered the study. This accommodates any differences that might exist between cohorts that might be related to such things as changes in school programs or policies or outside events that would affect one group of age-mates (or some groups of age-mates), but not others.

We employ two types of MLMs in our analyses. The first is the more common linear model, or HLM. These models are used with our six continuous outcome variables: SE and STV for the three STEM areas, science, math, and computers. Such models reveal intuitive changes in the outcome associated with unit changes in predictor variables in exactly the same manner as traditional linear regression models.

Our models include several types of predictors. First are predictors of individual intercepts. These predictors are time-invariant, either characteristics that do not change over time, such as gender, or the averages across available time points of time-varying characteristics measured on each student or reported by the parent or teacher, such as frequency of OOS STEM activities or parent and teacher ratings of student proficiency in a area. Predictors of the intercept provide information about how students differ from one another in ways that remain constant over time or on average; for example, what time-invariant or average variables predict which students have the highest ratings of science STV overall?

The second group of predictors are predictors of slope. This group is also time-invariant, and in fact draws upon the same set of predictors described above as predictors of individual intercepts. These tell us which of the time-invariant or average characteristics of a student predict a tendency to increase or decrease on an outcome, such as computer SE, over the course of the study.

Finally, our model includes time-varying predictors. These are simultaneous observations of predictor and outcome. Because these are related to the variables described above that have average values predicting the intercept and slope, the average values of these predictors have been subtracted from their values at each time point, or centered. Thus, they tell us about how each student changes over time. A relationship between a time-varying predictor, such as parental endorsement of stereotypes about STEM, and an outcome, such as math SE, shows how changes in predictors can translate directly to changes in an outcome.

Our second type of model is used to predict the more distal job aspirations outcome, in which students' desired jobs were coded as STEM, allied health, and non-STEM. This outcome is also observed over time, but cannot be captured as a linear trend because it is categorical. So instead of a linear model, we use a hierarchical generalized linear model (HGLM) — specifically, multinomial logistic regression — in which we estimate the odds of desiring a STEM vs. a non-STEM job and the odds of desiring an allied health vs. a non-STEM job. This analysis used the same predictors as the linear models discussed above. A key difference is that, as noted, the model consists of two sets of linked equations, each estimating the odds of choosing STEM over non-STEM or allied health over non-STEM.

Finally, the students in this study are clustered within schools, exactly the sort of situation MLM was originally developed to address. However, the number of schools in this study, eight, is below the commonly accepted number for unbiased estimation as a level, so this clustering was addressed by another means. Specifically, both the intercept and the slope were predicted by a bank of seven (N of schools–1) dummy variables representing the school attended. This adjusts for differences between the schools with regard to outcomes and change.

In order to make the best use of all available data, all missing data at a time point was addressed by multiple imputation. Multiple imputation works under the assumption of data missing at random (MAR). Under this assumption, available data are informative about the missing data and are used to estimate a plausible value for the missing observation. Because the plausible value is not as reliable as actual observed values, an error term is added to the estimated value. The addition of the error is repeated multiple times, and multiple data sets are created. Multiple imputation has been shown to be less biasing than complete case analysis (listwise deletion). In our case, for each analysis we created ten imputed data sets.

Predictors of Interest

Models for all outcomes included the primary predictor of student gender as well as a variable representing student minority status. We were also interested in the relationships linking the following variables to our intermediate outcomes of STEM SE and STV and our more distal outcome of job aspirations:

- Frequency of participation in STEM-related OOS activities,
- Identifying a STEM area as one's first or second favorite class, and
- Endorsement of boy-favoring stereotypes about STEM areas.

Models also included students' own beliefs (SE and STV) about the subject being predicted and their estimation of the importance the primary adult in their lives assigns to that subject. Models also included teacher ratings of student proficiency in the relevant subject. Finally, parents provided data on:

- Their own proficiency in the area,
- Their beliefs about the subject's area,
- Their rating of their child's proficiency in the area,
- Their endorsement of boy-favoring stereotypes about STEM areas, and
- Whether they held a STEM job (included allied health professions).

Additionally, to determine whether parents' endorsement of boy-favoring stereotypes about STEM areas had a differential impact on girls and on boys, we tested the interaction between student gender and parental stereotype endorsement. Further, to learn more about whether the strength of the relationship between beliefs and outcomes differed for girls and for boys, we also tested the intereaction between student gender and their own ratings of SE and/or STV for the relevant area.

Finally, as noted above, the time variable was represented by the student's grade (or age) at the time each year's data were provided, and covariates included a set of dummy variables representing the student's school along with the student's cohort, defined as the grade at which the student entered the study.

PROJECT MONITORING

External Monitoring/Evaluation

As required by NSF, GRG employed the services of an external monitor/evaluator. Cynthia Char of Char Associates of Montpelier, VT served as our monitor/evaluator for the duration of the project. We were in regular communication with her 4-9 times/year through teleconference and in-person meetings with GRG project staff. She provided feedback on all measures and all phases of the research. She provided annual monitoring reports that were included in our reporting to NSF. (See Appendix F for her Final Project Monitoring Report.)

External Institutional Review Board

GRG applied to and obtained approval from an independent Institutional Review Board (IRB), the New England IRB (NEIRB). The purpose of the IRB is to ensure human subjects are protected during the course of the research. Annually, the research protocol, consent forms, and instruments were sent to NEIRB for approval. In addition, two of the school districts in which we collected data have their own IRB or Testing, Research, and Evaluation Committee. Therefore, we completed and submitted their application forms as well. Finally, we received an audit site visit by NEIRB in summer 2011, a routine process.

After Wave 1, we sought supplemental NEIRB approval to allow passive parental consent for student survey administration, providing the rationale for changing the parent consent process from active to passive. During Wave 1, we encountered substantial difficulties in getting parents to return consent forms in all of the schools, but particularly the lower-income schools. This was despite going to extraordinary lengths to obtain a better consent return rate.

Further, principals found the active consent procedure to be a substantial strain on teachers and administrative staff. We successfully argued that passive consent procedures would be much fairer to the population of parents in several of the schools in our sample, as well as to staff and teachers in all the schools. Ironically, the one school for which passive consent would have made the most difference was not permitted by their district's research office to use it. In that school and a second school, we were still required to obtain active, written parent consent for student data collection.

In Fall 2012, prior to Wave 3, we also sought approval from NEIRB to offer incentives at the two active-consent schools to all students returning completed parental consent forms (regardless of whether the form granted or denied permission). We obtained approval to provide a nominal incentive to each student returning a completed consent form. The Winship principal approved a $1 incentive, while the Allentown principal approved an incentive of a small gift of a school supply worth about

$1. Even with incentives, we still faced significant challenges increasing participation in Winship, the large urban school, and the budget did not allow for incentives to parents for completing their surveys.

NEIRB also granted approval for us to collect Wave 3 contact information from students and parents in anticipation of potentially receiving future funds for a follow-up to the M-LEAP project. They also approved adding a question to the student survey about household composition and the alterations to our Wave 3 student interview protocol discussed above.

CHAPTER 4: THE SCHOOLS AND COMMUNITIES

This chapter contains vignettes describing each school and its community in order to provide a context in which to read the study's results. The data for the vignettes come from interviews with district science specialists, lead science teachers in the schools, and web-based information provided by the municipalities and informal STEM education institutions nearby. Exhibit 4-1 is an overview, comparing science resources, curriculum, and activities in the eight schools and communities.

Exhibit 4-1: Overview of Science Offerings In and Out of School for Each School

	Heybridge	Prescott	Girton	Davison	Beaufort	Pace	Winship[a]	Allentown
Access to Technology								
Computer lab	✓	✓	✓	✓	✓	✓		✓
Tech cart (laptops/tablets)		✓	✓			✓		✓
WiFi	✓	✓		✓	✓	✓		✓
Teacher Professional Development (PD)								
STEM-specific PD supported by district	✓	✓		✓	✓	✓		
Teaching Science								
Dedicated science classes in elementary school	✓	✓	✓		✓	✓		
3-5 classroom teacher	✓	✓	✓[b]	✓	✓	✓[c]		✓[b]
6-8 dedicated subject teacher	✓	✓	✓	✓	✓	✓		✓
Block scheduling			✓	✓[d]				✓
Science Curriculum								
Commercial-based	✓		✓					
Teacher-designed		✓		✓	✓	✓		✓
District waiting on new MA science standards	✓	✓	✓					
Dedicated technical education classes offered		✓		✓	✓			✓
Out-of-Classroom, School-Based Science Offerings								
Science fairs/events		✓	✓	✓				
Field trips	✓	✓	✓	✓	✓	✓		✓
Established relationship(s) with ISIs	✓	✓	✓	✓	✓	✓		✓
Out-of-School Offerings								
Afterschool STEM-related clubs	✓	✓	✓	✓	✓	✓		✓
Girl-specific programs	✓			✓				

[a]We were unable to interview the school or district-level science coordinator for the Winship School.
[b]The Girton School and the Allentown School have general classroom teachers for grades 3 and 4. Students switch between a math/science teacher and an ELA/social studies teacher in grades 5 and 6. Students in grades 7 and 8 have dedicated specialists.
[c]The Pace School has general classroom teachers for grades 3-6. Grades 7 and 8 have classes taught by dedicated specialists.
[d]The Davison School offers block scheduling on demand, i.e., if an experiment or other in-class project will take more than the usual allotted time, teachers will collaborate with each other to reschedule classes.

SCIENCE CURRICULUM, RESOURCES, AND ACTIVITIES ACROSS THE SCHOOLS

All of the schools in our study have made some effort to integrate technology into their lesson plans, some with more success than others. All eight of the schools in our study housed computer labs, though the extent to which they were used varied widely. Of the seven schools where we were able to collect this information, five have fairly reliable WiFi connectivity and the two that do not are hardwired to the Internet. Five of the seven schools provide teachers with STEM-specific PD training. Just two of the seven schools have dedicated daily science classes in elementary school; the five others vary between incorporating science principles into other lessons and switching every other day, weekly, or biweekly to another discipline, generally social studies.

All eight of the schools in our study have separate class structures for science instruction in elementary and middle school, e.g., all subjects, including science, taught by a classroom teacher in elementary school versus taught by individual subject specialists in middle school. Most schools define elementary as grades K-5 and middle as grades 6-8, though that definition varies somewhat among the schools surveyed. Another exception to this general rule is science classes for 5th and 6th graders at the Girton and Allentown Schools. Students at these schools switch between one teacher for math and science classes and another for ELA and social studies classes. About half of the schools we studied have block scheduling, much of it dictated by ELA minimum time requirements.

Most of the schools do not have a formal, integrated published science curriculum across the grades, and most do not use textbooks with all their students. The curricula are designed or heavily supplemented by the teachers themselves, as opposed to being provided by the district. Four of seven schools reported waiting for the state to release the new Massachusetts science standards before investing much time or money in developing or purchasing an updated curriculum.

Half of the surveyed schools offer a dedicated technical education class, either as part of the core curriculum or as a special subject; the other half either incorporate technical education (engineering) into their standard science curriculum or do not address it at all.

Only two of the schools surveyed offer science fairs for students. All eight of the schools take their students on field trips, but the frequency and distance of travel varies immensely between the schools. Additionally, all eight schools have some sort of relationship with ISIs but, again, this varies greatly between the schools. All of the schools offer some sort of afterschool STEM-themed clubs or activities, though it is minimal in most schools. Only two of the schools provide or have access to informal science programming targeted specifically to girls.

VIGNETTE: HEYBRIDGE[4]

Town Characteristics

Heybridge is an incredibly diverse city located just a few miles outside of Boston. Served by the MBTA's local bus, train, and commuter rail services, the city is easily accessible. The city supports many local and small businesses, especially manufacturers, service-oriented companies, and financial institutions. The city's median family income is just over $56,000. Like many New England towns, Heybridge's neighborhoods are often organized around squares that serve as centers of local business and community engagement. The city also has an extensive public park system and supports youth sports and community activities. It is governed by a mayor and city council, while education policy is determined by an elected school board.

School & District Characteristics

The Heybridge School is located within the city's public school district. The district operates seven schools, including a citywide preschool program, five K-8 schools within each of the city's neighborhoods, and one comprehensive high school that serves the entire city. Students come from socioeconomically and ethnically diverse backgrounds. The Heybridge School is 19.9% African American, 8.5% Asian, 23.8% Hispanic, and 43.3% White. Some 30.1% of its students do not speak English as a first language, and 8.3% have limited English proficiency. 19% of its students are enrolled in special education programs, and 48.4% receive free or reduced-price lunch. The percentage of students scoring proficient or higher on the MCAS exams at the Heybridge School is consistently well below the state average in all three subject areas, with the exception of 8th grade math and ELA scores, which are on par with the state averages.

Technology is incorporated into many aspects of education at the Heybridge School. Teachers and students have access to two computer labs, one intended for elementary students and one better equipped to accommodate middle school students. There are also computers for student use in the library and plans to put WiFi in place during the 2013-14 school year. All of the school's math classes have SMART boards.

There is an increasing effort to incorporate STEM-based PD within the district, especially among elementary and middle school teachers. PD is provided to teachers as part of collaboration among five school districts in the region. Focus is placed much more heavily on math than on science or other STEM fields. Despite that, teachers can receive payment for attending science trainings over the summer.

Curriculum

Lesson plans are built around the state education standards by the teachers, often in teams. The Heybridge School and the district are waiting on the issuance of the new state science standards before making a significant investment of time or money in developing new science curricula.

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[4] In order to protect the confidentiality of the participating schools and school districts, we do not cite the community and school profiles from which some of these data came. However, they can be accessed via Massachusetts' Executive Office of Housing and Economic Development Community Profiles and the Massachusetts Department of Elementary and Secondary Education School and District Profiles websites, respectively.

Students in all grades receive 90-120 minutes of ELA-focused education each day, incorporating both reading and writing, and 60-90 minutes of math. In grades 3-5, 30-45 minutes of each day are dedicated to science or social studies. Schools throughout the district have autonomy to switch between the two subjects on a daily, weekly, or biweekly basis. Students in grades 6-8 receive 45-55 minutes of science education each day. Because the No Child Left Behind Act emphasized improving students' math and ELA performance, science took a back seat in the district in order to comply with federal standards.

The district offers Carolina STC kits for elementary students, but many Heybridge teachers do not use them. The district provides pacing and curriculum guides for science in grades 5-8, though the textbooks they accompany are outdated. Teachers supplement the texts with online materials.

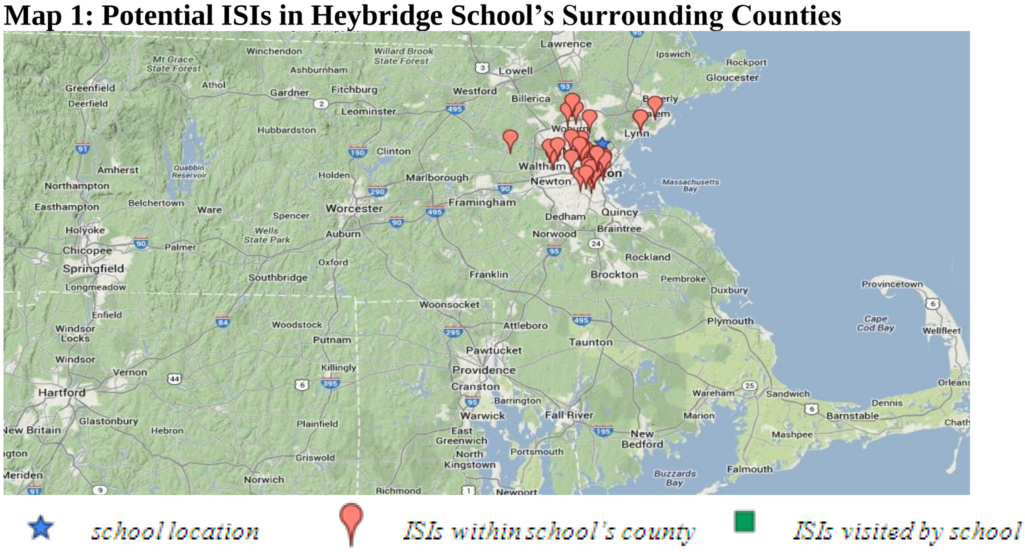
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

Relationships with ISIs are formed on an individual basis. One teacher at the Heybridge School is actively involved with Tufts University and the TERC program and therefore incorporates engineering and technology into lesson plans, while others base their curricula on textbook lessons. The district works with the Museum of Science, Boston, including participating in their Engineering is Elementary program. Students go on field trips to the museum as well as to the New England Aquarium.

Out-of-School (OOS) Offerings

The district sponsors a science night at the high school. This allows high school students enrolled in AP science classes to explain a science activity to middle- and elementary-school students and walk them through the activity at the fair. It has grown in both size and popularity over the past few years. Also, channel-surfing afterschool classes are available for students in grades K-5 and are designed to extend curriculum and content in a fun way. Many of them are science-focused. There are also many OOS activities for students, especially for girls, including "Women in Engineering" programs through local colleges and universities, though these types of programs are typically limited to middle school.

Map 1: Potential ISIs in Heybridge School's Surrounding Counties



VIGNETTE: PRESCOTT

Town Characteristics

Prescott is a relatively affluent town in central Massachusetts. The local economy is largely agriculture-based, with the town's orchards providing some residents their income. Although there is a rural character to the area, with farms and orchards, many who live in this district commute either to Worcester (20 minutes away), the town's nearest city, or further afield to Boston (about a 50-minute drive). Despite a reputation as a bedroom community, there is active community engagement in nature preservation, with several 4-H clubs; a large, annual agricultural fair; and two town-wide conservation groups. Prescott straddles the line between suburban and rural in many ways, with some commercial development in parts of the town. The town is quite homogenous, with more than 97% of its approximately 5,000 residents identifying as White. It is also quite affluent, with a median family income of nearly $109,000.

District & School Characteristics

The Prescott School is part of an affluent regional school district including several towns in addition to the one where the Prescott School is located. It is one of six schools in the district. The Prescott School serves students in grades K-8 and is rather large, with just under 800 students. It is the only K-8 school in the district; two other schools serve students in grades K-5, while two middle schools serve students in grades 6-8. One regional high school, located in Prescott, serves students from all these schools. Despite serving nearly 800 students, the student-to-teacher ratio at the Prescott School is 13.4 to 1. Like the town of Prescott, both the district and the school's student populations are over 90% White. Approximately 5% of students in the district and only 2% of students at Prescott receive free or reduced-price lunch. All of the Prescott School's MCAS scores are consistently well above state averages.

The school is quite resource-rich technology wise. All classroom teachers have their own laptop to use in school, and every room has Internet connectivity, including strong Wi-Fi. There is a large computer lab supported by an instructional technology specialist. There are also over 100 computer tablets for use in the school. Teachers receive PD training to use and integrate these technologies into their classroom activities. PD is provided to the science and math teachers by a technical university and other external PD providers. The district has been waiting until the new state science standards are unveiled before they tackle how the district will implement curricular changes.

In grades 3-5, grade-level teachers teach all subjects (excluding music, math, PE, etc.). Math is taught for an hour daily, whereas science is taught either once or twice a week. At the 5th grade level, the science classes also have a technology education component. In grades 6-8, core subjects are taught for one hour daily, with technology education taught by a separate teacher once a week.

Curriculum

District-wide science curriculum standards exist that each teacher incorporates. Any aligning of district-wide curriculum resources will wait until the new Massachusetts state science standards are addressed. The district has a strong technology component to their curriculum, with many teachers employing SMART boards and using a variety of educational software to support learning. In the middle grades, there is a strong engineering component through their scheduled technology education course. The school is looking to strengthen its engineering offerings in the elementary grades. Computers are used for research and activities rather than just for keyboarding.

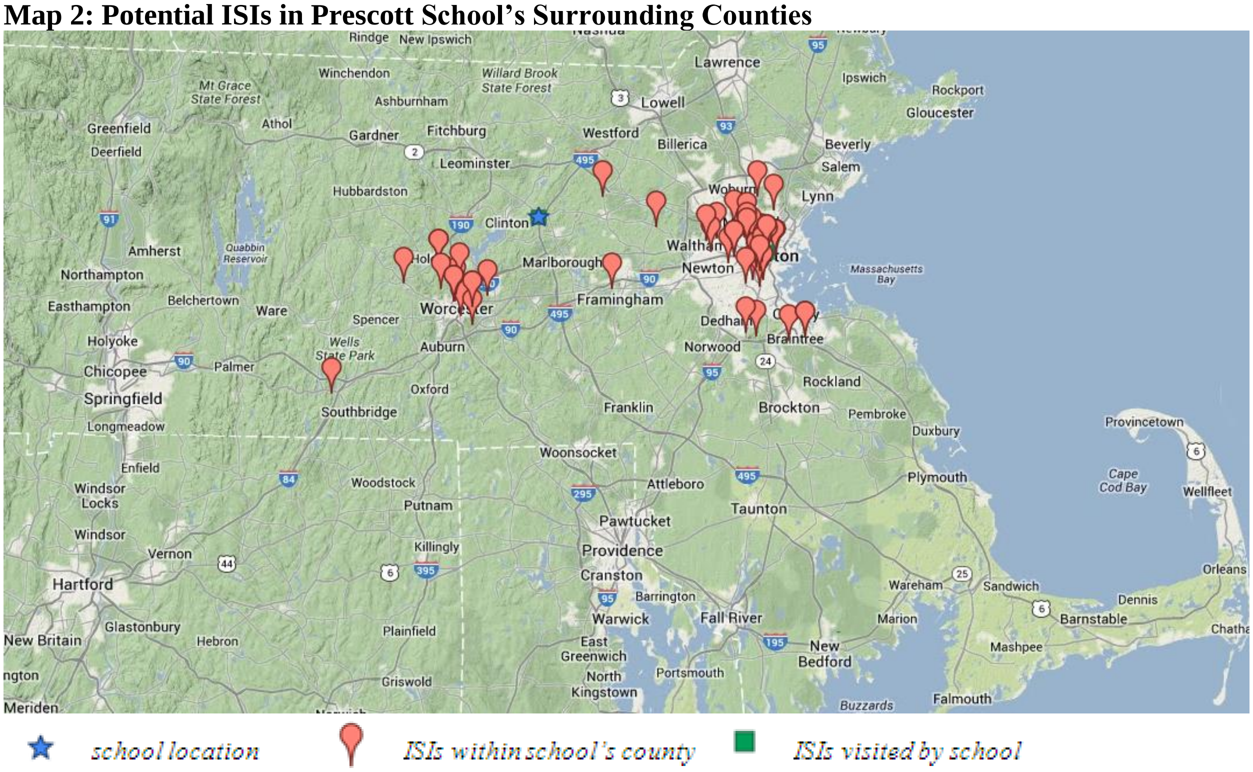
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

The specialist indicated that working with informal science education institutions (ISIs) is an area in which the district wishes to grow. While teachers have individual relationships with certain groups, there is nothing at the district level. However, the district is working with a major science museum to help it develop an action plan for building its STEM curriculum. Additionally, many teachers invite guest speakers to their classrooms to address relevant scientific topics.

Out-of-School (OOS) Offerings

A number of science events take place at the school, with visits from scientists and other STEM specialists. Additionally, there is a district-wide robotics club, and both a science club and a math club at the Prescott School. At the district level, there is a new enrichment coordinator, who is incorporating STEM content into enrichment activities. The district also offers enrichment camps during school vacation weeks for students in grades K-6. The focus for K-3 students is on exploring; this includes topics such as ecosystems and identifying changing flora and fauna when seasons change. For grades 4-6, the focus is more on environmental issues, and the enrichment camp teaches children how to use the environment in a survival situation.

Map 2: Potential ISIs in Prescott School's Surrounding Counties



VIGNETTE: GIRTON

Town Characteristics

Just a few miles from Boston, Girton is an exceptionally socioeconomically and culturally diverse community that has undergone dramatic changes in the past 20 years. Formerly a solidly working class city, parts of the city have experienced a great deal of gentrification since the 1990s. It has a population of over 75,000 people and consists of just over four square miles of land. The city is unofficially divided into several squares that serve as centers of local business and community. It is served by the area's bus, rail and commuter train systems, and many of its professional residents commute to work in Boston and adjacent communities. It is also home to many students, given its wealth of rental opportunities and location near to several universities. The city is governed by a mayor and city council and is supported by police and fire departments.

District & School Characteristics

The Girton School is part of the city's public school system. The district operates 11 schools, including several K-8 schools and a comprehensive high school. Over 50% of students in the district do not speak English as a first language, and just over 15% of students have limited English proficiency. Nearly 70% of the city's students receive free or reduced-price lunch, and its student population is very ethnically diverse. The Girton School itself is similarly diverse.

The percentage of students receiving a score of proficient or higher on the ELA MCAS at the Girton School tends to be slightly lower than the state average in grades 3-6 and significantly lower in grade 7. Math MCAS scores in grades 3-7 are comparable to state averages, while grade 5 science MCAS scores are significantly lower. It is worth noting, however, that MCAS scores across all three subject areas in grade 8 are either slightly above (ELA) or significantly above (both math and science) state averages.

For elementary school students (grades K-4), emphasis is placed on reading and mathematics over science. In 5th grade, students switch between two teachers for their core classes: one teacher for math and science, and the other for ELA and social studies. In grades 7-8, each subject area has a dedicated teacher, and students are taught each subject for 1 hour a day, every day. Teachers do not have common planning time in which to collaborate or design interdisciplinary teaching plans.

Technology seems to be embraced at varying levels and is highly dependent on individual teachers for incorporation. The school has laptop carts available for teacher use. The school is also home to two computer labs with approximately 20 computers each, while the library hosts 30 computers. All computers are hardwired, and there is no WiFi available.

Curriculum

There is no special focus on STEM themes at the Girton School, and curriculum is based on the standards for science classes set forth by the Massachusetts Department of Education. This includes topics in earth and planetary sciences as well as physics. Grade 7 science classes emphasize life science, especially cell structure and taxonomy, while grade 8 science emphasize genetics and evolution. The district is waiting for the issuance of new science standards before investing in a curriculum update. Currently, they use districtwide documents for science, based on the Carolina STC kits. Teachers have supplemented these kits with more recent information and various technologies, but this is heavily dependent upon the teacher. Labs occur at least once per week, with six longer projects every year. The structure of teaching at Girton varies greatly by teacher as well, with some placing greater emphasis on lectures and others placing more importance on hands-on experiments.

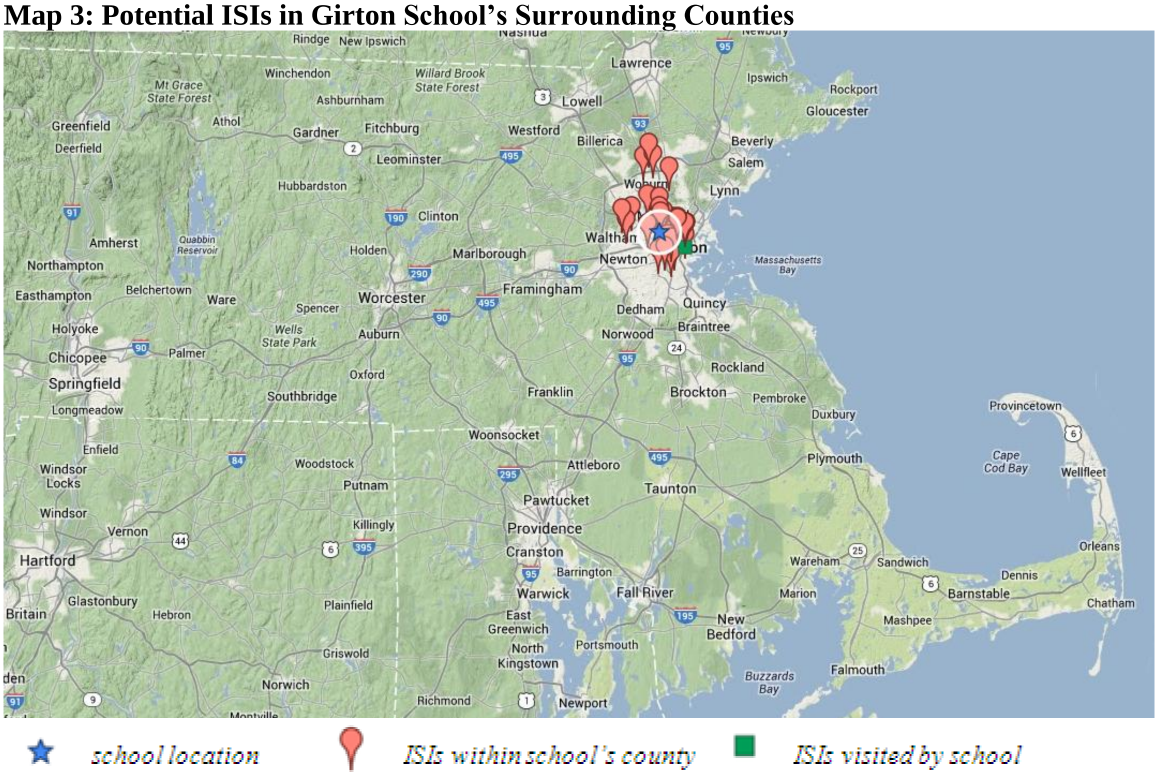
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

Each school in the district, Girton included, hosts a science fair for its students to showcase projects. Girton's science fair is for students in 5th grade. They have a relationship with the Museum of Science, Boston, where 5th grade students visit on field trips. They also maintain strong relationships with Biogen Idec, a biotechnology company that engages its surrounding neighborhoods in science with its community lab programs, located in its research and development facility. The community lab program hosts Girton students two to three times a year in grades 6-8. 7th graders also visit the labs at Electrofereis each year, with a program that is connected to the district's high school, which also sends students to the lab in 9th grade. 7th graders also go on a whale watch as part of their science curriculum.

Out-of-School (OOS) Offerings

Several programs with a STEM focus are offered after school and during the summer. A robotics club is offered for younger students after school, while the social studies teacher leads a scout troop. Many students also take advantage of the partnership with Biogen Idec during the summer after 8th grade to enroll in science programs.

Map 3: Potential ISIs in Girton School's Surrounding Counties



VIGNETTE: DAVISON

Town Characteristics

Located more than an hour outside Boston, Davison prides itself on its integration of modern life with a relatively rural environment. The town is socioeconomically and ethnically homogenous, with more than 95% of its population identifying as White and a median household income of over $90,000 a year. The town operates under the New England town system and is governed by a Board of Selectmen acting as executive arm. Davison is extremely community oriented, with multiple youth and recreational sports leagues organized by the town, as well as numerous community events throughout the year. It is close to many major highway systems, but not directly served by any public transit systems.

District & School Characteristics

The Davison School is part of a regional school district that operates local elementary and middle schools and one larger, regional high school that serves five towns. The Davison School itself is rather homogenous, with 1.9% of its student body identifying as African American, 1.8% as Asian, 4.2% as Hispanic, and 91.7% as White. Just 3.7% of the students do not speak English as a first language, and 1.4% have limited English proficiency. 5.6% of the students at the Davison School receive free or reduced-price lunch.

There is no districtwide standard for science curricula, but most schools offer core curriculum earth science classes in grade 6, life science classes in grade 7, physical science classes in grade 8, and technology courses as a special subject. This is not true, however, of grades 7-8 science at the Davison School, which places a much heavier focus on the integration of math, science, and technology. The Davison School's MCAS scores are consistently much higher than the state average in all three subject areas and across all grade levels.

Collaboration is evident throughout the Davison School's staff. The school's teachers make a special effort to integrate the principles being taught in students' standard math class into their science and technology classes. The district encourages Google docs as a means of collaboration between students, but it does not integrate with STEM fields as neatly as it does with ELA. The school has block scheduling on demand — if teachers design projects or experiments that will take more than their usual allotted time, they can create blocks on an individual classroom basis.

The Davison School is also making a strong effort to integrate technology into their classes. The science and technology classroom has a full set of computers, while the social studies teacher has a full set of iPads. Additionally, there is a computer lab available to classes for educational use for half the day, while the other half of the day is dedicated to teaching students keyboarding skills. The library also has a full set of computers. Most are hardwired, though some have wireless access. Every classroom in grades 6-8 has a SMART board, which students are also allowed to use during lessons.

Curriculum

The science curriculum varies by grade level, but collaboration is a strong focus across grades. Science classes in grades 3-5 are all taught by a general classroom teacher. Students receive math instruction for 60 minutes a day, but science instruction varies widely. In grades 6-8, students have dedicated math, science, and ELA teachers. The Davison School, uniquely in the district, also has dedicated teachers of engineering (also referred to as technology). Students in the district are required to have 60 minutes each of reading and writing instruction daily.

The science curriculum for grade 6 students is divided into science and technology; one teacher instructs students in science and geography and the other in math and technology, primarily drawing. In grades 7-8, students receive 100 minutes of science and technology instruction a day. Textbooks are supplemented by newspaper and scholarly articles and web research. Teachers at the Davison School also make efforts to integrate videos and other media into their teaching.

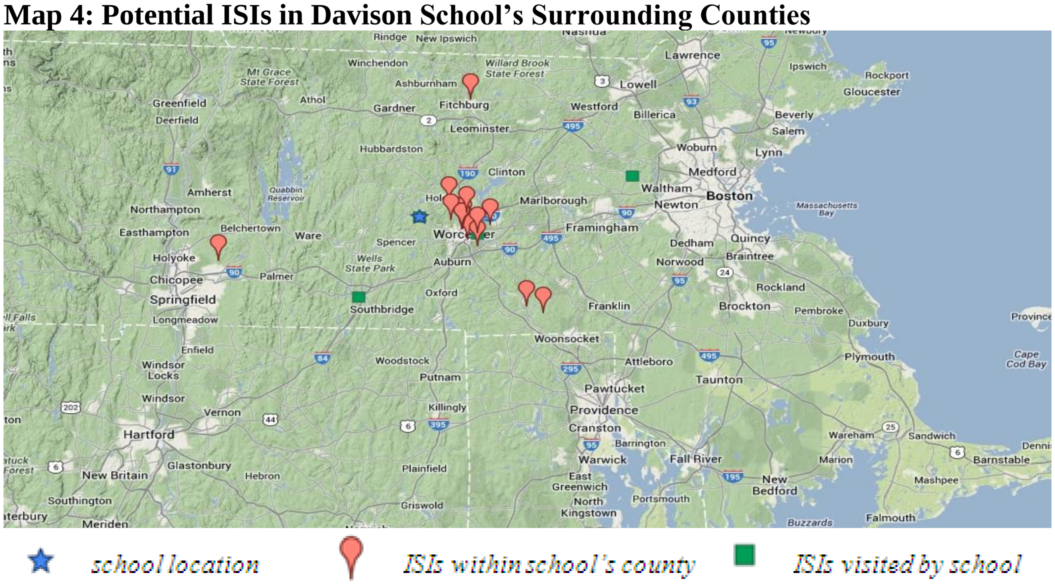
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

The Museum of Science, Boston, brings travelling classrooms for students in grades K-5. The science and technology teachers make a special effort to take students to the pond behind the school during class time for experiments and hands-on learning. Every other year, students go to Plum Island, a barrier island off the coast of Massachusetts, and 5th grade students sometimes visit Nature's Classroom in Maine. They have visited the Museum of Science, Boston and the Ecotarium in Worcester. Students are exposed to guest speakers who have expertise on relevant topics. The district has also established a partnership between local ISIs and universities to seek high-level funding to create a satellite museum center within the district for teacher training.

Out-of-School (OOS) Offerings

The Davison School organizes several STEM-related fairs for its students, with a particular emphasis on middle school students. The programs offered in the district vary widely and are dependent, especially at the elementary and middle school levels, upon PTA or parent involvement. The Davison School offers afterschool programs for both boys and girls interested in STEM-related topics, as well as partnering with the Worcester Polytechnic Institute (WPI) to offer summer programs to students. WPI also offers a program called WPI Girls in Science targeted at fostering interest in STEM fields in young girls.

Map 4: Potential ISIs in Davison School's Surrounding Counties



VIGNETTE: BEAUFORT

Town Characteristics

Beaufort is a small community on the western border of Massachusetts. It is extremely rural, with only 88 people per square mile. The town itself is residential in nature, though a few small commercial enterprises do exist. It operates in a traditional New England town structure and is governed by open town meeting, with a board of selectmen acting as the executive arm. Much of the town falls under zoning and local wetland bylaws, maintaining the rural character of the area. Though there are several large farms and orchards, many people also commute to Pittsfield, the town's nearest metropolitan area. The median family income in Beaufort is $67,036.

District & School Characteristics

The Beaufort School is the only school in the district, and it serves students in grades Pre-K-8. Older students attend several different high schools in neighboring communities. Class sizes are small, with an average of 17 students per class. The Beaufort School, like Beaufort itself, is rather homogenous: 1.3% of the students identify as African American, 1.3% as Asian, 1.3% as Hispanic, and 94.9% as White. 1.3% of the students do not speak English as a first language, but all of the students at the Beaufort School are deemed proficient in English. 17.8% of the student body receives free or reduced-price lunch.

The Beaufort School's MCAS scores have a broad range. In general, the percent of students scoring proficient or higher on the ELA exam is well above the state average, while math scores tend to be comparable with state averages. In grade 5 and 8 science examinations, the scores tend to be well above state averages.

The school does not use block scheduling to organize its classes; however, students in grades 6-8 receive science, math, and ELA instruction every day. The Beaufort School has one computer lab with 20 computers, and teachers have both a laptop and an iPad for classroom use, both of which are complemented by WiFi connectivity. There is also an active PTO that engages in fundraising and event planning, particularly to subsidize field trips.

Curriculum

Science education is specialized for 7th and 8th grade students. Grade 7 science instruction is divided between biology and life sciences and earth and planetary science. Because the Beaufort School is situated near Beaufort's large pond, students are able to use the natural resources there for experiments and on-site lessons. 8th grade students spend half the year studying physics and the other half studying chemistry. Students in grades 5-8 also take separate STEM classes one or two times a week; these classes are very hands on, and students are provided supplementary online resources. There is a heavy focus in these classes on engineering and technology.

Teachers are extremely committed to engaging students in learning. To that end, many teachers make special efforts to include hands-on activities in their instruction, particularly in science classes. Technology plays a large role in this, with teachers showing instructional videos, YouTube clips, and episodes of the popular television show "Mythbusters." Technology has been less integrated into ELA classes, though efforts are being made to increase its use in that setting.

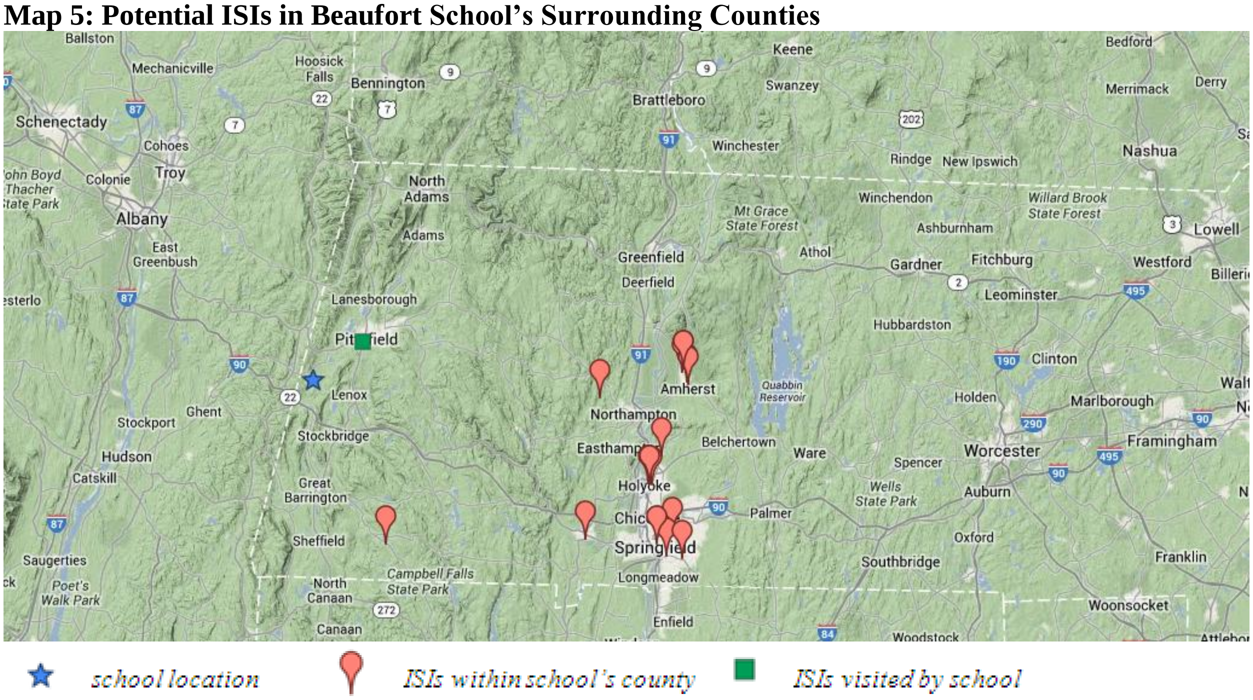
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

Students are able to take advantage of several field trips to museums and other institutions, despite the school's rural nature. Students visit the Berkshire Museum in nearby Pittsfield, and several grades go on extended, overnight trips to the Franklin Institute in Philadelphia and the Nature's Classroom site on Cape Cod.

Out-of-School (OOS) Offerings

Students in grades 4-8 have the opportunity to participate in a robotics club that meets after school. The club consists of 10-12 students and is organized by a parent.

Map 5: Potential ISIs in Beaufort School's Surrounding Counties



VIGNETTE: PACE

Town Characteristics

Pace is located on Massachusetts' North Shore. A former fishing community, this small city has since made a somewhat difficult transition to the service sector. Just a few miles north of Boston, residents frequently commute via ferry and commuter rail service to the state's capitol for work, though Pace itself supports a growing number of jobs. With a median family income of about $55,500, Pace is very socioeconomically diverse. The city has a large immigrant community and one of the most ethnically and linguistically diverse student populations in the state.

District & School Characteristics

The district supports 10 schools and one pre-K program. The Pace School is one of two K-8 schools in the district and has 359 students. The average class size is 18.3 students. This is larger than the average class size in the district itself. The Pace School's student population is 3.3% African American, 1.9% Asian, 24.5% Hispanic, and 64% White. Just over 17% of the students do not speak English as a first language, and nearly 12% have limited English proficiency. More than 38% of students receive free or reduced-price lunch.

The percentage of students receiving a score of proficient or higher on the MCAS at the Pace School tends to fluctuate in comparison to state averages; 3rd and 4th grade math and ELA scores tend to be below the state average, while scores in grades 5 and 6 both tend to be above average. Students in grades 7 and 8 tend to have math scores that are below state average, while they have ELA scores that are slightly above or comparable to the state average. 5th grade science scores are slightly above the state average, while 8th grade science scores are below the state average.

The Pace School's building houses a computer lab. The school is currently in a temporary building, but it still maintains an emphasis on the use of technology. Two sets of laptops circulate through the grades for use by the students on various projects. In addition to the laptop carts available, there are iPads dedicated to just the science classes that are used for research and demonstrations for students in grades 4-8. These are recent additions to the technology resources available at the Pace School, and teachers are continuing to expand the ways they use them.

The Pace School District offered PD training sessions on the iPad, in addition to offering an iPad training for those unfamiliar with tablets. The district also offers a program known as Technology Monday, which is designed to give teachers a chance to learn about different iPad applications they can integrate into their lesson plans. They are also used for Study Island testing.

The Pace School received a grant from the Reed Trust to fund K-6 science education. The grant included $50,000 for renovation of the school's science lab. All students in grades K-8 receive some science education. In K-6, the grade-level teachers instruct science classes, while students in grades 7-8 have a separate teacher for science classes. The 7th and 8th graders have three hours of science a week, separated into two classes: a two-hour block and a one-hour class. Lab sessions are led by the science instructor.

Curriculum

Teachers develop a curriculum and lesson plan in conjunction with the science integration specialist; they are paid a stipend to stay after school for these planning sessions. These curricula were developed by the teachers based on a framework document that they received. Grades 5 and 6 tend to focus heavily on engineering and on meeting state standards for science.

The Pace School has a strong technology focus, thanks in large part to the foundation grant mentioned above. Each school in the district has a set of iPads earmarked for science classes from the foundation's grant, which also pays the transportation and admissions costs to a science museum once a month for every family in the district.

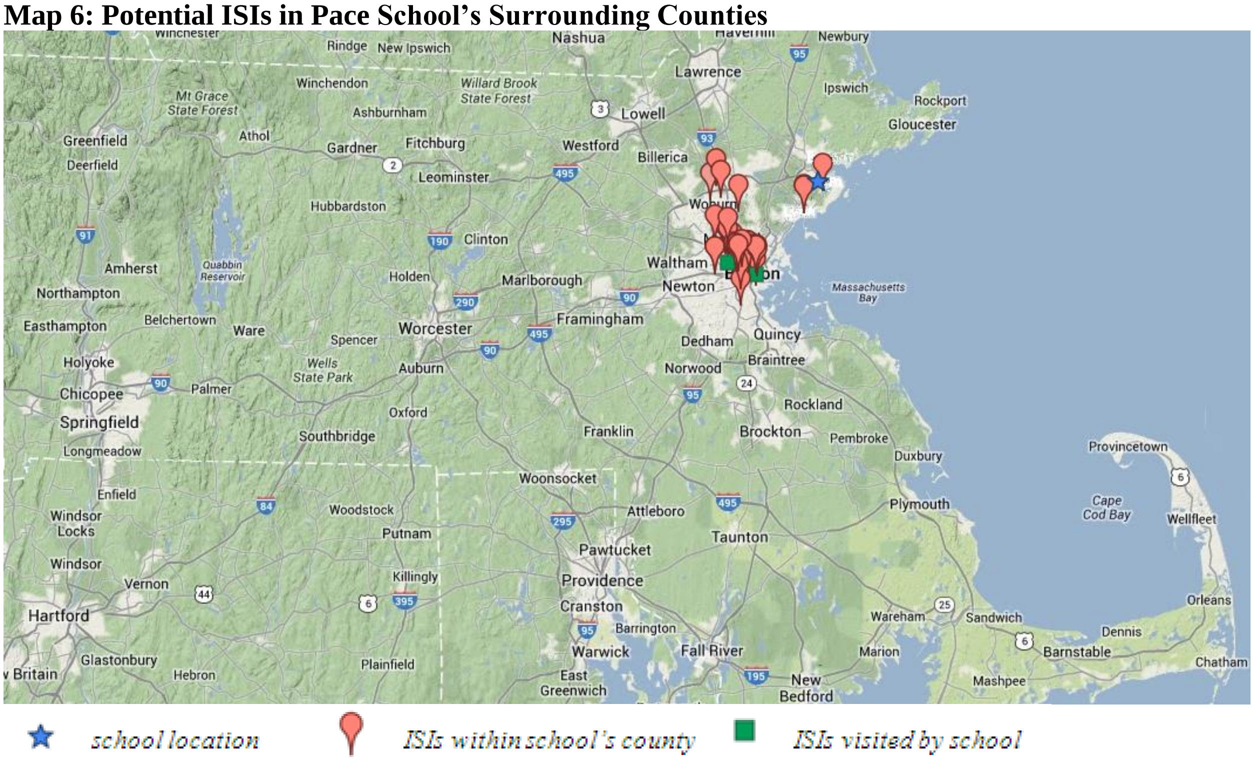
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

Field trips for public school students are funded by the Reed Trust. Every year, students go on a field trip to Boston, spending the day at the New England Aquarium, the Museum of Science, Boston, or the Harvard Museum of Natural History. Sometimes representatives from an ISI will come to the Pace School to work directly with students.

Out-of-School (OOS) Offerings

Each grade in the school district takes at least one science-focused field trip a year, generally to the New England Aquarium, the Harvard Museum of Natural History, or the Museum of Science, Boston. Sometimes educators from these ISIs visit the school and make presentations.

Map 6: Potential ISIs in Pace School's Surrounding Counties



VIGNETTE: WINSHIP

Town Characteristics

With 21 neighborhoods as diverse as its population, Winship is a major urban center that serves as a center of education and innovation for the state. Winship is extremely socioeconomically and racially diverse and has, at points in its recent past, been a majority-minority city. 24.4% of the population identifies as African-American, while 8.9% identifies as Asian, 17.5% as Hispanic or Latino and 53.9% as White. The economy is as diverse as the population, with educational institutions and hospitals acting as two of the city's largest employers. The median family income is $61,035, but varies greatly within the city's neighborhoods. The city is also known for its high tech and finance industries, as well as tourism. Thousands of people commute into the city each day from its surrounding suburbs for work, entertainment, schools, and health care. It has an excellent public park system, with a great deal of easily accessible and well-developed green space. This includes parks and playgrounds, as well as recreational facilities and beaches.

The city is governed by a mayor and city council, though many neighborhood communities also have semi-official governing structures. The school committee, which oversees the public school system, is appointed by the mayor. The city can be accessed by several major state and interstate highways, which also provide access to points north, south, and west. It is served by the MBTA's commuter rail, boat, train, and local bus systems, as well as Amtrak service to points across New England.

District & School Characteristics

Winship's school district operates 119 public schools serving over 55,000 students from across the city. 45.4% of its students do not speak English as a first language, while 30.6% of the students have limited English proficiency. Just over 18% of the student population requires special education, and 71.7% of the population receive free or reduced-price lunch. The district itself is also incredibly racially diverse, with 35.6% of its students identifying as African American, 8.6% as Asian, 39.9% as Hispanic, and 13.2% as White. The Winship School is similarly diverse, with 23.7% of its population identifying as African-America, 13.6% as Asian, 43.7% as Hispanic, and 15.1% as White. More than half (56%) of Winship students do not speak English as a first language, while 41% have limited English proficiency. Nearly 75% of the students receive free or reduced-price lunch.

The percentage of Winship students receiving a proficient or higher on the MCAS exams is consistently well below the state average. This is true for grades 3-8 and for science, math, and ELA.

Curriculum

Data unavailable

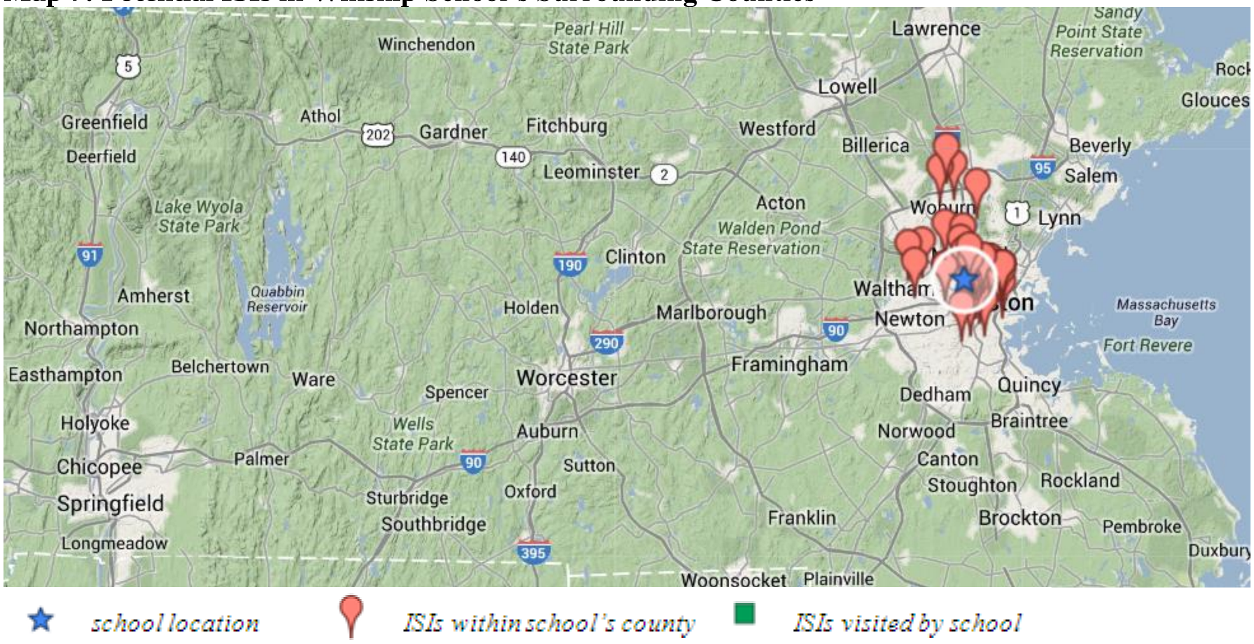
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

Data unavailable

Out-of-School (OOS) Offerings

Data unavailable

Map 7: Potential ISIs in Winship School's Surrounding Counties



VIGNETTE: ALLENTOWN

Town Characteristics

Located on an island off the coast, Allentown is a resort community that swells significantly in the summer months, with ferry service running year-round from the port. Its year-round residents, approximately 2,000 people, tend to be significantly less wealthy than its summer residents, who own much of the real estate on the island; median household income is $74,000. This dichotomy defines much of the island lifestyle; the town is much more active during the summer months, when tourists flock to the island for its beaches and restaurants. During the winter, the town of Allentown is home to most of the island's year-round stores. Tourism is by far the town's largest source of revenue. The town operates under a New England town structure. Particularly in off-season months, the community is somewhat isolated, with travel restricted in poor weather.

School & District Characteristics

The Allentown School is part of the larger school system, but is classified as its own distinct school district and is funded individually by the town of Allentown. The school serves 359 students in grades K-8, with approximately 17 students per class. It is the only school in the district; students attend grades 9-12 at the island's single high school, which pulls its student population from across the island. The population of the island is not very diverse, also reflected in the student body: slightly less than 4% of the students are African American, and less than 1% are Asian. The school does have a sizable Hispanic (slightly more than 14%) and Native American (3%) population, but nearly three-quarters identify as White. Nearly 16% of the student body does not speak English as a first language, while almost 7% of the students have limited English proficiency. Almost 30% receive free or reduced-price lunch.

The percentage of students at the Allentown School receiving a score of proficient or higher on the ELA MCAS exam tends to be significantly higher than the state average in every grade. Scores on the math MCAS are significantly higher than state averages in grades 3-5, though they are comparable for grades 6-8. Grade 5 and 8 science scores are comparable to state standards.

The Allentown School is extremely dedicated to integrating technology of all types into their curriculum. The science class room has a SMART board. The school has a cart with 24 laptops and a set of 10 iPads that students can use in their classes, as well as a two computer labs. The Allentown School also made a big push to integrate Google docs as a collaborative learning tool.

Teachers at the Allentown School integrate STEM into their classes with varying levels of success. Instruction in grades 3-4 is classroom-based, and classroom teachers determine how best to integrate STEM themes. In grades 5-6, STEM education is more structured, with almost an hour a day, five days a week of STEM instruction by dedicated subject teachers. Students are encouraged to reach out to teachers during a half-hour resource period each week. Students in grades 7-8 have science and math in blocks, with 7th grade math classes academically leveled, and 8th grade algebra classes more heterogeneous. Science and math blocks are on the same day.

Curriculum

Teachers at the Allentown School design a customized science curriculum that makes frequent references to the state's science standards. 7th grade science education is primarily life sciences, but includes a great deal of chemistry as well. 8th grade science classes deal with earth and planetary science, as well as some environmental science. Students take an instructional technology class that sometimes includes projects in programs like PowerPoint, Keynote, and Garage Band. Students also take a technology engineering class where they are introduced to various tools and engineering design processes.

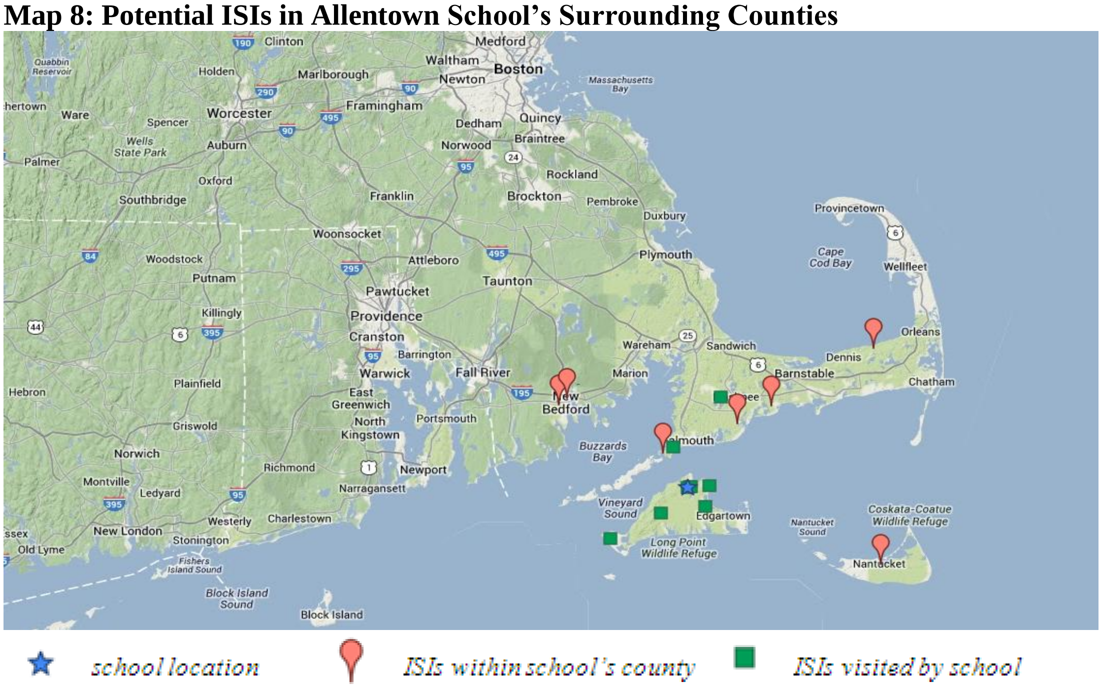
Relationship with Informal Science Education Institutions (ISIs), Informal STEM Offerings

The Allentown School has pursued many relationships with ISIs, both in their island community and on the mainland. Science teachers and grade-level teachers for students in grades 3-8 have units on taxonomy and seed collecting, which are taught in conjunction with a visit to a nearby arboretum, where students winterize the trees. Because the lead science teacher is a member of the MA Association of Science Teachers, students have worked with MIT researchers in the past to conduct dissections, though the lead science teacher will take over that instruction this year.

Out-of-School Offerings

There are a number of programs available for students outside of school hours, both after school and during the summer. During the school year, there is an engineering club for students in grades 1-3, while students in grades 4-8 are able to join a computer club that teaches programming. Outside of school, LEGO Robotics is available at the high school for students in grades 7-8. These students are also able to attend a three-week summer program at the Maritime Academy, a state university offering undergraduate and graduate degrees in maritime-related fields. This program focuses on advanced science and leadership training. Local organizations also offer STEM programming throughout the year, some of which is targeted specifically toward girls.

Map 8: Potential ISIs in Allentown School's Surrounding Counties



CHAPTER 5: SURVEY RESULTS

The M-LEAP study gathered three waves of longitudinal data (across three waves) on students' science-related beliefs, experiences, and aspirations (SBEAs) through surveys with 1,576 unique students, 690 unique parents, and 138 unique teachers. Standardization of indicators across these surveys created opportunities for direct comparisons between students', parents', and teachers' responses on several of the questions, with an aim of examining relationships between students' perceptions and those of adults.

The results presented in this chapter integrate descriptive and inferential analyses from all data sources simultaneously, rather than presenting results separately for the three groups. Key variables of interest include change over time and gender-based differences. In some cases, data are shown for all three waves of data collection, while elsewhere only results from Wave 3 (the final wave of data collection) are shown.

The chapter discusses results related to Expectancy Value Model indicators of self-efficacy (SE) and subjective task value (STV), out-of-school experiences, parent perceptions, gender stereotypes, favorite and least favorite subjects, and educational and career aspirations.

EXPECTANCY-VALUE MODEL INDICATORS

This section presents results from students, parents, and teachers on measures related to self-efficacy (SE) and subjective task value (STV) beliefs, as well as gender stereotypes.

Self-Efficacy (SE)

Each year, students were asked three questions related to SE about each of the five 21st Century subjects/skills: reading/ELA, math, science, computers, and teamwork:

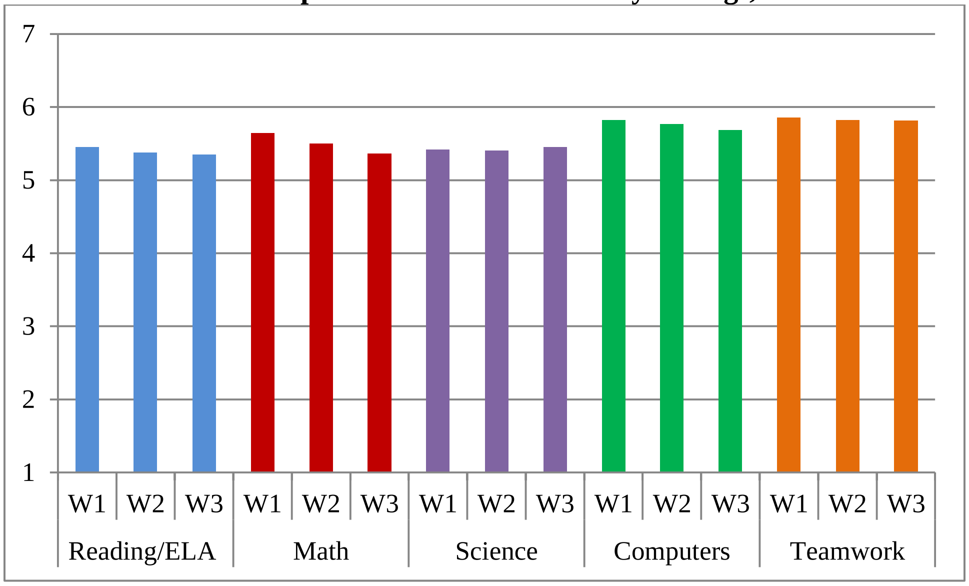
1. *Ability*: "How good are you in [subject/skill]?"
2. *Expectations*: "How well do you expect to do in school this year in [subject/skill]?"
3. *Expectations*: "How good would you be at learning something new in [subject/skill]?"

These three scores were then combined for a composite SE rating for each student in each subject/skill area.

Students had moderately high and positive self-efficacy self-ratings for each area every wave.

Overall, students had moderate to high self-ratings of ability and expectations for success in each school area and skill. Moreover, their expectations for success consistently exceeded their self-perceived ability, if only slightly. Composite SE scores were above 5.3 on a 7-point scale for each area during each data collection wave. Further breakdown of SE scores in each area by cohort, grade, and gender can be found in the technical appendices.

Exhibit 5-1: Mean Composite Student Self-Efficacy Ratings, Waves 1-3

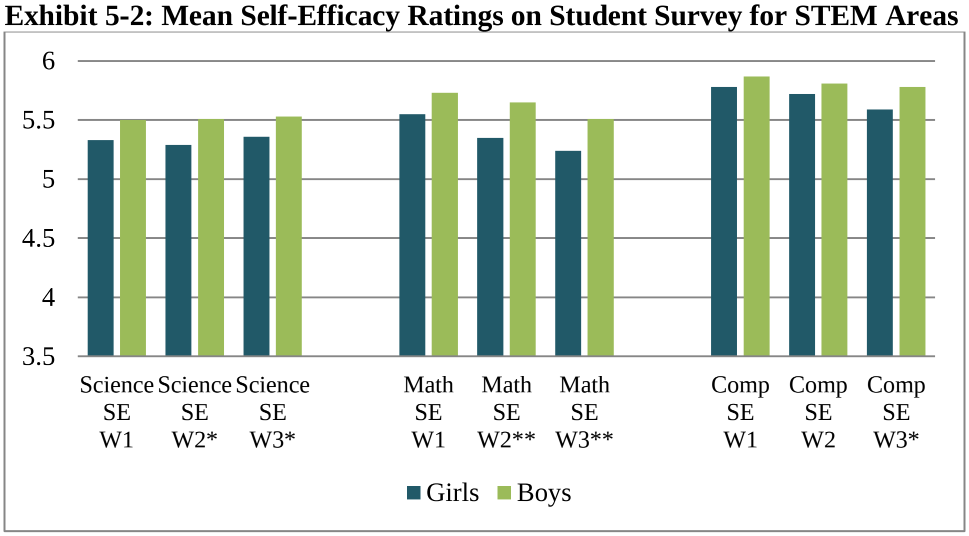


Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); *N* = 794–1,192; Note: Results are shown disaggregated by school and wave in technical appendices.

Boys' self-efficacy ratings in STEM areas were slightly higher than were girls'.

For both science and math, during Waves 2 and 3 of data collection, boys' mean SE ratings in STEM areas were statistically significantly higher than were girls' SE ratings, as shown in Exhibit 5-2. Girls' mean SE ratings for reading (not shown), however, were statistically significantly higher than boys' SE ratings for reading in all three waves by approximately a quarter of a point each wave. There was not a statistically significant difference in mean SE ratings for teamwork between the genders in any wave.

Exhibit 5-2: Mean Self-Efficacy Ratings on Student Survey for STEM Areas



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); Note: The vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.
* = $p < .05$, ** = $p < .001$; N_{W1} = 326-341, N_{W2} = 523-557, N_{W3} = 590-678

STEM self-efficacy scores of both boys and girls remained stable over time.

We were interested to see whether students' SE scores changed over time as the student population got older and moved up in grades, especially with regard to STEM areas. For the 390 students with a complete three-year record, the mean SE score did not differ statistically significantly between time points in any area.

We were also interested in whether or not changes in SE scores occurred disparately for girls and boys and found that this was not the case: there was no statistically significant interaction between gender and time. While SE scores may have changed dramatically for some individuals, this evidence suggests that, on the whole, the changes in SE scores that took place in 3rd-8th grades were not related to gender.

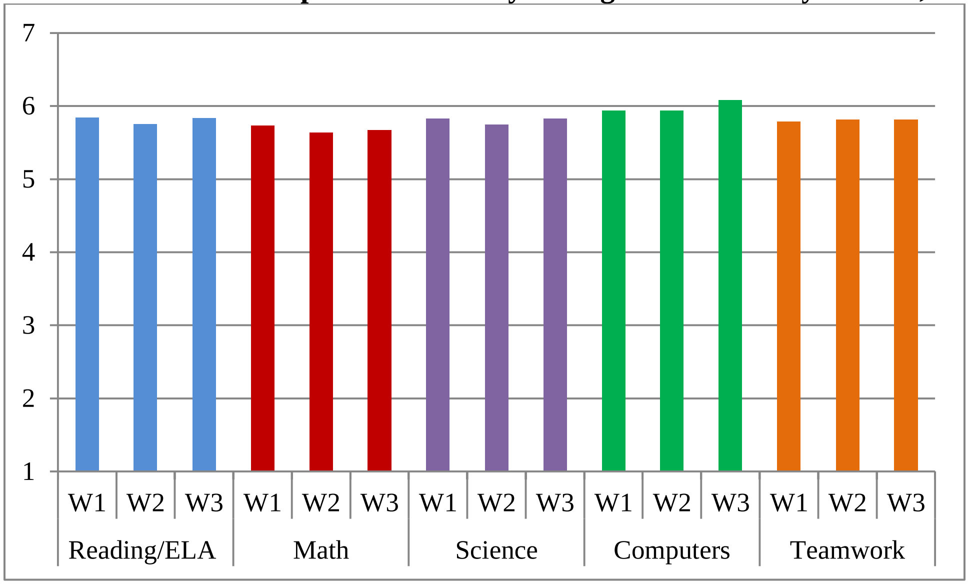
Parent ratings of proficiency for their children were highly positive and correlated with students' own self-efficacy ratings.

Parents and teachers rated students on their abilities and their expectations for success in each discipline, and the ratings were compiled into composite scores similar to ones for students. It is important to note that although the construct measured on the parent survey is referred to as "self-efficacy" for consistency, the parental SE ratings relate to their *children* and not themselves.

Parents' mean ratings of their children's abilities and their expectations for success were high, overall, with all ratings averaging above 5.66 on a 1-7 point scale. As was the case with students, parents' expectations for the success of their student in each area exceeded their assessment of the students' ability level, and this difference was statistically significant ($p < 0.001$) for each area in each wave.

The correlations between students' SE scores and their parents' SE scores for them were positive, strong, and statistically significant ($\alpha = 0.05$). Correlations with student ratings were highest for both parents in math and reading/ELA, suggesting that parents hold particularly similar ability and expectation beliefs for their students in these areas. In contrast, correlations were moderate in other areas and largely non-statistically significant in computers, especially for students and their fathers. This indicates that parents did not agree with their children on how good their children were with computers, with parents tending to hold slightly higher SE ratings on computers than their children.

Exhibit 5-3: Mean Composite Proficiency Ratings of Children by Parents, Waves 1-3



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 152-386, N_{W2} = 172-342, N_{W3} = 125-302

Mothers gave slightly higher self-efficacy ratings to their children than did fathers, on average, but this difference was only statistically significant in one wave.

While the trend was for mothers to give slightly higher SE ratings to their children than fathers in most areas and waves, pairs of parents who rated the same child did not rate them statistically significantly differently. There were only a few instances where mothers' and fathers' SE ratings differed statistically significantly; these were during Wave 2, when mothers rated their students slightly higher on math, science, and computer SE. In other words, mothers of students in 4th-7th grade gave their children slightly higher ratings than fathers in terms of ability and expectations for success in these areas. Descriptive results indicated that there were no differences between the student genders, as this trend applied to both male and female students.

Similar to students, parents' self-efficacy ratings for their children remained mostly stable over time.

We examined parent SE ratings for change over time and for gender interactions. As with students, they remained mostly stable over time. The only two statistically significant findings were for change in mothers' ratings of computer SE over time and for fathers' ratings of reading/ELA SE. Mothers' rated their children slightly higher on computer SE in the final wave of the study than they did to begin with, and fathers rated their children slightly higher on reading/ELA SE.

Teacher ratings of student ability were moderately positive, but they were the lowest among all groups surveyed.

As part of the teacher survey, teachers rated their students on ability and interest. While interest is a construct that relates more to STV than SE, teacher results related to both constructs are presented here, simultaneously. The two questions asked were:

1. *Ability*: "How good is this student at [subject/skill]…?"
2. *Interest*: "How interested is this student in [subject/skill]?"

Teachers of younger students were able to rate the students on multiple areas because they taught each or most of the areas to the same students, while teachers of older students only rated them in subject areas and skills they taught. Because they were asked to rate their entire class in areas where they had relevant knowledge of student performance and interest, all teachers rated multiple students, and in some cases, students were rated by multiple teachers. Teacher ratings were compiled into an average ability and an average interest rating for each student for each wave of the study.

Teacher ratings of student ability and interest were moderately positive in each area, although among the three groups (students, parents, and teachers), teachers' ratings were by far the lowest, with half of the ratings averaging below 5 on a 7-point scale, whereas no average ratings fell below 5 for the other two groups. Teachers, like students, used a wider range of the available rating scale than did parents, using the entire 1-7 range where it was highly uncommon for a parent to give a rating below 2.

Correlations between students' self-ratings of ability and interest in each area and their teachers' ratings of these students were calculated for each wave of data collection. Overall, correlations between student and teacher ratings of student ability and interest were strong, positive, and statistically significant. While the correlations were not as strong, on average, as they were between students and parents, there was still a high degree of agreement between students and teachers on their ability and interest levels in the subjects and skills we asked about.

- This was especially true for the core areas of reading/ELA and math, not coincidentally the areas receiving the most attention in high-stakes testing across the state.
- Teachers' ratings of students' science ability yielded higher correlations than did ratings for student interest in science, yet both were moderately positive and statistically significant in each wave.
- Computer ability and interest ratings were the anomaly to the trend of positive correlations. For computer ability, correlations were very low and not statistically significant, except in Wave 2, and for computer interest, they were also low and were only statistically significant in Wave 2 and Wave 3. This suggests that students and teachers did not generally agree about how good the students were at computers or how interested they were in them.

Teachers gave students slightly higher ability ratings than interest ratings in science, but moderately higher interest ratings than ability ratings in computers and teamwork.

As with parent ratings and student ratings, we tested to see if teachers rated students differently on ability versus interest.

Exhibit 5-4: Average Teacher Ratings of Student Ability and Interest, Wave 3

		Ability	Interest
		1. How good is this student at…? (mean)	2. How interested is this student in…? (mean)
Reading/ELA	*W3*	4.97	5.01
Math	*W3*	4.93	4.96
Science**	*W3*	5.06	4.90
Computers**	*W3*	5.36	5.55
Teamwork**	*W3*	4.80	5.04

Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); Number of ratings: 1,035-1,385 across 56 teachers
** = p<.001 as result of pairwise comparison t-tests for difference in means

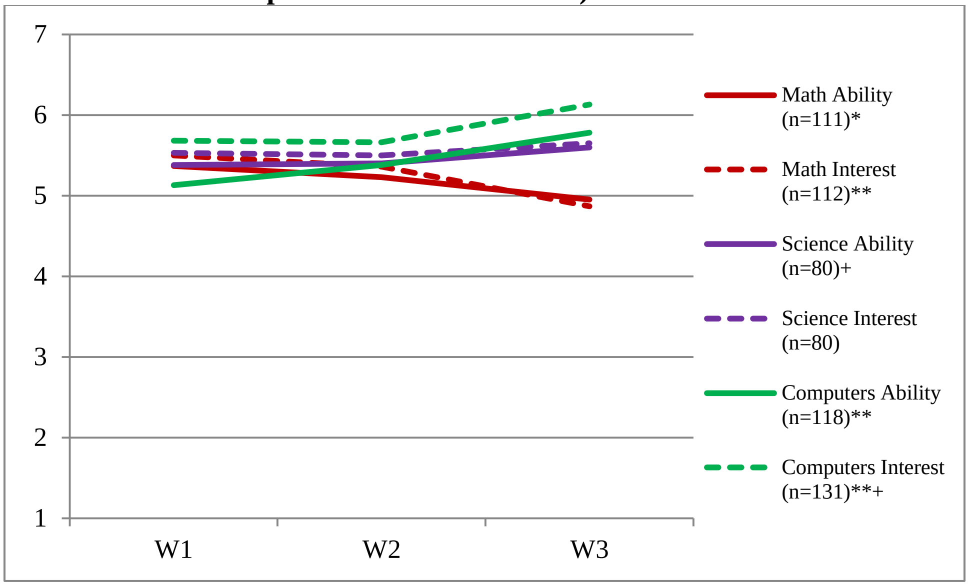
There were some statistically significant differences between teachers' ratings of ability among their students and teachers' ratings of interest among their students in the various disciplines and skills during Wave 3 of data collection. Teachers reported that their students had slightly higher abilities than interest in science, while the opposite was true for computers and teamwork. Science ability ratings were the second-highest among all the disciplines and skills, but computers ability ratings were highest by a wide margin. Science also received the lowest rating in terms of interest in Wave 3, while computers was rated the highest on interest. This trend is similar to the one seen in students' self-reported STV scores, shown in Exhibit 5-11.

Over the three waves, teacher ratings of students' ability and interest in math fell, while ratings in computers increased and science remained stable.

The average teacher ratings of students' abilities and interests changed over time as students got older and moved up in grade. These statistically significant changes were only observed in the STEM-related areas and not in reading/ELA or teamwork. In some cases, gender differences were seen, where girls' average ability or interest rating may have gone up over time while boys' may have dropped, or vice versa. Exhibit 5-5 shows trends in average teachers' ratings of students' ability and interest for each STEM area over time, with both genders combined, for only those students with a complete three-year record of teacher ratings (n = 80-131).

For both genders, mean teacher ratings of student ability and interest in math declined as the students moved up in grades, while science ability and interest levels did not change significantly over time for the students as a group. In contrast, average ratings for both ability and interest in computers increased over time.

Exhibit 5-5: Changes in Teacher Ratings of Student Ability and Interest over Time (For Students with a Complete Three-Year Record)



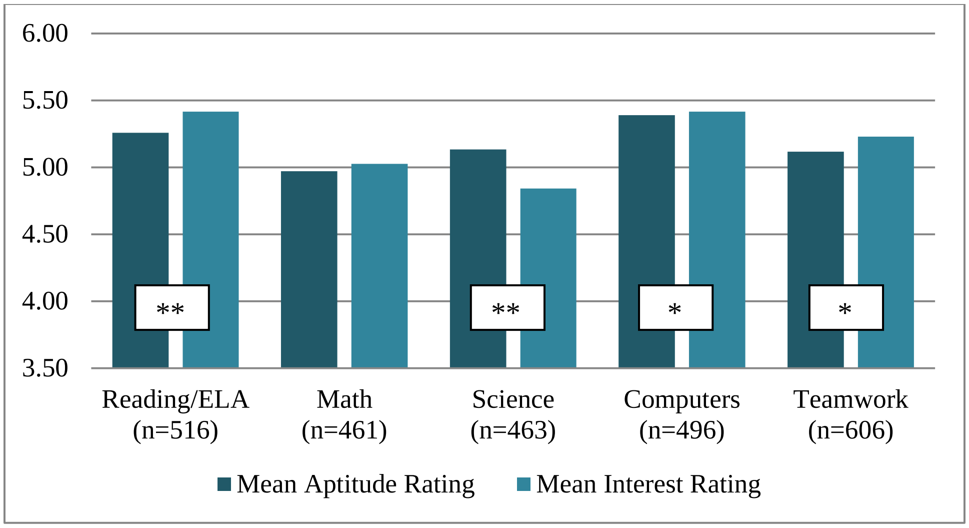
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
Note: Statistical tests refer to repeated-measures ANOVA analysis of change over time.
* = $p < .05$, ** = $p < .01$, + = Sig. gender interaction

Teachers rated girls and boys similarly in terms of ability in science in Wave 3, but girls were seen as lacking interest.

Several interesting patterns emerged when these results were broken down by gender. In Wave 3 of data collection, teachers rated girls' ability level in science moderately higher than their interest level in science. This indicates that teachers thought that girls were better in science than they were interested in science. This effect disappeared when comparing teachers' mean ability rating in science for boys with their interest rating for boys, despite the fact that teachers rated boys' and girls' ability levels as the same. Teachers did not perceive there to be a difference between boys' ability level in science and their interest in science, as they did with their female students.

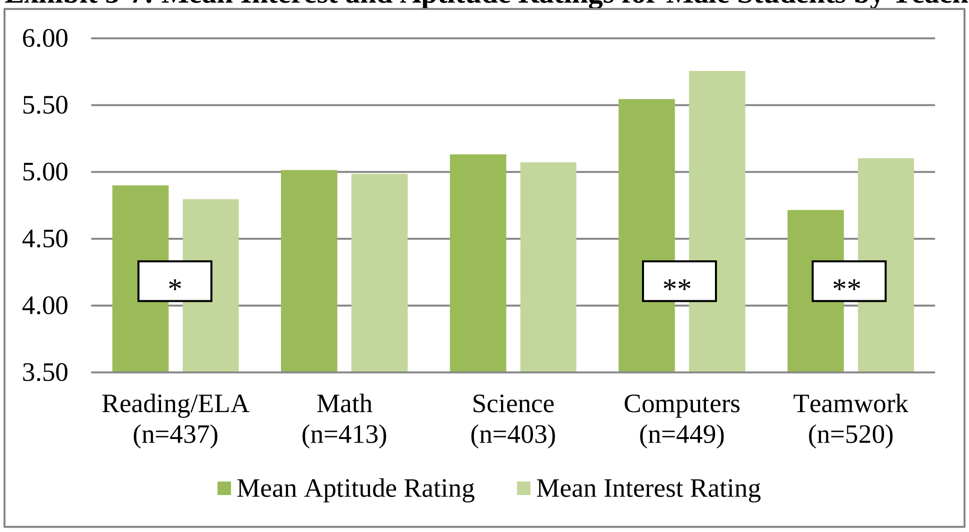
Teachers also rated their male and female students statistically significantly differently on their interest and ability levels in reading/ELA, computers, and teamwork in Wave 3 of data collection. In Wave 3 of data collection, teachers tended to rate girls higher than boys on interest in ELA, aptitude in ELA, and aptitude for teamwork. In contrast, they rated boys higher than girls on interest in science, interest in computers, and aptitude in computers. All ratings showed statistically significant differences. Exhibits 5-6 and 5-7 illustrate the mean interest and aptitude ratings for girls and boys as rated by teachers at Wave 3.

Exhibit 5-6: Mean Interest and Aptitude Ratings for Female Students by Teachers in Wave 3



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$, ** = $p < .001$
Note: The vertical axis is truncated in order to highlight the findings. True range was 1-7.

Exhibit 5-7: Mean Interest and Aptitude Ratings for Male Students by Teachers in Wave 3



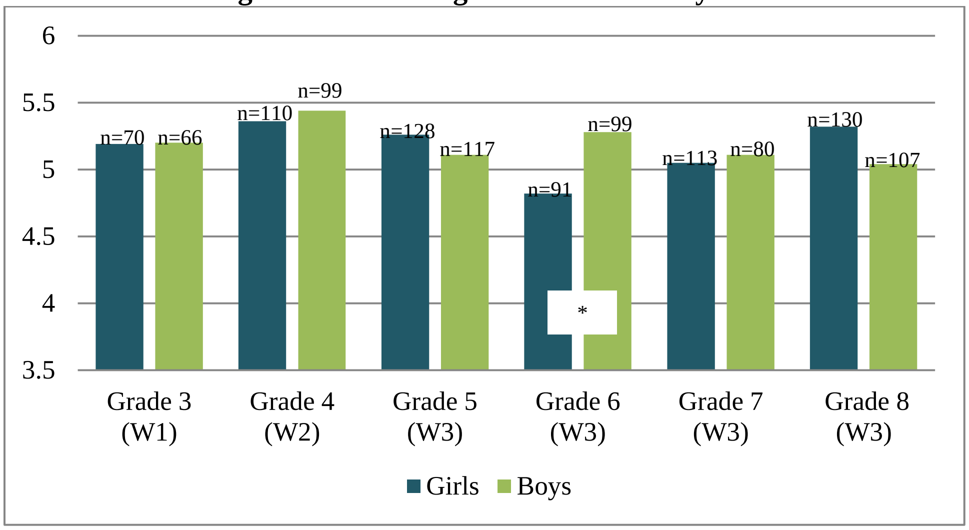
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$, ** = $p < .001$
Note: The vertical axis is truncated in order to highlight the findings. True range was 1-7.

The biggest gender gap in teacher ratings of students' science ability and interest occurred for 6th grade students, for whom teachers rated boys as having more interest in science than girls.

Additional analyses on previous waves' data were conducted for science ratings and showed the same pattern during each wave of the study: teachers rated boys as having a slightly higher interest in science than girls, but they generally did not distinguish between the two groups in terms of aptitude. Exhibits 5-8 and 5-9 show how teacher ratings of ability and interest differed between boys and girls at each grade level.

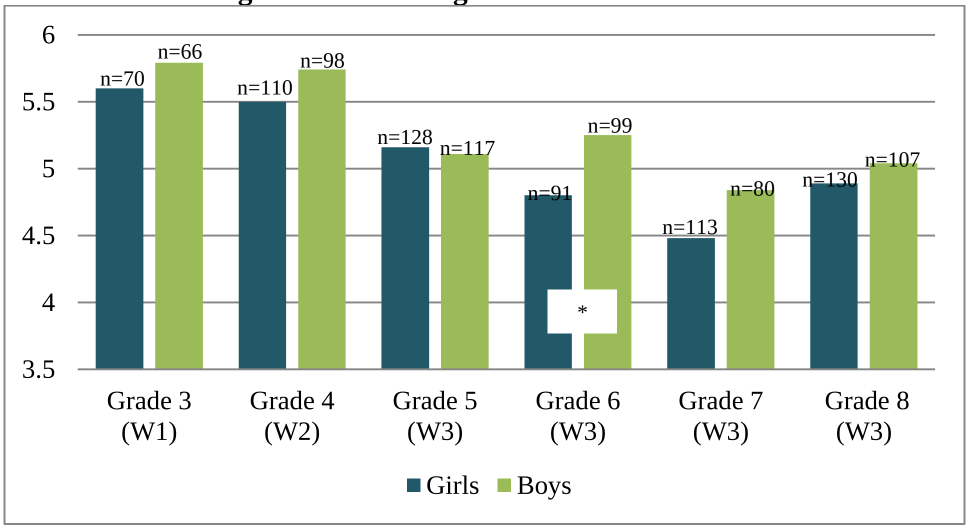
For most grades, using the most recently collected data from our three waves of data collection, there was not a statistically significant difference between boys and girls in terms of the ratings of aptitude and interest in science that their teachers assigned to them. The trend, however, was for boys to be rated slightly higher than girls on both aptitude and interest. In 6th grade, this gap was found to be statistically significant in both ability and interest. This coincides with students' own SE and STV ratings of science, to an extent; whereas the gap in teacher ratings between boys and girls was only statistically significant in 6th grade, boys' science SE and STV scores were statistically significantly higher than girls' SE and STV scores in 4th, 5th, and 6th grades.

Exhibit 5-8: Average Teacher Ratings of Student Ability in Science



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$, ** = $p < .01$
Note: Calculated using most recent wave of data collection (W1, W2, or W3). Also, the vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.

Exhibit 5-9: Average Teacher Ratings of Student Interest in Science



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$, ** = $p < .01$
Note: Calculated using most recent wave of data collection (W1, W2, or W3) Also, the vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.

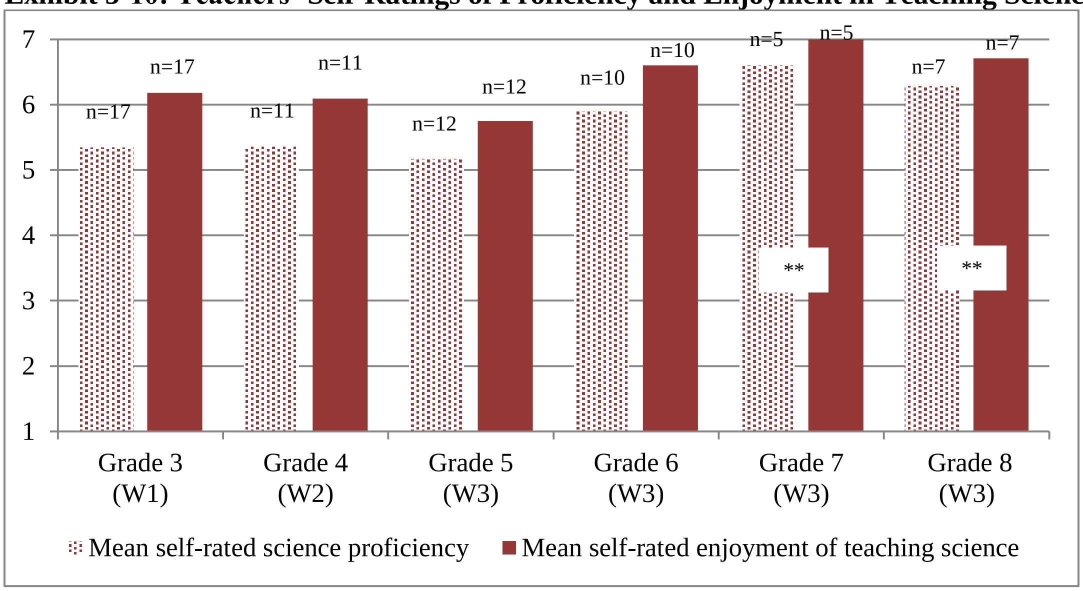
Teacher ability and interest ratings of students were generally moderately to strongly correlated with student self-efficacy and subjective task value ratings.

Teacher ratings of ability and interest among their students were compared with students' own SE and STV scores in STEM subjects and skills. Across all three waves, students who had high SE and STV ratings in math tended to have high teacher ratings of ability and interest in math, on average. In Waves 2 and 3, students who had high SE and STV ratings in science tended to have high teacher ratings of ability and interest in science, on average, but this relationship was not as strong as for math ratings. As with parents, correlations between teacher ratings of ability and interest in computers and students' ratings were not very strong. They were not statistically significantly correlated with students' ratings of SE and STV in computers in Wave 1, and were weakly correlated in Waves 2 and 3. In other words, there was no relationship between students' SE and STV ratings in computers and their teachers' ratings of them on ability and interest in computers, on average.

Educators across all grades (3rd-8th) who teach science consistently rated their enjoyment of teaching the area higher than they rated their proficiency.

Teachers who teach science rated themselves on their own knowledge/proficiency in science and rated how much they enjoyed teaching science. They consistently rated their enjoyment higher than their proficiency teaching science, as shown in Exhibit 5-10.

Exhibit 5-10: Teachers' Self-Ratings of Proficiency and Enjoyment in Teaching Science



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); Note: Calculated using most recent wave of data collection (W1, W2, or W3); ** = $p < .01$

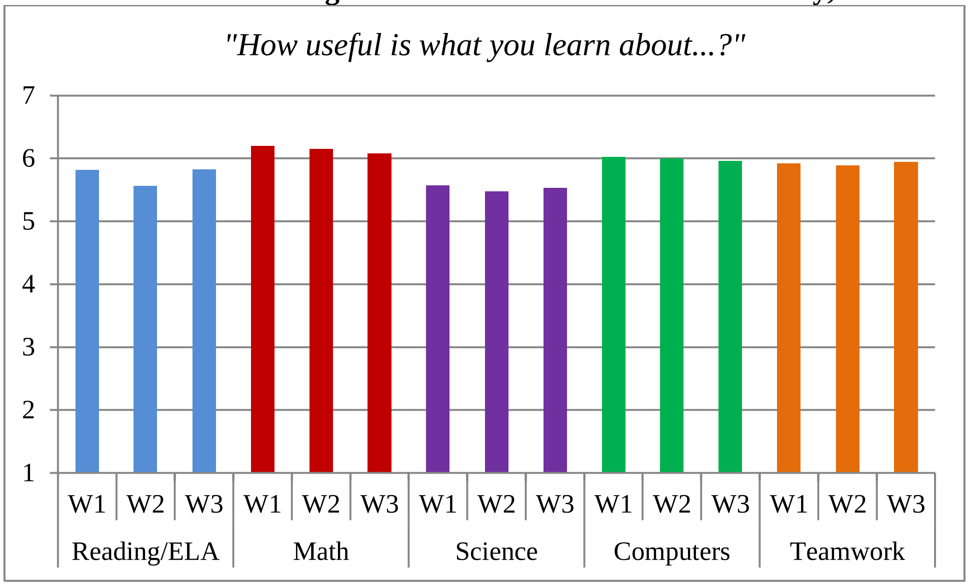
Subjective Task Value (STV)

On the student survey, we measured STV using six questions, each asked on a scale from 1 (“Not at all”) to 7 (“Extremely”):

1. *Utility*: How useful is what you learn about [subject/skill]?
2. *Utility*: How important is it to you to be good at [subject/skill]?
3. *Interest*: How much do you like [subject/skill]?
4. *Interest*: Not counting homework, how often do you do an activity with [subject/skill] outside of school?
5. *Interest*: When you are older, how likely are you to choose to take classes in [subject/skill]?
6. *Interest*: When you are older, how much would you like to have a job that uses [subject/skill]?

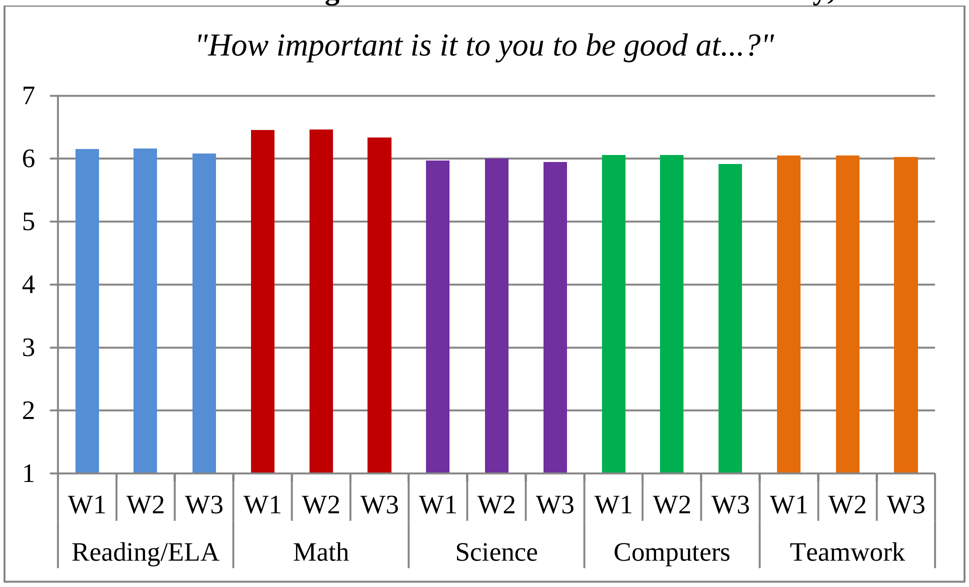
Exhibit 5-11 through Exhibit 5-17 show the mean calculated utility and interest item scores for the M-LEAP student survey at each data collection point, as well as a composite STV score in each area, which was calculated as the average of all students’ scores on the two utility and four interest items. Further breakdown of STV scores in each area by cohort, grade, and gender can be found in the technical appendices.

Exhibit 5-11: Mean Ratings on STV Item 1 on the Student Survey, Waves 1-3



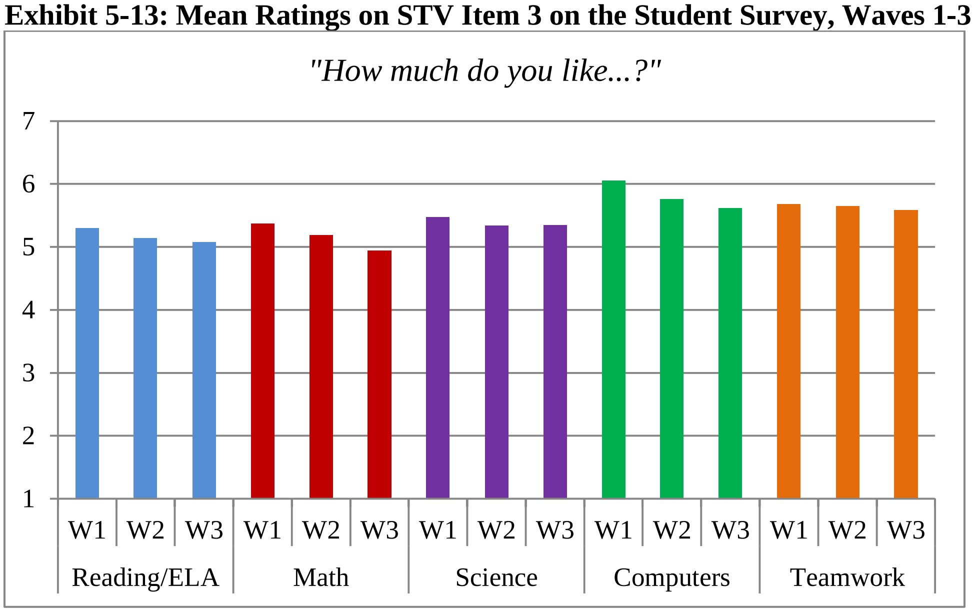
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327

Exhibit 5-12: Mean Ratings on STV Item 2 on the Student Survey, Waves 1-3



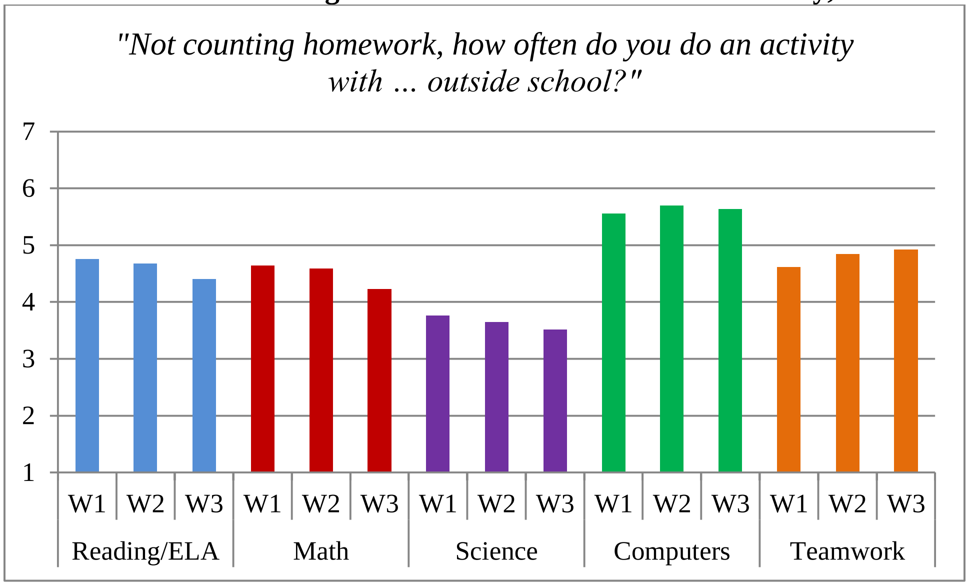
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327

Exhibit 5-13: Mean Ratings on STV Item 3 on the Student Survey, Waves 1-3



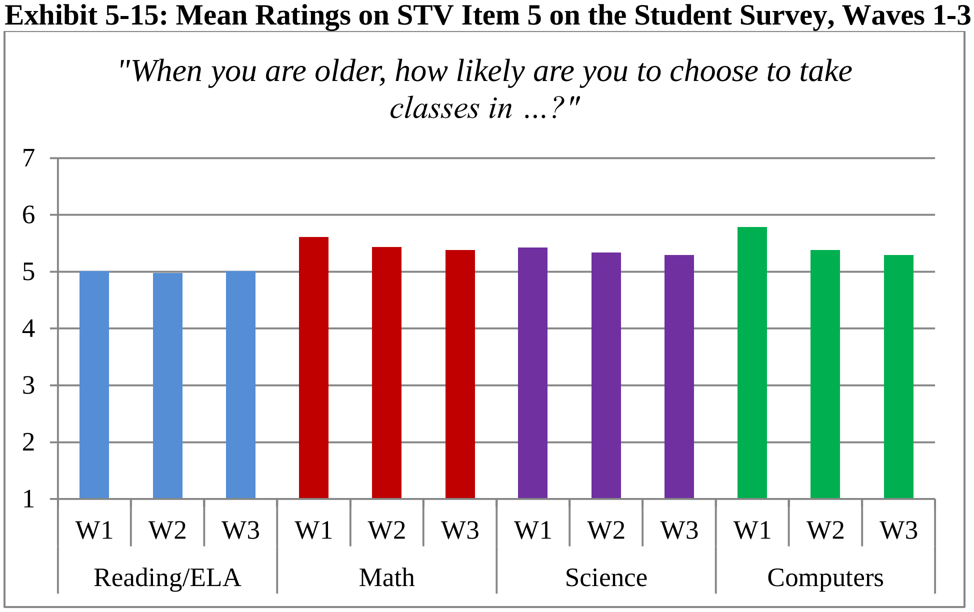
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327

Exhibit 5-14: Mean Ratings on STV Item 4 on the Student Survey, Waves 1-3



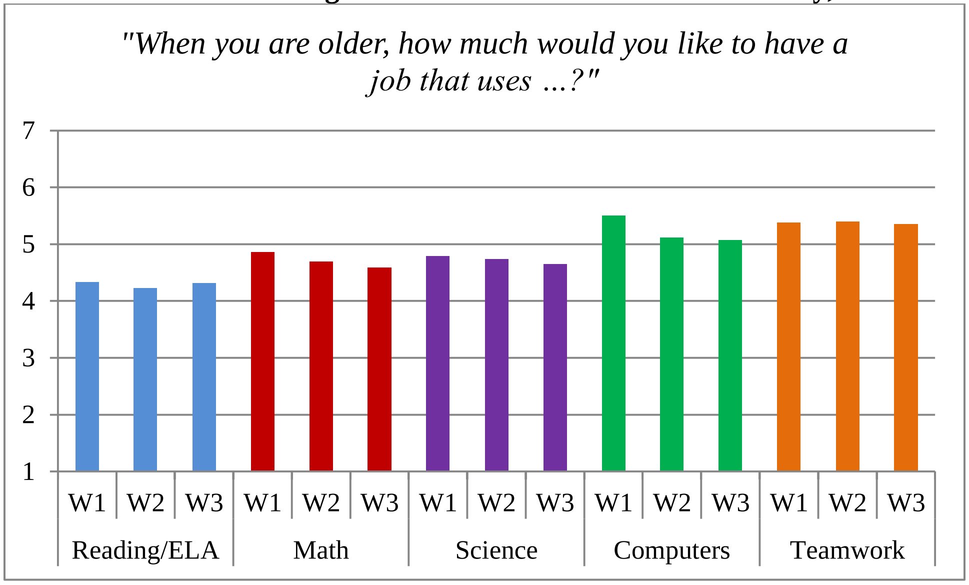
Scale: 1 (Never or almost never), 2 (a few times/year), 3 (about every other month), 4 (about once/month), 5 (every week or every other week), 6 (a few times/week), 7 (Every day or almost every day)
N_{Y1} = 667, N_{Y2} = 1,128, N_{Y3} = 1,327

Exhibit 5-15: Mean Ratings on STV Item 5 on the Student Survey, Waves 1-3



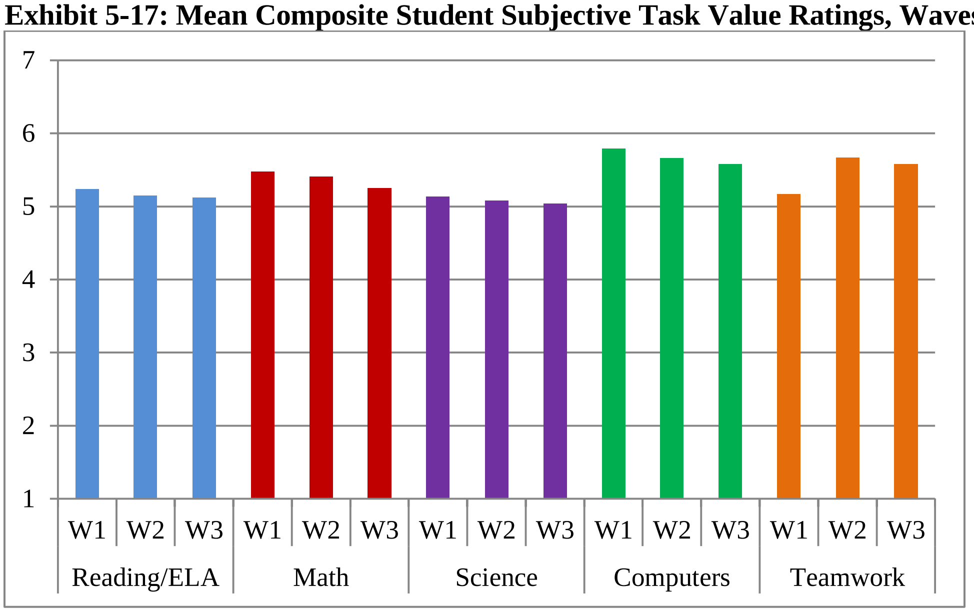
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327

Exhibit 5-16: Mean Ratings on STV Item 6 on the Student Survey, Waves 1-3



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327

Exhibit 5-17: Mean Composite Student Subjective Task Value Ratings, Waves 1-3



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327
Note: Results are shown disaggregated by school and wave in the technical appendices.

Students found STEM areas to be more useful than interesting.

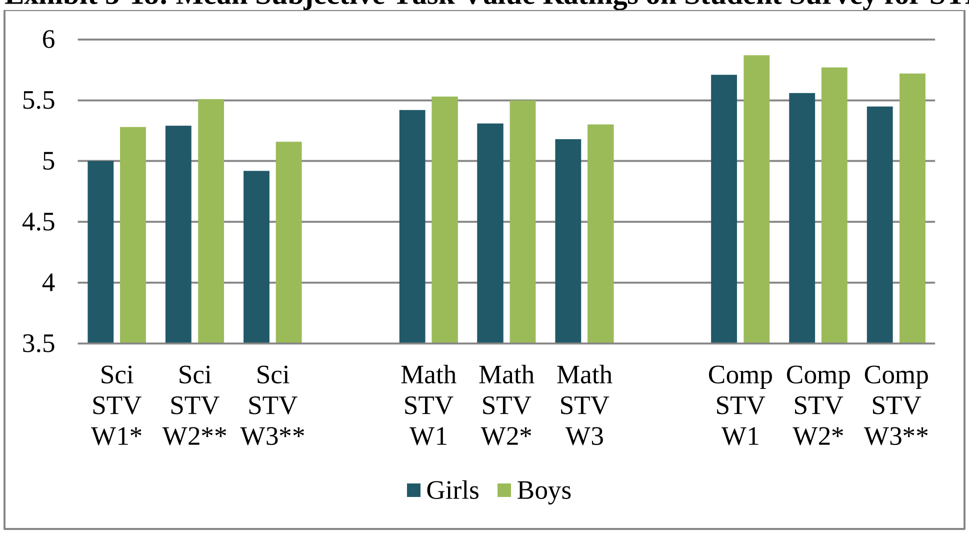
Composite STV ratings were high, on average. Students gave generally strongly positive assessments of the utility of each academic discipline and skill, while interest ratings tended to fall more toward the middle of the 7-point scale, though were still generally positive. Each wave, for each academic discipline and skill, the mean utility value was statistically significantly higher than the mean reported interest level (α = 0.05). For example, the mean utility value for math in Wave 3 was statistically significantly greater than the mean reported interest level in math in Wave 3.

The mean STV score for the STEM areas of math, science, and computers as a whole was not statistically significantly different from the STV score for the non-STEM areas of reading/ELA and teamwork in Waves 1 and 2. However, in Wave 3, students viewed the STEM areas and activities as a whole as being slightly more useful and/or interesting than reading/ELA and teamwork ($p < .05$).

Boys' subjective task value ratings were generally slightly higher than were girls', except in ELA/reading.

Boys' mean STV ratings in science were statistically significantly higher than girls' mean STV ratings in science during each wave of data collection, as shown in Exhibit 5-18. Girls' STV ratings for reading (not shown in Exhibit 5-18), however, were statistically significantly higher than boys' STV ratings for reading in all three waves by approximately half a point on a scale of 1-7. There was not a statistically significant difference between the genders in teamwork STV in any wave.

Exhibit 5-18: Mean Subjective Task Value Ratings on Student Survey for STEM Areas



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); Note: The vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.
* = *p* < .05, ** = *p* < .001; N_{W1}=326-341, N_{W2}=523-557, N_{W3}=590-678

Boys' mean STV ratings in math were statistically significantly higher than girls' mean STV ratings in math during Wave 2 of data collection, only. The size of this difference was smaller than it was in any wave for science STV, where there was a small but statistically significant difference between boys' and girls' ratings during each wave, where boys' ratings were higher. In Wave 2 and 3 of data collection, boys' mean STV ratings in computers were statistically significantly higher than girls' mean STV ratings in computers.

Students' subjective task value ratings dropped in science and math over the three waves, while ratings for reading/ELA, computers, and teamwork remained constant.

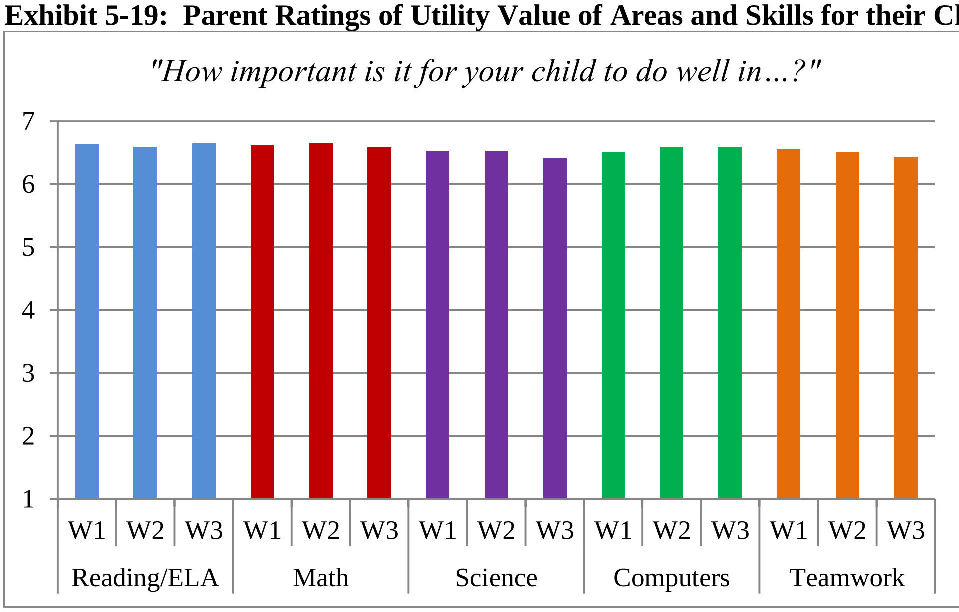
As with SE, we were interested to see whether students' STV scores changed over time as the mean age of the sample went up and the students moved up in grades. Descriptively, students STV composite scores for reading/ELA, computers, and teamwork remained fairly constant from Wave 1 to Wave 3. In contrast, the mean STV score differed statistically significantly between time points in math and science, with these areas becoming less interesting or useful to students over time.

Analyses of whether boys and girls differed in terms of how STV scores changed over time showed no statistically significant interaction between the two. While these scores may have changed in some areas, the evidence suggests that, on the whole, any changes in STV scores in 3rd-8th grade were not related to gender.

Parents rated each area and skill as having high utility value.

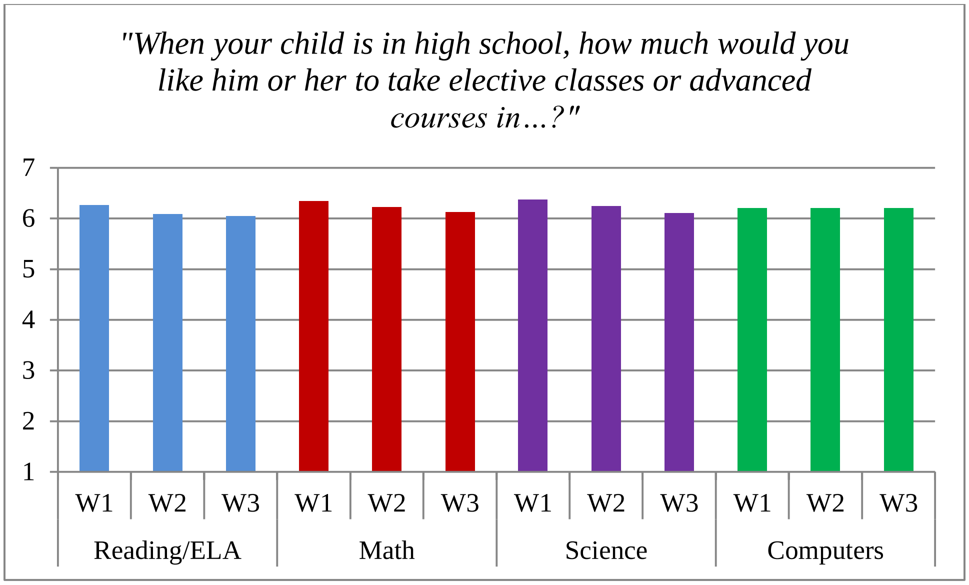
Parents were asked similar questions about the utility of each academic area and skill, and then their responses were used to calculate a composite utility score for each area. The items that formed the utility subscale of the parent survey, with average scores for parents from each wave of data collection, are shown in Exhibits 5-19 through 5-21, and the composite score is shown in Exhibit 5-22.

Exhibit 5-19: Parent Ratings of Utility Value of Areas and Skills for their Child



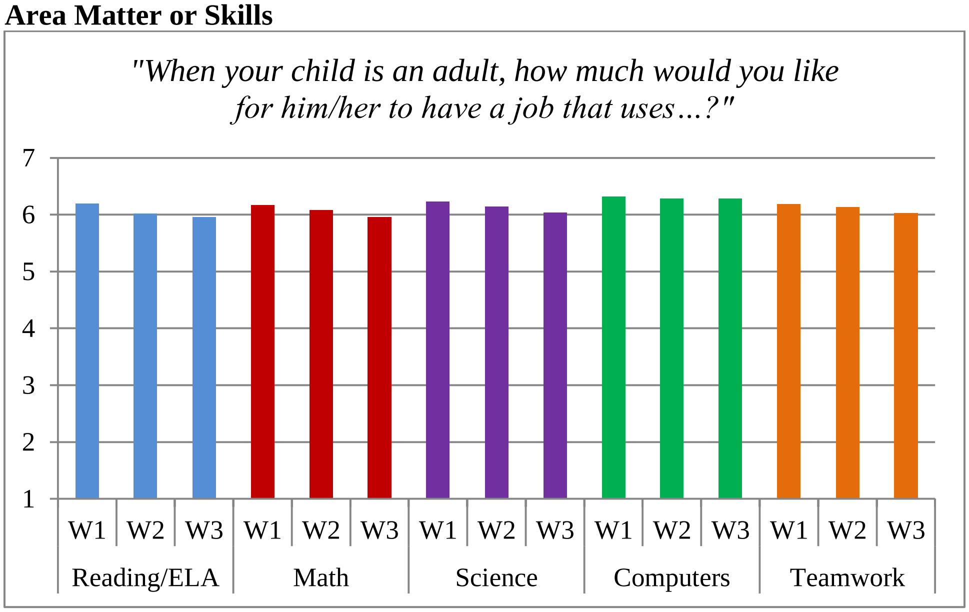
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 124-384, N_{W2} = 140-339, N_{W3} = 99-301

Exhibit 5-20: Parent Ratings of Importance of their Child Taking High School Courses in Particular Areas



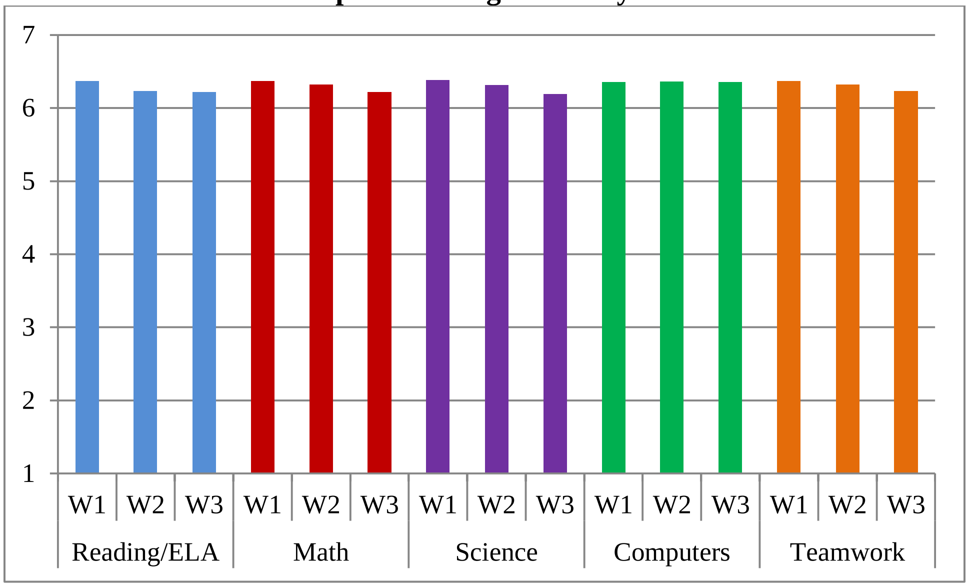
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 124-384, N_{W2} = 140-339, N_{W3} = 99-301

Exhibit 5-21: Parent Ratings of Importance of their Child Having a Job Using Particular Area Matter or Skills



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 124-384, N_{W2} = 140-339, N_{W3} = 99-301

Exhibit 5-22: Parent Composite Ratings of Utility of Areas and Skills



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 124-384, N_{W2} = 140-339, N_{W3} = 99-301

While the trend was for mothers to give slightly higher utility ratings than fathers, mothers and fathers tended to agree with one another on the importance of doing well in each area and continuing to take classes in those areas; there was no statistically significant difference between the two groups on these items.

Students and parents did not agree as strongly about utility as they did about self-efficacy.

Because parents were not asked about interest (a sub-construct of student STV), we did not compare students' STV ratings with the utility scores of parents. Instead, correlations were calculated between parents' and students' utility ratings in order to examine the concordance between these two measures. The correlations between students' utility scores and their parents' utility scores are shown in the technical appendices.

Overall, correlations were positive, moderately strong, and statistically significant ($\alpha = 0.05$); however, they were also smaller than correlations between students' and parents' SE ratings. The strongest correlations were seen for both parents in science, and then math. Mothers' ratings correlated statistically significantly with students' ratings at more points in time than did fathers' ratings, but the number of observations was also greater for mothers. For example, there were moderately strong and positive correlations between mothers and students on the utility of teamwork, but no statistically significant correlations between students and fathers in any wave on this measure.

Parent ratings of the utility of STEM areas remained mostly stable over time.

Parent utility ratings were examined for change over time and for gender interactions. Three statistically significant findings were observed: (1) for mothers' ratings of teamwork utility, (2) for mothers' ratings of reading/ELA utility, and (3) for fathers' ratings of reading/ELA utility.

For mothers with all three waves of data (*N* = 107), the mean composite teamwork utility score for mothers fell slightly over the course of the 3 waves, but there was not a statistically significant interaction effect with gender. This indicates that mothers viewed teamwork as being slightly less useful as time progressed for both boys and girls.

The mean composite reading/ELA utility score for both mothers and fathers (*N* = 37) fell slightly between Wave 1 and Wave 3, although there was not a statistically significant interaction effect with gender. Both mothers and fathers reported that they viewed reading/ELA as being moderately less useful over time, and expressed this view when rating both boys and girls.

Student self-efficacy and subjective task value scores were highly correlated.

We examined the relationship between how students felt about their ability and expectations for success in each area (student SE scores) and how interested and useful they found each area and skill to be (student STV scores). Correlations between these two constructs were strong, positive, and statistically significant ($\alpha = .05$, $p<.001$) for each area and each of the three waves of data collection, that is, having a higher self-rating in one was associated with having a higher self-rating in the other.

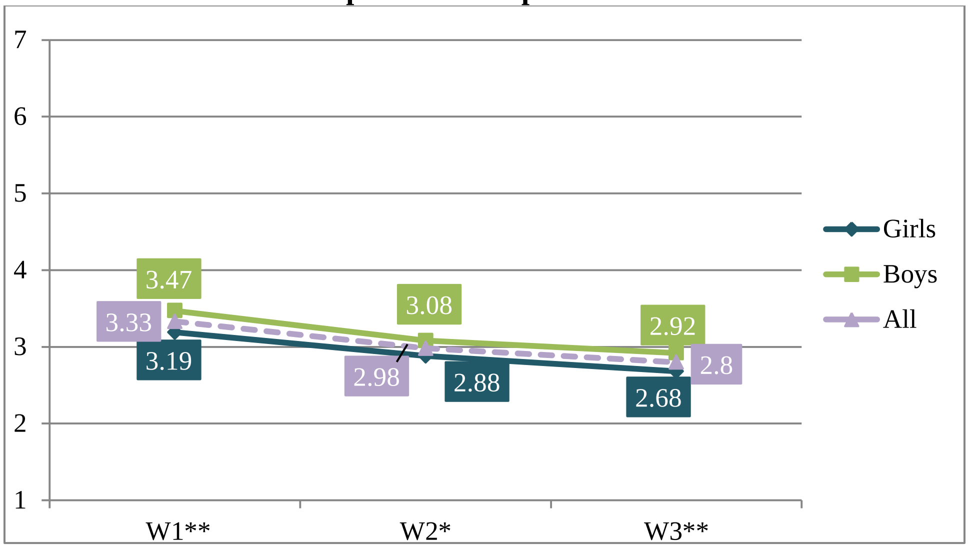
STUDENT OUT-OF-SCHOOL ACTIVITIES

The M-LEAP study was focused not just on measuring SE beliefs and STV beliefs through survey and interview instruments with students, parents, and teachers, but also the context for these beliefs. Student experiences (the “E” in science beliefs, experiences, and aspirations, or SBEAs) outside of school were measured on the student survey with questions regarding their frequency of participation in numerous Out-of-School (OOS) activities related to STEM. This included reading STEM-related literature, watching STEM-themed TV and movies, visiting informal science learning institutions, and participating in other activities. Their responses were used to calculate a composite score of STEM-related activity level with a scale of 1 to 7, as shown in Exhibit 5-23; means are shown for girls and boys at each wave, as well as the results of independent samples t-tests comparing boys’ and girls’ mean participation level during each wave.

Students did not frequently participate in STEM-related out-of-school activities, and participated in fewer activities over time. Boys participated in these activities more frequently than did girls.

Students engage in out-of-school STEM-related activities, on average, approximately once every other month, as shown by their relatively low mean scores (which fell well below the possible midpoint). Furthermore, their scores decreased over time; for students with a complete three-year record (n = 390), the mean activity level score differed statistically significantly between time points. The difference in the change in participation between boys and girls was not statistically significant; both experienced a decline over time. There was also no interaction between the activity variable and selection of a STEM career in Wave 3, indicating that students who selected a STEM career in the final wave of data collection and those who did not experienced a similar decline in frequency of participation in OOS STEM activities. There were, however, statistically significant differences between boys' and girls' self-reported frequency at each time point, with boys engaging in more OOS STEM-related activities than did girls during each wave.

Exhibit 5-23: Mean Self-Reported Participation Level in STEM-Related Activities



Scale: 1 (Never or almost never), 2 (a few times/year), 3 (about every other month), 4 (about once/month), 5 (every week or every other week), 6 (a few times/week), 7 (Every day or almost every day)
N_{W1} = 341-326, N_{W2} = 523-557, N_{W3} = 590-678; * = $p < .05$, ** = $p < .01$

Students who participated in more STEM-related activities also believed they were better at STEM areas (SE); this was particularly true for science.

The correlation between frequency of engagement in activities and SE beliefs was positive across all three waves of data collection. In each STEM area, engaging in more STEM activities was associated with higher SE beliefs. For science, more than for any other area, what students believed about their ability and expectations for success was tied to their frequency of engagement in out-of-school STEM activities. The results of multivariate HLM models predicting student SE and STV in STEM areas, discussed in a later chapter, revealed that students who participated in fewer STEM OOS activities had higher math SE scores, a finding which contradicts what was found here.

Students who participated in more STEM-related out-of-school activities also thought that STEM areas were more interesting and useful (STV).

Across all three waves, correlations were positive and statistically significant between students' self-reported frequency of engagement in OOS STEM-related activities and their belief in the utility of STEM areas and their level of interest (STV beliefs). In each STEM area, engaging in more STEM activities was associated with higher STV beliefs, on average. In fact, these correlations were stronger than they were between SE beliefs and activities, indicating an even closer relationship between participation in OOS STEM activities and interest and utility beliefs. Again, STV scores correlated most highly with OOS STEM activity level for science.

During each of the three survey waves, students who engaged in more STEM-related activities were moderately more likely to say they wanted a STEM job when they're adults.

Across all three waves of the M-LEAP study, girls and boys who self-reported engaging in more OOS STEM-related activities were more likely to present a STEM-related career choice when asked about what job they would like to have when they grow up (STEM job coding included only foundational STEM jobs such as engineer or scientist). Correlations between the OOS activity frequency measure and the dichotomous STEM career outcome variable were moderately strong. The correlation between these two measures was slightly stronger for girls than it was for boys in Waves 1 and 2 of data collection, while in Wave 3 it was stronger for boys. Independent samples t-tests confirmed that students who selected a STEM career reported participating in OOS STEM activities more frequently than those who selected a non-STEM career, on average, for all three waves of data collection.

Parents' ratings of their own proficiency in science and math were positively correlated participation rate in STEM-related out-of-school activities amongst students in Wave 3.

Students whose parents felt confident about their own abilities tended to report participating more frequently in extracurricular STEM activities than students whose parents did not feel confident about their own abilities, on average, in Wave 3. This relationship was stronger for fathers than mothers, but while the relationship also appeared in Wave 2 for mothers, it did not emerge in any other wave for fathers.

STUDENTS' PERCEPTIONS OF THEIR PARENTS' ATTITUDES TOWARD SCHOOL SUBJECTS

Students identified the parent or adult with whom they spend the most time, and then described their relationship with this adult. In the sample as a whole, 72% of students identified a female adult — typically a parent — and 28% chose a male adult, also typically a parent. We asked: "*How important is it to this adult that you do well in…* [school subject or skill]*?"* Likewise, we also asked parents how important it was to them that their children do well in certain school areas.

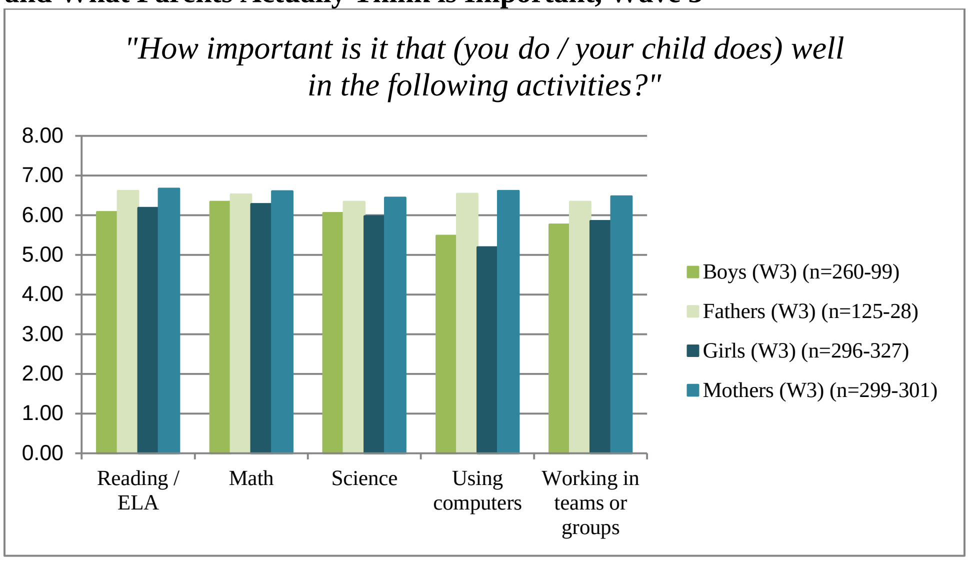
Students' ratings of how important it was to their parents to do well in certain areas remained stable over time.

For students with a complete three-year record (n = 192-271), the perceived parents' importance of doing well in these areas did not differ statistically significantly between time points in any area ($\alpha = 0.05$). Furthermore, there were no statistically significant gender interactions with time, suggesting that perceived importance of doing well in areas did not change differentially between boys and girls over time. Given this finding, Exhibit 5-24 presents student and parent responses side by side, divided by gender, for Wave 3 only.

Students believed their parents think it is slightly more important to do well in math and reading/ELA than in science.

On average, the students in Wave 3 of the M-LEAP study rated each discipline as holding moderate to high importance in their parents' view. Students believe that their parents think it is important for them to do well in reading/ELA, math, and science, and working in groups. The area rated as most important to do well in in the overall student sample was math, which had an average rating of 6.30, followed by reading/ELA (6.10) and science (5.99). "Using computers" received a score closer to the midpoint of the scale, with average ratings of 5.25 out of 7.00. These results remained relatively stable when students were asked to reflect on the beliefs of a second parent or adult.

Exhibit 5-24: Comparison between What Children Believe their Parents Think is Important and What Parents Actually Think is Important, Wave 3



Scale: 1 (Not at all important), 7 (Extremely important)

Parents thought it was important for their children to do well in all five areas and skills, but students did not perceive that their parents assigned such importance to these areas and skills; the gap was especially large for computers.

As seen in Exhibit 5-24, above, there was a gap between how important parents felt it was that their children do well in certain areas and how important students believed their parents thought it was to do well. For each core class and skill, parents rated the importance of doing well higher than their children thought their parents would. Paired-samples t-tests using only pairs of matched student and parent surveys showed that this difference was statistically significant at $\alpha = .05$ for each class. Exhibit TI-21, in Technical Appendix I, shows the size of the difference in means between matched mothers, fathers, and students for each area.

The gap between parental and student perceptions was smallest in the STEM areas of math and science, and somewhat larger in reading/ELA and teamwork. Interestingly, this difference was roughly three times larger for computers than for any other area; parents thought that doing well in computers was as important as doing well in any of the other areas, but their children did not perceive this.

Students who perceived that their parents thought it was important to do well in an area gave that area higher utility and interest ratings, on average.

There was a strong positive association between students perceiving that their parents thought it was important for them to do well and the utility and interest value that students assigned to each area.

In general, students who chose a STEM job and those who chose a non-STEM or allied health job did not differ in terms of how important they thought it was to their parents to do well in STEM areas.

By and large, students who picked a STEM career did not perceive it as being more or less important to their parents to do well in STEM areas, as shown by independent samples t-tests. Correlations between the job selection variable and the various measures of perceived parental importance were also not significant in almost all cases and waves.

The exception to this trend was in Wave 1, where there was positive association between perceiving it as important to parents to do well in science and selecting a STEM job, where students who perceived it as important to their parents to do well in science also tended to select a STEM job more often than those who did not, on average.

GENDER STEREOTYPES

We asked students, parents, and teacher each a variation of the following question: “In general, do you think that boys or girls are better at these areas and skills?” For each of five subject and skill areas, they indicated the degree to which they thought girls were better, that boys were better, or that boys and girls were about the same, as shown in Exhibits 5-25 through 5-29. Data are presented for Wave 3 of data collection, separated by gender. Note that all graphs total 100% except in cases of rounding error, and that the sample of male teachers responding is relatively small.

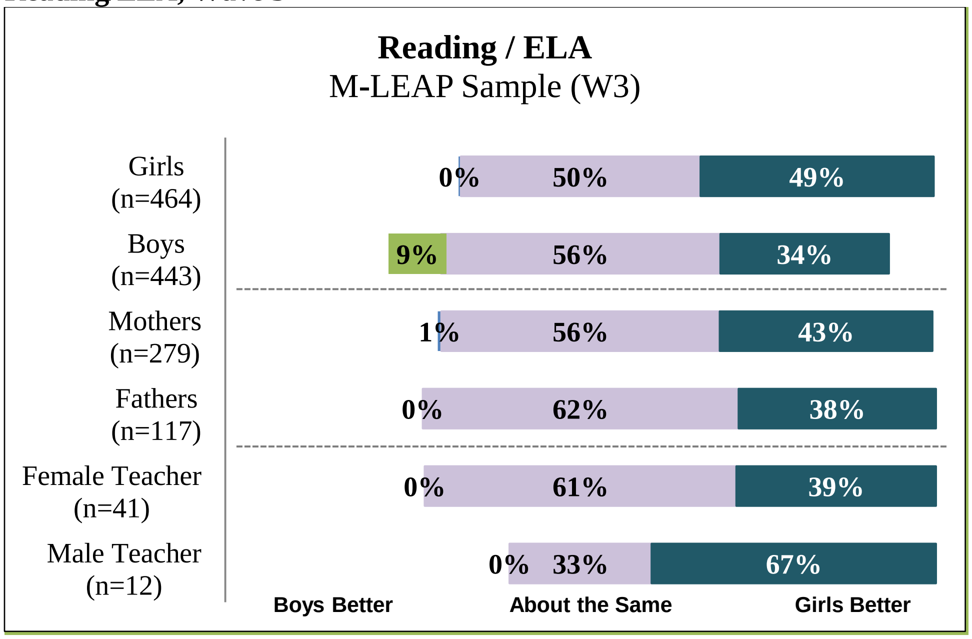
Reading/ELA

All groups thought that girls do better in reading/ELA than do boys.

In the overall M-LEAP sample, approximately half of both girls and boys said that both genders are about the same in ability when it comes to reading/ELA. Yet for both girls and boys, there was a pronounced skew toward rating girls as better at reading/ELA, and almost no girls indicated that boys were better. Responses from parents followed a similar pattern. However, while 9% of boys said that boys were better at reading/ELA, no fathers said this, and instead a greater percentage of fathers said both genders were about the same or that girls were better.

A large percentage of both male and female teachers said that girls were better at reading/ELA, while none said that boys were better. Approximately 60% of female teachers said that boys and girls were about the same, while two-thirds of male teachers said that girls were better.

Exhibit 5-25: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Reading/ELA, Wave 3



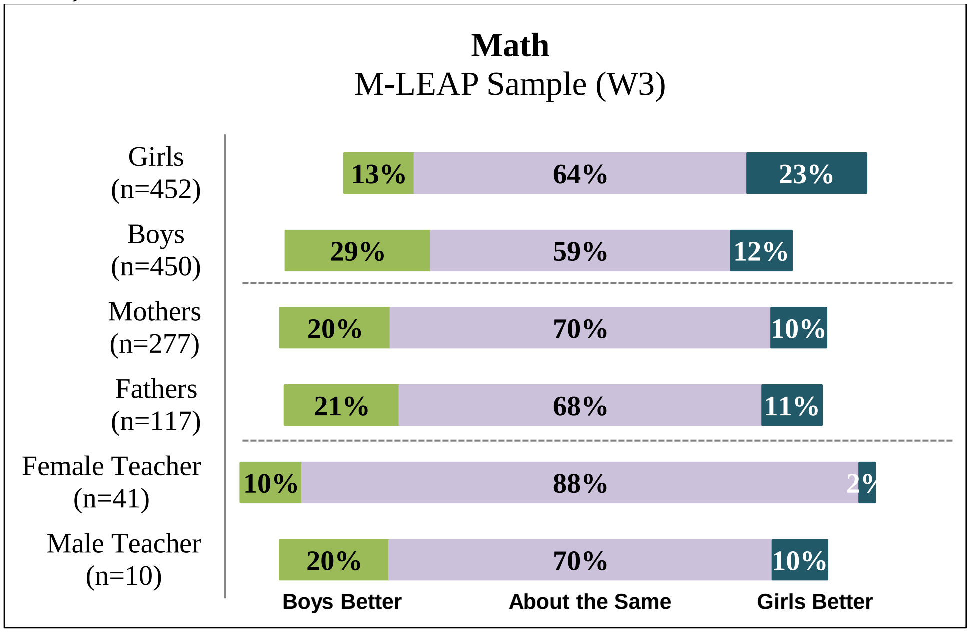
Mathematics

Most students and adults believed boys and girls are about the same in mathematics ability. While traditional math stereotypes favoring boys persisted among a fifth of adults and a quarter of boys, about a quarter of female students favored their own gender.

In math, the majority of girls and boys in the M-LEAP sample said that both genders are about the same in ability, although about a quarter of respondents from each gender gave the nod to their own gender. Responses from mothers and fathers lined up more closely with one another than the two sets of student responses, but mothers did not exhibit the same tendency to favor their own gender in math as much as female students did. The majority of parents said that both genders are about as good at math as one another.

The overwhelming majority of both male and female teachers said that boys and girls are about the same in terms of ability when it comes to math. Most of the remaining male and female teachers favored boys.

Exhibit 5-26: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Math, Wave 3



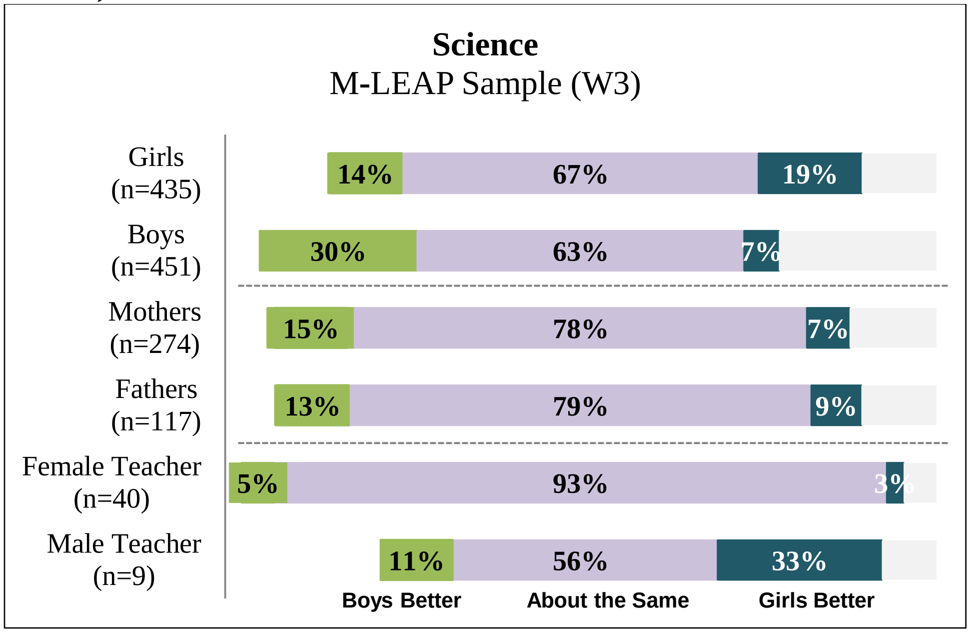
Science

Girls thought they are as good as, or better than, boys at science.

Among students, approximately two-thirds of respondents from each gender said that boys and girls are about as good as one another at science, with the remainder of girls split roughly evenly between seeing girls as better and boys as better, and with the remaining boys tending to favor their own gender. Once again, the two sets of parental responses lined up more closely than did the student responses, with a greater proportion of mothers and fathers saying that boys and girls are about the same in terms of science ability and the remaining respondents giving a slight edge to boys.

Female teachers, by and large, said that boys and girls were about the same in terms of ability in science. In comparison to students and parents on this and any other area, this was the largest instance of a group converging on this option. In contrast, a far smaller majority of male teachers said that both genders were about equal, with one third of male respondents giving the edge to girls.

Exhibit 5-27: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Science, Wave 3



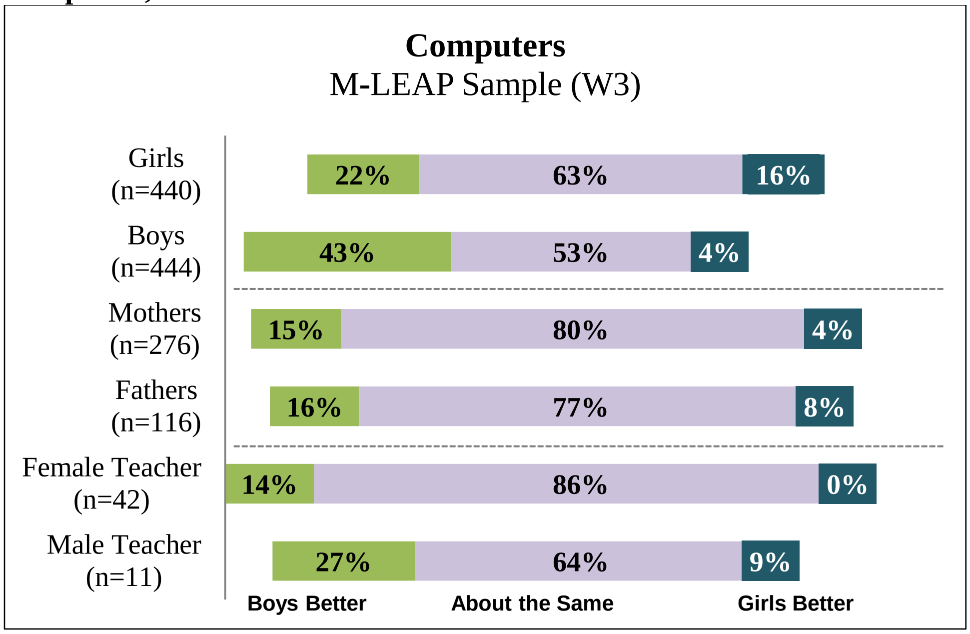
Computers

Students, teachers, and parents all had different views on computer ability stereotypes.

Regarding computer ability, the majority of girls said that both genders are about the same in ability, with the remaining female respondents giving a slight edge to boys. In contrast, about half of boys said that both genders are about as good as one another at computers, but the remaining male student respondents skewed heavily toward seeing boys as better. Parents, on the other hand, seemed to agree more with each other that boys and girls have the same ability with computers, with the remaining parents favoring boys over girls.

The vast majority of female teachers said that both groups of students were about the same in terms of ability in computers, with a small percentage giving the edge to boys. No female teachers said that girls were better at computers than boys. Over a quarter of male teachers favored boys when it came to computers.

Exhibit 5-28: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Computers, Wave 3



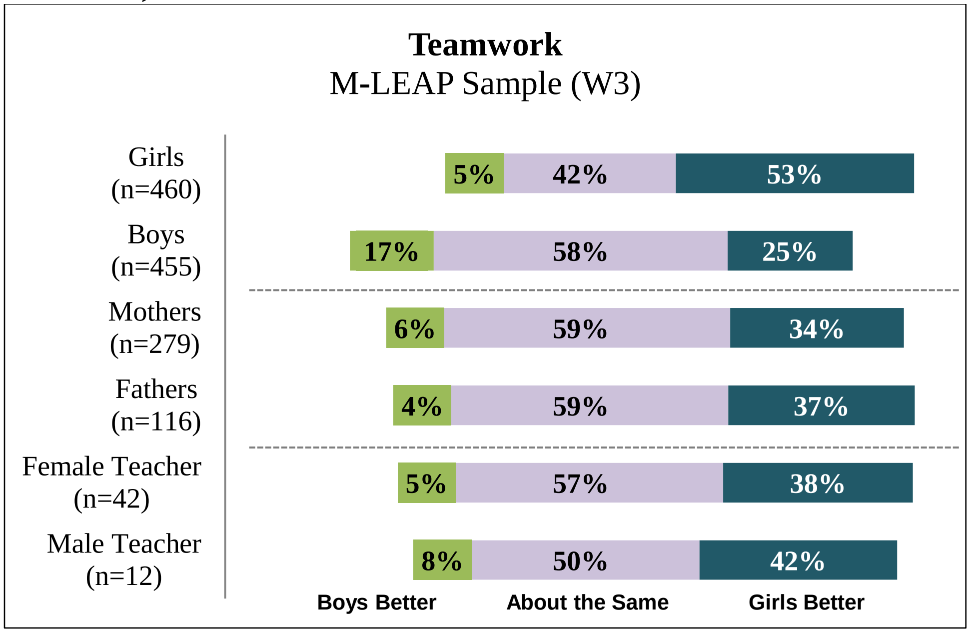
Teamwork

When it came to teamwork, students, parents, and teachers all said that girls are as good as, if not better than, boys.

The majority of girls said that girls are better than boys at working in teams. In contrast, the majority of boys said that both genders were about the same in terms of teamwork ability, with the remaining male respondents giving the edge to girls. As with the other subjects and skills, the two sets of parents were in closer alignment with one another than their children were with one another, with the majority of both mothers and fathers saying that boys and girls had the same aptitude for teamwork, and approximately a third saying that girls are better.

Around half of teachers from each gender said that boys and girls were about the same, while the vast majority of the remaining percentage of both groups said that girls were better

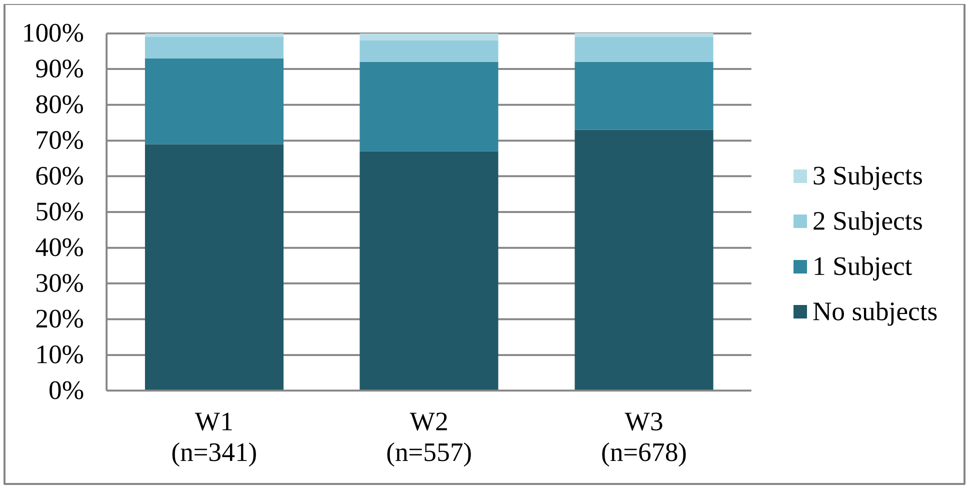
Exhibit 5-29: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Teamwork, Wave 3



Relationship of Gender Stereotypes to Student Outcomes

We explored the relationship between holding stereotypes that favor one gender or another and outcomes relevant to the M-LEAP study, especially for girls who hold stereotypes that are boy-favoring and unfavorable to girls with regard to STEM areas (e.g., that girls are not as good in science as are boys). As a measure of the strength of girls' boy-favoring stereotype beliefs, we created a variable reflecting the number of STEM areas (math, science, and computers) in which they held a boy-favoring stereotype. The distribution of boy-favoring stereotypes across these areas among girls for each wave is presented in Exhibit 5-30, which shows that most girls held boy-favoring stereotypes in either no area (69%) or only one area (24%). An identical variable was computed for mothers and fathers and is discussed below.

Exhibit 5-30: Number of STEM Areas in which Girls Held Boy-Favoring Stereotypes, Waves 1-3



In Wave 1, 3rd-6th grade girls who held more pro-boy gender stereotypes also had moderately lower self-efficacy and subjective task value beliefs in STEM areas, but this effect did not hold over time.

We explored the relationship between gender stereotypes and how students felt about their abilities in STEM and about the value of STEM school areas. In Wave 1, holding a boy-favoring stereotype in one or more areas was statistically significantly negatively related to SE and STV scores for girls in each STEM area at $\alpha = 0.05$. Girls who thought that boys were better at STEM areas also tended to feel moderately worse about their own abilities in those areas and saw those areas as less valuable.

Interestingly, most of these significant correlations became insignificant in Waves 2 and 3, with some notable exceptions:

- In Wave 2, girls who held a boy-favoring stereotype had lower SE scores in computers.
- In Wave 3, girls who held boy-favoring stereotypes in science had lower science STV (a re-emergence from Wave 1) and lower computer STV.
- Girls who held boy-favoring stereotypes in more areas also felt that science was less useful or interesting, on average, in two of the three waves of data collection.

Holding more gender stereotypes was unrelated to participation in STEM activities or selecting a STEM career, on average.

Girls who held boy-favoring stereotypes in more STEM areas did not participate in fewer STEM activities and did not have lower STEM career aspirations in any wave, on average. The only exception was that girls who endorsed boy-favoring stereotypes in more STEM areas participated in fewer STEM activities outside of school, on average, in Wave 3 of data collection. Analyses revealed no statistically significant correlations between holding a boy-favoring stereotype in STEM areas and selecting a STEM-related career.

Students who held more gender stereotypes tended to have mothers who also held more gender stereotypes.

Students' holding boy-favoring stereotypes in more STEM areas was not statistically significantly correlated with parents' holding boy-favoring stereotypes in any wave when both genders of students were grouped together. However, when boys' and girls' frequency of holding boy-favoring gender stereotypes were compared with mothers and fathers, separately, a few significant correlations emerged:

- In Wave 1, girls who held more boy-favoring gender stereotypes tended to have mothers who held more gender stereotypes. This correlation remained statistically significant in Wave 2 but not in Wave 3.
- For boys, holding more boy-favoring stereotypes was statistically significantly associated with having a mother who held more gender stereotypes, as well, but only in Wave 1.
- The association between student and parent stereotypes was stronger for boys in Wave 1 than it was for girls in either Waves 1 or 2.

Parent gender stereotypes generally did not correlate with student outcomes.

Parents' holding boy-favoring gender stereotypes of ability in STEM areas was not statistically significantly correlated with students' SE or STV beliefs, or their career aspirations. The exception was that in Wave 3, boys and girls whose father held more boy-favoring gender stereotypes tended to have slightly lower STV scores in math, on average.

Also:

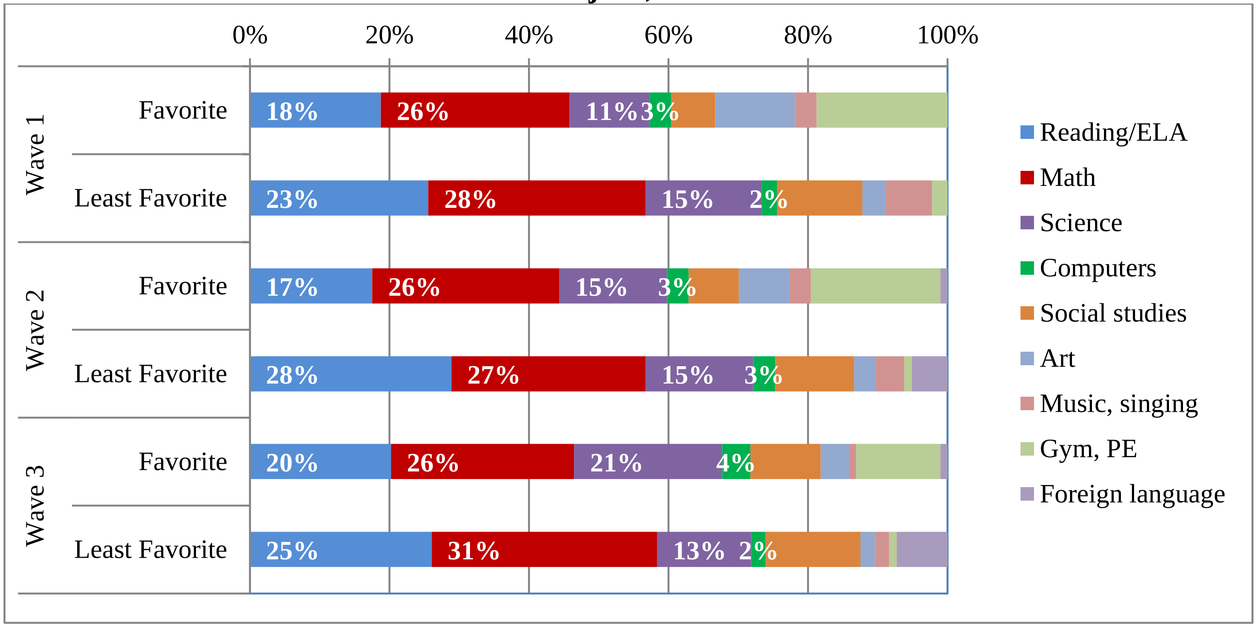
- In Wave 2, girls whose mothers held more boy-favoring stereotypes tended to select a STEM job slightly more often.
- In Wave 2, boys whose fathers held more boy-favoring stereotypes tended to select a STEM job slightly less often.

The results of HLM models predicting student SE and STV scores in STEM areas discussed in Chapter 7 revealed relationships between parental stereotype endorsement and student outcomes not found here. These included the findings that boys whose parents endorse more boy-favoring gender stereotypes have higher science, math, and computers SE and lower math STV, whereas girls whose parents endorse more boy-favoring gender stereotypes have lower science, math, and computers SE, but higher math STV.

FAVORITE AND LEAST FAVORITE SUBJECTS

Students chose both their favorite and least favorite subject in school. The percentages of students selecting each area are presented in Exhibit 5-31 (N = 625-1,142). Wave 1 represents 3rd-6th graders, Wave 2 is 4th-7th graders, and Wave 3 is 5th-8th graders.

Exhibit 5-31: Favorite and Least Favorite Subjects, Waves 1-3



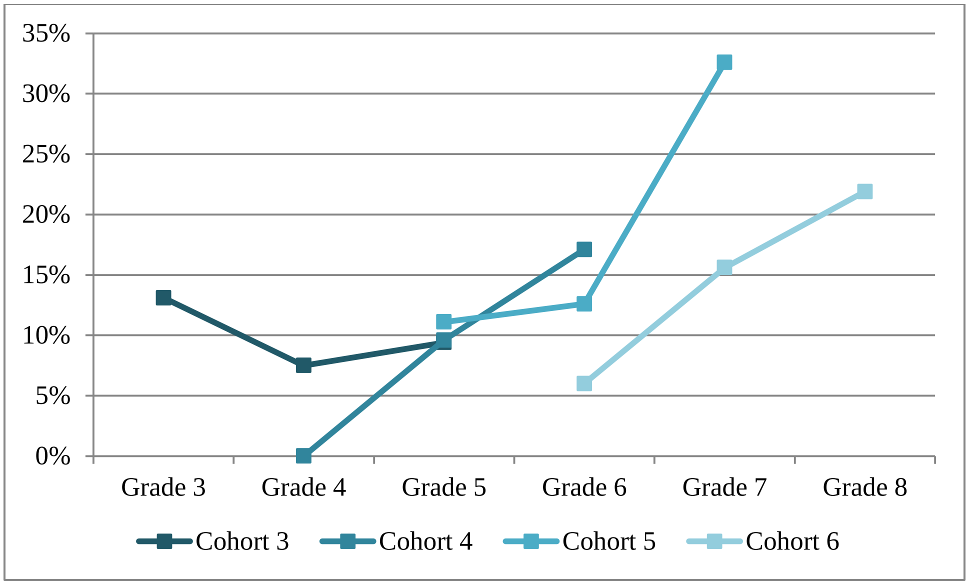
N=625-1,142

Most of the favorite and least favorite class selections involved core areas, like reading/ELA, math, science, and social studies; however, gym/PE was also a popular selection for favorite class. The percentage of students who responded with "None" or "Don't have one" was nearly zero.

The percentage of students selecting science as a favorite subject increased as they moved into higher grades, and this increase was more dramatic for girls than it was for boys.

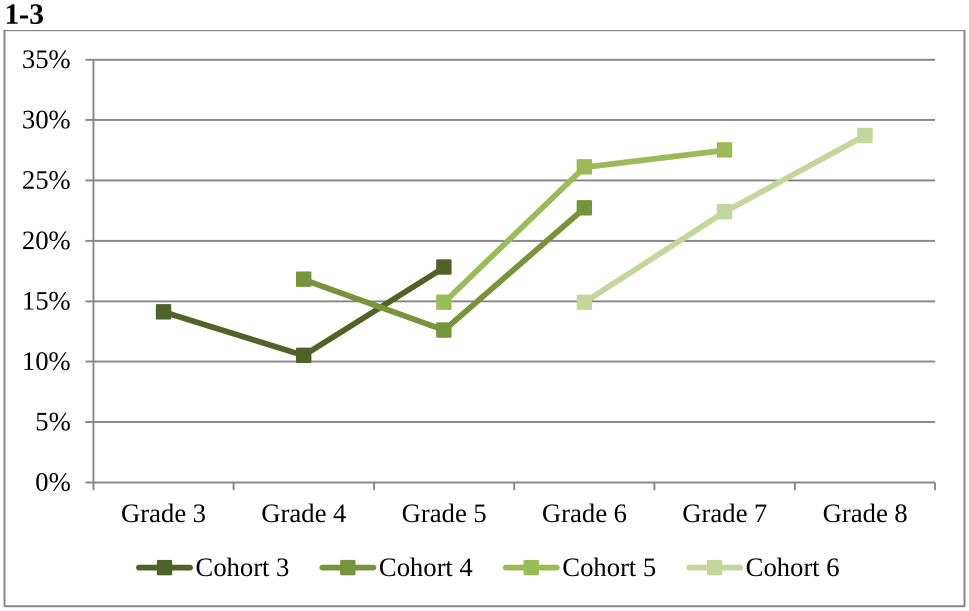
A few notable trends emerge from the data regarding the core areas. In science, the distribution of favorite versus least favorite showed an interesting reversal, with a greater percentage of students in Wave 1 disliking science than liking it and a greater percentage of students in Wave 3 liking science than disliking it. For girls, specifically, this change was even more dramatic: in Wave 1, only 7% of girls (*n* = 335) said that science was their favorite class, with 20% selecting it as their least favorite, while in Wave 3, 20% of girls (*n* = 438) said that science was their favorite subject and 15% said that it was their least favorite. This trend is illustrated in Exhibits 5-32 and 5-33, broken down by cohort, and Exhibits 5-34 and 5-35, which shows the trend in selecting science as a least favorite subject.

Exhibit 5-32: Percentage of Girls Selecting Science as a Favorite Subject, by Cohort, Waves 1-3



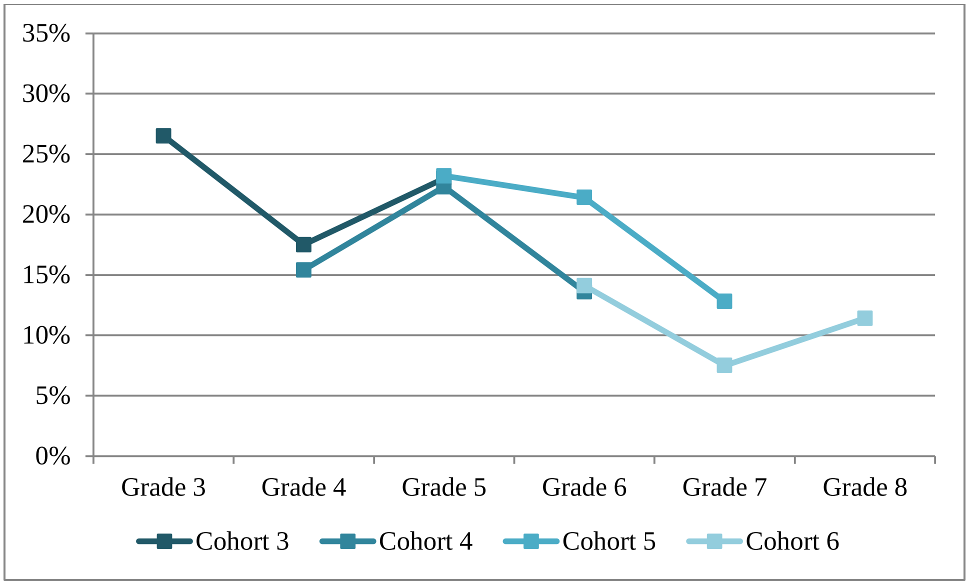
N = 72-123 per data point (for example, 84 3rd grade girls in Cohort 3 surveyed in Wave 1 responded to this item)

Exhibit 5-33: Percentage of Boys Selecting Science as a Favorite Subject, by Cohort, Waves 1-3



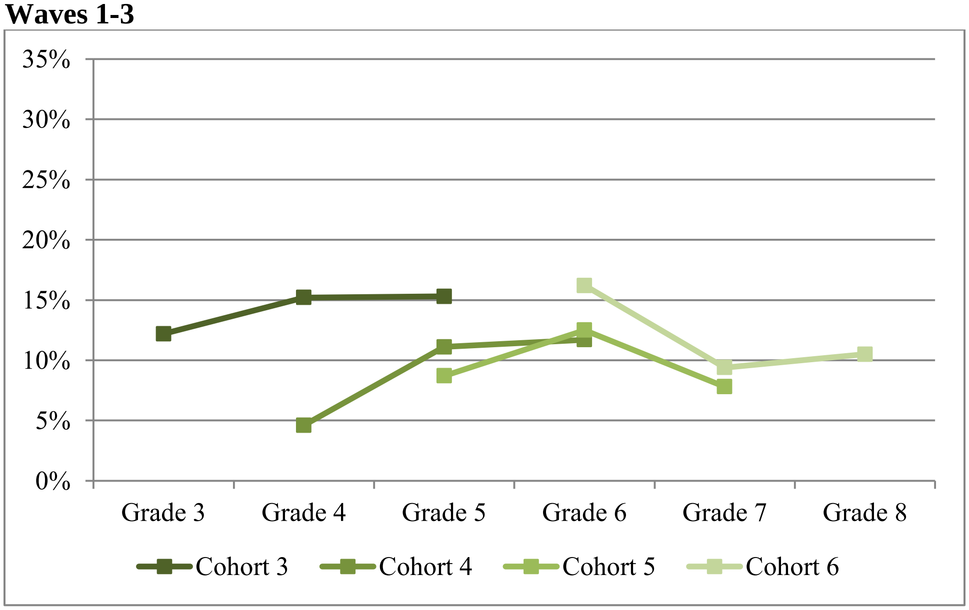
N = 74-105 per data point (for example, 89 6th grade boys in Cohort 5 surveyed in Wave 2 responded to this item)

Exhibit 5-34: Percentage of Girls Selecting Science as Least-Favorite Subject, by Cohort, Waves 1-3



N = 69-118 per data point

Exhibit 5-35: Percentage of Boys Selecting Science as Least-Favorite Subject, by Cohort, Waves 1-3



N = 69-99 per data point

For the M-LEAP sample as a whole, the ratio between favorite and least favorite for math stayed relatively constant, with “least favorite” edging out “favorite” slightly each wave. Again, though, the gap between these two options was greater for girls than it was for the sample as a whole: the average percentage of girls selecting math as their favorite subject over the three-wave period was 23% while the average percentage of girls selecting math as their least favorite subject over the same period was 32%. This ratio stayed relatively constant over all three waves.

Students who picked a STEM area as their first or second favorite class had higher self-efficacy and subjective task value scores in STEM areas than those who did not, on average.

Whether or not a student selected a STEM area such as science, math, or computers as their first or second favorite class was related to their composite SE and STV scores in the STEM areas and skills, in the present sample. For each wave of data, the mean composite SE and STV scores for students who selected a STEM area as their favorite were statistically significantly higher than for those who did not select a STEM area ($p < .01$ in all cases). Students who picked a STEM class as their favorite had moderately higher SE and STV scores in STEM areas, on average.

The exception to this pattern was the relationship between selecting a STEM area and computers SE, where the difference in mean SE scores between students who selected a STEM area as their first or second favorite and those who did not was smaller than it was for the other areas and only statistically significant in Waves 1 and 2. Students who picked a STEM class as one of their favorites had slightly higher SE scores in computers, on average, but this difference was not as large as it was in other subject areas. The results of the multivariate HLM models predicting student SE and STV scores in STEM areas discussed in a later chapter showed that students whose favorite area is non-STEM actually have higher computer STV.

Students who picked a STEM area as their first or second favorite class chose a STEM career at twice the rate of those who did not choose a STEM area.

Across all three waves, the percentage of students who chose a STEM career versus a non-STEM career differed statistically significantly between students whose first or second favorite class was STEM-related and those who favored another class ($p < .01$ in all cases). The mean percentage of students who selected a STEM career was higher among students who chose a STEM area than it was among those who did not choose a STEM area.

EDUCATIONAL AND CAREER ASPIRATIONS

Educational Aspirations

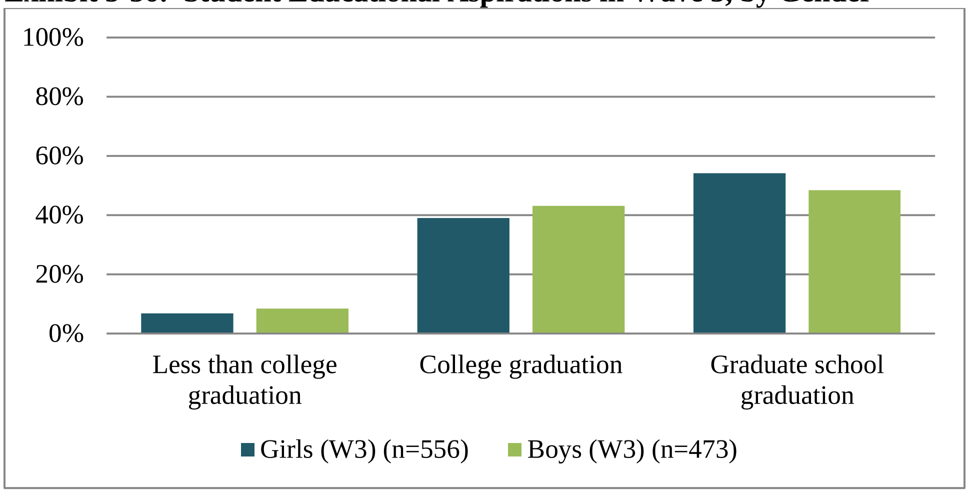
Students self-reported how far they thought they would advance in school, choosing from: "Some high school," "High school graduation or G.E.D.", "Some college", "College graduation", "Graduate degree (medicine, law, or advanced study of any subject)", and "Some other school or training program". To simplify our analyses and zero-in on the outcomes most relevant to this study, we collapsed students' responses to this question into a variable with the following three categories: "Less than college graduation," "College graduation," and "Graduate school graduation." In some analyses we use the term "underrepresented minority" to refer to African American, Latino, American Indian, Pacific Island and Hawaiian students in the sample.

Both genders aspired to higher levels of education as they progressed into higher grades.

According to U.S. government statistics, of the 3.2 million youth aged 16 to 24 who graduated from high school between January and October 2012, about 2.1 million (66.2%) were enrolled in college in October 2012 (Bureau of Labor Statistics, 2013) (This rate was slightly lower than the October 2011 rate of college entrance of 68.3%.) For 2012 graduates, the college enrollment rate was 71.3% for young women and 61.3% for young men. The college enrollment rate of Asians (82.2%) was higher than for recent white (66.6%), black (58.2%), and Hispanic (70.3%) graduates.

Exhibit 5-36 shows the percentage of boys and girls in the M-LEAP sample who selected each level of education in Wave 3 (2013). For students with a complete three-year record (n = 288), the mean educational aspiration score differed statistically significantly over the three waves ($p < .001$), rising slightly over time from a mean that corresponded to just above "College graduation" to a mean that corresponded to just below "Graduate school graduation." However, there was no statistically significant interaction between educational aspiration and gender, meaning that both genders experienced a similar growth pattern over time.

Exhibit 5-36: Student Educational Aspirations in Wave 3, by Gender



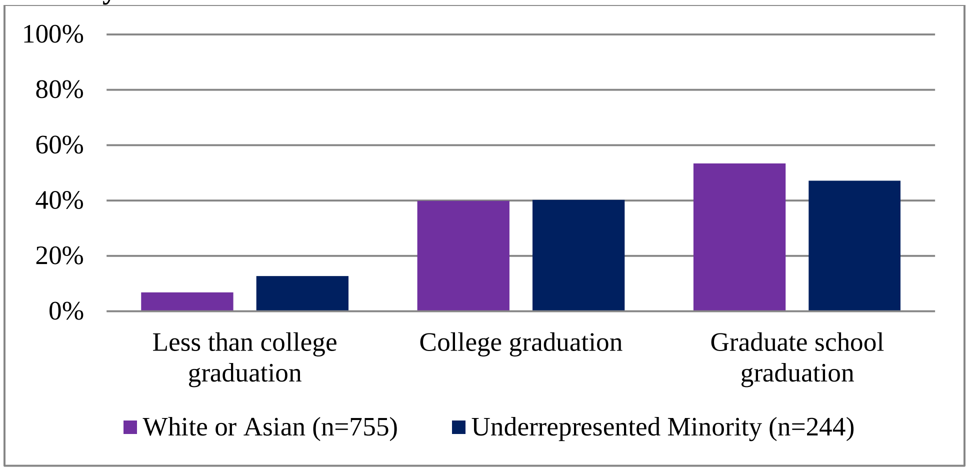
A large percentage of both girls and boys aspired to a graduate degree.

A slightly greater proportion of girls than boys in the M-LEAP sample expected to obtain a graduate school degree in Wave 3, with a greater percentage of boys indicating that they expected to advance as far as a college degree or somewhere less than college graduation. There was no statistically significant relationship between gender and educational aspiration in Wave 3.

There was a small but statistically significant difference between underrepresented minorities and white and Asian students in educational aspirations in Wave 3.

As shown in Exhibit 5-37, White and Asian students were slightly more likely, on average, to aspire to graduate school, and underrepresented minority students were slightly more likely to aspire to "less than college graduation" ($p < .01$).

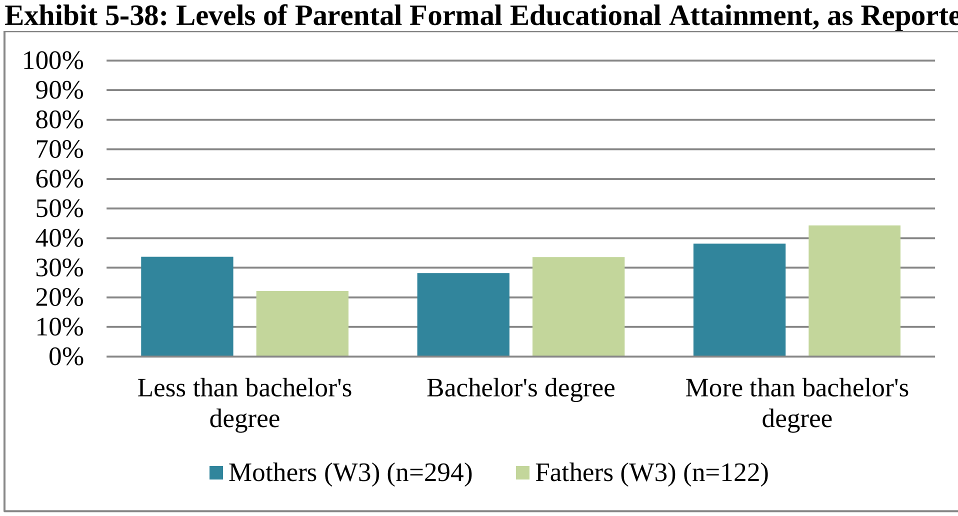
Exhibit 5-37: The Distribution of Formal Educational Aspirations for Minority and Non-Minority Students in Wave 3



The more education a mother had, on average, the higher her daughter's own educational aspiration.

Parents also reported their own level of educational attainment. Responses from Wave 3 are presented below by parent gender. The proportion of male parents who have at least a Bachelor's degree exceeded that of female parents, while a greater proportion of mothers reported an education level below bachelor's degree. The difference is shown in Exhibit 5-38.

Exhibit 5-38: Levels of Parental Formal Educational Attainment, as Reported in Wave 3



Each parent's own level of education attainment was compared with her or his child's educational aspirations. In Waves 2 and 3, mothers' (but not fathers') education level was moderately positively related to girls' education aspirations, but it was not statistically significantly related to boys' aspirations. Girls whose mothers had higher educational attainment also aspired to go farther in school, in Waves 2 and 3, but this relationship was not found to be statistically significant for boys.

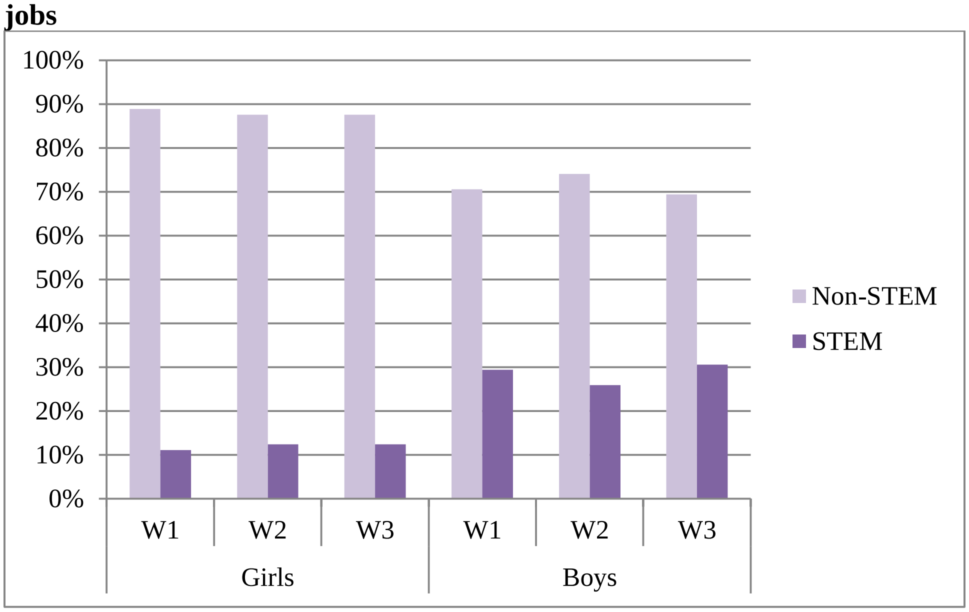
Career Aspirations

Students wrote down the jobs that they would like to have as adults. We coded their responses into the following categories: science, technology, engineering, and math (STEM) jobs versus non-STEM jobs. At this level of analysis, "STEM" jobs included those that match the NSF definition of a STEM career. The most commonly selected STEM jobs were engineer, architect, and marine biologist. "Non-STEM" jobs included allied health careers and other jobs. The three most popular non-STEM jobs were lawyer, teacher, and artist. Exhibit 5-39, below, shows the percentage of boys and girls selecting a STEM job or a non-STEM job during each wave of data collection.

While the majority of students in both genders preferred non-STEM careers, boys selected a STEM career with greater frequency than did girls during all three waves of data collection.

During eave wave of data collection, the majority of both boys and girls preferred non-STEM careers. Boys selected STEM jobs statistically significantly more frequently than did girls in all three waves ($p < .0001$).

Exhibit 5-39: Percentage of Male and Female Students Selecting STEM and Non-STEM jobs

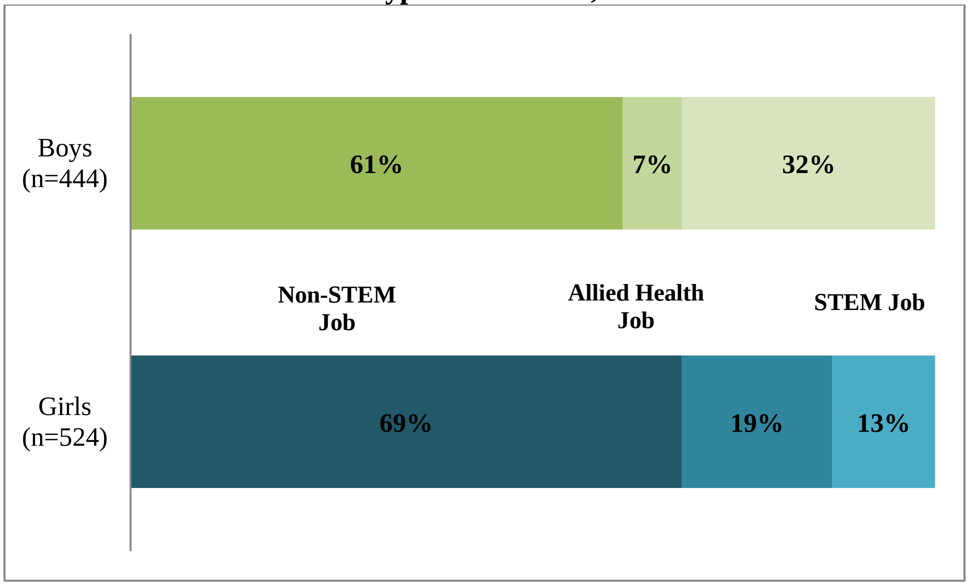


N_{GIRL} = 333-539, N_{BOY} = 313-495

More girls than boys aspired to work in allied health.

In order to get a more fine-grained insight into the kinds of careers that students wanted to pursue, non-STEM jobs were further divided into "allied health" jobs versus regular non-STEM jobs. The most popular "allied health" jobs were doctor, veterinarian, and nurse. Here, we present the results of this additional level of coding for the sample as a whole, separated by gender.

Exhibit 5-40: Preferred Job Type for Students, Wave 3



Note: STEM job choice results are shown disaggregated by school and wave in the technical appendices.

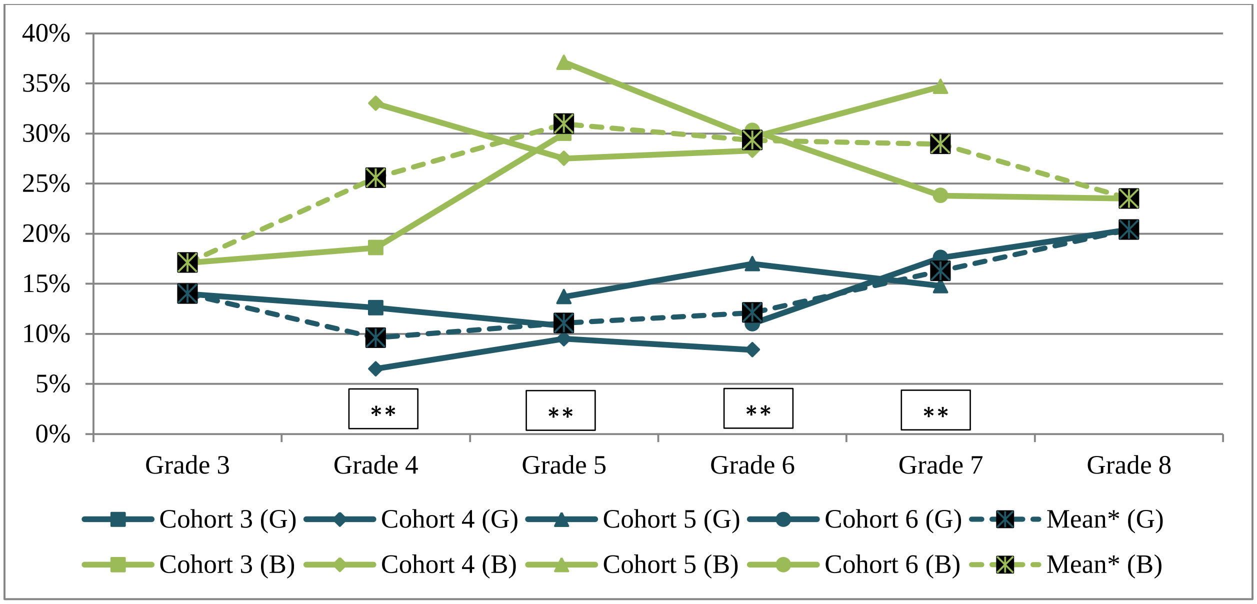
There was a statistically significant relationship between student gender and career choice in Wave 3, with boys being more likely to select a STEM job and less likely to select a non-STEM job or allied health job. Of the boys who picked a broadly-defined non-STEM career in Wave 3, only 11% selected an allied health job, such as doctor or nurse, whereas 22% of girls who picked a non-STEM career chose an allied health job.

Wave 3 results are relatively similar to the findings from Waves 1 and 2. For instance, the percentage of girls selecting a STEM career was 11% in Wave 1 and 13% in Wave 3. For those girls who had a complete three-year record (n = 165), there was not a statistically significant change in the percentage selecting a STEM career over time. For boys, 31% in Wave 1 and 32% in Wave 3 selected STEM careers. Surprisingly, though, for boys with a complete three-year record (n = 134), the percentage selecting a traditional STEM career actually dropped from an average of 34% to 29% over the three waves, and this result was statistically significant.

Boys and girls exhibited opposite trends in the rate of selecting a STEM career over the course of their schooling. After 3rd grade, the percentage of boys selecting a traditional STEM job went up and then back down, while girls went down and then up.

About 15% of boys and girls in 3rd grade chose a STEM career, such as engineering, but the general trend after this grade was for a higher percentage of boys than girls to select a STEM job. Exhibit 5-41 shows the percentage of students selecting a STEM job during each wave of data collection by gender, grade, and cohort.

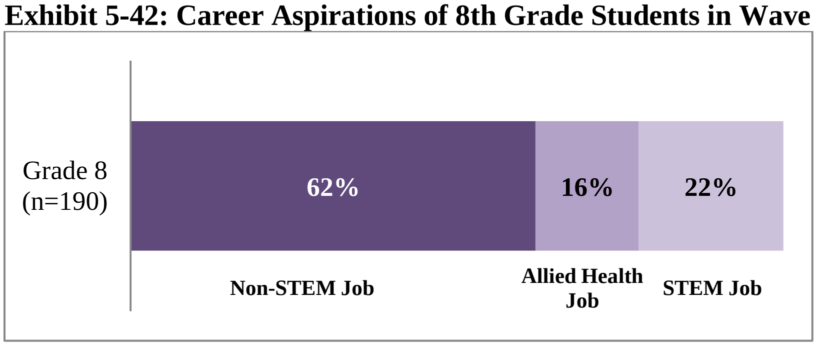
Exhibit 5-41: Percentage of Boys and Girls Selecting a STEM Career in Waves 1-3, by Grade



N = 68-108 per data point (for example, there were 86 3rd grade girls surveyed in Wave 1)
*Note that due to the study design, the number of data points being averaged within each gender per grade ranges from one to three. This mean represents a weighted arithmetic mean. ** = $p < .01$ in two-tailed z-test of difference in proportions between two groups.

Exhibit 5-42 shows the percentage of students in our sample selecting a non-STEM job, allied health job, and STEM job at the end of 8th grade.

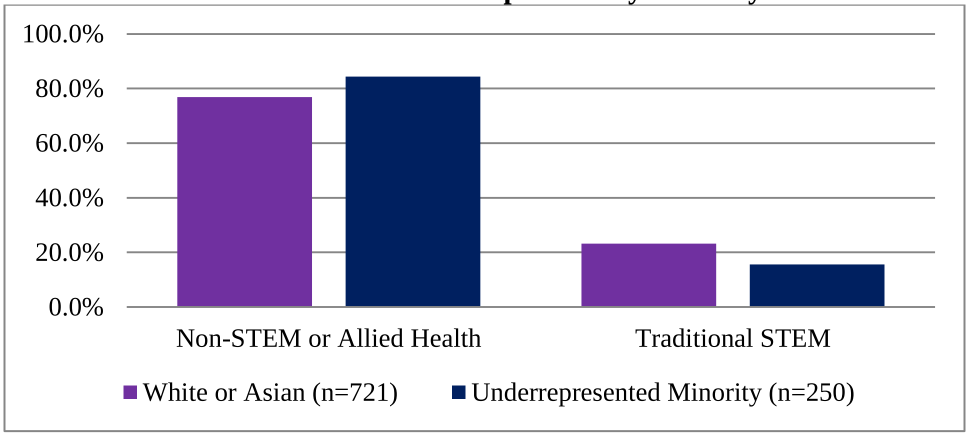
Exhibit 5-42: Career Aspirations of 8th Grade Students in Wave 3



Underrepresented minority students were moderately less likely to aspire to a STEM career than were white or Asian students.

There was a statistically significant difference in the distribution of career aspirations among the two groups in Wave 3, with White and Asian students were slightly more likely to aspire to a traditional STEM career, on average, and underrepresented minority students were slightly more likely to aspire to a non-STEM or allied health career (p<.05).

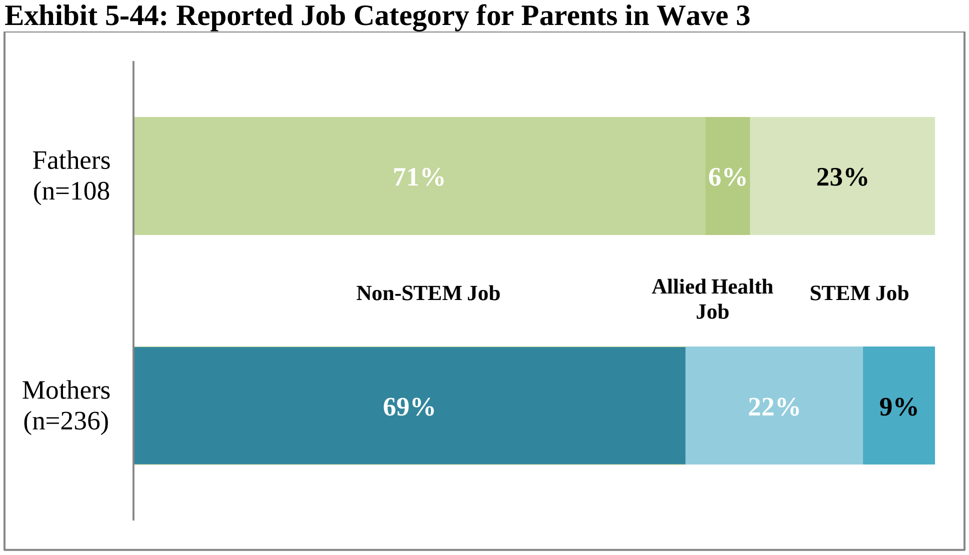
Exhibit 5-43: Distribution of Career Aspiration by Minority Status in Wave 3



There was no correlation between parent STEM job status and student job choice.

Parents who completed the parent survey also self-reported their career, which was similarly coded. Results of this coding for parents who submitted a survey in Wave 3 of data collection are presented below.

Exhibit 5-44: Reported Job Category for Parents in Wave 3



The distribution of parental job status was not statistically significantly different for students who selected a STEM career versus those who selected a non-STEM or allied health career. In other words, the parents of students who selected a STEM job or a non-STEM job had a similar job distribution, indicating that there was not a heavy skew toward parents having a STEM job amongst students who chose a STEM job, or a skew toward parents not having a STEM job amongst students who selected a non-STEM job. Testing for correlations yielded the same finding: children of parents who worked in a STEM field were not statistically significantly more or less likely to choose a STEM job, on average, and this trend was seen in both genders.

There was generally no statistically significant relationship between parents' STEM job status and students' gender stereotypes in STEM areas.

No statistically significant correlations were found between parent STEM job status and students' gender stereotypes, except for a moderately strong correlation in Wave 3 between mothers and female students where female students whose mothers worked in a STEM field also tended to hold boy-favoring stereotypes in more STEM areas, on average ($\rho = .21$, $n = 126$, $p < .05$).

The relationship between career aspirations and student self-efficacy and subjective task value

We examined whether or not students who aspired to a STEM career tended to have higher SE and STV ratings in STEM areas. When boys and girls were compared as one group, holding a STEM career aspiration was associated with higher SE beliefs, on average. Holding a STEM career aspiration was also associated with having higher STV beliefs, on average, and this relationship was even stronger than it was for SE beliefs. Additional analyses revealed that the strengths of these relationships were not statistically significantly different by gender, suggesting that students from both genders who held a STEM career aspiration tended to have higher SE and STV beliefs in STEM areas.

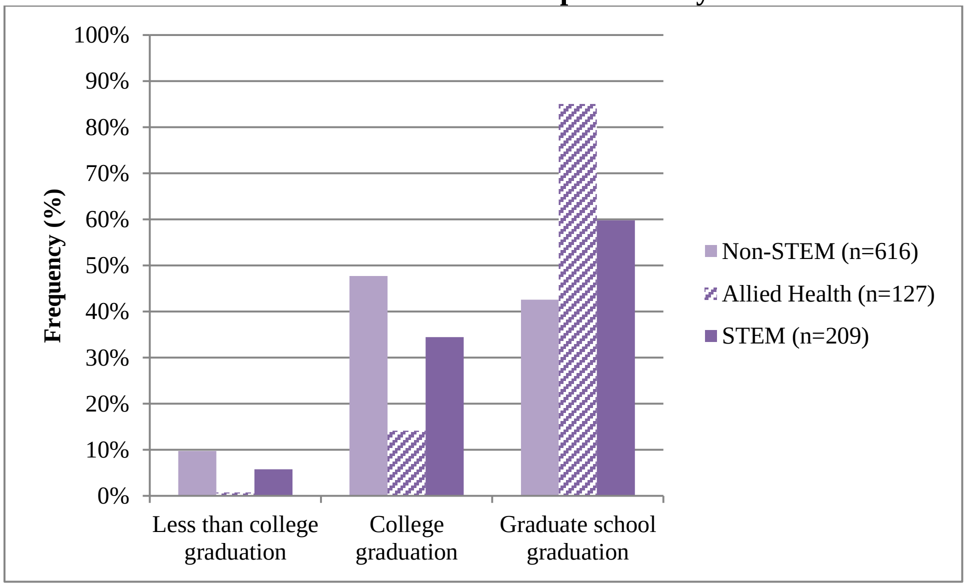
The relationship between educational aspirations and career aspirations

We examined whether or not students who held higher aspirations for advancement in formal education were also more likely to self-report wanting a STEM job when they grew up.

Students with STEM career aspirations envisioned getting more formal schooling than students who aspired to a non-STEM career.

Correlations between our measure of academic aspirations and our various measures of STEM career aspiration consistently hinted toward a positive association between aspiring to hold a STEM job and aspiring to an advanced academic degree. Across the three waves, correlations between career choice and educational aspirations were statistically significant at $\alpha = .01$ and moderately strong, suggesting that students who held STEM career aspirations also tended to hold higher aspirations for formal education. The following exhibit shows the distribution of educational aspiration for students dependent on their career choice; a statistical test confirmed that the distribution of educational aspiration differed across the career choices. In other words, there was a relationship between educational aspiration and career choice.

Exhibit 5-45: Distribution of Educational Aspirations by Career Choice in Wave 3



CHAPTER 6: STUDENT INTERVIEWS

Student interviews conducted with a subset of the M-LEAP student sample allowed for deeper insights into the underlying reasons and motivations behind changes in students' ratings of self-efficacy and subjective task value, as well as outcomes related to educational and career aspirations. In Waves 1 and 2, we asked students interview questions that aligned closely with the student questionnaire, but we did not address the changing internal and external factors in students' lives in a longitudinal fashion. Thus, the results from those earlier interviews were primarily useful in validating our research instrument, and will not be discussed here.

We revised the interview protocol prior to Wave 3 administration in order to have the students reflect on their experiences from the previous three years and identify key factors that might have influenced them to change their science-related beliefs, experiences, and aspirations (SBEAs). As in prior years, students were selected for interview based on their survey responses. However, selection criteria were adjusted. Selected students who were of interest for the interview process were assigned into one of three categories, reflecting how they had responded to the student survey over the years:

1. "High-STEM Sustainers" (HSS), meaning that their scores on STEM self-efficacy (SE) and subjective task value (STV) remained high across the three waves of data collection
2. "High Across-the-Board" (HAB), meaning that they had high SE and STV scores in most if not all five subjects and skills
3. "STEM Changers with a focus on Gainers" (SCG), meaning they had either increased or declined in their STEM SE and STV, and we were particularly interested in those whose self-ratings had gone up from Waves 1 or 2 to Wave 3.

136 students were interviewed in Wave 3, and the gender distribution across each of these three categories is presented below. Equal representation between the genders was sought, but additional factors included student age (with preference given to older students) and whether or not the student had been interviewed in previous waves. Although boys were interviewed more frequently in the HSS category, girls were interviewed more frequently for the HAB category, and the gender distribution was approximately equal in the SCG category.

Exhibit 6-1: Gender Distribution within Each Interview Category in Wave 3

		High-STEM Sustainer (HSS)	*High Across-the-Board (HAB)*	*STEM Changers with focus on Gainers (SCG)*	*Total*
Girls	n	10	24	30	64
	column %	29.4%	61.5%	47.6%	47.1%
Boys	n	24	15	33	72
	column %	70.6%	38.5%	52.4%	52.9%
Total	n	34	39	63	136
	row %	25.0%	28.7%	46.3%	100.0%

Students were also categorized as "changers" and "sustainers" within individual subject areas. Changers were students who either saw a sizeable increase or a decrease in their scores over time, while sustainers were those who stayed more or less consistently high (or low) on the indicators for the relevant subjects/skills on the student survey across all three waves. This label was applied to each student for each area, so that a student could be both a changer in one area (e.g., a "science changer") and a sustainer in another (e.g., a "math sustainer").

Exhibit 6-2: Gender Breakdown by Sustainer and Gainer within Each School Area in the Interview Sample, Wave 3

		Science		*Math*		*Computers*	
		Negative Changers	Positive Changers	Negative Changers	Positive Changers	Negative Changers	Positive Changers
Girls	n	5	30	5	22	8	18
	column %	33.3%	46.9%	45.5%	44.9%	53.3%	42.9%
Boys	n	10	34	6	27	7	24
	column %	66.7%	53.1%	54.5%	55.1%	46.7%	57.1%
Total	n	15	64	11	49	15	42
	sample %	11.0%	47.1%	8.1%	36.0%	11.0%	30.9%

Each subgroup was targeted for a different reason: with changers, we were interested in learning about what caused them to have either a more positive or negative view of themselves and STEM Areas, while with sustainers we were especially interested to know what factors caused those who scored highly across all three waves to maintain these positive beliefs. The interview protocol was revised slightly based on this designation in order to obtain the information we sought to learn from each subgroup. To be time-efficient during the interview, we worded questions in such a way as to address changes related to self-efficacy and subjective task value simultaneously; for example, a typical question that changers were asked was:

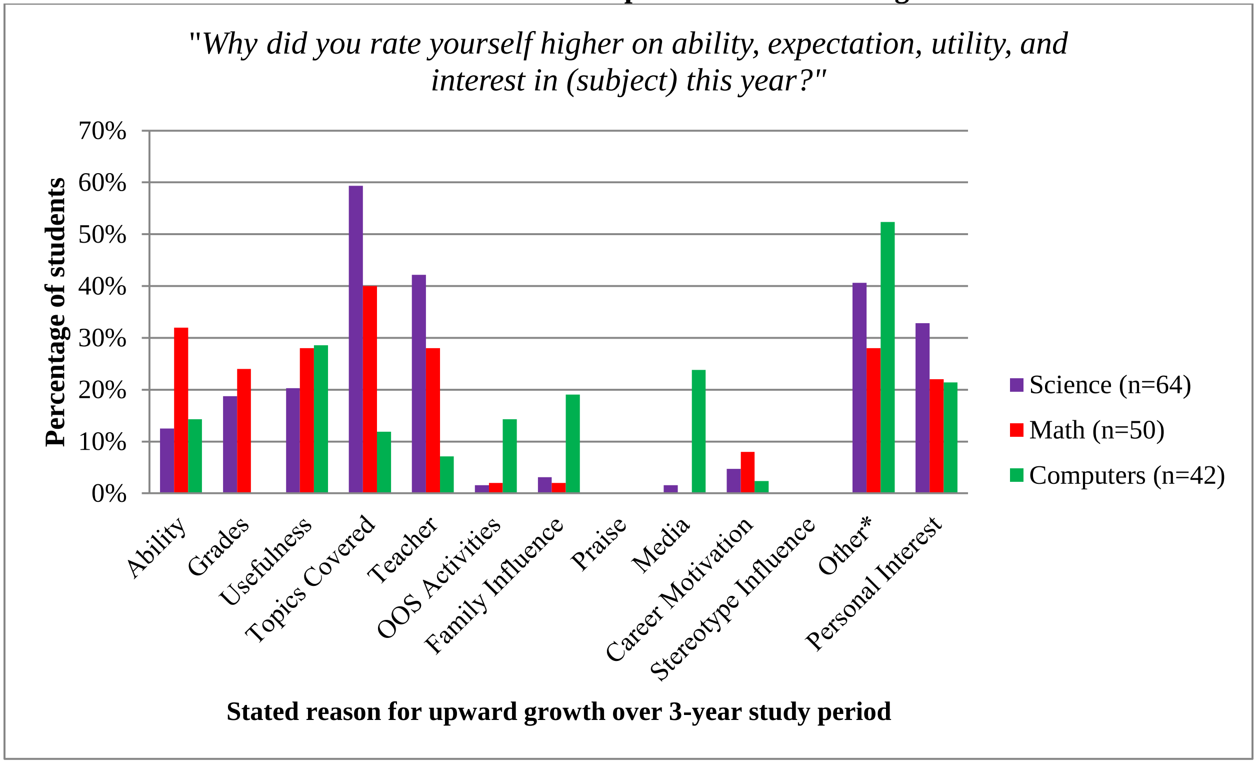
> *On the M-LEAP survey two years ago, it looks like you started out by rating yourself [LOW/MEDIUM/HIGH] in terms of how good you were at science, how well you expected to do in science, how useful you thought science was, and how interested you were in science. This year, that changed: You rated yourself [LOW/MEDIUM/HIGH] in terms of your ability and grades in science and how useful and interesting you think science is. Why do you rate science [LOWER/HIGHER] now?*

Responses for the Wave 3 student interviews were coded and analyzed for patterns related to our research questions, and the resulting findings are presented in this chapter.

SELF-EFFICACY AND SUBJECTIVE TASK VALUE INDICATORS

Students were asked to explain why they might have gone up or down in their self-ratings in various areas. The reasons for increases or decreases were coded (see Exhibit 6-3).

Exhibit 6-3: Distribution of Stated Reasons for Upward Growth Among Gainers in Wave 3



*Note: Additional analyses on "Other" category below. Students could be coded as giving more than one reason. Vertical axis range restricted to 70%; true range 0-100%.

STEM-related SE and STV scores increased because of the topics covered in class, the subject teachers, developments in students' personal interests, and various other reasons.

The most commonly cited reason behind the increase for students who went up in their SE and STV beliefs regarding science was the topics covered in class (59% of science gainers), followed by the teacher of the class (42%), "other" (41%), and personal interest (33%). Changes in their science ability level were barely mentioned.

Students who went up in their SE and STV beliefs in math said that they did so primarily because of the topics covered (40%), and because they felt that they got better at it (ability, 32%). Nearly one in three students also mentioned a reason for the upward change being their perception of math as useful and the role their teacher played. Reasons behind growth in computers touched upon a variety of explanatory factors not mentioned in science and math, including out-of-school activities, family influences, and media influences. Praise and stereotypes were not mentioned in the context of any area or skill.

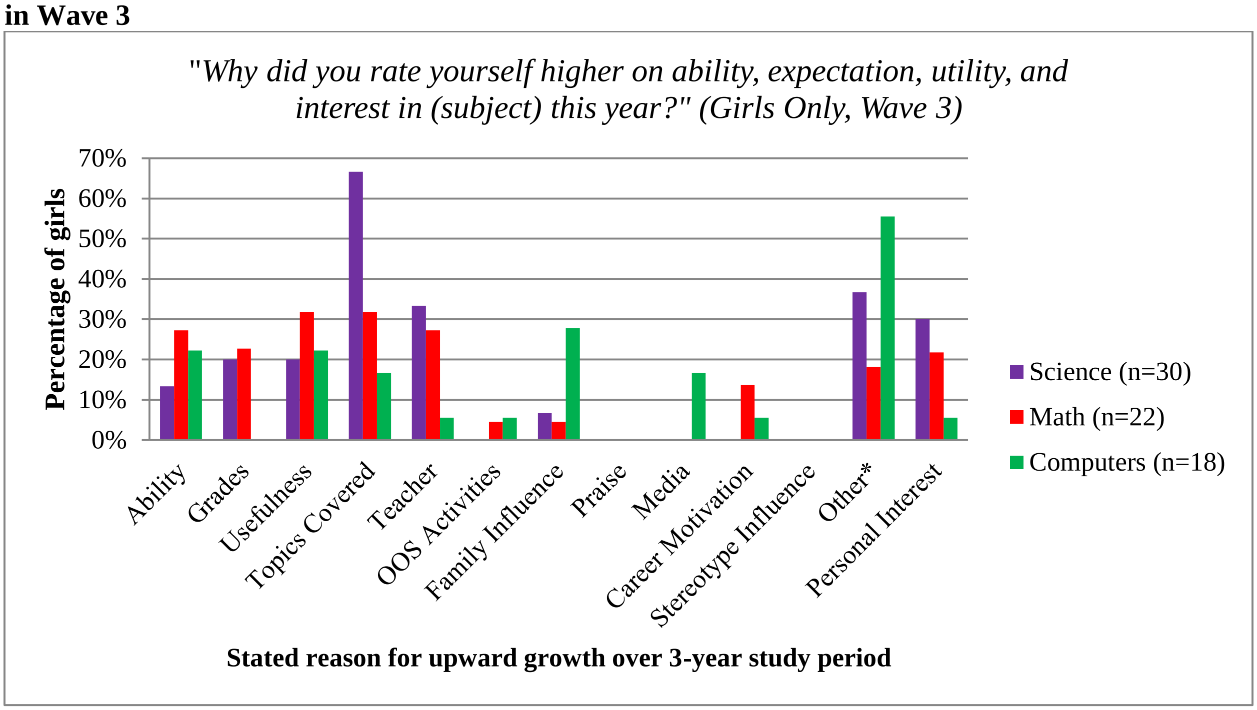
Career motivation was only mentioned by a few students. For those whose scores increased in STEM areas, career and job aspirations were mentioned as catalysts for changes in beliefs and attitudes in the following way: students said that they had come to realize that STEM areas and skills (especially math) would be useful to know about in college and the workplace or in order to find a good job. They spoke in general terms about "a lot of jobs" requiring math and science abilities, but very few students connected the increase in STEM SE and STV to aspirations they had developed towards specific STEM jobs and careers. One student said, "If I want to pursue a scientific career, I would need math."

Many students who provided explanations for their upward shift in STEM areas cited reasons that did not align with the categories of our coding scheme, and these were analyzed for general themes. Gainers in science in the "other" category tended to say that their higher ratings had to do with allocation of science classroom time, with an emphasis on it being more interactive and collaborative. Those who went up in math tended to emphasize their own personal effort (using phrases like "I am challenging myself more now" or "I push myself," as well as words such as "determination") or cited the difficulty of the material (e.g., that it was either harder or easier for them). Those who went up in computers talked about using computers more. This was discussed in the context of the school setting, citing computers being integrated more into day-to-day operations (e.g., "going paperless") and starting a technology class, but also in out-of-school settings, for which some students mentioned using computers recreationally more often at home.

Girls' scores went up in science because of the topics covered, while boys' scores went up because of the influence of their teacher as well as because of the topics covered.

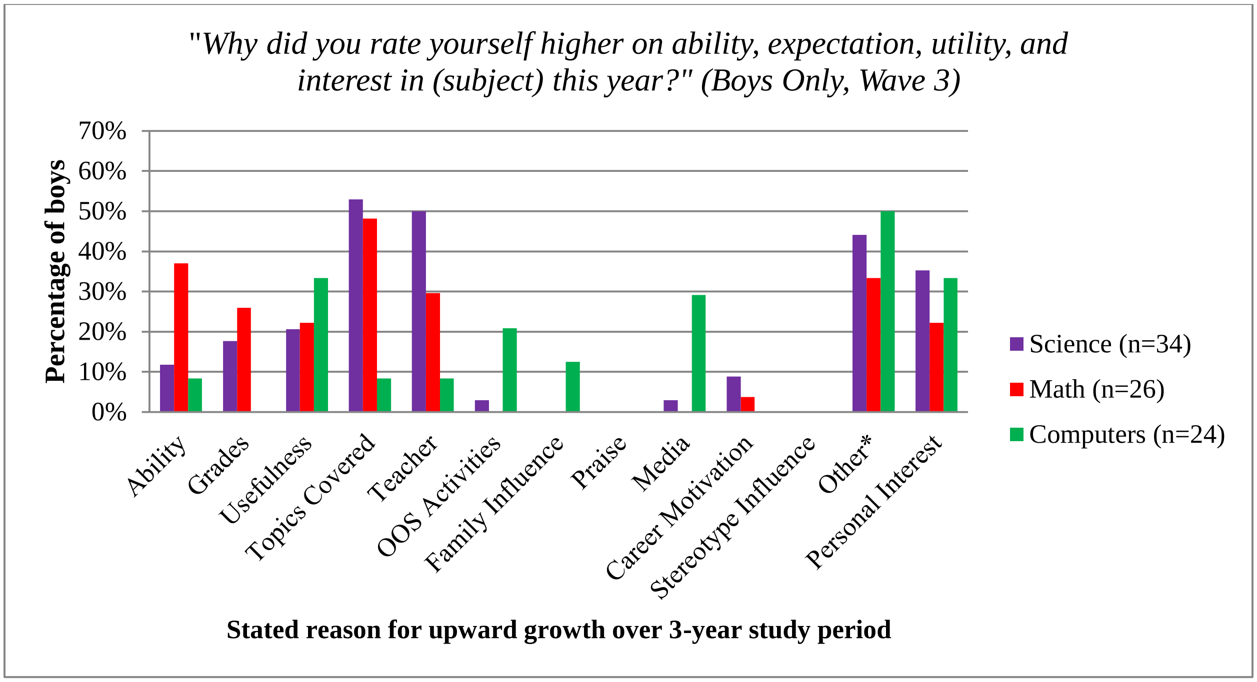
Students' reported reasons for upward changes in science, math, and computers were split along gender lines. Below, we present the same chart displayed in Exhibit 6-1 separately for girls (Exhibit 6-4) and for boys (Exhibit 6-5).

Exhibit 6-4: Distribution of Stated Reasons for Increasing Scores Among Female Gainers in Wave 3



*Note: Additional analyses on "Other" category below. Students could be coded as giving more than one reason.
Vertical axis range restricted to 70%; true range 0-100%.

Exhibit 6-5: Distribution of Stated Reasons for Increasing Scores Among Male Gainers in Wave 3



*Note: Additional analyses on "Other" category below. Students could be coded as giving more than one reason.
Vertical axis range restricted to 70%; true range 0-100%.

Among girls, changes in the topics covered in science class were by far the most commonly cited reason for upward developments in self-efficacy and subjective task value scores in that area, while for boys, the topics covered were less important, but about as important as the teacher, which was not a factor cited by as many girls. In math, boys and girls showed similar pattern to one another, nor were there clear gender discrepancies in computers, except that a higher percentage of boys than girls reported being motivated in their upward growth by personal interest and out-of-school activities.

Two representative quotes from girls for whom science became more interesting were related to "Topics Covered."

> "What we're doing this year is much more fun and interesting to me because the kind of science we're doing is more what I like, whereas last year we were doing science that I don't care that much about."

> "It is more interesting and easier to understand, get into, and be a part of because we get to do more activities."

Girls who went up in math said:

> "Math is an interesting thing. There are so many layers and things to it. And you use it every day."

"[I went up in math] because now I see how useful math is. So, I try to do very good in it because it will help me a lot. Before, I didn't really see how useful it was."

Boys who indicated that their teachers were an influence in their rating themselves higher in Wave 3 said:

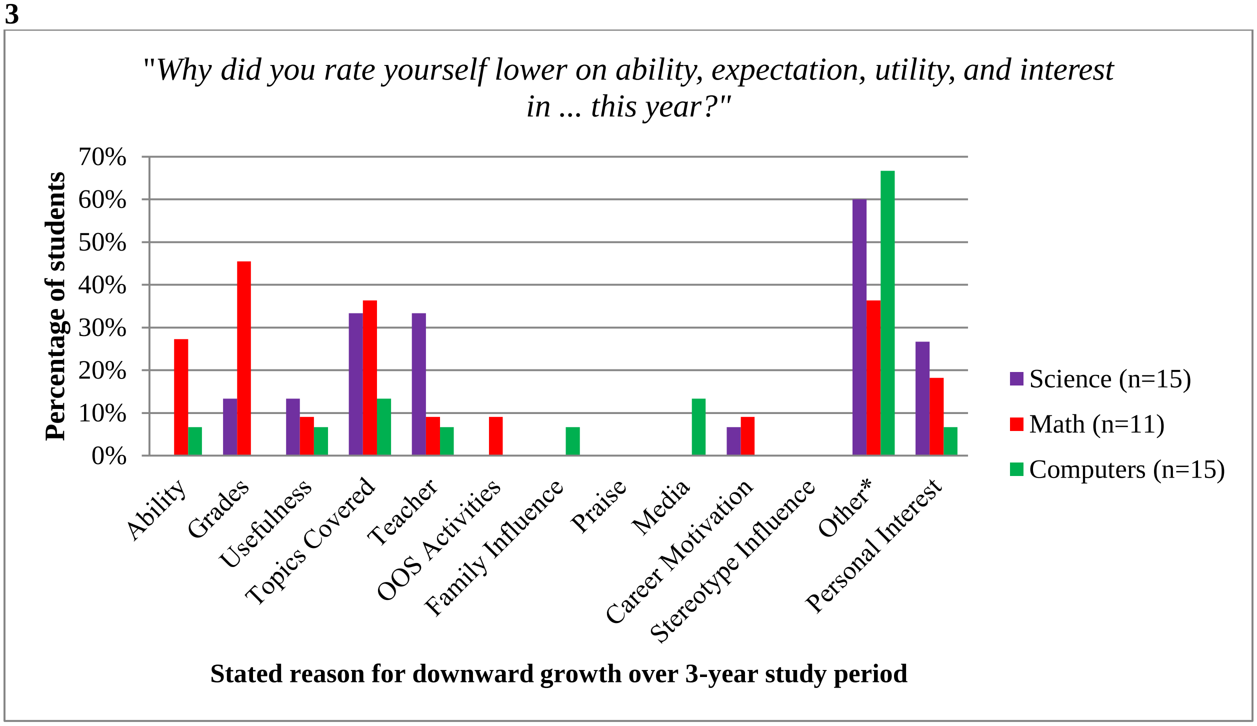
"This year, science really kicked it up a notch. My teacher got me interested in some new stuff, especially technology."

"My teacher makes the topics more interesting this year."

Aside from idiosyncratic "other" responses, grades, topics, and teacher were the most commonly cited reasons for declines in students' SE and STV beliefs.

Students designated as decliners mentioned a variety of reasons for their drop in self-ratings over time, a large percentage of which did not map on to the coding scheme developed for the gainers (who were the primary focus of the interviews). Thus, a large percentage of answers were coded as "other." Of the coded responses, however, the two most commonly cited reasons for a decline in science beliefs, expectations, and interest were the topics covered and the teacher. For math, students pointed to grades, especially, and to their teacher as motivating the decline in their SE and STV beliefs. See Exhibit 6-6.

Exhibit 6-6: Distribution of Stated Reasons for Declining Scores Among Decliners in Wave 3



*Note: Additional analyses on "Other" category below. Students could be coded as giving more than one reason.
Vertical axis range restricted to 70%; true range 0-100%.

Of the responses coded as "other", those who had declined in science said this was because they had started prioritizing other areas like math and ELA or because the material covered in science class had become more difficult. The difficulty of the material was also the primary theme in discussing why self-ratings in math had gone down. For computers, students whose self-ratings had declined said it was because they no longer enjoyed or used computers as much. One student said that he had come to realize that "computers are taking over" students' lives and that he felt they should be outside playing more sports.

As with the upward changers, downward changers did not mention receiving praise (e.g., being told that they were good at a certain area) or gender stereotype influences as playing any role in their beliefs changing over time. Nor did career motivations play a major role in the decrease for most students. Only two students with declining ratings in any of the STEM areas mentioned career aspirations in their explanations. One whose SE and STV ratings had gone down in math said that he had decided to become a writer and so he had "stopped focusing on math because it was not important to [him], and so [he] stopped trying." The other said that he had lower ratings in science because "science is only used in a few jobs, not every job," and so he had decided to prioritize math, ELA, and history instead as he believed these had broader applications.

These downward changes were not analyzed for gender differences because of the small numbers of downward-changing students interviewed.

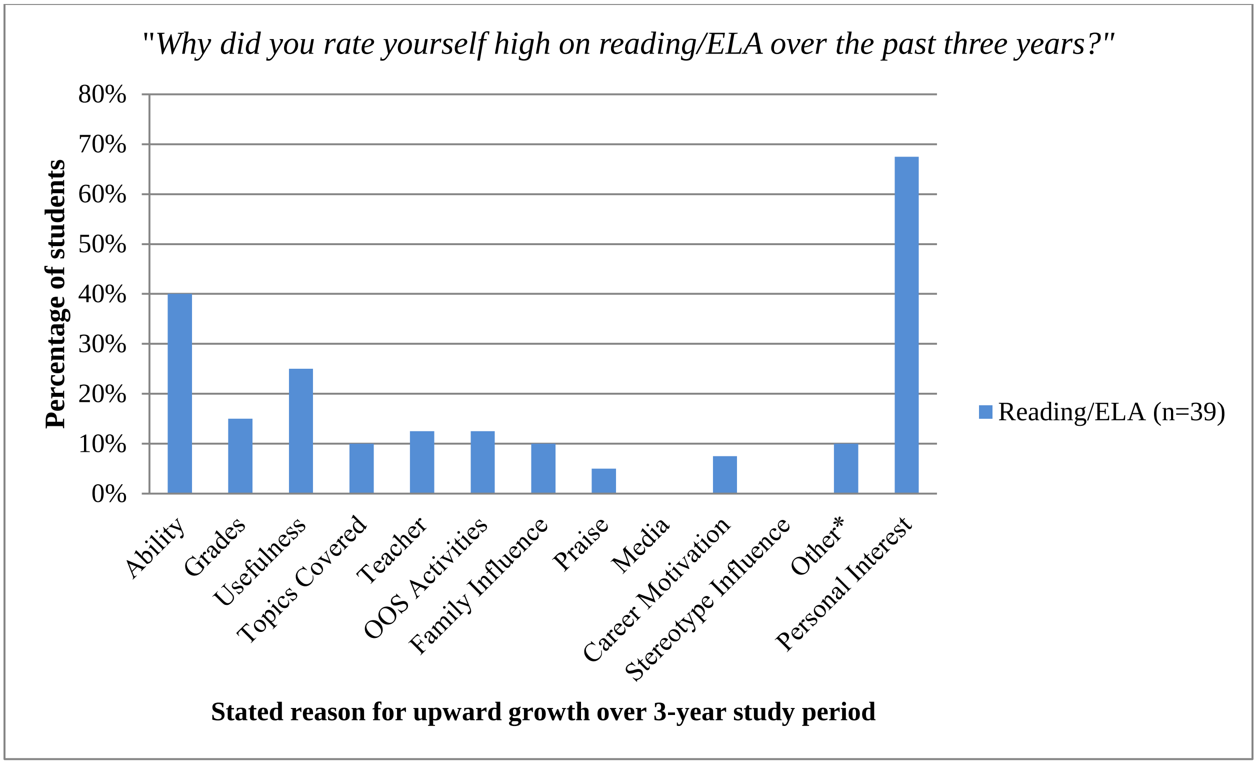
In contrast to STEM areas, high ELA scores were driven primarily by personal interest.

STEM motivations and explanations looked drastically different from students' explanations for sustaining high self-ratings in Reading/ELA. In Wave 3, 40 students were designated as "High Across the Board" (HAB), meaning that they had maintained high self-ratings of ability, expectations for success, utility, and interest across all areas for all waves of data collection. This subgroup was asked the following question:

> *This question is about ELA. By ELA, we mean English, reading, and writing. On the M-LEAP survey, it looks like for the past 3 years, you gave high ratings to how good you are at ELA, how well you expect to do in ELA, how useful you think ELA is, and how interested you are in ELA. Why is it that you rate ELA-English-reading-writing so highly?*

Students' coded responses are presented in Exhibit 6-7.

Exhibit 6-7: Distribution of Stated Reasons for High ELA Ratings Among "High Across the Board" Students in Wave 3



Note: Students could be coded as giving more than one reason.

Nearly 70% of HAB students said one reason they rated themselves highly in reading/ELA was that they found this area personally interesting. A typical quote from one of these students was, "Well, I love to read; it's one of the things I love to do… I also love to write." 40% said they rated reading/ELA highly because they were good at this subject and about a quarter said they thought it was useful. For example, students said that ELA would be useful because "a lot of jobs need you to be able to read and write."

CAREER ASPIRATIONS

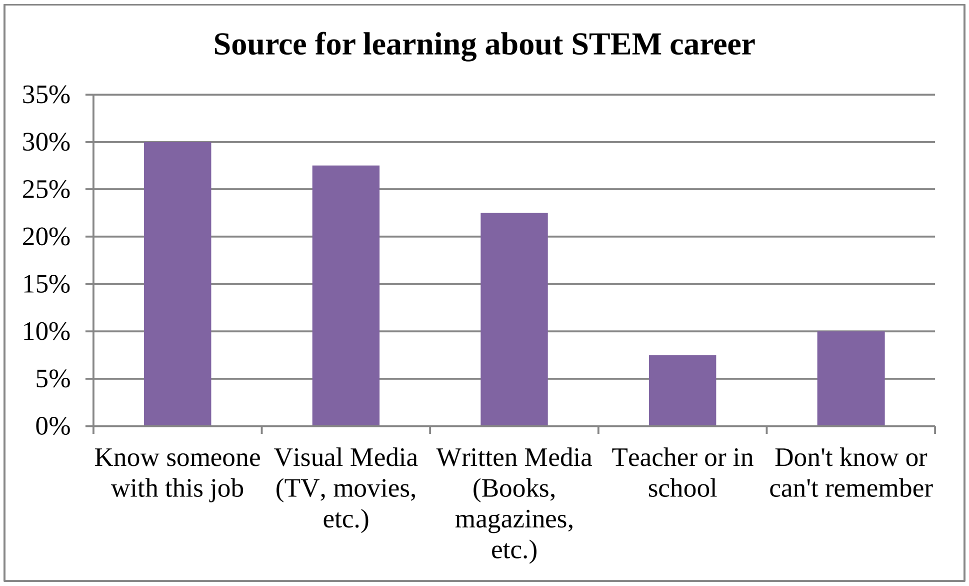
In Wave 3 interviews, students were also asked in greater detail than in prior years about their career aspirations. In addition to learning more about the kinds of jobs students were interested in having, the goal of this portion of the interview was to gain a better sense of what attracted students to these jobs to begin with and why their aspirations may have stayed the same or changed over time.

Students were presented with their job preference as stated on the student survey in Wave 3 and asked a series of questions regarding how they had heard about that job, who they had spoken with about that job, and what information they had about the qualifications for that job. As the focus of this study was on STEM areas and careers, the analyses below focus primarily on students who said they wanted to have a STEM-related job when they grew up.

The most common ways to learn about STEM jobs were exposure to people who have that job and viewing visual media.

Exhibit 6-8 shows students' coded responses to the question: "Where did you learn about being a [job choice]?" These results are only for students who indicated on the student survey that they wanted to have a job which could be categorized as STEM on the trichotomous career outcome variable as defined in the academic and career outcomes results section, above. Examples of STEM careers included engineer, architect, and marine biologist.

Exhibit 6-8: Students' Responses When Asked Where They Had Heard About Their STEM Job of Choice



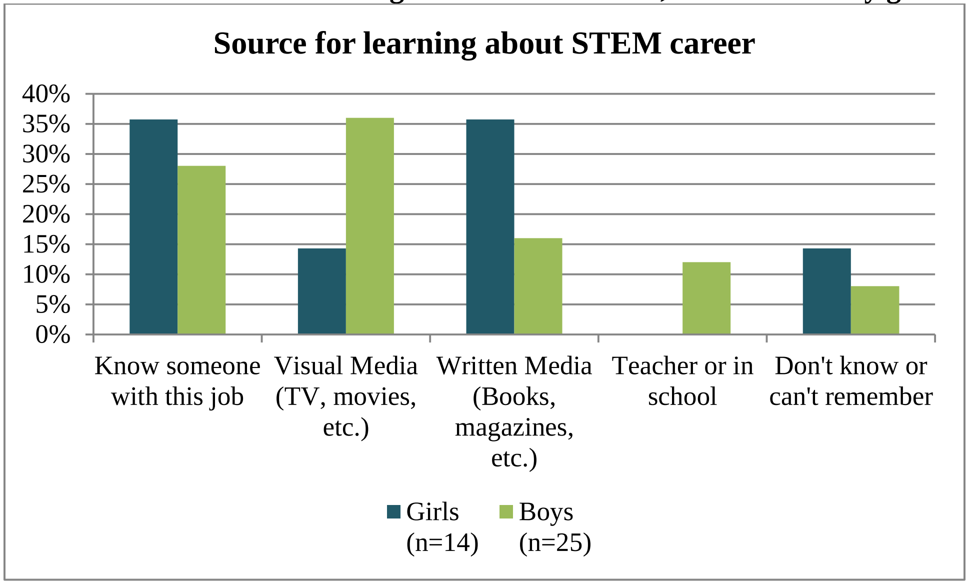
N = 39, W3 data
Note: Vertical axis range restricted to 35%; true range 0-100%.

The most common way students had learned about a STEM career was knowing someone who held that job (30%). This finding was consistent with the results of a follow-up question asking whether these students who chose a traditional STEM job had discussed their career choice with someone who already had that job. About a third (31%) of students who selected a STEM career had discussed it with someone who had that job. "Knowing someone with that job" was followed by visual media (more common with boys) and written media (more common with girls). Interestingly, almost no students with STEM career aspirations mentioned learning about those careers at school.

Visual media was most common source for boys for learning about their preferred STEM job, followed by knowing someone, while for girls it was either knowing someone or written media.

Although the number of interviewed girls who selected a traditional STEM career was low (n = 14), it is nevertheless interesting to see how these results look when broken down by gender, as shown in Exhibit 6-9.

Exhibit 6-9: Source for learning about STEM career, broken down by gender



Note: W3 data. Vertical axis range restricted to 40%; true range 0-100%.

Only boys report initially learning about their chosen STEM job from their teacher or in school. Their primary source for learning about their preferred job was visual media, while for girls, there was an even split between learning about STEM jobs from people who have that job and from written media.

Most students did not have a complete understanding of what it took to get their job of choice.

In addition to asking students where they had heard about their job of choice, we wanted to know whether they had a clear understanding of the steps they might need to take to obtain that job. We sought to determine, for example, whether they knew what subjects they might need to take extra courses in, what they should study in college, and how far they needed to advance in school. Results indicated that the majority of students in each job category only had an incomplete or no understanding of what steps they would need to take, as shown in Exhibit 6-10.

Exhibit 6-10: Distribution of Interviewed Students' Understanding of What It Takes to Obtain Their Chosen Job, by Job Category, Wave 3

	Non-STEM	Allied Health	STEM
Does not know what is required	16 (32%)	2 (11%)	11 (23%)
Knows something, but not fully accurate or complete	26 (52%)	11 (58%)	19 (40%)
Knowledge is accurate and fairly complete	8 (16%)	6 (32%)	17 (36%)

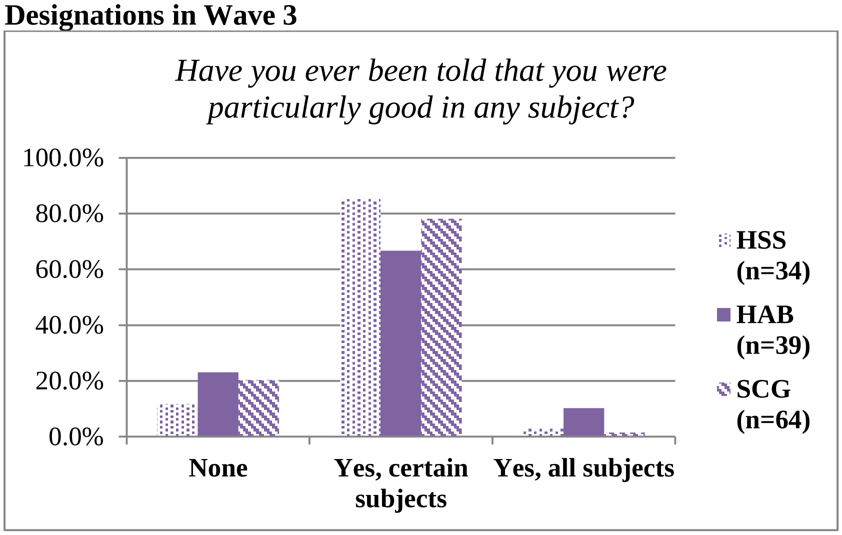
STEM IDENTITY

As mentioned in the Literature Review, STEM identity formation is an emerging area of study within the STEM career pipeline literature. In Wave 3 of our study, we revised our interview protocol to include an additional item related to STEM identity: recognition by others. We were interested to know if the sample of students selected for interview — composed primarily of changers and high-SE/STV students — had begun to form their academic identities in specific areas and if they had received feedback from others that might have influenced this identity formation. Thus, we asked them if anyone had ever told them they were particularly good at a certain area, who that person was, and when they had been told that. These items addressed the recognition component of academic identity.

Most students interviewed had been told that they were especially good at one or more areas.

First, we present responses to the recognition item, broken down by the interviewees' categorization as HSS, HAB, or SCG, as shown in Exhibit 6-11.

Exhibit 6-11: Distribution of Subject-Specific Recognition Across Interviewee Category Designations in Wave 3

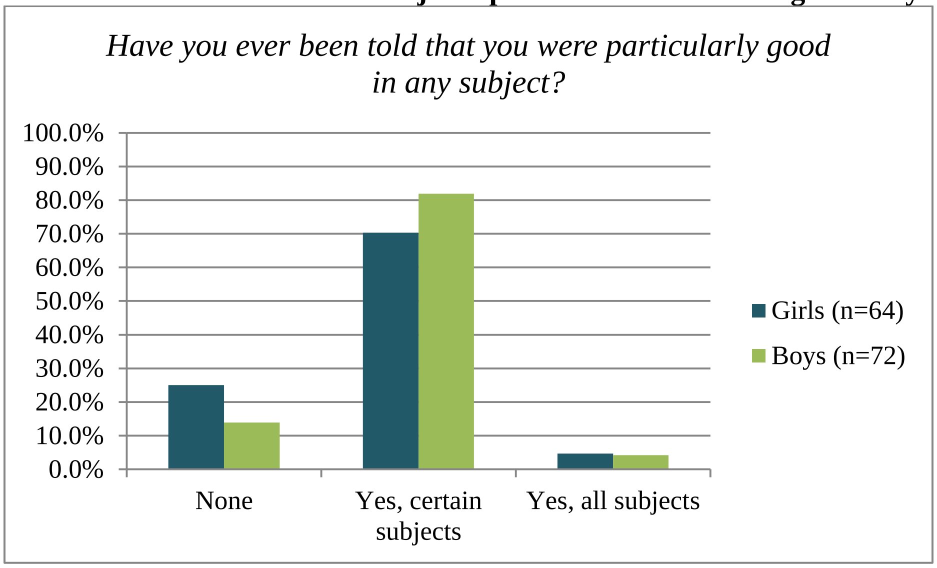


The majority of students from each designation had received recognition for one or a small number of subjects. Overall, 77% of interviewees had been told they were especially good at one or more subjects. Among the other response options, HAB students were the most likely not to have been recognized at all or to have been told that they are good at all subjects. Almost no students from the other groups had been told that they were especially good at all subjects.

Both genders were recognized as being good at certain subjects, but a greater percentage of girls than boys reported not receiving any such recognition.

The distribution of students' responses to the recognition item was also examined for gender differences, shown in Exhibit 6-12.

Exhibit 6-12: Distribution of Subject-Specific Positive Encouragement by Gender in Wave 3

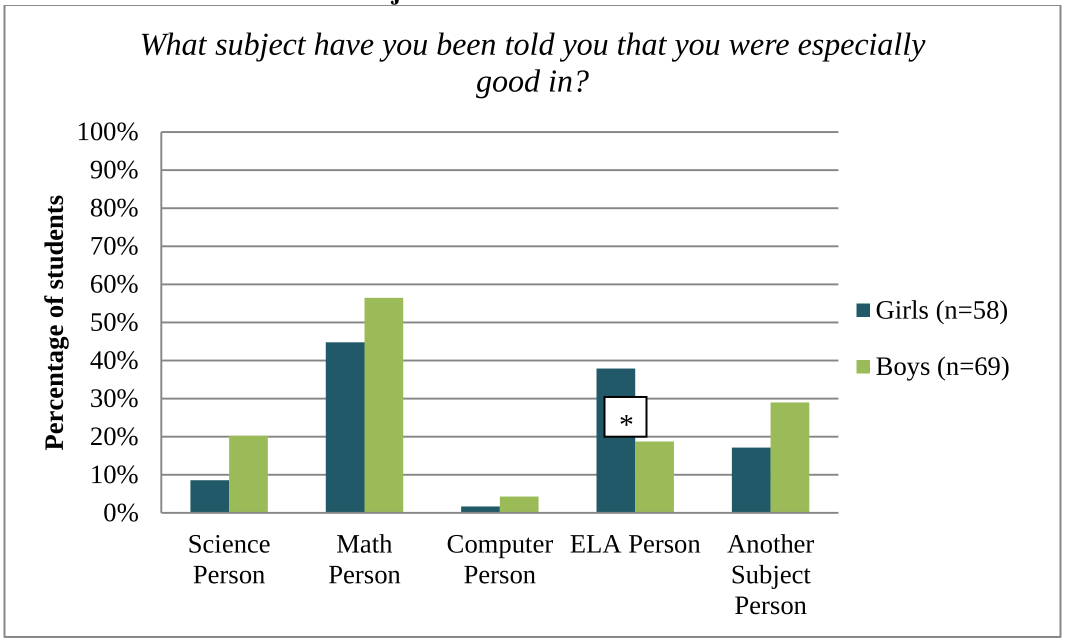


The majority of interviewed students from both genders had received recognition as being especially good at one or more subjects. Approximately twice as many girls as boys said they had not heard from anyone that they were especially good at any subjects, although the split was relatively even for those who had been told they were good at all subjects. However, a chi-squared test with two degrees of freedom showed that the distributions of boys and girls on this measure were not statistically significantly different from one another (X^2 = 2.8, *df* = 2, $p \approx .25$).

The most commonly reported subject identity was "math person," while very few students reported being called a "science person."

Next, we show the percentage of students who reported being told that they were "that kind of student" for each subject that we asked about in our study; see Exhibit 6-13. For these analyses, we only considered students who identified with one or more subjects (thus, we excluded those who said "None" in response to the previous question).

Exhibit 6-13: Percentage of Interviewed Students Who Had Been Told They Were "That Kind of Student" for Each Subject in Wave 3



* = $p < .05$

Note: This sample excludes interviewed students who had never been told that they were particularly good at one or more subjects. Interviewees were able to report being told that they were especially good in more than one subject.

Approximately 50% of interviewed students who had been recognized as being especially good at one or more areas reported having been called a "math person." The next most popular option was "ELA person" (27%). Only 15% of students had been told they were a "science person," and even fewer had been told they were a "computer person" (4%). The "another subject person" response category included students who thought of themselves as good at everything and those who identified with other areas, like social studies, sports, and art.

The distributions of boys' and girls' responses on this measure were not statistically significantly different from one another in any area except for ELA, where girls were significantly more likely to have received feedback that they were an "ELA person" than boys ($X^2 = 5.75$, $df = 1$, $p < .05$). There was also a slight trend for boys to be more likely than girls to have been told that they were a "science person" or "math person."

Identifying as a "math person" was associated with aspiring to a traditional STEM career, but similar results were not found for the remaining STEM areas.

In connecting the encouragement and recognition that students report receiving in various areas with the key outcomes of the M-LEAP study, we examined relationships between STEM or reading/ELA identity and educational and career aspirations were explored. For most areas, there were no links between STEM or reading/ELA recognition and aspirations for educational attainment or selecting a traditional STEM career. However, identifying oneself as a math person was moderately positively correlated with selecting a traditional STEM career on the student survey ($\rho = .25$, $p < .01$), suggesting that students who received recognition in math or identified themselves as "math people" were slightly more likely to aspire to a traditional STEM career. We also looked for gender differences. Recognition in reading/ELA was significantly related to higher educational aspirations, but for boys only ($\rho = .25$, $p < .05$). For girls, this association was negative and not statistically significant ($\rho = -.13$, $p = .33$). The difference between these two Spearman correlations was significantly different ($z = 2.07$, $p < .05$ two-tailed), confirming that the link between reading/ELA identity and educational aspirations held true only for boys.

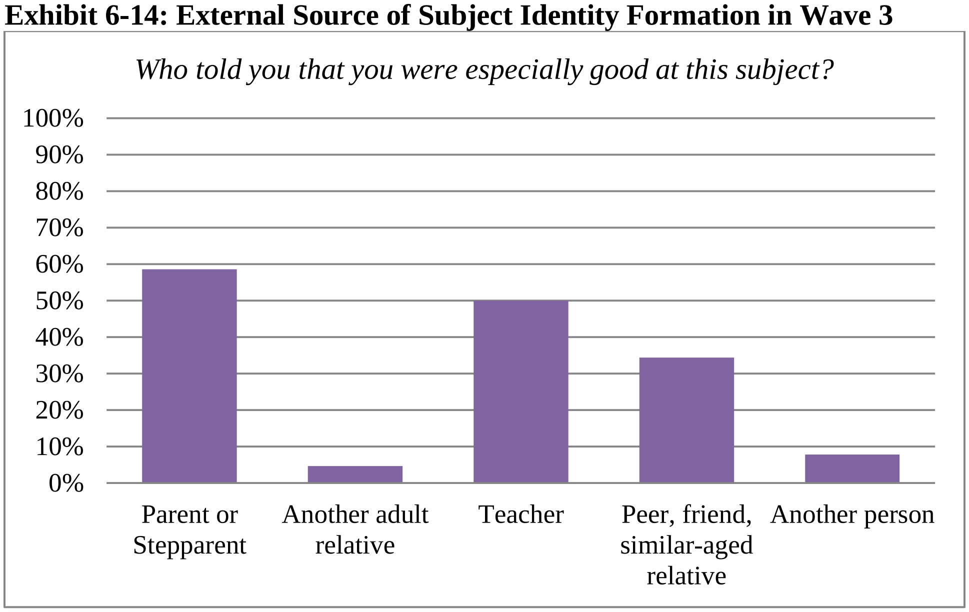
Boys and girls who identified with STEM areas held a similar number of boy-favoring stereotypes, on average.

We related students' responses on this interview question with key outcomes and predictors from the student survey. Among students identifying as STEM (science, math, or computer) people, there was no gender difference in the likelihood of endorsing boy-favoring stereotypes in STEM subjects. However, among students who did not think of themselves as a STEM person, boys were significantly more likely than girls to endorse boy-favoring stereotypes. In other words, boys and girls who expressed STEM identities agreed more about gender stereotypes than those who did not express STEM identities. However, STEM-identifying students were just as likely to endorse boy-favoring stereotypes as were students who did not identify as STEM people.

The most common external source for feedback regarding school subject identity was parents, followed by teachers.

As shown in Exhibit 6-14, below, parents and stepparents (59%) were the most commonly cited external source of identity formation that emerged during our interviews, followed by teachers and friends. There were no statistically significant gender differences between boys and girls on the source of this recognition.

Exhibit 6-14: External Source of Subject Identity Formation in Wave 3



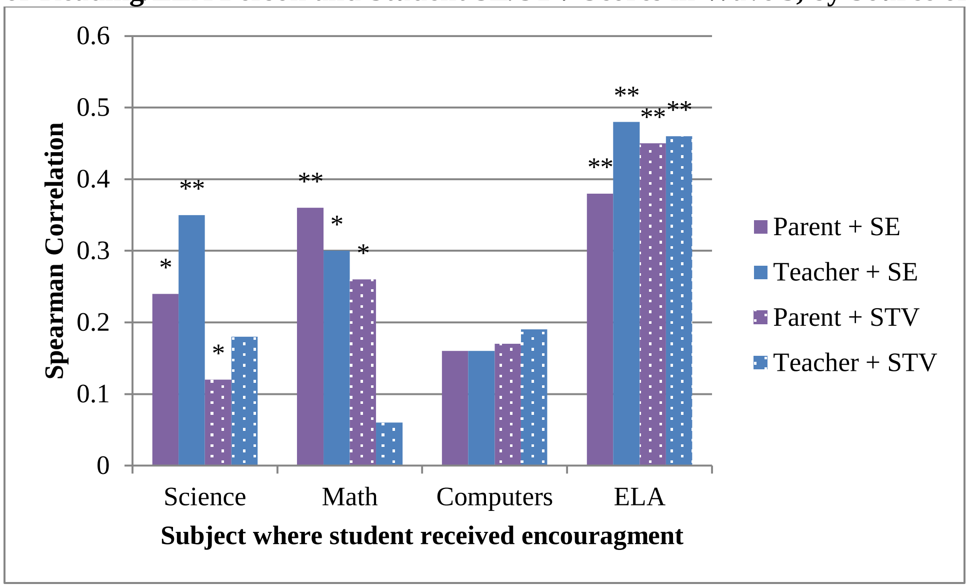
N = 128
Note: Students were able to report being told that they were especially good at a subject by more than one person.

Recognition as being good at a subject was associated with higher self-efficacy and subjective task value scores in that subject, regardless of the source of this feedback.

Keeping in mind that the sample of students who were selected for interviews tended to be those with high SE and STV scores in at least some areas, we compared SE and STV scores for students who were and were not recognized as being especially good in a certain area. Regardless of the source of feedback, being told they were especially good at an area was linked to higher SE scores in science (ρ = .22, $p < .05$), higher SE and STV scores in math (ρ_{SE} = .35, $p < .01$; ρ_{STV} = .19, $p < .05$), and higher SE and STV scores in reading/ELA (ρ_{SE} = .39, $p < .01$; ρ_{STV} = .40, $p < .01$), on average.

These results were then further examined to determine whether recognition by parents and recognition by teachers were differentially linked to students' SE and STV scores.

Exhibit 6-15: Spearman Correlations Between Recognition as a Science, Math, Computers, or Reading/ELA Person and Student SE/STV Scores in Wave 3, by Source of Feedback



N_{parent} = 74, $N_{teacher}$ = 64; * = *p-value* for rho < .05, ** = *p-value* for rho < .01

Exhibit 6-15 shows that for students who had received encouragement in each area, parent and teacher ratings of student ability and interest were generally statistically significantly correlated with students' own SE and STV scores, except in computers. While there were some apparent differences in the strengths of the Spearman correlations between teachers and parents (e.g., for students who had received encouragement in science, teacher ratings of ability were more closely related to student SE scores than were parents' ratings), these differences were not statistically significant. Thus, it seems that while receiving positive ratings from parents and teachers was associated with higher SE and STV scores, on average, the source of the recognition that might lead a student to think of themselves as a "science person" or a "math person" was not differentially linked to SE/STV scores.

Teacher ratings of ability and interest were related to students' reported math, science, and reading identities.

Receiving higher teacher ratings of math and science ability was linked to students reporting being told that they were especially good in those areas and thinking of themselves as "that kind of student" (ρ_{Math} = .25, p <.05; $\rho_{Science}$ = .24, p <.05). The same was true for teacher ratings of interest, where students who reported identifying with math and science in the interviews tended, on average, to be perceived as having greater interest in those areas by their teachers (ρ_{Math} = .26, p <.05; $\rho_{Science}$ = .36, p <.01). This association was also seen in reading/ELA ($\rho_{Ability}$ = .30, p <.01; $\rho_{Interest}$ = .31, p <.01), but not computers ($\rho_{Ability}$ = .02, p =.86; $\rho_{Interest}$ = .17, p =.12).

Girls were more likely than boys to report having received feedback about their abilities and STEM identity more than one year ago.

We also examined how recently the students had received recognition as being particularly good at a certain area or all areas. 42% of interviewees who had some sort of subject identity reported having received external feedback from parents or teachers that they were particularly suited for a specific subject within the past year. Approximately one quarter of interviewees said that they had started receiving identity recognition feedback the previous year, and only 22% said that they had been receiving this kind of input for multiple years; however, this figure was 33% for girls and 13% for boys. Taken together, these results suggest that most external feedback regarding STEM identity formations was perceived by most students to be a recent occurrence.

CHAPTER 7: PREDICTING OUTCOMES

We built multivariate, longitudinal models designed to predict two of our key outcomes: students' STEM-related beliefs — that is, their science, math, and computer SE and STV — and students' STEM-related job aspirations. As discussed in the Literature Review, students' SE and STV beliefs are critically important because beliefs in late elementary and middle school predict later outcomes such as high school math and science course enrollment, college attendance, and eventual job choices (e.g., Eccles et al., 2004; Nagy et al., 2007; Wang & Degol, 2013).

MULTIVARIATE MODELS PREDICTING STEM BELIEFS

In this section, we focus on the strongest and most consistent patterns of results from the six HLM analyses predicting STEM SE and STEM STV; that is, the findings that hold up across STEM areas and across both time-invariant and time-varying relationships between predictors and outcomes. The complete HLM results are shown in Exhibit 7-1 at the bottom of this section, but we do not speculate about the more idiosyncratic and unpatterned individual results.

There are, however, several very striking patterns in the models predicting student self-efficacy (SE) and subjective task value (STV) in science, math, and computers; these are discussed in further detail below. For the most part, these findings are consistent with those of the descriptive and univariate analyses reported earlier. However, the relationships linking parent endorsement of stereotypes favoring boys in STEM to student beliefs only became apparent in the multivariate longitudinal analyses reported below.

Self-efficacy and subjective task value are very tightly linked.

Overall, STV and SE are linked to distinct constellations of predictors, as described below. However, it is notable that for all three STEM areas, SE and STV are linked on average across time, and they also increase and decrease together over time. Given this strong link, it is possible that intervening to increase students' valuing of or interest in a STEM area could lead to increases in self-efficacy in that area, and vice versa.

Students are attuned to the value they perceive adults assigning to particular areas.

STV in all three STEM areas is linked on average across time and travels together over time with the following:

- The student's favorite subject being a STEM area,
- The student engaging more frequently in out-of-school STEM activities (reading about, watching, doing hands-on activities, and visiting places), and
- The student thinking the adult with whom they spend the most time (usually a parent) values that particular area.

Given that STV scores reflect students' interest in and valuing of these areas, this set of predictors is not surprising. It is notable that what matters is student *perceptions* of the value key adults assign to particular areas, more than what parents themselves report about their actual valuing of these areas.

There may be some disconnect between parent values and what their children perceive those values to be. Increased perceptions that adults value STEM areas are also linked to increases in STEM STV in a time-varying way (see rightmost column of Figure 7-1), which supports the idea that these perceptions might serve as a leverage point for intervention. For example, as discussed in the Literature Review, an intervention designed to enhance parents' valuing of STEM courses was linked to their children's valuing of the areas and enrollment in math and science courses over the next semester (Harackiewicz et al., 2012).

Frequent participation in out-of-school STEM activities is linked to higher STEM STV.

The role of out-of-school STEM activities is also noteworthy. It is likely that students who are already interested in STEM areas and believe them to be important are more likely to pursue STEM activities on their own time outside of school. However, the time-varying results in Exhibit 7-1 (rightmost column) suggest that this relationship also operates in the other direction: Engaging in STEM activities is linked to yet further increases in STV — and perhaps thereby to SE — in a self-reinforcing way. Thus, out-of-school STEM activities might serve as another leverage point for intervention.

Parent endorsement of boy-favoring STEM stereotypes can be detrimental to daughters.

In contrast to STV ratings, SE ratings are linked to several predictors derived from the adults in students' lives. On average and across time, high SE ratings are linked to the following:

- For all three STEM areas, the parent reporting that the student is proficient in that area,
- For science and math, teachers reporting that the student is proficient in that area, and
- For all three STEM areas, the parent endorsing STEM stereotypes, with an important qualification: For science and math, stereotype endorsement interacts with student gender such that parents who believe boys are better at STEM areas have sons with *higher* STEM SE scores and daughters with *lower* STEM SE scores.

These findings are consistent with past research demonstrating the importance of parental beliefs; for example, one study found that parent beliefs about their children's proficiency were more directly linked to their children's SE than was actual past performance in that area (Eccles et al., 1982). When these beliefs are influenced by gender stereotypes about who is good at STEM areas, there can be detrimental consequences for girls' SE (Priess & Hyde, 2008; Tiedemann, 2000).

Another area in which rejection of STEM stereotypes proves beneficial to student outcomes is that, on average across time, students who do not endorse these stereotypes rate math as more interesting and valuable than students who do endorse such stereotypes.

Other findings involving parental endorsement of STEM stereotypes are more equivocal. For example, parental endorsement of STEM stereotypes does not appear to have a disparate impact on girls and boys in terms of the positive link to computer SE across time, or to girls' math STV across time, or to increasing math SE over time. Less surprisingly, boys who themselves endorse STEM stereotypes show higher computer SE.

Nevertheless, given the clear negative links between parental stereotype endorsement and girls' beliefs about their own competence in math and science, we would argue that parental stereotypes favoring boys in STEM are a key leverage point for intervention.

Gender and other demographic variables are linked in complicated ways to SE and STV outcomes.

On average and across time, boys rate themselves as more proficient in math (SE) than do girls, whereas girls rate math as more interesting and valuable (STV) than do boys. In the case of math, then, gender-specific interventions may be indicated to target these different beliefs. Further, while math SE and math STV are linked for both boys and girls, these variables are significantly more tightly linked for girls. Thus, interventions targeting math STV in hopes of increasing math SE (or vice versa) may be particularly effective for girls.

There were also differences by race and ethnicity. On average and across time, White students rated themselves as more proficient in science (SE) than did African American, Hispanic, and Asian students. In contrast, African American, Hispanic, and Asian students rated computer skills as more interesting and valuable than did White students, on average and across time.

Exhibit 7-1: Results of HLM Models Predicting Student Self-Efficacy (SE) and Subjective Task Value (STV) in STEM Subjects

	Time-Invariant Predictors and Outcomes	**Time-Invariant Predictors of Change**	**Time-Varying Predictors and Outcomes**
	On average, who scores higher on the outcome across time?	***Whose scores on the outcome increase over time?***	***As outcome scores increase over time, what other variables change along with them?***
	SCIENCE		
STV	▪ Students with high science SE (no interaction: same for girls/boys) ▪ Students whose favorite subject is STEM ▪ Students who engage more frequently in STEM activities ▪ Students who think Adult 1[a] values science ▪ Students with low teacher ratings of science proficiency	▪ Students who engage more frequently in STEM activities	▪ Increasing science SE (no interaction: same for girls/boys) ▪ Increasing likelihood that favorite subject is STEM ▪ Increasingly frequent STEM activities ▪ Student increasingly thinking Adult 1 values science ▪ Decreasing parent[b] ratings of own science proficiency
SE	▪ White students ▪ Students with high science STV (no interaction: same for	▪ Students with lower science STV (no interaction: same for girls/boys)	▪ Increasing science STV, especially for girls ▪ Increasing teacher ratings of student science

	Time-Invariant Predictors and Outcomes	Time-Invariant Predictors of Change	Time-Varying Predictors and Outcomes
	On average, who scores higher on the outcome across time?	***Whose scores on the outcome increase over time?***	***As outcome scores increase over time, what other variables change along with them?***
	girls/boys) ▪ Students who engage less frequently in STEM activities ▪ Students with high parent ratings of science proficiency ▪ Boys whose parent endorses STEM stereotypes (opposing effect for girls) ▪ Students with high teacher ratings of science proficiency	▪ Students with high teacher ratings of science proficiency	proficiency
MATH			
STV	▪ Girls ▪ Students with high math SE (no interaction: same for girls/boys) ▪ Students whose favorite subject is STEM ▪ Students who engage more frequently in STEM activities ▪ Students who do not endorse STEM stereotypes (no interaction: same for girls/boys) ▪ Students who think Adult 1 values math ▪ Students whose parent values math ▪ Girls whose parent endorses STEM stereotypes (opposing effect for boys)	▪ Students whose parent has a non-STEM/non allied health job	▪ Increasing math SE (no interaction: same for girls/boys) ▪ Increasing likelihood that favorite subject is STEM ▪ Increasingly frequent STEM activities ▪ Student increasingly thinking Adult 1 values math ▪ Parent increasingly valuing math
SE	▪ Boys ▪ Students with high math STV; this is especially true for girls ▪ Students who engage less frequently in STEM		▪ Increasing math STV (no interaction: same for girls/boys) ▪ Increasing likelihood that favorite subject is STEM ▪ Increasing parent ratings

	Time-Invariant Predictors and Outcomes	Time-Invariant Predictors of Change	Time-Varying Predictors and Outcomes
	On average, who scores higher on the outcome across time?	*Whose scores on the outcome increase over time?*	*As outcome scores increase over time, what other variables change along with them?*
	activities ▪ Students with high parent ratings of math proficiency ▪ Boys whose parent endorses STEM stereotypes (opposing effect for girls) ▪ Students with high teacher ratings of math proficiency		of student math proficiency ▪ Increasing parent endorsement of STEM stereotypes (no interaction: same for girls/boys)
	COMPUTERS		
STV	▪ African American, Hispanic, and Asian students ▪ Students with high computer SE (no interaction: same for girls/boys) ▪ Students whose favorite subject is STEM ▪ Students who engage more frequently in STEM activities ▪ Students who think Adult 1 values computers	▪ Students whose parent values computers	▪ Increasing computer SE (no interaction: same for girls/boys) ▪ Increasing likelihood that favorite subject is STEM ▪ Increasing frequency of STEM activities ▪ Student increasingly thinking Adult 1 values computers
SE	▪ Students with high computer STV (no interaction: same for girls/boys) ▪ Students whose favorite subject is non-STEM ▪ Students with high parent ratings of computer proficiency ▪ Students whose parent endorses STEM stereotypes (no interaction: same for girls/boys) ▪ Boys who endorse STEM stereotypes (opposing effect for	▪ Students with high parent ratings of computer proficiency	▪ Increasing computer STV (no interaction: same for girls/boys) ▪ Increasing parent ratings of student computer proficiency

	Time-Invariant Predictors and Outcomes	Time-Invariant Predictors of Change	Time-Varying Predictors and Outcomes
	On average, who scores higher on the outcome across time?	***Whose scores on the outcome increase over time?***	***As outcome scores increase over time, what other variables change along with them?***
	girls)		

Note: Models also included school and cohort covariates; however, only primary predictors are shown in the table.

[a]Adult 1 was defined as the adult with whom the student spends the most time. For most students (94%), this was a parent, typically a mother. Questions about adult valuing of different school subjects were asked about this adult.

[b]Most parent data came from the parent survey. Just under half of students (44%) had a parent fill out a survey in at least one data collection wave; almost all (90%) were mothers.

MULTIVARIATE MODEL PREDICTING JOB ASPIRATIONS

The results of the HGLM analysis described above in the Data Analysis Plan section are shown in Exhibit 7-2 at the end of this section. Importantly, the univariate findings described earlier in the Survey Results section, which showed links between gender and job aspirations, did not hold up in the HGLM analysis described here. That is, HGLM did not support the univariate finding of boys being more likely to aspire to strictly defined STEM jobs and girls being more likely to aspire to allied health jobs. It seems that in the simpler, univariate analyses, gender was acting as a carrier or proxy variable for the more specifically math- and science-related predictors linked to job aspirations in the HGLM.

While the findings for computer-related predictors (highlighted in grey below) do not hang together well with the rest of the findings, patterns linking science- and math-related predictors to STEM job aspirations are generally clear, as well as being consistent with past research described in the Literature Review. On average and across time, those most likely to aspire to STEM jobs are:

- Students with high math SE but (surprisingly) low math STV,
- Students with high science STV,
- Students whose favorite subject is STEM,
- Students who engage more frequently in STEM activities,
- Students who think the adult with whom they spend the most time (usually a parent) values math, and
- Students whose parents rate them high in science proficiency.

Over time, the variables related to increasing likelihood of aspiring to a STEM job are:

- Increasing science STV in students,
- Increasing likelihood that the student’s favorite subject is STEM, and
- Increasing parent ratings of parents’ own science proficiency.

Oddly, students with low science STV were increasingly more likely to aspire to a STEM job over time.

For allied health job aspirations, most of the significant predictors were the same as for STEM job aspirations:

- Students with high math SE but (surprisingly) low math STV,
- Students with high science STV, and
- Students who think the adult with whom they spend the most time (usually a parent) values math.

Finally, the model also shows that African American, Hispanic, and Asian students are about one and a half times more likely to aspire to an allied health job.

Exhibit 7-2: Results of HLM Model Predicting Student Job Aspirations

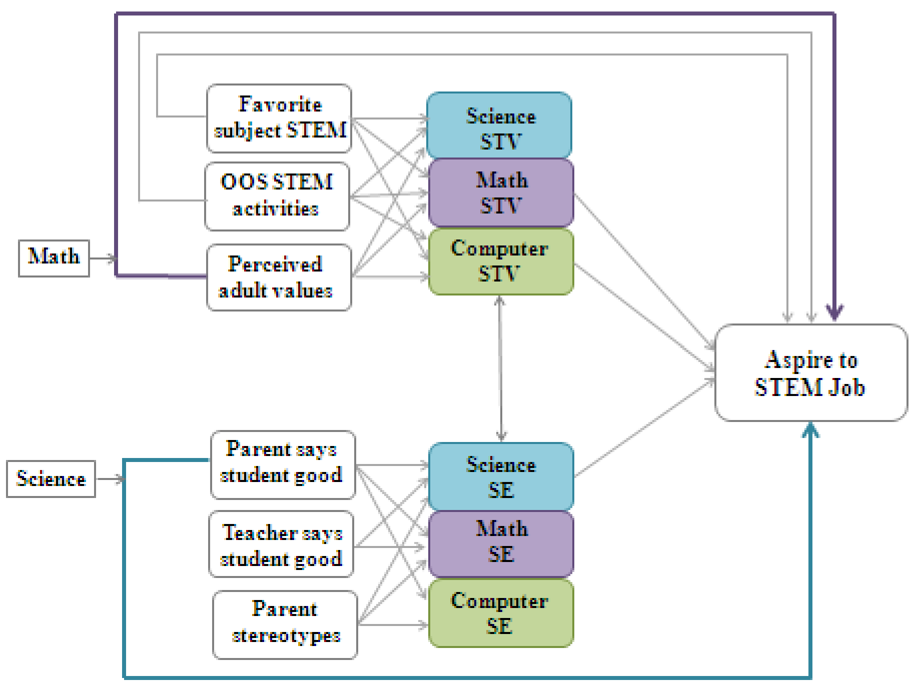
	Time-Invariant Predictors and Outcomes	Time-Invariant Predictors of Change	Time-Varying Predictors and Outcomes
	On average, who scores higher on the outcome across time?	***Whose scores on the outcome increase over time?***	***As outcome scores increase over time, what other variables change along with them?***
STEM	▪ Students with high math SE ▪ Students with low math STV ▪ Students with high science STV ▪ Students with high computer STV ▪ Students whose favorite subject is STEM ▪ Students who engage more frequently in STEM activities ▪ Students who think Adult 1[a] values math ▪ Students with high parent[b] ratings of science proficiency	▪ Students with low science STV ▪ Students whose parent values computers less	▪ Increasing science STV ▪ Increasing likelihood that favorite subject is STEM ▪ Increasing parent ratings of own science proficiency ▪ Decreasing parent ratings of own computer proficiency ▪ Decreasing teacher ratings of computer proficiency
Allied Health	▪ African American, Hispanic, and Asian students ▪ Students with high math SE ▪ Students with low math STV ▪ Students with high science STV ▪ Students who think Adult 1 values math		▪ Decreasing teacher ratings of computer proficiency

Note: Models also included school and cohort covariates; however, only primary predictors are shown in the table.
[a]Adult 1 was defined as the adult with whom the student spends the most time. For most students (94%), this was a parent, typically a mother. Questions about adult valuing of different school subjects were asked about this adult.
[b]Most parent data came from the parent survey. Just under half of students (44%) had a parent fill out a survey in at least one data collection wave; almost all (90%) were mothers.

SUMMARY OF HLM AND HGLM FINDINGS

Exhibit 7-3 summarizes the strongest and most consistent patterns of results from the HLM and HGLM findings; that is, those that hold up across STEM subjects and across both time-invariant and time-varying relationships between predictors and outcomes.

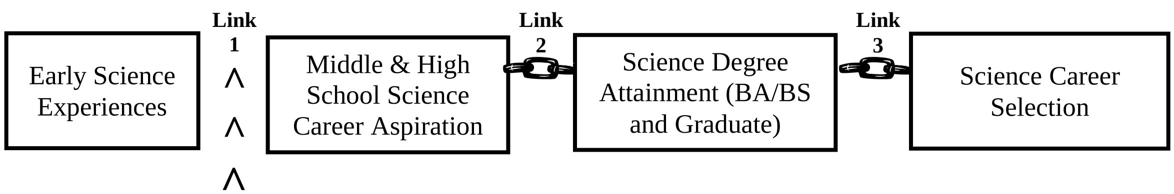
Exhibit 7-3: Conceptual Model of Primary Predictors of STEM-Related Beliefs and Aspirations



CHAPTER 8: CONCLUSIONS

We believe that the findings from the M-LEAP project can inform educational practices, policies, programs, and interventions seeking to promote STEM engagement among students, especially girls, in elementary and middle school. In this chapter, we first summarize the primary conclusions drawn from the results (of surveys, student interviews, and predictive outcome models). We then offer recommendations upon which various stakeholders may act.

In the Introduction, we introduced the Chain of Understanding about what is known about science pathways. We had posited that there has been a "missing link" between earlier childhood experiences and 8th grade interest in science career aspirations. The HLM analyses indicated that students' science self-efficacy (SE) and their math subjective task value (STV) beliefs directly predict students' aspiring to a STEM job.



There is evidence of link between the following and students aspiring to a STEM job:

- A student's science SE
- A student's math STV
- A student's favorite subject being a STEM subject
- A student frequently participating in out-of-school STEM activities
- A child perceiving that her/his parent values math
- A parent believing that her/his child has strong science abilities

From both the descriptive and HLM analyses, we conclude the following:

SE and STV are very tightly linked. Given that there is a strong relationship between SE and STV, it is possible that intervening to increase students' valuing of or interest in a STEM subject could lead to increases in SE in that subject, and vice versa. *Thus, for math, gender-specific interventions targeting SE for girls and STV for boys may be indicated. Interventions targeting math STV in hopes of increasing math SE (or vice versa) may be particularly effective for girls. For science, results indicate a need for interventions focusing on SE for African American, Hispanic, and Asian students. To the extent that math SE and science STV are enhanced, students will be more likely to aspire to STEM jobs.*

Students are highly attuned to the value they perceive adults assigning to particular subjects. Parental attitudes — actual and as perceived by their children — are very important when it comes to students' SE and STV about science, math, and computers, as well as their job aspirations. Although we did not find a relationship between parent job status and students' job aspirations in our study, we did find that parental attitudes towards STEM — be they about the value of doing well in STEM subjects, their children's abilities in those subjects, or their own level of comfort with these subjects — are important determinants of these student outcomes. *Thus, parents can do a clearer job of conveying to their children their valuing of STEM subjects and skills.*

Frequent participation in out-of-school (OOS) STEM activities is linked to higher STEM STV. It could be that students who already value STEM do tend to seek out OOS activities. On the other hand, our findings show evidence that participating in STEM activities could boost STV beliefs. These types of OOS activities are a powerful way to promote STEM beliefs and aspirations among students in elementary and middle school. Frequent participation in extracurricular activities related to STEM, such as reading or watching shows about science, math, and computers; engaging in hands-on activities involving STEM subjects; and visiting science and technology museums was consistently positively related to their attitudes about these subjects and the type of job that they aspired to. Unfortunately, most students in our sample reported participating in such activities no more often than about once a month. *Thus, encouraging students to engage in more out-of-school STEM activities may increase STV — and perhaps thereby SE — in a self-reinforcing way.*

Parent endorsement of boy-favoring STEM stereotypes can be detrimental to daughters. Parents who believe boys are better at STEM subjects have sons with *higher* science and math SE scores and daughters with *lower* science and math SE scores. To the extent girls have lower SE in math, they are correspondingly less likely to aspire to STEM jobs. *Thus, working to change parents' endorsement of boy-favoring stereotypes about STEM may be beneficial to girls' SE in math and science.*

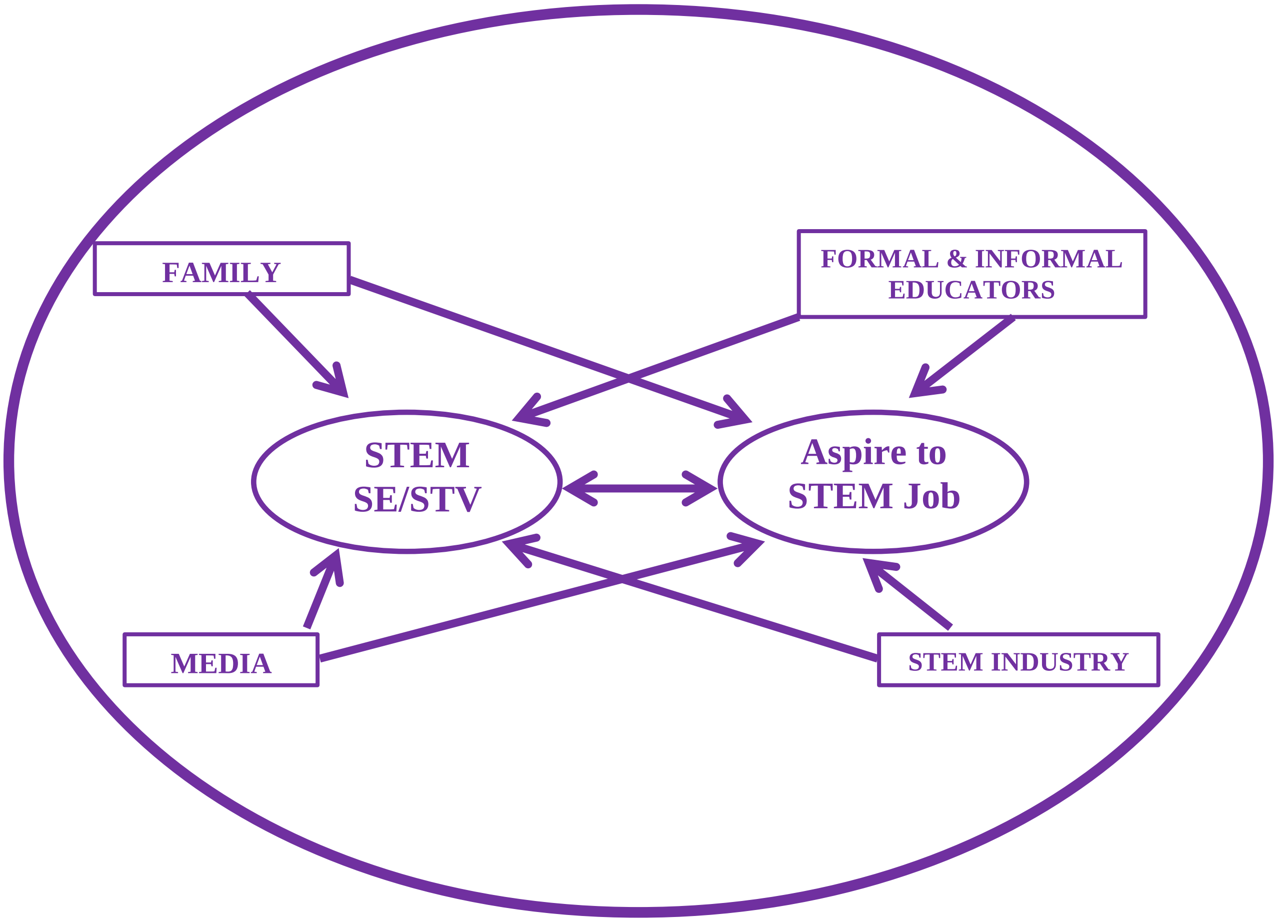
DIRECT DOMAINS OF INFLUENCE

Our study confirms that there are a variety of factors influencing students' beliefs, experiences, and aspirations in STEM, and that these are dynamic and interrelated. Thus, the findings suggest that there are multiple potential leverage points for intervention if we wish to enhance students' SE and STV related to STEM subjects and areas and to prepare students better for possible STEM careers. While public policy at all levels has the potential to influence students, we restrict our discussion to four domains of influence in which direct interventions are possible:

1) The family domain,
2) The work of formal and informal educators,
3) STEM industry's relationship with students, and
4) Various media, whether intended as educational or not.

This dynamic and interrelated network of influencers is diagrammed in Exhibit 8-1. It is important to point out that interventions mentioned in one domain are often applicable to one or more of the other domains. While reading our recommendations, we ask the reader to keep that in mind.

Exhibit 8-1: Potential Domains of Influence for Intervention



FAMILY

"Family" encompasses parents, grandparents, siblings, and other significant people with whom children interact at home every day. For the purposes of this report, we focus primarily on parents, although other family members can act upon our recommendations.

M-LEAP results showed that parental beliefs emerged as a powerful influence on what elementary and middle school students believe about math, science, and computers and their abilities in these STEM subjects and skills.

- Parents' boy-favoring gender stereotypes relate to higher SE scores in science and math for boys and lower scores for girls,
- Students' STV beliefs also closely reflected how valuable and important they perceived it to be to their parents to succeed in each of the STEM subjects.
- When students think that the adults around them value math, science, or computers, then their own beliefs about the utility and interest value of those subjects rise accordingly. Unfortunately, while parents thought each of the subjects and skills that we asked about

was valuable and important to do well in, students tended to underestimate their parents' ratings, especially with respect to the value of computer skills.

- How good at subjects parents thought their children were was strongly related to students' own ratings of ability and their expectations for success within each of the STEM subjects and skills that we asked about.
- Also, on average, parents' high ratings of students' abilities in science were associated with a higher rate of selecting a STEM job. The students did not see these ratings, but there is ample research showing that parents relay their attitudes in both subtle and not-so-subtle ways to their children. Therefore, parents' positive feelings about their child can make a positive impact on how that student sees her or himself. Over time, it is parents' ratings of their own science ability that predicts STEM job aspirations.
- Frequent participation in out-of-school STEM activities is linked to higher STEM STV. Family members, especially parents, are instrumental in children participating in these activities.

These findings highlight the importance involving parents of elementary and middle school students in policies and interventions that seek to promote STEM among students (especially girls). While there is a dearth of research literature investigating the effects of interventions geared towards parents, we believe that the results of the M-LEAP study can help lay the foundation for a new and potentially high-impact area of intervention. The following recommendations build directly from these results.

Parents should provide students with positive reinforcement about STEM subjects and skills.

Parents' providing positive reinforcement may help change students' attitudes toward these subjects and skills; this in turn, can encourage the students to become more interested in STEM and think about possible careers.

> ***We recommend that parents indicate to their children how important and valuable the parent believes STEM is. Even if they do not themselves feel comfortable about STEM areas, parents can relay positive messages about their importance. Even if students do not go into STEM jobs, per se, the level of STEM literacy can be increased dramatically. In the same line, we recommend that parents encourage their children's SE, stressing that all children — and all people — are natural scientists.***
>
> ***We recommend that parents be supplied messages and materials by other important influencers (educators, industry, media) that help them convey to their children the value of STEM subjects and skills. These materials should instruct them on how to provide students with positive reinforcement and tips for having discussions with their children on the value of STEM. (Research on a similar intervention done with high school students showed that this very simple approach embedded in an experimental design resulted in students taking nearly one semester more of science and math in the last two years of high school than a control group; Harackiewicz et al., 2012).***

Parents should be encouraged to involve their children in STEM-related out-of-school activities, even if a child does not seem to "gravitate toward" these areas.

The self-reinforcing relationship between participation in extracurricular STEM activities and student outcomes was a consistent finding in M-LEAP. Unfortunately, we found that most students in our study (especially girls) do not engage in STEM activities outside of school, and actually participated in them with less frequency as time went on. A commonly cited outcome of out-of-school STEM programs is increased confidence in one's abilities and competence in science. In the context of the E-V framework, the implication is that many of these programs succeed by promoting students' SE in science and other subjects. They also used engaging approaches to promote interest (Afterschool Alliance, 2011), an important component of STV.

In a recent study by McCreedy and Dierking (2013), two-thirds of their 159 respondents mentioned that their informal learning experience had changed their attitude toward and perception of STEM subjects in some way. Many expressed a belief that the informal learning had given them an increased level of confidence and interest in STEM subjects, both of which are directly related to SE and STV.

There is also a strong connection between students' experiences with STEM activities and their parents' beliefs. When parents thought that their children had high abilities in a STEM subject, the students tended to view these subjects as being more interesting and useful. When a student thought that the adult with whom they spend the most time values doing well in science, math, or computers, then their own judgments of the interest and utility of these subjects were usually higher, as well.

> ***We recommend that parents and other family members play a key role in reversing the trend of infrequent and decreasing participation in STEM-related OOS activities. They can do this by encouraging students to seek out such activities and stick with them. When children are in Kindergarten and primary grades, it is the parents who typically make the choices of activities in which the child will participate. Reading and watching programs, doing hands-on activities, visiting museums and other informal science institutions are among the activities that students can do directly with their parents and/or as group activities with other children.***
>
> ***There are also a number of organizations (e.g., Girl Scouts/Boy Scouts, FIRST LEGO League, Robotics, environmental organizations) that encourage parents to be a volunteer leader so that a group of children can have a STEM experience. Although a strong connection existed in only a few of the schools in our study between the school and community activities, this need not be the case.***
>
> ***We recommend parents emphasizing the enjoyable nature of these out-of-school activities. If a student has fun with an activity outside of school, self-confidence may/can increase about one's ability. If self-perception of ability increases, the value one places on that activity can also increase.***

Ideally, parents should participate in "family science learning" with their children.

Getting one's child involved in STEM activities at an early age can be extremely beneficial. Parents getting involved in an organized STEM program or at-home activities **with** their child may be even more beneficial Learning together can help reinforce the value and delight one can gain from the shared experience. If a parent shows interest in a subject (even if they feel insecure about it), the child sees that this is not something to be afraid of, in fact, it is something that is fun. They can look at websites, books, magazines, videos, TV programs together and they can work on kits together or attend family programs together to make it a family learning experience. Zarrett and Eccles (2009) explain that parents could socialize their children to become interested and engaged in activities by not only providing children with experiences but also by serving as "interpreters of experience" (p.35). In other words, by getting involved, parents can convey the positive value of these subjects and give their children positive feedback, which in turn may promote their engagement and persistence in these activities.

Research regarding effective science learning in informal settings reinforces the importance of parent-child and even sibling-sibling interactions in promoting engagement, motivation, and retention (Fenichel & Schweingruber, 2010; Gonzales et al., 2005). While high-profile examples of informal settings where these types of interactions are facilitated between children and parents exist, they are not widespread as they could or should be.

One additional outcome of getting parents more involved in STEM activities is that it could mitigate the correlation we saw between parents' own feelings of proficiency in science and math and students' frequency of participation in STEM activities (children of parents who themselves thought they were not proficient in science and math tended to engage in activities less frequently, on average).

> ***We recommend that parents investigate possible shared family experiences, such as Family Science Days at their local science or children's museums. Many public libraries offer free or reduced-cost passes to these types of informal science institutions (ISIs). Many of these ISIs have workshops and vacation and summer camps for children and families of all ages. In some cities, there are family STEM activities at local community-based organizations, often in partnership with local ISIs.***
>
> ***We recommend providing parents, especially those who feel negatively about their abilities in STEM subjects, with scaffolding, materials, and opportunities to boost their own confidence in science and math. This might encourage them to sign their children up for more activities, do activities with them at home, and help them persist in them. This would also be a good thing given our finding from HLM analyses that lifting parents' own feelings of proficiency could raise the students' likelihood of aspiring to a STEM job.***

Parents need to be informed about the risks of holding gender stereotypes and encouraged to be gender neutral in how good they think boys and girls are at STEM subjects and skills.

Many people do not believe that they hold stereotypic views in the new millennium because stereotyping has been discussed so much in the media. One stereotype that is alive and well is the boy-favoring STEM stereotype that boys are good in math and science and girls are not.

M-LEAP results showed that:

- The majority of both mothers and fathers said that boys and girls are "about the same" in terms of natural abilities in math, science, and computers. However, the remaining minority was typically heavily skewed towards rating boys as being better in these areas.

- We also found a correlation between parents' and students' gender stereotypes, such that students who held more gender stereotypes tended to have mothers who also held more gender stereotypes. This was troubling because students' endorsement of boy-favoring stereotypes in STEM subjects was associated with thinking of math as less interesting and valuable than it was for students who did not hold such stereotypes.
- We also assessed kids own endorsement of stereotypes, and those weren't directly linked to beliefs in the way parental endorsement of stereotypes was.
- Results on the relationship between parents' stereotypes and student outcomes, however, were mixed. HLM analyses showed that while having parents who endorsed boy-favoring stereotypes in STEM subjects was associated with higher computer SE scores for both boys and girls and higher SE ratings in math and science for boys, these beliefs were also detrimental to girls' beliefs about their abilities in math and science.

"Stereotype threat" is a term used to explain that the more one is aware of a stereotype, the more one's behavior may be affected in ways that inadvertently confirm or reinforce the stereotype. (The term was first coined by 1995 by Claude Steele and Joshua Aronson, who conducted an experiment demonstrating that stereotype threat can undermine intellectual performance.) This is pertinent to M-LEAP because parents' stereotyped beliefs were shown to influence their children's stereotyped beliefs. Given the interest in promoting STEM among girls, we believe that these results, on the whole, suggest that targeting stereotypes among parents can be a powerful remediator.

> ***We recommend that parents work on overcoming their own stereotyped views and present gender-neutral views to their children. We understand that stereotyped beliefs can be unintentional and exhibited in subtle but numerous ways (e.g., by encouraging boys in science and math, having higher expectations of them, questioning them more deeply about them, etc.***
>
> ***This is easier said than done and probably takes a more systemic approach. Nonetheless, we recommend that parents act through both word and deed: explaining to their children that both boys and girls are as good as each other in STEM subjects should mitigate the negative influences of parental gender stereotypes on children. Furthermore, if parents serve as models for their children in their own words and behaviors, they can help their children to adjust their own stereotyped views. These can, in turn, affect children's beliefs about the utility of STEM areas and how good they see themselves as being.***

FORMAL AND INFORMAL EDUCATORS

The Massachusetts Department of Elementary and Secondary Education voted in 2010 to accept the Common Core standards as a baseline for Massachusetts educational standards. Sponsored by the National Governors' Association and the Council of Chief State School Officers, the standards are designed to ensure that all American students are adequately prepared to succeed in college or the workplace upon high school graduation.

MCAS exams (the Massachusetts "high-stakes" tests) are competency determinations which are meant to demonstrate and assess a student's readiness for college or the workplace. The MCAS exams for all grade levels are designed to determine to what extent students are meeting the standards laid out in the Massachusetts curriculum frameworks for various topics, including English language arts and literature, mathematics, and science. The Department of Elementary and Secondary Education released new standards for English and math in 2011 that integrate the Common Core standards; all MCAS exam questions in the 2014 MCAS cycle will reflect the core competencies and skill sets described in these frameworks. The Common Core standards are not reflected in the science standards, which have not been reissued since 2006.

Because of the greater focus on math and ELA, it is not surprising that these two subjects are often seen as being more valuable than is science by students and by parents. District science coordinators agreed that planning science curricula and professional development has been "in a holding pattern" while waiting for the Next Generation Science Standards to be issued in Massachusetts. We found that in most of the eight districts, science teachers adhere to basic science standards while "doing their own thing" in terms of how they teach curricula and what materials they use.

Regardless of what transpires statewide, our literature review and results suggest that educators inside and outside of schools can have a powerful influence on students' beliefs, experiences, and aspirations.

Educators should promote engagement and interest in STEM subjects by infusing enthusiasm, hands-on teaching methods, and focusing on process skill as much as content. This is important for all students and critical for girls.

Research has shown that students respond particularly well to hands-on science activities (National Research Council, 2007; Marx et al, 2004; Minner, Levy, & Century, 2009; Wolf & Fraser, 2008). Thus, interventions targeting STEM STV in hopes of increasing STEM SE (or vice versa) may be particularly effective for girls. Our findings should help teachers and informal program educators consider enhancing existing efforts or developing new activities for girls and boys in elementary and middle school.

Our student interviews showed that a strong motivating factor behind increases in students' SE and STV scores in STEM subject areas was the type of instruction taking place in those classes. For girls especially, covering interesting topics and doing so in an interactive and collaborative way was cited as a main reason for why they started to think more positively about their abilities in and expectations for success in math and science, as well as how interesting and useful they perceived these subjects to be. Science coordinators and lead science teachers mentioned that hands-on science demonstrations were far more successful with students than teacher lecture, and that some topics lent themselves more to this pedagogical method. Science coordinators also promoted the idea of a more interdisciplinary approach across science, social studies, and ELA.

> ***We recommend that science and math teachers recognize that demonstrating their enthusiasm about what they teach can be "contagious" in a positive way.***
>
> ***We recommend that both formal and informal educators continue to promote more hands-on and collaborative learning in their classrooms and programs and that they make the subject matter as relatable to students as possible. Tying in as much from other subjects as possible and co-teaching with other subject matter teachers is important for students to see interdisciplinary integration.***

Formal and informal educators must educate their students about STEM jobs.

When we asked a subset of 39 5th-8th grade students who aspired to a STEM job where they had heard about their chosen job, only a few reported learning about these kinds of jobs from teachers or in school. Science specialists admitted that formal education "falls down on the job" in terms of providing students with information about the wide range of jobs in STEM fields at all levels. We believe that these findings reveal a missed opportunity for dialog between teachers, counselors, and other formal and informal educators and their students about STEM-related jobs and jobs. In addition, other influencers such as industry have a role in communicating about STEM careers.

> ***We recommend that educators in both informal and formal realms incorporate in any programming the types of jobs that are available at all levels, what level of education is required, and what types of preparatory classes/subjects are needed.***
>
> ***We recommend teachers to encourage students to make connections between what they learn about math, science, and computers and potential jobs they might want to obtain someday. An important reason for this is that students who aspired to a STEM job, by and large, did not have a complete understanding of the things they would need to do in order to get that job. Educators trained in conveying this kind of information could help fill this knowledge gap.***

Professional development of educators in both formal and informal educational settings should include a greater emphasis on the crucial role of family engagement in STEM learning.

> ***We recommend that educators work to bring parents into the learning equation. This is seen as difficult, if not impossible, in many schools. However, parents can get involved at school, not only those who have STEM jobs, but other parents who can be co-learners with their children. Schools need to offer parents assistance and suggestions about supporting STEM at home. This can be in the form of newsletters, take-away activities to do at home, and other strategies, in addition to the more traditional activities such as science fairs, "bring your parent to school day," parents accompanying classes on field trips, etc.***
>
> ***We recommend more attention be paid to coordination between formal and informal educators and best practices for delivering professional development to formal educators in informal settings (Surrounded by Science, 2009).***

Higher education has a role to play in introducing students to STEM fields.

There have been many outreach efforts by colleges and universities to students, with a large number focusing on the high school pre-college years. There is a growing body of research that highlights best practices for these kinds of programs (Afterschool Alliance, 2010; UMass Donahue Institute Research and Evaluation Group, 2011).

> ***We recommend that local elementary and middle schools partner with colleges and universities that engage in outreach efforts to teach students about working and studying in STEM areas.***

STEM INDUSTRY

Over the past decade or so, the number of jobs in STEM fields has grown three times as fast as the number of jobs in other fields. In 2010, 1 in 18 workers in the U.S. held STEM jobs. Moreover, STEM workers are less likely to experience joblessness than their non-STEM counterparts. Other key findings from this U.S. Department of Commerce (2011) report, *STEM: Good Jobs Now and for the Future* (Langdon et al, 2011), are:

- STEM workers command higher wages, earning 26% more than their non-STEM counterparts.
- STEM degree holders enjoy higher earnings, regardless of whether they work in STEM or non-STEM occupations. For instance, workers with Bachelor's degree only who work in STEM occupations earn an average of $35.81/hour, compared to a non-STEM worker who averages $28.27/hour.

Moreover, 75% of the fastest growing occupations require proficiency in some component of STEM (Adecco, 2014). The Boston Private Industry Council (PIC) states that 80% of jobs created in the next decade will require math and science skills, and that 1 in 5 jobs at life sciences firms requires no more than a two-year associate's degree (BPIC, 2013). Given these statistics, there is much that STEM industry can do to promote interest in STEM careers. There are, of course, many companies and initiatives across organizations that provide outreach to schools. For instance, PIC convenes the Boston STEM Network "to increase awareness of the many career opportunities becoming available for those who are well-prepared in these subjects."

Both corporations and the various STEM-related professional societies have a large role to play in helping young students get actual experience in and become interested in STEM fields. Our own experience evaluating STEM-related informal learning and formal education programs suggests that training these professionals to effectively communicate and work with young learners is of utmost importance. Institutions and programs have brought STEM professionals into broader view in the public, in classrooms, and in informal education settings. Just a few examples include:

- Science festivals (www.sciencefestivals.org), which now operate in a number of cities, give members of the public a chance to interact with actual scientists and other STEM professionals;
- Science cafés (www.sciencecafes.org) introduce the public to STEM professionals in informal settings such as cafés, pubs, or coffee houses or bars, and there are some science cafés designed specifically for young students;

- Society of Automotive Engineers (www.saeinternational.org) developed A *World in Motion* engineering design curriculum that includes bringing engineers to the classroom on a regular basis during the course of the curriculum.

The Bayer Corporation's company-wide initiative, *Making Science Make Sense*, has published *Planting the Seeds for a Diverse U.S. STEM Pipeline: A Compendium of Best Practice K-12 STEM Education Programs* (2010). It includes many programs that have corporate and/or professional organization support.

A properly trained support network of professionals working in STEM fields can visit schools to get students thinking about aspiring to a STEM job and mentor students interested in pursuing these jobs.

Nearly a third of all students who were interviewed in Wave 3 of data collection (and had written that they aspired to a STEM job on the student survey) said that they had learned about their STEM job of choice from knowing someone who had that job. Although this was only a snapshot into the experiences of a select group of students in our sample, it echoes what others have found about the importance of mentoring and outreach programs in secondary school and undergraduate settings (Packard, 2012; Goodman et al., 2002).

Eccles (2013) argues that providing young female students with the opportunity to interact with STEM role models and learn about STEM careers could "combat attrition from STEM fields due to misinformation or stereotypes."

Mentors need to be apprised of the most current and accurate research about how students relate to STEM, learn best practices for interacting with students, and be provided with materials and training so there can be consistency in the messages given.

> ***We wish to emphasize the important role that industry has to play in educating students about STEM jobs and what it takes to go into them. We recommend that private industry be more aggressive in reaching out to schools and out-of-school programs to help students learn about STEM jobs.***
>
> ***We recommend that this outreach extend to younger students and their parents. They can promote hands-on science activities in out-of-school and summer programs. They can also offer internships and "shadowing" to students as young as middle school. In this way, students can feel they are part of a community of STEM learners, which has been shown to be so important to students, especially to girls.***
>
> ***Mentors can be powerfully positive role models for students. However, one-on-one mentoring is labor intensive and often not sustainable. We recommend that industry have STEM ambassadors who visit classrooms and also bring students to their workplaces. Some examples are DIGITS (a program pairing STEM professionals with 6th grade classrooms). If trained properly, mentors or ambassadors can bring a human face to STEM — their own stories, motivations to take their job, what they like about it, quirky things they've discovered, etc.***

MEDIA

Media is a powerful influence on all members of society, and especially children. Without our even being aware, various media, including the web, project powerful messages either through content or advertising. There has been much press about how our country is inadequately prepared for the science and technological demands of the 21st century and how the U.S. falls way behind other industrialized countries in terms of student proficiency in STEM areas. This problem is compounded by the persistence of unfair stereotyped characterizations of STEM professionals in the popular media as well as in academia. Many prime time television sitcoms and dramas perpetuate negative stereotypes about STEM fields and professionals. The media **can** play a positive role in encouraging public engagement in and understanding of STEM and STEM professionals, especially among young and impressionable learners.

Make science relatable so that the public sees it as part of everyday life.

In fall 2013, MIT Museum and the Cultural Kettle brought together 60 professionals for an invitational conference called *Evolving Culture of Science Engagement* conference. The conference organizers presented examples of six dimensions of science engagement: Story/storytelling (incl. relationship between teller and audience), Humor, Mystery/The Unknown, Artistic Expression, Participatory Engagement (e.g., citizen science projects), and Informality/Science as Part of Everyday Life (relatable, informal, playful). Conference participants raised broader questions about personality/subjectivity, authority, and pop culture.

> ***It is important that all spheres of influence mentioned in this chapter consider making science more relatable.***

We call for an evidence-based, multi-media, multi-platform campaign that will introduce young students to STEM jobs and boost their attitudes towards STEM subjects.

In addition to knowing someone who had that job, visual and written media were commonly cited sources for learning about STEM jobs in the Wave 3 student interviews. Girls reported learning about STEM jobs that they might like to have from written sources, like books and magazines, while boys referred to TV, movies, and other visual media as a place where they got information about potential STEM jobs. While the sample of students who was asked this question was small relative to our overall sample, when combined with our findings of the strong relationship between participation in STEM-related out-of-school activities (which included reading and viewing TV shows about STEM subjects) and key outcomes, these results are taken to indicate yet another avenue for potential intervention.

Two states have recently kicked off media campaigns related to increasing awareness of STEM

- In Utah, “STEM Utah: Curiosity Unleashed” is aimed at encouraging students to consider careers in STEM. It consists of a series of television commercials and advertisements for newspaper, radio, and Internet platforms, and has raised more than $2 million from the private sector.

- Iowa's Governor Terry Branstad announced a media campaign to boost awareness of the state of Iowa's effort to encourage students to pursue careers in math and science fields, called "Greatness STEMS from Iowans." The campaign will include televised public service announcements, billboards, STEM program "toolkits," and other public relations efforts to make more Iowans aware of the opportunities available to students in STEM careers. Branstad said the state currently has 10,000 unfilled jobs requiring advanced knowledge in STEM disciplines.

  In building off our entire body of M-LEAP findings, we recommend a targeted media campaign involving educators, industry, and policymakers that:
  - ***Exposes young students to information about STEM jobs,***
  - ***Reinforces the value of doing well in STEM subjects and skills,***
  - ***Appeals to both children and parents while promoting communication between them, and***
  - ***Tackles stereotype beliefs that persist among these groups.***

  This campaign has the strong potential to lead to improvements in all the student outcomes addressed in this study, and ultimately encourage more girls to study STEM and obtain jobs in these fields.

An interesting question raised by our findings is whether or not the optimal medium for such a campaign differs between boys and girls. Future research might investigate whether girls respond more to a campaign based on written media and boys more to one based on visual media.

A truly coordinated effort is needed to provide resources to students, parents, teachers, and professionals who wish to help students, particularly girls, become more interested in STEM.

A simple Internet search for math and science games or websites will produce thousands of responses. The hard part for parents, teachers, and other educators is determining which of these results combines an engaging interface with real, educational content. While small, aggregated lists of recommended websites exist, there is no single, comprehensive compendium of resources highlighting high-quality content with good educational value. The most engaging STEM-themed, content-rich resources at present tend to be games or texts. There is a distinct lack of STEM-themed videos or audio files that are aimed at engaging younger children, and especially girls, in the STEM fields. Most resources that do exist — the Crash Course and SciShow YouTube series or MythBusters, for example — are more suitable for an older audience.

Additionally, what media does exist does little to directly engage with girls as they think about their interest in STEM. NASA, through their Women@NASA program, has made a notable effort to increase their outreach to girls interested in the STEM fields through campaigns like Aspire 2 Inspire (a2i), which showcases the stories of women in the STEM fields and also offers a message board where NASA employees and aspiring scientists can connect, ask questions, and learn more about what types of education, training, and experiences it takes to have a STEM career. Other organizations have produced resources to help establish and train mentors for students interested in STEM, especially girls, but few do so through truly engaging web media.

One person who has helped children see themselves as having more SE in math is Danica McKellar, a child star of "The Wonder Years" television series and a UCLA graduate in mathematics, who has published several books that are particularly appealing to girls. *Math Doesn't Suck* presented math lessons for 9-12 year olds in the style of a teen magazine, followed by *Kiss My Math* (pre-Algebra, for ages 11-13), *Hot X: Algebra Exposed* (for ages 13-15 and up), and *Girls Get Curves: Geometry Takes Shape*. She explained on her website, www.danicamckellar.com, that "Getting emails from readers – especially from girls who are feeling confident in math for the first time – is my favorite part of being an author. I know I'm making a difference and I'm so grateful to be having this experience."

Some other online materials praised by educators include the following:
Science:
http://www.sciencedaily.com/
https://www.facebook.com/ScienceIsSeriouslyAwesome

Mathematics:
http://www.youtube.com/user/Vihart
https://www.khanacademy.org/
http://www.ixl.com/math/

Computers:
http://csisfun.com/

Engineering:
Videos on such topics as "What is Engineering?" http://www.youtube.com/watch?v=bipTWWHya8A
Engineering projects for young students, such as http://www.instructables.com/id/Project-Based-Engineering-for-Kids/

POLICY IMPLICATIONS AT LOCAL AND NATIONAL LEVELS

We have discussed in this chapter what we believe educators, parents, industry professionals, and the media can do in classrooms, schools, and out-of-school educational environments. In addition, there are certainly broader implications for policy at all levels. Many studies, thought pieces, articles, and speeches have been given about the dire circumstances pertaining to STEM in the U.S. and the need for policymakers to make changes. While it is beyond the scope of this study to make results-based recommendations to these policymakers, we mention the most obvious ways in which they can address these issues.

- Pervasive negative STEM stereotypes will not go away until they are addressed consistently and systemically by all influencers at all levels and in all arenas. At the district and state levels, it is important for the message to get across loud and clear that children's SE and their STV in STEM areas are extremely important variables in the picture of how children's early science experiences affect later decision making. If girls are to be encouraged to pursue these fields, there is a lot more work to do to enhance their self-confidence and interest.

- The national 100K in 10 Project is a national program designed to recruit, place, and retain 100,000 STEM teachers nationally by 2021. This push to educate them has to include instructing them in how to prevent and combat stereotypes, teaching them curricula that prepare students to be college-and-career-ready and acquire the skills to compete in a growing STEM-based economy, and incorporating much more about the range of possible jobs in the STEM workforce.

- At both the state and federal levels, stakeholders should use the results of the M-LEAP study to implement successful funding strategies as they develop or refine programs and initiatives to enhance all students' sense of the usefulness of STEM, the fact that STEM subjects and skills are desirable, and that they can be proficient in these areas.

OUR NEXT RESEARCH STEPS — OR LEAPS!

When we initially proposed M-LEAP, we posited that future extensions to our study could follow students through high school, using growth modeling to follow attitudinal changes toward STEM training and job aspirations, and participation in related curricular and extracurricular activities. In fall 2013, we learned that our proposal for M-LEAP 2 was awarded by NSF for three years of study. In it, we will follow a small subset (N=84) families from M-LEAP — students, their parents, and siblings — with the intent of more deeply understanding external and internal motivations for pursuing interests in STEM and/or non-STEM fields.

REFERENCES

Adecco. (Artist). (2014). Where's the STEM gap stemming from? [Web Graphic]. Retrieved from http://www.adeccousa.com/engineering-and-technical/employer-services/resource-center/PublishingImages/stem-jobs-infographic.png

Afterschool Alliance. (2010). *Afterschool: Middle school and science, technology, engineering, and math (STEM)* (Issue Brief No. 44). Retrieved from Afterschool Alliance website: http://www.afterschoolalliance.org/issue_briefs/issue_stem_44.pdf

Afterschool Alliance. STEM & Afterschool. (2011). *STEM learning in afterschool: An analysis of impact and outcomes*. Washington, DC: Afterschool Alliance.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child development*, *72*(1), 187-206.

Barton, Angela C. (1998). Teaching Science with Homeless Children: Pedagogy, Representation, and Identity. *Journal of Research and Science Eduction.* 35:4 379-394.

Bayer Corporation. Making Science Make Sense, (2010).*Planting the seeds for a diverse U.S. STEM pipeline: A compendium of best practice K-12 STEM education programs*. Retrieved from Bayer Corporation website: http://www.bayerus.com/msms/web_docs/compendium.pdf

Beede, D., Julian, T., Langdon, D., McKittrick, G., Khan, B., & Doms, M. (2011). Women in STEM: A gender gap to innovation. *Economics and Statistics Administration Issue Brief*, (04-11).

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107*, 1860–1863. doi:10.1073/pnas.0910967107.

Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. National Academies Press.

Blumenfeld, P.B. (1997). Change in children's competence beliefs and subjective task values across the elementary school years: A three-year study. *Journal of Educational Psychology*, *89*, 451–469.

Brickhouse, N. W. and Potter, J. T. (2001), Young women's scientific identity formation in an urban context. J. Res. Sci. Teach., 38: 965–980.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching*, *43*(5), 485-499.

Britner, S.L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering*, *7,* 271 –285.

Chapman, J.W., & Tunmer, W.E. (2003). Reading difficulties, reading-related self-perceptions and strategies for overcoming negative self-beliefs. *Reading and Writing Quarterly*, *19,* 5-24.

Char, C. (1999*) Looking Back: A Retrospective Study of Dartmouth Science Alumnae (1973-1996).* A report for the Women in Science Project at Dartmouth College, Hanover, NH.

Clewell, B.C. & Campbell, P.B. (2002). Taking stock: where we've been, where we are, where we're going. *Journal of Women and Minorities in Science and Engineering,* 8, 255-284.

Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (2000). *Land of Plenty: Diversity as America's competitive edge in science, engineering and technology.*

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science*, *12*(3), 258-261.

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math–gender stereotypes in elementary school children. *Child development*, *82*(3), 766-779.

Department of Labor. U.S. Department of Labor, Bureau of Labor Statistics. (2013). College enrollment and work activity of 2012 high school graduates (USDL-13-0670). Retrieved from website: http://www.bls.gov/news.release/hsgec.nr0.htm

Dorsen, J., Carlson, B., & Goodyear, L. (2006). Connecting informal STEM experiences to career choices: Identifying the pathway. *ITEST Learning Resource Center*.

Eccles J., Wigfield A., Harold R.D., & Blumenfeld P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development, 64,* 830-847.

Eccles [Parsons], J.E., Adler, T.F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. I., & Midgley, C. (1983). Expectations, values and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75-145). San Francisco: W.H. Freeman.

Eccles, J. S. (2005a). Studying gender and ethnic differences in participation in math, physical science, and information technology. *New Directions for Child and Adolescent Development, 110*, pp. 7-14.

Eccles, J. S. (2005b). Subjective task value and the Eccles et al. model of achievement-related choices. *Handbook of competence and motivation*, 105-121.

Eccles, J. S., Vida, M. N., & Barber, B. (2004). The relation of early adolescents' college plans and both academic ability and task-value beliefs to subsequent college enrollment. *The Journal of Early Adolescence*, *24*(1), 63-77.

Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of Science Education and Technology, 16*(2), 171-190.

Farenga, S., & Joyce, B. (1999). Intentions of Young Students to Enroll in Science Courses in the Future: An Examination of Gender Differences. *Science Education*, *83*, 55–75.

Feather, N. T. (1988). From values to actions: Recent applications of the expectancy-value model. *Australian Journal of Psychology*, *40* (2; Spec Issue), 105–124.

Fenichel, M., and Schweingruber, H.A. (2010). *Surrounded by Science: Learning Science in Informal Environments*. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Freeman, C. E. (2004). *Trends in Educational Equity of Girls and Women*. Washington, DC: National Center for Educational Statistics (NCES 2005-016).

Friedel, J. M., Cortina, K. S., Turner, J. C., & Midgley, C. (2007). Achievement goals, efficacy beliefs and coping strategies in mathematics: The roles of perceived parent and teacher goal emphases. *Contemporary Educational Psychology, 32*(3), 434-458.

Friedman, L. N., & Quinn, J. (2006). Science by Stealth. *Education Weekly*, *25(24)*, 45-49.

Frome, P.M., & Eccles J.S. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology, 74*, 435-452.

Gonzalez-DeHass, A. R., Willems, P. P., & Holbein, M. F. D. (2005). Examining the relationship between parental involvement and student motivation. *Educational Psychology Review*, *17*(2), 99-123.

Goodman, I.F., Cunningham, C.M., Lachapelle, C., Thompson, M., Bittinger, K., Brennan, R.T., & Delci, M. (2002). The Women's Experiences in College Engineering (WECE) Project. Cambridge, MA: Goodman Research Group, Inc. (NSF Grant REC 9725521, Sloan Foundation Grant 96-10-16).

Guay, F., Marsh, H.W., & Boivin, M. (2003). Academic self-concept and academic achievement: developmental perspectives on their causal ordering. *Journal of Educational Psychology, 95 (1),* 124–136.

Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*(3-4), 153-166.

Handelsman, J., Cantor, N., Carnes, M., Denton, D., Fine, E., Grosz, B., Hinshaw, V., Marrett, C., Rosser, S., Shalala, D., & Sheridan, J. (2005). More women in science. *Science, 309*, 1190–1191.

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping Parents to Motivate Adolescents in Mathematics and Science An Experimental Test of a Utility-Value Intervention. *Psychological science*, 23(8), 899-906.

Hazari, Z., Potvin, G., Tai, R.H., Almarode, J. (2010). For the love of learning science: Connection learning orientation and career productivity in physics and chemistry. *Physics Education Research,* 010107.

Hill, C., Corbett, C., & St Rose, A. (2010). *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. American Association of University Women. 1111 Sixteenth Street NW, Washington, DC 20036.

Hyde, J.S., Lindberg, S.M., Linn, M.C., Ellis, A.B., & Williams, C.C. (2008). Gender similarities characterize Math performance. *Science, 321*, 494-495.

Jacobs, J.E. & Bleeker, M.M. (2004). Girls' and Boys' Developing Interests in Math and Science: Do Parents Matter? *New Directions for Child and Adolescent Development, 106,* 5-21.

Jacobs, J. E., & Eccles, J. S. (1985). Gender differences in math ability: The impact of media reports on parents. *Educational Researcher, 14*(3), 20-25.

Jacobs, J.E., Finken, L.L., Griffen, N.L., & Wright, J.D. (1998). The Career Plans of Science-Talented Rural Adolescent Girls. *American Educational Research Journal, 35(4),* 681-704.

Jacobs, J.E., Hyatt, S., Osgood, W.D., Eccles, J.S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development, 73(2)*, 509-527.

Landivar, L. C. U.S. Department of Commerce, Economics and Statistics Administration. (2013). Disparities in STEM employment by sex, race, and Hispanic origin. Retrieved from website: http://www.census.gov/prod/2013pubs/acs-24.pdf

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future* (ESA Issue Brief #03-11). Retrieved from U.S. Department of Commerce, Economics and Statistics Administration website: http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinalyjuly14_1.pdf

Legewie, J., & DiPrete, T. A. (2012). High School Environments, STEM Orientations, and the Gender Gap in Science and Engineering Degrees. *STEM Orientations, and the Gender Gap in Science and Engineering Degrees (February 21, 2012)*

Li, Q. (1999).Teachers' beliefs and gender differences in mathematics: A review. *Educational Research, 41*, 63-76.

Mann, A., & DiPrete, T. A. (2013). Trends in gender segregation in the choice of science and engineering majors. Social Science Research, 42(6), 1519-1541. Retrieved from http://www.sciencedirect.com/science/article/pii/S0049089X13001051

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tal, R. T. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching, 41*(10), 1063-1080. doi: 10.1002/tea.20039

McCreedy, D., & Dierking, L. D. (2013). *Cascading influences: Long-term impacts of informal STEM experiences for girls.* Philadelphia, PA: The Franklin Institute Science Museum.

Meece, J. L., Glienke, B. B., & Burg, S. (2006). Gender and motivation. *Journal of School Psychology, 44*(5), 351-373.

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Change in teacher efficacy and student self- and task-related beliefs in mathematics during the transition to junior high school. *Journal of Educational Psychology, 81*, 247–258. doi:10.1037/0022-0663.81.2.247.

Minner, D. D., Levy, A. J., & Century, J. (2009). Inquiry-based science instruction-what is it and does it matter? results from a research synthesis years 1984-2002. *Journal of Research in Science Teaching, 47*(4), 474-496. doi: 10.1002/tea.20347

Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation*, *12*(4), 323-345.

National Research Council. (2007). R. A. Duschl, H. A. Schweingruber & A. W. Shouse (Eds.), *Taking science to school: Learning and teaching science in grades K-8.* Retrieved from http://www.nap.edu/openbook.php?record_id=11625&page=1

National Science Board (2003). *The Science and Engineering Workforce: Realizing America's Potential*. Arlington, VA: (NSF 03-69).

National Science Board (2008). *Science and Engineering Indicators 2008.* Pub. No. NSB 08-01. Arlington, VA: National Science Foundation. Available on-line at http://www.nsf.gov/statistics/seind08/

National Science Foundation (2003). *New Formulas for America's Workforce: Girls in science and engineering.* Arlington, VA, 2003 (NSF 03-207).

National Science Foundation (2004). *Women, Minorities and People with Disabilities in Science and Engineering*. Arlington, VA (NSF04-317).

National Science Foundation (2013). *Science and Engineering Degrees (1966-2010: Detailed Statistical Tables).* Arlington, VA (NSF 13-327).

Office for Civil Rights. U.S. Department of Education, Office for Civil Rights. (2012). Gender equity in education: A data snapshot. Retrieved from website: http://www2.ed.gov/about/offices/list/ocr/docs/gender-equity-in-education.pdf

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International journal of science education*, *25*(9), 1049-1079.

Packard, B. W. L. (2011). In George Boggs (Chair).*Effective outreach, recruitment, and mentoring into STEM pathways: Strengthening partnerships with community colleges*. In Olson, S. & Labov, J. B. (Eds.), *Community colleges in the evolving STEM educational landscape: Summary of a summit* (pp. 58-79). Retrieved from http://cue.usc.edu/assests/Dowd_CCs Evolving STEM Landscape_NAS_2012.pdf

Parsons, J. E., Adler, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. *Child Development*, 310-321.

Priess, H. A., & Hyde, J. S. (in press). Gender and academic abilities and preferences. In J. Chrisler & D. McCreary (Eds.), *Handbook on Gender Research in Psychology*.

Riegle-Crumb, C., King, B., Grodsky, E., & Muller, C. (2012). The more things change, the more they stay the same? Prior achievement fails to explain gender inequality in entry into STEM College majors over time. *American Educational Research Journal*, *49*(6), 1048-1073.

Roe, A. (1952). A Psychologist Examines 64 Eminent Scientists. *Scientific American, 187 (5),* 21-25.

Rudasill, K. M., & Callahan, C. M. (2007). Parenting and gender stereotypes: Are we limiting our children's career paths?. *Parenting for High Potential*, 18-19.

Senler, B., & Sungur, S. (2009). Parental influences on students' self-concept, task value beliefs, and achievement in science. *Spanish journal of psychology*, *12*(1), 106-117.

Shumow, L., & Schmidt, J. A. (2013). Academic grades and motivation in high school science classrooms among male & female students: Associations with teachers' characteristics, beliefs, and practices. In R. Haumann & G. Zimmer (Ed.), *Handbook of Academic Performance: Predictors, Learning Strategies and Influences of Gender* (pp. 53-72). Nova Scientific.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental psychology*, *42*(1), 70.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, 69(5), 797-811. doi: 10.1037/0022-3514.69.5.797

Tai, R.H., Liu, C.Q., Maltese, A.V., & Fan, X. (2006) Career Choice: Enhanced: Planning Early for Careers in Science. *Science, 312(5777)*, 1143-1144.

Tenenbaum, H. R., Snow, C. E., Roach, K. A., & Kurland, B. (2005). Talking and reading science: Longitudinal data on sex differences in mother–child conversations in low-income families. *Journal of Applied Developmental Psychology*, *26*(1), 1-19.

Tiedemann, J. (2000). Parents' gender stereotypes and teachers' beliefs as predictors of children's concept of their mathematical ability in elementary school. *Journal of Educational Psychology*, *92*(1), 144.

Trusty, J., Robinson, C.R., Plata, M., & Ng, K. (2000). Effects of gender, socioeconomic status, and early academic performance on post secondary educational choice. Journal of Counseling and Development, *78*, 463–472.

Turner S.V., Bernt P.W., & Pecora, N. (2002). Why Women Choose Information Technology Careers: Educational, Social, and Familial Influences. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

UMass Donahue Institute Research and Evaluation Group. (2011). *Increasing student interest in science, technology, engineering, and math (STEM): Massachusetts STEM Pipeline Fund programs using promising practices*. Retrieved from UMass Donahue Institute website: http://www.mass.edu/forinstitutions/prek16/documents/Student Interest Summary Report.pdf

Venville, G., Rennie, L., Hanbury, C., & Longnecker, N. (2013). Scientists Reflect on Why They Chose to Study Science. *Research in Science Education*, 1-27.

Wang, M. T., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields. *Developmental Review*.

Wang, M. T., Eccles, J. S., & Kenny, S. (2013, March 27). What exactly is drawing young women away from STEM fields?. *The Huffington Post*. Retrieved from http://www.huffingtonpost.com/mingte-wang/women-stem-education_b_2967180.html.

Wang, M. T., Eccles, J. S., & Kenny, S. (2013). Not Lack of Ability but More Choice Individual and Gender Differences in Choice of Careers in Science, Technology, Engineering, and Mathematics. *Psychological science*, *24*(5), 770-775.

Watt H.M.G. (2005). Explaining Gendered Math Enrollments for NSW Australian Secondary School Students. *New Directions for Child and Adolescent Development*, *110*, 15-29.

Wigfield, A., Byrnes, J.P., & Eccles, J.S. (2006). Development during early and middle adolescence. In P. A. Alexander & P. H. Wynne (Eds.), *Handbook of Educational Psychology* (pp. 87-114). Mahwah, N.J.: Lawrence Erlbaum.

Wigfield, A., & Eccles, J.S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25,* 68-81.

Wigfield, A., Harold, R. D., Freedman-Doan, C., Eccles, J. S., Yoon, K. S., Arbreton, A. J. A., & Blumenfeld, P. C. (1997). Change in children's competence beliefs and subjective task values across the elementary school years: A 3-year study. *Journal of Educational Psychology*, *89*(3), 451-469. Retrieved from http://www.rcgd.isr.umich.edu/garp/articles/eccles97s.pdf

Wolf, S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education*, *38*(3), 321-341. Retrieved from http://link.springer.com/article/10.1007/s11165-007-9052-y

Woolnough, B. (1994). Effective Science Teaching. Buckingham: Open University Press.

Xie, Y., & Shauman, K. (2005). *Women in science: Career processes and outcomes.* Cambridge, MA: Harvard University.

Zarrett, N., & Eccles, J. (2009). The role of family and community in extracurricular activity participation. In L. Shumow (Ed.), *Promising practices for family and community involvement during high school* (pp. 27-52). Charlotte, NC: Information Age Publishing

Zeldin, A.L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, *37*, 215 –246.

LIST OF APPENDICES

A. Student Survey

B. Student Interview Protocol

C. Parent Survey

D. Teacher Survey and Rating Form

E. Science Specialist Interview Protocol

F. External Project Monitoring Report by Cynthia Char, Ed.D.

G. Technical Appendices I & II

APPENDIX A: STUDENT SURVEY

M-LEAP
Linking Experiences and Pathways

ASSENT TO PARTICIPATE

I understand that:

- It is my choice whether I want to take this survey or not.
- If I decide to take this survey, I will not get anything for doing it.
- There are no right or wrong answers, and I will not be graded on this survey.
- Nobody will see my answers except the researchers.
- If there are any questions I do not feel comfortable answering, I can skip them.
- If I decide to take the survey but change my mind, I can stop at any time.
- I can ask questions before I decide if I want to take this survey or not.

If I choose to take this survey:

- I will answer the survey questions honestly and as best I can.
- I will not talk about my answers with other students as I work.

BOX #1: SURVEY (*check YES or NO*)

☐ YES, I will take the survey. ☐ NO, I do not want to take the survey.

BOX #2: YOUR NAME

________________ First name (*please print*) ________________ Nickname (*if any*) ________________ Last name (*please print*)

________________________ Your signature ________________ Date

PRACTICE QUESTION

How much do you like these ice cream flavors?

	Not at all			Ok			A great deal
Chocolate	1	2	3	4	5	6	7
Strawberry	1	2	3	4	5	6	7
Vanilla	1	2	3	4	5	6	7

APPENDIX B: STUDENT INTERVIEW PROTOCOL

M-LEAP
Linking Experiences and Pathways

Student Interview

[IF FEASIBLE, GO OVER THIS WHILE WALKING TO INTERVIEW SPACE]

- **Hi, [NAME]; I'm [NAME].**
- **Do you remember taking the M-LEAP survey a few months ago? It was about your interest in different school subjects and what you do outside of school.**
- **Today I'm going to ask you a few more questions about those same topics. It should take about 15 minutes.**

[ONCE IN THE INTERVIEW LOCATION]

- **I'm going to tape record our conversation just so I don't have to take notes, but only our research team will listen to the tape. Nobody else will hear it.**
- **I also won't use your name on the tape; we have an ID number that we'll use instead.**
- **Is that okay?** [IF NOT, WE'LL HAVE TO TAKE NOTES]

- **Do you have any questions before we start?** [ANSWER QUESTIONS, IF ANY]
- **Okay; let's get started.** [TURN ON TAPE RECORDER AND READ IN ID#]

Section One

SCIENCE ITEMS

1A. [SCIENCE CHANGER] **On the M-LEAP survey two years ago, it looks like you started out by rating yourself** [LOW/MEDIUM/HIGH] **in terms of how good you were at science, how well you expected to do in science, how useful you thought science was, and how interested you were in science.**

This year, that changed: You rated yourself [LOW/MEDIUM/HIGH] **in terms of your ability and grades in science and how useful and interesting you think science is.**

Why do you rate science [LOWER/HIGHER] **now?**

PROBES:
Was there a change in how good you think you are at science, your grades in science, how interested you are in science, or how useful you think science is?
Why did that change?

POSSIBLE REASONS FOR CHANGE; PROBE, IF NECESSARY:
Things they're doing in science class this year
Topics they're covering in science class this year?
  FOLLOW-UP:
  What topics are you studying in sci this year: bio/life, chem, earth, space?
  What do you like/dislike about those topics?
Their science teacher this year
  FOLLOW-UP: What makes a science teacher better or worse?
Their out-of-school science activities this year
Their parents, their friends, their siblings
Someone told them they are good or could be good at science
A TV show, magazine, book, game, movies, other media?
Their career aspirations
[ONLY IF NERD/GEEK/UNCOOL STEREOTYPE COMES UP]
  What do you mean by [STEREOTYPE]?
  Why do you think science is [STEREOTYPE]?
  Do kids who are good at or like science get treated differently from other kids?

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE CHANGED, OR HOW THEY MAKE SENSE OF THE CHANGE.

1B. [SCIENCE SUSTAINER] **On the M-LEAP survey, it looks like for the past 3 years, you gave** [LOW/MEDIUM/HIGH] **ratings to how good you are at science, how well you expect to do in science, how useful you think science is, and how interested you are in science.**

Why is it that you rate science this way? (i.e., consistently on the LOW/MED/HIGH end of the scale)

PROBE:
Is it something about how good you are at science, your grades in science, how interested you are in science, or how useful you think science is?

POSSIBLE REASONS FOR SUSTAINING; PROBE, IF NECESSARY:
Things they do in science class
Topics they cover in science class:
  FOLLOW-UP:
  What topics are you studying in sci this year: bio/life, chem, earth, space?
  What do you like/dislike about those topics?
Good science teacher or teachers
  FOLLOW-UP: What makes a science teacher better or worse?
Out-of-school science activities
Their parents, their friends, their siblings
Someone told them they are good or could be good at science
TV shows, magazines, books, games, movies, other media?
Their career aspirations
[ONLY IF NERD/GEEK/UNCOOL STEREOTYPE COMES UP]
  What do you mean by [STEREOTYPE]?
  Why do you think science is [STEREOTYPE]?
  Do kids who are good at or like science get treated differently from other kids?

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE SUSTAINED THEIR POSITIVE ATTITUDES/EXPECTATIONS.

Section Two

MATH ITEMS

2A. [MATH CHANGER] **On the M-LEAP survey two years ago, it looks like you started out by rating yourself** [LOW/MEDIUM/HIGH] **in terms of how good you were at math, how well you expected to do in math, how useful you thought math was, and how interested you were in math.**

This year, that changed: You rated yourself [LOW/MEDIUM/HIGH] **in terms of your ability and grades in math and how useful and interesting you think math is.**

Why do you rate math [LOWER/HIGHER] **now?**

PROBE:
Was there a change in how good you think you are at math, your grades in math, how interested you are in math, or how useful you think math is?
Why did that change?

POSSIBLE REASONS FOR CHANGE; PROBE, IF NECESSARY:
Things they're doing in math class this year
Topics they're covering in math class this year
Their math teacher this year
    FOLLOW-UP: What makes a math teacher better or worse?
Their out-of-school math activities this year
Their parents, their friends, their siblings
Someone told them they are good or could be good at math
A TV show, magazine, book, game, movies, other media?
Their career aspirations
[ONLY IF NERD/GEEK/UNCOOL STEREOTYPE COMES UP]
    What do you mean by [STEREOTYPE]?
    Why do you think math is [STEREOTYPE]?
    Do kids who are good at or like math get treated differently from other kids?

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE CHANGED, OR HOW THEY MAKE SENSE OF THE CHANGE.

2B. [MATH SUSTAINER] **On the M-LEAP survey, it looks like for the past 3 years, you gave** [LOW/MEDIUM/HIGH] **ratings to how good you are at math, how well you expect to do in math, how useful you think math is, and how interested you are in math.**

Why is it that you rate math this way? (i.e., consistently on the LOW/MED/HIGH end of the scale)

PROBE:
Is it something about how good you are at math, your grades in math, how interested you are in math, or how useful you think math is?

POSSIBLE REASONS FOR SUSTAINING; PROBE, IF NECESSARY:
Things they do in math class
Topics they cover in math class
Good math teacher or teachers
    FOLLOW-UP: What makes a math teacher better or worse?
Out-of-school math activities
Their parents, their friends, their siblings
Someone told them they are good or could be good at math
TV shows, magazines, books, games, movies, other media?
Their career aspirations
[ONLY IF NERD/GEEK/UNCOOL STEREOTYPE COMES UP]
    What do you mean by [STEREOTYPE]?
    Why do you think science is [STEREOTYPE]?
    Do kids who are good at or like math get treated differently from other kids?

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE SUSTAINED THEIR POSITIVE ATTITUDES/EXPECTATIONS.

Section Three

COMPUTER ITEMS

[SAY TO BOTH CHANGERS AND SUSTAINERS] **The next question is about computers. We're not just asking about programming or fixing computers, we really want to know about how you use computers, laptops, or tablets at school or at home, whether that means using programs, using the Internet, playing games, etc.**

3A. [COMPUTER CHANGER] **On the M-LEAP survey two years ago, it looks like you started out by rating yourself** [LOW/MEDIUM/HIGH] **in terms of how good you were at using computers, how well you expected to do using computers, how useful you thought computers are, and how interested you were in using computers.**

This year, that changed: You rated yourself [LOW/MEDIUM/HIGH] **in terms of your ability to use computers and how useful and interesting you think using computers is. Why do you rate using computers** [LOWER/HIGHER] **now?**

PROBE:
Was there a change in how good you think you are at using computers, how interested you are in using computers, or how useful you think computers are? Why did that change?

POSSIBLE REASONS FOR CHANGE; PROBE IF NECESSARY:
Things they're doing with computers in school
Topics they're covering using computers in school
Their computer teacher this year, if applicable
  FOLLOW-UP: What makes a computer teacher better or worse?
Their out-of-school computer activities this year
Their parents, their friends, their siblings
Someone told them they are good or could be good at computers
A TV show, magazine, book, game, movies, other media?
Their career aspirations
[ONLY IF NERD/GEEK/UNCOOL STEREOTYPE COMES UP]
  What do you mean by [STEREOTYPE]?
  Why do you think computers are [STEREOTYPE]?
  Do kids who are good at or like computers get treated differently from other kids?

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE CHANGED, OR HOW THEY MAKE SENSE OF THE CHANGE.

[SAY TO BOTH CHANGERS AND SUSTAINERS] **The next question is about computers. We're not just asking about programming or fixing computers, we really want to know about how you use computers, laptops, or tablets at school or at home, whether that means using programs, using the Internet, playing games, etc.**

3B. [COMPUTER SUSTAINER] **On the M-LEAP survey, it looks like for the past 3 years, you gave** [LOW/MEDIUM/HIGH] **ratings to how good you are at using computers, how well you expect to do using computers, how useful you think computers are, and how interested you are in using computers.**

Why is it that you rate using computers this way? (i.e., consistently on the LOW/MED/HIGH end of the scale)

PROBE:
Is it something about how good you are at computers, your grades in subjects that use computers, how interested you are in computers, or how useful you think computers are?

POSSIBLE REASONS FOR CHANGE; PROBE IF NECESSARY:
Things they're doing with computers in school
Topics they're covering using computers in school
Their computer teacher this year, if applicable
FOLLOW-UP: What makes a computer teacher better or worse?
Their out-of-school computer activities this year
Their parents, their friends, their siblings
Someone told them they are good or could be good at computers
A TV show, magazine, book, game, movies, other media?
Their career aspirations
[ONLY IF NERD/GEEK/UNCOOL STEREOTYPE COMES UP]
What do you mean by [STEREOTYPE]?
Why do you think computers are is [STEREOTYPE]?
Do kids who are good at or like computers get treated differently from other kids?

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE SUSTAINED THEIR POSITIVE ATTITUDES/EXPECTATIONS.

Section Four

READING-ELA ITEMS*

4. [*HAB KIDS ONLY] **This question is about ELA. By ELA, we mean English, reading, and writing. On the M-LEAP survey, it looks like for the past 3 years, you gave high ratings to how good you are at ELA, how well you expect to do in ELA, how useful you think ELA is, and how interested you are in ELA.**

   Why is it that you rate ELA-English-reading-writing so highly?

PROBE:
Is it something about how good you are at ELA, your grades in ELA, how interested you are in ELA, or how useful you think ELA is?

POSSIBLE REASONS FOR SUSTAINING; PROBE, IF NECESSARY:
Things they do in ELA class
Topics they cover in ELA class
Good ELA teacher or teachers
  FOLLOW-UP: What makes an ELA teacher better or worse?
Out-of-school ELA-reading-writing activities
Their parents, their friends, their siblings
Someone told them they are good or could be good at ELA-writing-reading
TV shows, magazines, books, games, movies, other media?
Their career aspirations

MAKE SURE THEY EXPAND ON THEIR REASONING SO IT'S CLEAR TO US WHY THEY THINK THEY'VE SUSTAINED THEIR POSITIVE ATTITUDES/EXPECTATIONS.

Section Five

IDENTITY RECOGNITION ITEMS

5. [ALL STUDENTS] **Has anyone ever told you that you're especially good at a certain school subject?**

[IF YES] **What subject?**

POSSIBLE IDENTITIES; PROBE IF NECESSARY
Have they said you're a science person?
A math person?
A computer person?
An English-ELA-reading-writing person?

[IF YES] **Who's told you that?**

POSSIBLE RECOGNIZERS; PROBE, IF NECESSARY:
Parent(s)
Other adult relative(s)
Teacher(s)
Peer(s): friend(s), other student(s), similar-age relative(s)
Other(s)

[IF YES] **When did they tell you that?**

Section Six

JOB ASPIRATION ITEMS

6A. [ALL STUDENTS] **You said on your survey this year that you want to be a** [JOB TITLE] **when you grow up. Why do you think you would like that job?**

Do you know anybody who has that job?

[IF YES] **Do you ever talk to them about what it's like to do that job?**

Where else have you learned about being a [JOB TITLE]**? Have you seen it on TV or in movies, read about it, or anything like that?**

Can you tell me what you know about what it takes to have that job? For example, what kinds of classes you need to take, if you need to do well in certain classes, and how far you have to go in school?

6B. [IF JOB ASPIRATION CHANGED] **Last year** [and/or the year before]**, you said you wanted to be a** [JOB TITLE]**. Can you tell me about what changed that made you pick a different job this year?**

Section Seven

OUT-OF-SCHOOL ACTIVITIES

7. [ALL STUDENTS] **How do you spend your time <u>when you're not in school</u> (so, after school, on weekends, during the summer, etc.)?**

LET THE INITIAL RESPONSE BE VERY OPEN-ENDED.

[IF THEY MENTION ORGANIZED ACTIVITIES LIKE CLUBS OR SPORTS]
How much time do you spend on these activities?
Why do you do [ACTIVITY/IES]?
How did you first get interested in these activities?

[IF THEY MENTION STEM-RELATED ACTIVITIES]
Why do you do [STEM ACTIVITY/IES]?
How often do you do [STEM ACTIVITY/IES]?
How long have you been doing [STEM ACTIVITY/IES]?
How did you first get interested in these activities?

That's all the questions I have. Thanks so much for talking to me! Let's get you back to your class now.

APPENDIX C: PARENT SURVEY

M-LEAP
Linking Experiences and Pathways

Survey for [School] Parents
For Parent/Guardian #1
[For Parent/Guardian #2 (*if available*)]

[School] is one of eight schools across Massachusetts that has joined the *Massachusetts Linking Experiences and Pathways* (M-LEAP) Research Project funded by the National Science Foundation (NSF) and conducted by Goodman Research Group, Inc (GRG). GRG and Principal [PRINCIPAL] are excited to contribute to understanding how student experiences in 3rd-8th grade influence their later interests and choices about jobs and careers. As part of M-LEAP, [School] students, parents, and teachers will take a short survey each year.

Your participation is voluntary, you are free to skip questions or stop the survey at any time, and we promise confidentiality. If you have any questions, concerns, or feedback about the M-LEAP study, please contact Dr. Irene F. Goodman (866-577-4377 or *goodman@grginc.com*).

Instructions
There are two ways to complete this parent survey:
1. You can complete the survey online at www.grgsurveys.com/[SCHOOL].
2. You can complete this paper survey and return it in the attached postage-paid envelope.*

All children in grades 5-8 at [School] will bring home two surveys.
- At least one parent/guardian should fill out a survey for each child in grades 5-8.
- If a second parent/guardian is available, that person should also fill out a survey for each child in grades 5-8.

Parents/guardians don't always share the same opinions, so it is very important for us to hear from both of you.

Required Information
This cover sheet will only be used to match your responses with your child's. An ID number will be assigned to you and your child, and this page with names and other identifying information will be removed from the survey. *Without your name and your child's name, we cannot use your survey.*

Your name (*please print*): First: __________________ Last:___________________

Child's name (*please print*): First: _________________ Last:__________________

-Por favor llame al 1-866-577-4377 para recibir una copia de este formulario en español.
-Por favor ligue para 1-866-577-4377 para obter uma cópia deste questionário em Português
-Silvouplè rele 1-866-577-4377 jwenn yon kopi sa a keksyonè an kreyòl ayisyen.

*If you need a new postage-paid envelope, please contact GRG toll free at 866-577-4377 or *m-leap@grginc.com*.

We are asking for your contact information because we hope to extend the M-LEAP study after this school year. In the future, we plan to contact parents to ask permission to survey or interview their child outside of school. We will not share this information with anyone and will only use it to contact you and your child(ren) about continuing to participate in the M-LEAP study. It is your choice whether to provide the information requested on this form, and this information will not be linked to your survey responses.

Your name: ______________________________

Name(s) of child(ren) in grades 5-8: ______________________________

Your email address: ______________________________

Your phone number: ______________________________

Your mailing address: ______________________________

____

If you moved, who would know how to get in touch with you?

Person's name: ______________________________

Email address: ______________________________

Phone number: ______________________________

Mailing address: ______________________________

____

ABOUT YOUR GRADE 5-8 CHILD(REN)

1. How many children do you have who are in grades 5-8?

❒ One ❒ Three ❒ Five
❒ Two ❒ Four ❒ Six

QUESTIONS ABOUT CHILD WHOSE NAME IS ON FRONT OF THIS SURVEY

Please answer the following questions for the child whose name is on the front of this survey. Please fill out a survey for each child in grades 5-8.

2. Child's birth date: Month__________ Day__________ Year__________

3. Child's grade in school (*circle one*): 5th 6th 7th 8th

4. What is your relationship to this child? (*circle one*):

Parent Stepparent Legal guardian Other (*please describe:* __________________)

Please note: In the following questions, language arts refers to English literature, reading, and writing.

5. How much does your child like the following subjects and skills?

	Not at all			Ok			A great deal	Don't know
Reading and language arts	1	2	3	4	5	6	7	DK
Math	1	2	3	4	5	6	7	DK
Science	1	2	3	4	5	6	7	DK
Using computers	1	2	3	4	5	6	7	DK
Working in teams or groups	1	2	3	4	5	6	7	DK

6. How proficient (skilled) do you think your child is at the following subjects and skills?

	Not at all proficient			Ok			Extremely proficient	Don't know
Reading and language arts	1	2	3	4	5	6	7	DK
Math	1	2	3	4	5	6	7	DK
Science	1	2	3	4	5	6	7	DK
Using computers	1	2	3	4	5	6	7	DK
Working in teams or groups	1	2	3	4	5	6	7	DK

7. **<u>How well do you expect your child to do in school this year</u> in the following subjects and skills?**

	Not at all well			Ok			Extremely well	Don't know
Reading and language arts	1	2	3	4	5	6	7	DK
Math	1	2	3	4	5	6	7	DK
Science	1	2	3	4	5	6	7	DK
Using computers	1	2	3	4	5	6	7	DK
Working in teams or groups	1	2	3	4	5	6	7	DK

8. **<u>How good do you think your child would be at learning something new</u> in the following subjects and skills?**

	Not at all good			Ok			Extremely good	Don't know
Reading and language arts	1	2	3	4	5	6	7	DK
Math	1	2	3	4	5	6	7	DK
Science	1	2	3	4	5	6	7	DK
Using computers	1	2	3	4	5	6	7	DK
Working in teams or groups	1	2	3	4	5	6	7	DK

9. **<u>How important is it to you</u> for your child to be good at the following subjects and skills?**

	Not at all important						Extremely important	No preference
Reading and language arts	1	2	3	4	5	6	7	NP
Math	1	2	3	4	5	6	7	NP
Science	1	2	3	4	5	6	7	NP
Using computers	1	2	3	4	5	6	7	NP
Working in teams or groups	1	2	3	4	5	6	7	NP

10. **When your child is in high school, <u>how much would you like for him/her to take</u> elective or advanced courses in each of the following subjects (beyond the required courses)?**

	Not at all			Ok			A great deal	No preference
English, literature, and language arts classes	1	2	3	4	5	6	7	NP
Math classes	1	2	3	4	5	6	7	NP
Science classes	1	2	3	4	5	6	7	NP
Computer classes	1	2	3	4	5	6	7	NP

11. **When your child is an adult, <u>how much would you like for him/her to have a job</u> that uses each of the following areas?**

	Not at all			Ok			A great deal	No preference
Reading and language arts	1	2	3	4	5	6	7	NP
Math	1	2	3	4	5	6	7	NP
Science	1	2	3	4	5	6	7	NP
Using computers	1	2	3	4	5	6	7	NP
Working in teams or groups	1	2	3	4	5	6	7	NP

12. When your child is an adult, how likely do you think s/he is to have a job that uses each of the following areas?

	Not at all likely			Ok			Extremely likely	Don't know
Reading and language arts	1	2	3	4	5	6	7	DK
Math	1	2	3	4	5	6	7	DK
Science	1	2	3	4	5	6	7	DK
Computers	1	2	3	4	5	6	7	DK
Working in teams or groups	1	2	3	4	5	6	7	DK

GIRLS AND BOYS

13. Some people believe that boys are naturally better at some subjects and skills and that girls are naturally better at other subjects and skills, and other people believe that boys are girls aren't so different. What is your opinion about how naturally good boys and girls are at the following activities?

In general, do you think that boys or girls are naturally better at…	Boys are much better			Boys and girls are about the same			Girls are much better	No opinion
Reading and language arts	1	2	3	4	5	6	7	N/O
Math	1	2	3	4	5	6	7	N/O
Science	1	2	3	4	5	6	7	N/O
Using computers	1	2	3	4	5	6	7	N/O
Working in teams or groups	1	2	3	4	5	6	7	N/O

OUT-OF-SCHOOL ACTIVITIES

14. During the school year, about how many hours per week, on average, does your child spend doing each of the following activities outside of school?

	Hours per week, on average	Zero hours/not applicable
Reading for fun (not for homework).	___hrs/wk	❒
Participating in **organized performing arts activities or lessons** (for example, singing, practicing a musical instrument, dance, acting).	___hrs/wk	❒
Participating in **organized art activities or lessons** (for example, painting, arts & crafts, pottery).	___hrs/wk	❒
Playing **organized sports, taking sports lessons, or doing sports or athletics for fun** (for example, soccer, hockey, gymnastics, martial arts).	___hrs/wk	❒
Attending **organized activities, clubs, or after-school programs** (for example, Scouts, computer club, debate club, Lego League)	___hrs/wk	❒

Now we have some questions about things your child does outside of school that have to do with science, computers, engineering, or math.

15. Not counting homework, <u>how often does your child do an activity involving the following subjects outside school</u>; for example, in a club or after-school program or just for fun?

Not counting school or homework…	**Never or almost never**	**A few times a year**	**About every other month**	**About once a month**	**Every week or every other week**	**A few times a week**	**Every day or almost every day**	**Don't know**
Reading about science, computers, engineering or math *(This could be a book, magazine, or website.)*	1	2	3	4	5	6	7	DK
Watching educational shows or videos about science, computers, engineering or math *(for example, Cyberchase, Design Squad, dirtgirlworld, Wild Kratts, How It's Made, etc.)*	1	2	3	4	5	6	7	DK
Playing computer or electronic games about science, computers, engineering or math *(on the computer, Xbox, Wii, DS, phone apps, etc. For example, Brain Age, Tetris, Math Blaster, etc.)*	1	2	3	4	5	6	7	DK
Doing hands-on activities to learn about science, computers, engineering or math *(for example, science kit, crystal-growing set, models, telescope, etc.)*	1	2	3	4	5	6	7	DK
Participating in a club or after-school program about science, computers, engineering or math	1	2	3	4	5	6	7	DK
Visiting places where s/he can learn about science, computers, engineering or math *(for example, a museum, science center, planetarium, weather station, zoo, etc.; school field trips don't count.)*	1	2	3	4	5	6	7	DK

ABOUT YOU

If you have more than one child in grades 5-8, you only need fill out this section about yourself on one of the surveys.

16. Are you *(circle one)*: Female Male

17. What is your age? _____ years old

18. What is your current occupation? *(Check all that apply.)*

- ❒ Working for pay
- ❒ Volunteer work
- ❒ Military service or training
- ❒ In school or educational/training program
- ❒ Home with children
- ❒ Unemployed, looking for work
- ❒ Other (*please describe:* _________________)

19. What is your job title? Please be as specific as possible. (*If you are not currently employed, please write your usual job title*.)

____

20. What is your field of work? (*If you are not currently employed, please check your usual field of work*.)

- ❒ Agriculture/Fishing
- ❒ Arts/Entertainment
- ❒ Communications
- ❒ Construction/Building Trades
- ❒ Education
- ❒ Finance/Insurance/Real Estate
- ❒ Government
- ❒ Health Care/Medicine
- ❒ Human/Social Services
- ❒ Manufacturing/Factory
- ❒ Marketing
- ❒ Military
- ❒ Personal Services
- ❒ Professional Services/Consulting
- ❒ Public Safety
- ❒ Research
- ❒ Restaurant/Food Service/Hospitality
- ❒ Retail/Store
- ❒ Science/Technology/Engineering
- ❒ Transportation
- ❒ Utilities
- ❒ Other (*please describe:* ____________________________________)

21. Thinking about the occupation or job described above, how much do you use the following subjects and skills as part of your work?

	Not at all						A great deal
Reading and language arts	1	2	3	4	5	6	7
Math	1	2	3	4	5	6	7
Science	1	2	3	4	5	6	7
Using computers	1	2	3	4	5	6	7
Working in teams or groups	1	2	3	4	5	6	7

22. How good (proficient) do you think you are at the following subjects and skills?

	Not at all good			Ok			Extremely good
Reading and language arts	1	2	3	4	5	6	7
Math	1	2	3	4	5	6	7
Science	1	2	3	4	5	6	7
Computers	1	2	3	4	5	6	7
Working in teams or groups	1	2	3	4	5	6	7

23. What is the highest level of education you have completed?

❒ No formal education
❒ Grade school education
❒ Some high school
❒ High school diploma or equivalent (GED)
❒ Some college
❒ Associate degree(s) or 2-year college program(s)
❒ Bachelor's degree(s)
❒ Some graduate school
❒ Master's degree(s)
❒ Professional degree(s) (e.g., MD, DDS, JD, MBA)
❒ Doctorate degree(s) (e.g., Ph.D., Ed.D.)
❒ Other (*please describe:* ____________________)
❒ Prefer not to respond

24. If applicable: In what subject(s) (is/are) your degree or training? ____________________

25. What is your race and/or ethnicity? *(Check all that apply.)*

❒ American Indian or Alaska Native
❒ East Asian or South Asian
❒ Black or African American
❒ Hispanic or Latino(a)
❒ Native Hawaiian or Other Pacific Islander
❒ White
❒ Other (*please describe:* ______________________)
❒ Prefer not to respond

26. What language(s) (do/does) your family speak at home?

____

27. Please use the space below to share any additional comments.

Thank you for completing this survey!
Please return this survey to GRG in the postage paid envelope.*

*If you need a new postage-paid envelope, please contact GRG at 866-577-4377 or *m-leap@grginc*.

APPENDIX D: TEACHER SURVEY

M-LEAP
Linking Experiences and Pathways

Teacher Survey

SCHOOL SUBJECTS

We ask students about a number of different subjects and skills they work on in school. We would like to get your ratings of your own knowledge and enjoyment of these same subjects and skills.

28. First, how would you rate <u>your own knowledge</u> in these subject areas?

	Not at all proficient			Ok			Extremely proficient
Reading and language arts	1	2	3	4	5	6	7
Math	1	2	3	4	5	6	7
Science	1	2	3	4	5	6	7
Using computers	1	2	3	4	5	6	7
Working in teams or groups	1	2	3	4	5	6	7

29. How much do you <u>enjoy teaching</u> the following subjects and skills?

	Not at all			Some			A great deal	I do not teach this
Reading and language arts	1	2	3	4	5	6	7	N/A
Math	1	2	3	4	5	6	7	N/A
Science	1	2	3	4	5	6	7	N/A
Using computers	1	2	3	4	5	6	7	N/A
Working in teams or groups	1	2	3	4	5	6	7	N/A

GIRLS AND BOYS

30. Some people believe that boys are naturally better at some subjects and skills and that girls are naturally better at other subjects and skills, and other people believe that boys are girls aren't so different. What is <u>your opinion</u> about how naturally good boys and girls are at the following activities?

In general, do you think that boys or girls are naturally better at…	Boys are much better			Boys and girls are about the same			Girls are much better	No opinion
Reading and language arts	1	2	3	4	5	6	7	N/O
Math	1	2	3	4	5	6	7	N/O
Science	1	2	3	4	5	6	7	N/O
Using computers	1	2	3	4	5	6	7	N/O
Working in teams or groups	1	2	3	4	5	6	7	N/O

ABOUT YOU

31. Are you *(circle one)*: Female Male

32. How many years have you been teaching? _____ years

33. What grade(s) do you teach? *(Check all that apply.)*

❐ Kindergarten
❐ 1st
❐ 2nd
❐ 3rd
❐ 4th
❐ 5th
❐ 6th
❐ 7th
❐ 8th
❐ 9th
❐ Other (please describe: ______________________)

34. What subject(s) do you teach? *(Check all that apply.)*

❐ Reading/language arts
❐ Math
❐ Science
❐ Social studies/history
❐ Computers
❐ Other (please describe: ______________________)

35. Please describe your education, including degrees that are currently in progress as well as degrees obtained.

Degree	Graduation (or expected graduation) year	Major or specialization
Bachelor's degree		
Master's degree		
Specialist's degree		
Doctorate		
Other (please describe: __________________________)		

36. What is your race and/or ethnicity? *(Check all that apply.)*

❐ American Indian/Alaska Native
❐ Asian
❐ Black/African American
❐ Hispanic/Latino(a)
❐ Native Hawaiian/Pacific Islander
❐ White
❐ Other (please describe: ______________________)

PLEASE PROVIDE THE BEST MAILING ADDRESS FOR US TO USE TO SEND YOUR $40 STIPEND:

Name:________________________________Address:____

City:____________________________State:__________________________ZIP:_________________

____

M-LEAP STUDENT RATING FORM: ALL SUBJECTS

Please rate each student's interest and aptitude in each subject/skill area using the scale below, and write the number in the appropriate column of the form. There is no need to be precise — just give a quick estimate for each student. You can also write in "CR" ("Cannot Rate") for any student for whom you have no relevant information. Note that students whose parents did not wish for them to participate have not been included in the list below.

Interest Scale:

Not at all interested						Extremely interested	Cannot rate
1	2	3	4	5	6	7	CR

Aptitude Scale:

Not at all good						Extremely good	Cannot rate
1	2	3	4	5	6	7	CR

	INTEREST: How interested is this student in…					APTITUDE: How good is this student at…				
STUDENT NAME	Reading/ Language Arts	Math	Science	Using computers	Working in teams/groups	Reading/ Language Arts	Math	Science	Using computers	Working in teams/groups
Sample Student	*5*	*5*	*4*	*7*	*5*	*6*	*5*	*4*	*6*	*6*

Interest Scale:

Not at all interested						Extremely interested	Cannot rate
1	2	3	4	5	6	7	CR

Aptitude Scale:

Not at all good						Extremely good	Cannot rate
1	2	3	4	5	6	7	CR

APPENDIX E: SCIENCE SPECIALIST INTERVIEW PROTOCOL

Does your school have a special focus on one or more of the STEM fields: science, technology, engineering, mathematics?

If Y, on which of the following is your school's special program or magnet focused? Select all that apply.
□ Engineering.
□ Mathematics.
□ Science, including health professions.
□ Technology, including Tech Prep.

Scheduling
Does your school use block scheduling (class periods scheduled to create extended blocks of instructional time) to organize most classes? Select one.

Technology Resources
Does your school have one or more computer labs?

If Y, how many computers are in the computer lab(s) (do not include computers that do not work)? (If there is more than one lab, enter the total across all labs. Do not include computers that do not work.) 1–5 6–10 11 – 15 16–20 21–25 26–30 31+

Does your school have:
a. laptop carts available for teachers to use with their classes?
b. Wi-Fi?

In-school STEM teaching
Explain how science, math (and ELA) are taught in ______ School in grades 3-8. We're interested in the following: (will repeat for each subject, as needed)

Grade	Division of labor	Contact hours/week (& # of days/week; hrs/day or wk)
3rd		
4th		
5th		

6th		
7th		
8th		

What science curriculum used?

- District-wide curriculum versus individual schools
- Role of technology
- Role of engineering
- Use of computers by the students
  - Computer class – keyboarding vs using for research
  - Computer lab

Any supplemental curricula used? *Describe*
Any use of media:
Web sites (digital media)
Online games
Videos
TV shows
Stories/science fiction

- Science
- Engineering
- Technology

Other science events/activities at your school, e.g., Science Fair – for what grades?

Relationship with Informal Science Institutions/Informal STEM offerings
Does your school district have a formal relationship with ISI institutions in the area?

- regular visits to science labs/biotech companies
- Field trips to ISIs
- ISIs come to the school

Type of ISI	**Grade levels**	**Type of activity**	**When/how often**
Science museum			
Aquarium			
Zoo			
Planetarium			
Natural history			
Children's museum			
Botanical garden/arboretum			
Other			
Other			

Out-of-School Programs at School or in Community
After school program offerings in which students participate
(where, under whose auspices, grade levels of students participating

	At the school	Outside of school
Robotics		
Lego League		
Girls Science		
4-H chapter		
Girl Scouts/Boy Scouts		
Boys and Girls Club		
Hands on Science		
Local library branch		
Design/build		
Nature club		
Astronomy club		
Chemistry club		
Computer programming language		
Design web pages		
Other		

APPENDIX F: EXTERNAL PROJECT MONITORING REPORT

G. TECHNICAL APPENDIX I: TECHNICAL SURVEY RESULTS

Note: Technical Appendix I is an expanded version of Chapter 5, "Survey Results." It includes details of relevant statistical tests and some additional exhibits and analyses.

The M-LEAP study gathered three waves of longitudinal data (across three years) on students' science-related beliefs, experiences, and aspirations (BEAs) from 1,576 unique students, 690 unique parents, and 138 unique teachers. Data were collected annually in the spring from each of these populations using surveys and interviews. Standardization of indicators across these instruments created opportunities for direct comparisons between students', parents', and teachers' responses on several of the questions with the aim of understanding of what students' experiences were like over the course of the study and the relationships between students' perceptions and those of adults. Although our research questions (see p. 5) revolved primarily around students' internal developments, the analyses afforded by collecting data from such a wide range of stakeholders helped us relate our outcome variables of interest — namely, whether or not students hold a STEM job aspiration at the end of middle school — to multiple factors in students' lives.

The results presented here integrate descriptive and inferential analyses from all data sources simultaneously, rather than presenting results for students, parents, and teachers separately. Key areas of interest include change over time and gender-based differences. In some cases, data are shown for all three waves of data collection, while elsewhere only results from Wave 3 (the final wave of data collection) are shown.

The chapter discusses results related to Expectancy Value Model indicators of self-efficacy (SE) and subjective task value (STV), out-of-school experiences, parent perceptions, gender stereotypes, favorite and least favorite subjects, and educational and career aspirations.

EXPECTANCY-VALUE MODEL INDICATORS

This section presents results from students, parents, and teachers on measures related to self-efficacy (SE) and subjective task value (STV) beliefs, as well as gender stereotypes.

Self-Efficacy (SE)

Each wave, students were asked three questions related to SE about each of the five 21st Century subjects/skills: reading/ELA, math, science, computers, and teamwork:

4. *Ability*: "How good are you in [subject/skill]?"
5. *Expectations*: "How well do you expect to do in school this year in [subject/skill]?"
6. *Expectations*: "How good would you be at learning something new in [subject/skill]?"

These three scores were then combined for a composite SE rating for each student in each subject/skill area.

Students had moderately high and positive self-efficacy self-ratings for each area every wave.

Exhibit TI-1 shows the mean calculated ability and expectation item scores for the M-LEAP student survey at each data collection point, as well as a composite SE score in each subject, which was calculated as the average of all students' scores on the ability item and two expectation items. Overall, students in the M-LEAP sample had moderate to high self-ratings of ability and expectations for success in each school area and skill. Composite SE scores were above 5.3 on a 7-point scale for each area during each wave of data collection. Further breakdown of SE scores in each area by cohort, grade, and gender can be found in Technical Appendix II.

Exhibit TI-1: Self-Efficacy Indicator Means on the Student Survey, Waves 1-3

		Ability	Expectations		Composite Self-Efficacy Score
		1. How good are you in…?	2. How well do you expect to do in school this year in…?	3. How good would you be at learning something new in…?	
Reading/ELA	*W1*	5.20	5.79	5.38	**5.45**
	W2	5.13	5.72	5.29	**5.38**
	W3	5.09	5.65	5.32	**5.35**
Math	*W1*	5.39	5.99	5.63	**5.64**
	W2	5.23	5.85	5.42	**5.50**
	W3	5.10	5.68	5.31	**5.36**
Science	*W1*	5.14	5.75	5.46	**5.42**
	W2	5.11	5.72	5.40	**5.40**
	W3	5.20	5.71	5.44	**5.45**
Computers	*W1*	5.72	6.04	5.81	**5.82**
	W2	5.59	6.00	5.72	**5.77**
	W3	5.55	5.86	5.65	**5.68**
Teamwork	*W1*	5.66	6.09	5.89	**5.85**
	W2	5.66	6.02	5.79	**5.82**
	W3	5.67	5.98	5.77	**5.81**

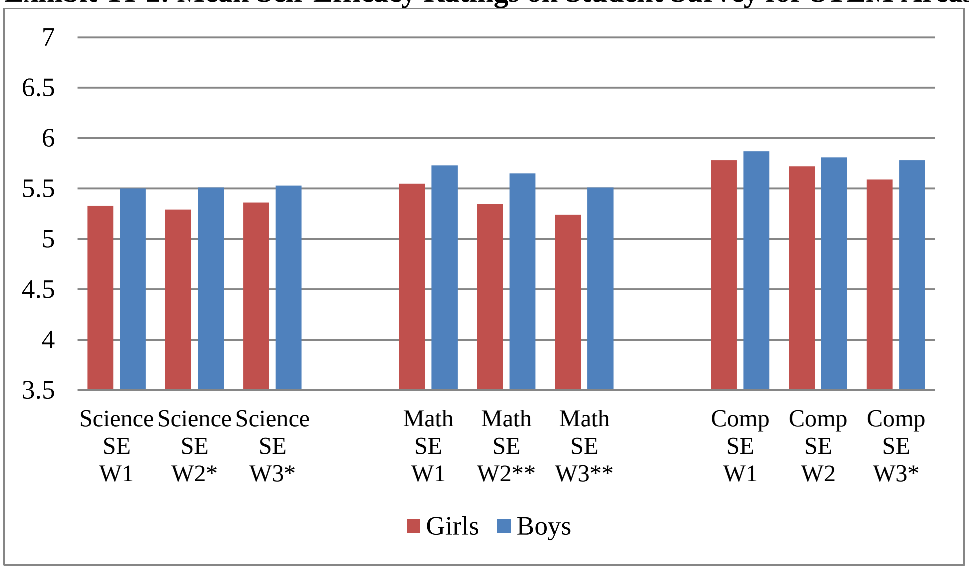
Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); N_{W1} = 667, N_{W2} = 1,128, N_{W3} = 1,327
Note: Results are shown disaggregated by school and wave in Technical Appendix II.

On average, students in the M-LEAP sample had slightly higher expectations for success in each academic domain than their ratings of current ability. In other words, their expectations for success consistently exceeded their self-perceived ability. This difference was usually small (ranging between 0.15 and 0.45 points on a 7-point scale) but was found to be statistically significant for each discipline at each time point at a significance level of $\alpha = 0.05$.

Boys' self-efficacy ratings in STEM areas were slightly higher than were girls'.

We conducted independent samples t-tests to explore differences in mean SE scores by gender at each wave of data collection. As shown in Exhibit TI-2, which shows these differences for the STEM areas over time, boys' mean SE ratings in science were statistically significantly higher than girls' mean SE ratings in science during Waves 2 and 3 of data collection. The size of this difference in means ranged from 0.17 to 0.23, an effect size that was calculated to be relatively small ($d'_{W2} = 0.2$, $d'_{W3} = 0.17$). Boys' mean SE ratings in math were statistically significantly higher than girls' mean SE ratings in math during Waves 2 and 3 of data collection. The size of this difference in means was larger than it was for science and ranged from 0.27 to 0.3, although a sensitivity analysis determined that this effect size was small ($d'_{W2} = 0.24$, $d'_{W3} = 0.23$). In Wave 3 of data collection, boys' mean SE ratings in computers were statistically significantly higher than girls' mean SE ratings in computers by 0.18 points, an effect size that was calculated to be small ($d'_{W3} = 0.17$).

Exhibit TI-2: Mean Self-Efficacy Ratings on Student Survey for STEM Areas, Waves 1-3



Note: The vertical axis is truncated to a range of 3.5 to 7 in order to highlight the findings. True range was 1-7.
* = $p < .05$, ** = $p < .001$; $N_{W1} = 326\text{-}341$, $N_{W2} = 523\text{-}557$, $N_{W3} = 590\text{-}678$

Girls' mean SE ratings in reading/ELA (not shown), were statistically significantly higher than boys' mean SE ratings in reading/ELA during each wave by approximately a quarter of a point ($p < 0.001$). There was not a statistically significant difference in mean SE ratings for teamwork between the genders in any wave.

STEM self-efficacy scores of both boys and girls remained stable over time.

We were interested to see if students' SE scores changed over time as the student population got older and moved up in grades, especially with regard to STEM areas. Descriptively, students' SE scores in math dropped nearly 0.3 points between Wave 1 and Wave 3, stayed approximately the same in science, and fell 0.14 points over this time period in computers. However, a repeated-measures ANOVA with a Greenhouse-Geisser correction conducted with students with a complete three-year record (n = 390) determined that the mean SE score did not differ statistically significantly between time points in any area.

Exhibit TI-3: Results of Repeated-Measures ANOVA on Student Self-Efficacy Scores

Subject		Test of Within-Subjects Effects	N	F	Sig.	Interpretation
Math	SE	Greenhouse-Geisser	390	0.763	0.462	No significant change over time.
Science	SE	Greenhouse-Geisser	390	0.687	0.500	No significant change over time.
Computer	SE	Greenhouse-Geisser	390	1.280	0.278	No significant change over time.
Teamwork	SE	Greenhouse-Geisser	390	0.041	0.957	No significant change over time.
Reading	SE	Greenhouse-Geisser	390	1.941	0.145	No significant change over time.

We were also interested in whether or not changes in SE scores occurred disparately for girls and boys. A repeated-measures ANOVA with a Greenhouse-Geisser correction conducted with students who had a complete three-year record determined that there was no statistically significant interaction between gender and time in terms of SE scores. While SE scores may have changed dramatically for some individuals, this evidence suggests that, on the whole, the changes in SE scores that took place in 3rd-8th grades were not related to gender.

Parent proficiency ratings for their children were highly positive and correlated with students' own self-efficacy ratings.

Parents and teachers rated students on their abilities and their expectations for success in each discipline, and the ratings were compiled into composite scores similar to ones for students. Composite ratings from parents are presented in Exhibit TI-4.

It is important to note that although the construct measured on the parent survey is referred to as "self-efficacy" for consistency, the parental SE ratings relate to their children and not themselves. Parents' mean ratings of their children's' abilities and their expectations for success were high, overall, with all ratings averaging above 5.66 on a 1-7 point scale. As was the case with students, t-test revealed that parents' expectations for the success of their student in each area exceeded their assessment of the students' bility level, and this difference was statistically significant ($p < 0.001$) for each area in each wave.

Exhibit TI-4: Mean Composite Self-Efficacy Ratings of Students by Parents, Waves 1-3

			Ability	Expectations		
			1. How proficient (skilled) do you think your child is at…?	2. How well do you expect your child to do in school this year in…?	3. How good do you think your child would be at learning something new in…?	Composite Self-Efficacy Score
Reading/ELA	*W1*	*MOTHER*	5.65	5.91	5.91	**5.82**
		FATHER	5.67	5.98	6.04	**5.90**
	W2	*MOTHER*	5.59	5.85	5.81	**5.75**
		FATHER	5.62	5.83	5.81	**5.75**
	W3	*MOTHER*	5.60	5.90	5.94	**5.81**
		FATHER	5.71	5.98	5.94	**5.88**
Math	*W1*	*MOTHER*	5.54	5.86	5.75	**5.72**
		FATHER	5.48	5.92	5.85	**5.75**
	W2	*MOTHER*	5.47	5.79	5.71	**5.66**
		FATHER	5.38	5.75	5.62	**5.58**
	W3	*MOTHER*	5.50	5.75	5.73	**5.66**
		FATHER	5.51	5.81	5.76	**5.69**
Science	*W1*	*MOTHER*	5.63	5.92	6.01	**5.85**
		FATHER	5.45	5.86	6.02	**5.78**
	W2	*MOTHER*	5.60	5.89	5.89	**5.79**
		FATHER	5.40	5.77	5.76	**5.64**
	W3	*MOTHER*	5.62	5.89	5.96	**5.82**
		FATHER	5.60	5.98	5.90	**5.83**
Computers	*W1*	*MOTHER*	5.70	6.01	6.16	**5.96**
		FATHER	5.55	5.96	6.13	**5.88**
	W2	*MOTHER*	5.78	6.04	6.08	**5.97**
		FATHER	5.59	5.97	6.05	**5.87**
	W3	*MOTHER*	5.93	6.14	6.27	**6.11**
		FATHER	5.78	6.05	6.18	**6.00**
Teamwork	*W1*	*MOTHER*	5.66	5.88	5.94	**5.83**
		FATHER	5.41	5.79	5.87	**5.69**
	W2	*MOTHER*	5.76	5.95	5.89	**5.87**
		FATHER	5.51	5.84	5.83	**5.73**
	W3	*MOTHER*	5.70	5.88	5.93	**5.84**
		FATHER	5.61	5.86	5.85	**5.77**

Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
N_{W1} = 152-386, N_{W2} = 172-342, N_{W3} = 125-302

The correlations between students' SE scores and their parents' SE scores are shown in Technical Appendix II, for mothers and fathers, respectively. Overall, correlations were positive, strong, and statistically significant at $\alpha = 0.05$. Correlations with student ratings were highest for both parents in math and reading/ELA, suggesting that parents held particularly similar ability and expectation beliefs for their children in these areas, while correlations were moderate in other areas and largely non-statistically significant in computers, especially for students and their fathers. This indicates that the parents did not agree with their children on how good they thought they were with computers, on average, with parents tending to hold slightly higher SE ratings on computers than their children.

Mothers gave slightly higher self-efficacy ratings to their children than did fathers, on average, but this difference was only statistically significant in one wave.

While the trend was for mothers to give slightly higher SE ratings than fathers in most areas and waves (differences ranged from .02 to .20 on a scale of 1-7), paired-samples t-tests conducted on pairs of parents who rated the same student indicated that these differences were largely not statistically significant at $\alpha = 0.05$. There were only a few instances where mothers' and fathers' SE ratings differed statistically significantly. These were during Wave 2, where mothers rated their students higher on math, science, and computer SE. In other words, mothers of students in 4th-7th grades gave their children slightly higher ratings than fathers in terms of ability and expectations for success in these areas.

Although differences by gender were examined descriptively, the sample size for paired t-tests comparing mother and father ratings for male and female students separately was too small to yield statistically significant findings. That said, the trend exhibited in the means for mothers to give slightly higher SE ratings than fathers held true for both girls and boys, suggesting that parents did not tend to rate students differently based on their gender.

Similar to students, parents' self-efficacy ratings for their children remained mostly stable over time.

Parent SE ratings were examined for change over time and for gender interactions. Only two statistically significant findings were observed. These were for mothers' ratings of computer SE and for fathers' ratings of reading/ELA SE.

A repeated-measures ANOVA assuming sphericity conducted with mothers with a complete three-year record (n = 107) determined that the mean composite computers SE score for mothers differed statistically significantly between time points ($F = 7.34$, $df = 2$, $p < .01$), although there was not a statistically significant interaction effect with gender. The mean computers SE score for mothers with a complete three-year record rose slightly from 5.97 in Wave 1 to 6.24 in Wave 3, but this trend in ratings was not different for boys and girls. Fathers' computer SE ratings rose similarly, but the sample size of fathers with a complete three-year record was not large enough to conclude that this change was statistically significant.

Nevertheless, a repeated-measures ANOVA assuming sphericity conducted with fathers with a complete three-year record (n = 37) determined that the mean composite reading/ELA SE score for fathers differed statistically significantly between time points ($F = 3.5$, $df = 2$, $p < .05$), although there was not a statistically significant interaction effect with gender. Mean reading/ELA SE for fathers with a complete three-year record rose slightly by .22 points over the course of the three waves, and this trend was exhibited in both boys' and girls' ratings.

Teacher ratings of student ability were moderately positive, but they were the lowest among all groups surveyed.

As part of the teacher survey, teachers rated their students on ability and interest. While interest is a construct that relates more to STV than SE, teacher results related to both constructs are presented here, simultaneously. The two questions asked were:

3. *Ability*: "How good is this student at [subject/skill]…?"
4. *Interest*: "How interested is this student in [subject/skill]?"

Teachers of younger students were able to rate the students on multiple areas, because they taught each or most of the areas to the same students, while teachers of older students only rated them in subject areas and skills related to the course that they taught. Because they were asked to rate their entire class in areas where they had relevant knowledge of student performance and interest, all teachers rated multiple students, and in some cases, students were rated by multiple teachers. Teacher ratings were compiled into an average ability and an average interest rating for each student for each wave. The average ability and interest ratings across all rated students for Wave 3, as well as the results of a paired t-test comparison between these two measures, are presented in Exhibit TI-5.

Exhibit TI-5 Average Teacher Ratings of Student Ability and Interest, Wave 3

		Ability	Interest					
		1. How good is this student at…? (mean)	2. How interested is this student in…? (mean)	Ability - Interest (calculated using pairwise comparison)	Std. Error Mean	t	df	Sig. (2-tailed)
Reading/ELA	*W3*	4.97	5.01	-0.04	0.02605	-1.345	1151	.179
Math	*W3*	4.93	4.96	-0.04	0.02633	-1.461	1034	.144
Science	*W3*	5.06	4.90	0.16**	0.03041	5.210	1072	.000
Computers	*W3*	5.36	5.55	-0.26**	0.02849	-9.060	1096	.000
Teamwork	*W3*	4.80	5.04	-0.24**	0.03078	-7.850	1384	.000

Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
** = p<.001, Number of ratings: 1,035-1,385 across 56 teachers

Teacher ratings of student ability and interest were moderately positive in each area, although among the three groups (students, parents, and teachers), teachers' ratings were the lowest, with half of the ratings averaging below 5 on a 1-7 scale, where no average ratings fell below 5 for the other two. Teachers, like students, used a wider range of the available rating scale than did parents, using the entire 1-7 range where it was highly uncommon for a parent to give a rating below 2.

Correlations between students' self-ratings of ability and interest in each area and their teachers' ratings of these students were calculated for each wave of data collection. These can be seen in the Technical Appendix II. Overall, correlations between student and teacher ratings of student ability and interest were strong, positive, and statistically significant at α = .05, especially in the core areas of reading/ELA and math. Within these areas, correlations of ratings of ability were especially strong, ranging from 0.30 to 0.55. Correlations between student and teacher ratings of science ability were higher than they were for student interest in this area, but both were moderately positive and statistically significant in each wave.

Computer ability and interest ratings were the anomaly to the trend of positive correlations. For computer ability, correlations were very low and not statistically significant, except in Wave 2, and for interest, they ranged from .05 to .14 and were only statistically significant in Wave 2 and Wave 3. This suggests that students and teachers did not generally agree about how good the students were at computers or how interested they were in them.

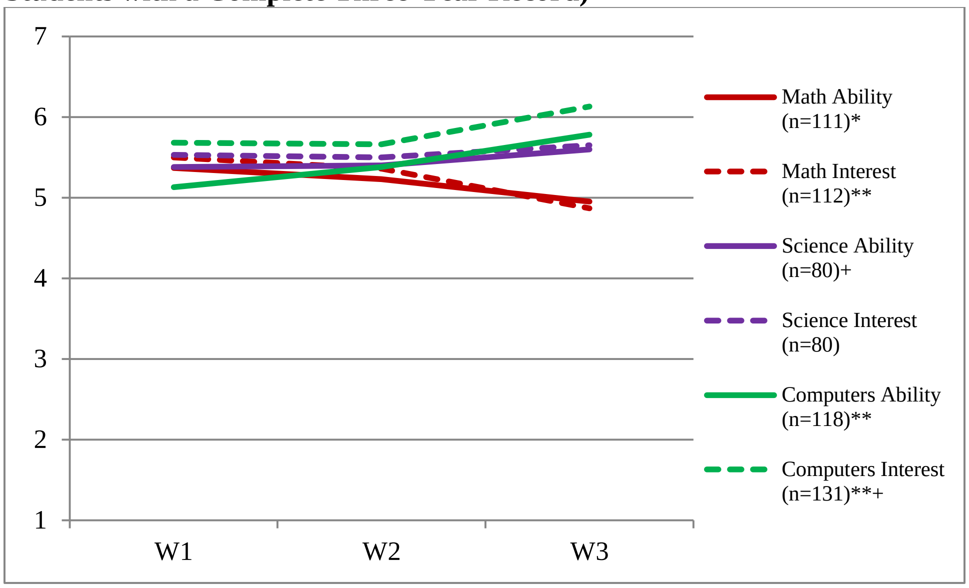
Teachers gave students slightly higher ability ratings than interest ratings in science, but moderately higher interest ratings than ability ratings in computers and teamwork.

As shown in Exhibit TI-5, above, there were some statistically significant differences between teachers' ratings of ability among their students and teachers' ratings of interest among their students in the various disciplines and skills during Wave 3 of data collection. Teachers reported that their students had slightly higher abilities than interest in science, while interest surpassed ability by approximately a quarter of a point on a 1-7 scale for computers and teamwork. Science ability ratings were the second-highest among all the disciplines and skills, but computers ability ratings were highest by a wide margin. Science also received the lowest rating in terms of interest in Wave 3, while computers was rated the highest on interest. This trend is similar to the one seen in students' self-reported STV scores, shown in Exhibit TI-12.

Over the three waves, teacher ratings of students' ability and interest in math fell, while ratings in computers increased and science remained stable.

The average teacher ratings of students' abilities and interests changed over time as sample mean age went up and the students moved up in grade. These statistically significant changes were only observed in the STEM-related areas and not in reading/ELA and teamwork. In some cases, gender differences were seen, where girls' average ability or interest rating may have gone up over time while boys' may have dropped, or vice versa. Below, in Exhibit TI-6, we present trends in average teacher ability and interest ratings for each STEM area over time with both genders combined using only students with a complete three-year record of teacher ratings (n = 80-131). Following this figure, we discuss gender differences in the direction of these changes where they occurred.

Exhibit TI-6: Changes in Teacher Ratings of Student Ability and Interest over Time (For Students with a Complete Three-Year Record)



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely)
Note: Statistical tests refer to repeated-measures ANOVA analysis of change over time
* = $p < .05$, ** = $p < .01$, + = Sig. gender interaction

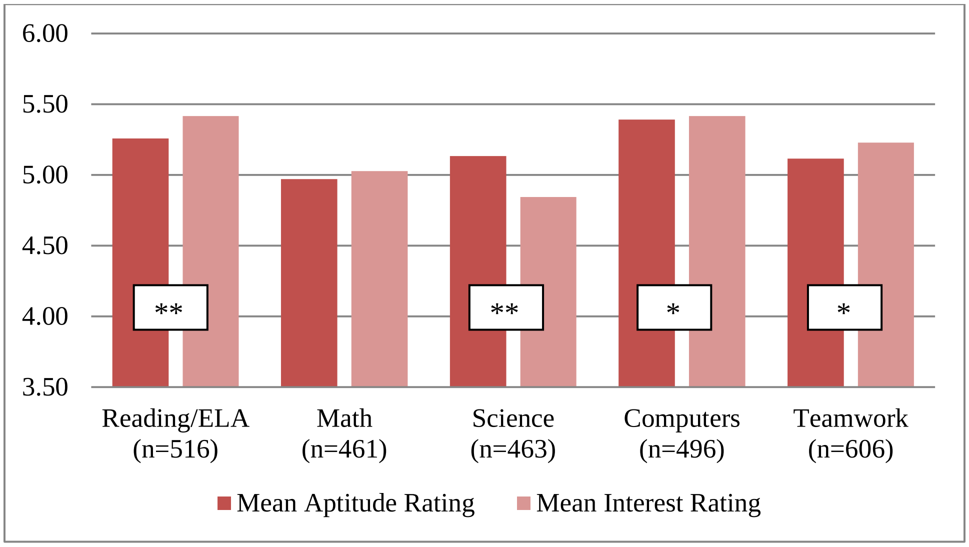
For both genders, mean teacher ability and interest ratings in math fell as the students moved up in grades, while science ability and interest levels did not change significantly over time for the students as a group. In contrast, the average teacher ability and interest rating in computers rose over time. Gender interactions were observed in teacher ratings of science ability and computers interest, meaning that the direction of change differed for boys and girls over the three waves or at least for one wave. In the case of computers, boys' interest ratings started around the same level as girls' and rose steadily over the three wave period, while girls' interest rating dropped dramatically in W2 and then rose again in W3 ($F = 5.62$, $df = 2$, $p < .05$). See Exhibits 5-7 and 5-8, below, for a comparison of mean ability and interest ratings by gender over time.

Teachers rated girls and boys similarly in terms of ability in science in Wave 3, but girls were seen as lacking interest.

Several interesting patterns emerged when these results were broken down by gender and paired-samples t-tests were conducted. In Wave 3 of data collection, teachers rated girls' ability level in science (5.13) statistically significantly higher than their interest level (4.84) in science ($t = 6.39$, $df = 462$, $p < .001$). This indicates that teachers thought that girls were slightly better in science than they were interested in science. This effect disappeared when comparing teachers' mean ability rating in science for boys (5.13) with their interest rating for boys (5.07), despite the fact that teachers rated boys' and girls' ability levels as the same ($t = 1.38$, $df = 402$, $p \approx 1.67$). Teachers did not perceive there to be a difference between boys' ability level in science and their interest in science, as they did with their female students. Teachers also rated their male and female students statistically significantly differently on their interest and ability levels in reading/ELA, computers, and teamwork in Wave 3 of data collection. In computers and teamwork, teachers rated interest higher than ability for both groups of students, on average, although the gap between these two was somewhat smaller for girls.

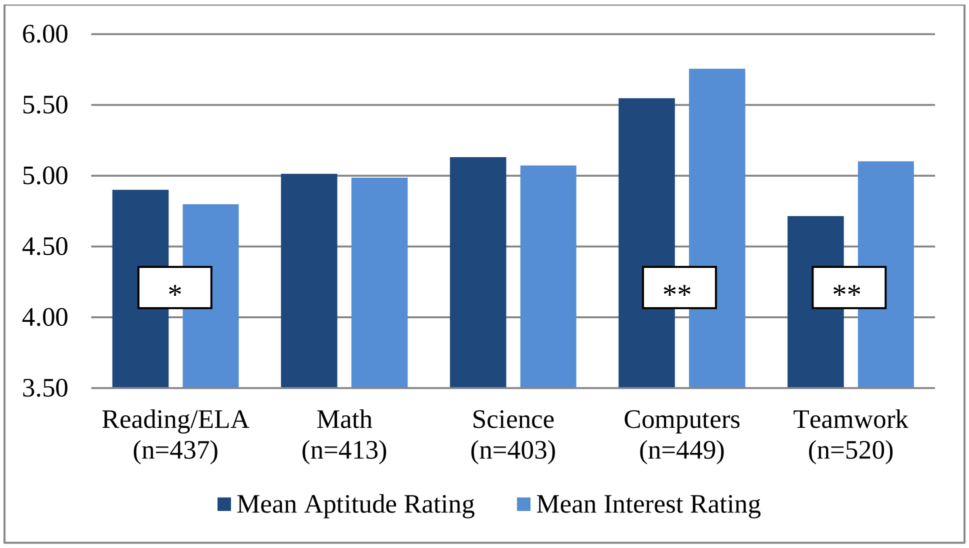
Independent samples t-tests were conducted to compare average teacher aptitude and interest ratings across genders in the final wave of data collection. In Wave 3, teachers tended to rate girls higher than boys on interest in ELA (t = 6.56, df = 822.19, p < .001), aptitude in ELA (t = 3.97, df = 951, p < .001), and aptitude for teamwork (t = 5.43, df = 1124, p < .001). They rated boys higher than girls on interest in science (t = 2.48, df = 864, p < .05), interest in computers (t = 5.02, df = 917, p < .001), and aptitude in computers (t = 2.43, df = 943, p < .05).

Exhibit TI-7: Mean Interest and Aptitude Ratings for Female Students Made by Teachers in Wave 3



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = p < .05, ** = p < .001
Note: The vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.

Exhibit TI-8: Mean Interest and Aptitude Ratings for Male Students Made by Teachers in Wave 3

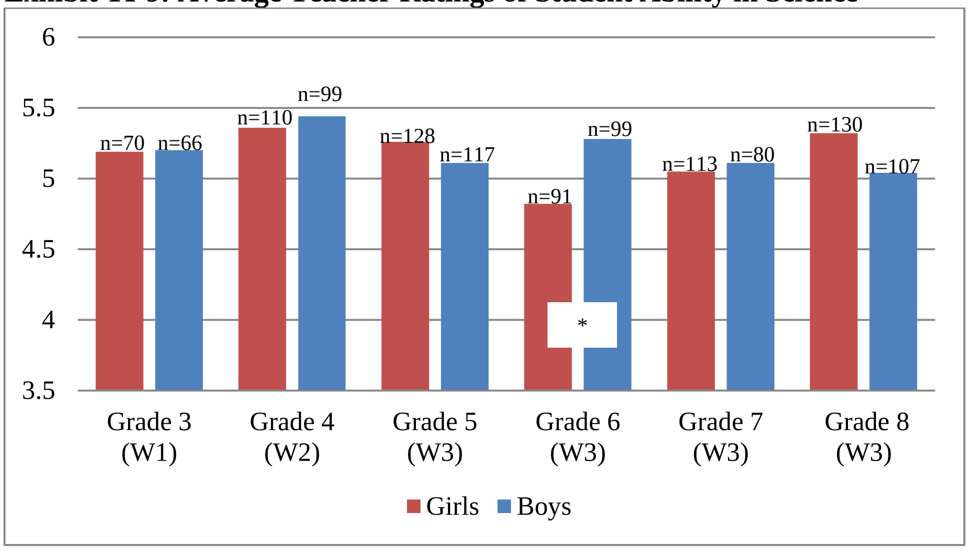


Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = p < .05, ** = p < .001
Note: The vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.

The biggest gender gap in teacher ratings of students' science ability and interest occurred for 6th grade students, for whom teachers rated boys as having more interest in science than girls.

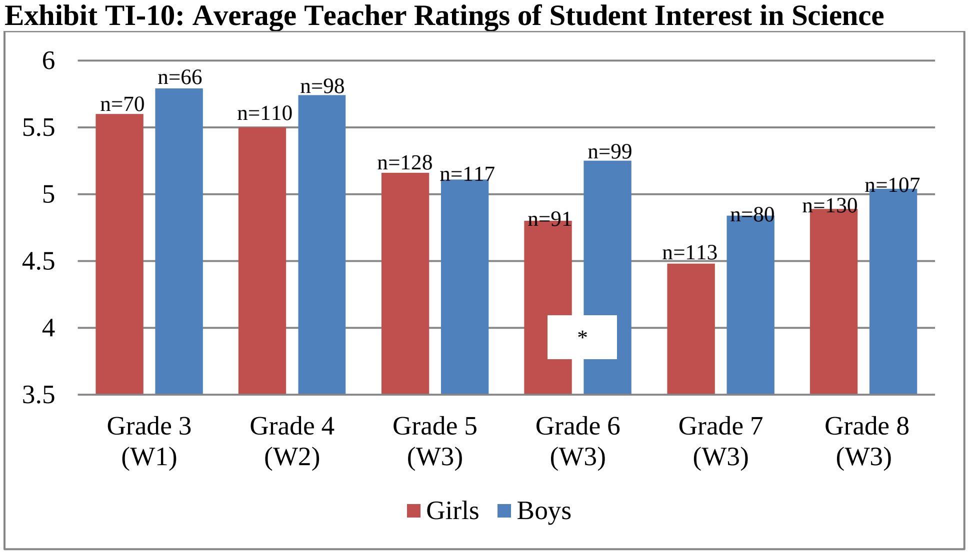
Additional analyses on previous waves' data were conducted for science ratings. These analyses confirmed that the same pattern was exhibited during each wave of the study: teachers rated boys as having a slightly higher interest in science than girls, but they generally did not distinguish between the two groups in terms of aptitude. Exhibits 5-9 and 5-8 show how teacher ratings of ability and interest differed between boys and girls at each grade level.

Exhibit TI-9: Average Teacher Ratings of Student Ability in Science



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$
Note: Calculated using most recent wave of data collection (W1, W2, or W3). Also, the vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.

Exhibit TI-10: Average Teacher Ratings of Student Interest in Science



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$, ** = $p < .01$
Note: Calculated using most recent wave of data collection (W1, W2, or W3) Also, the vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.

For most grades, using the most recently collected data from our three waves of data collection, there was not a statistically significant difference between boys and girls in terms of the ratings of aptitude and interest in science that their teachers assigned to them. The trend, however, was for boys to be rated slightly higher than girls on both aptitude and interest. In 6th grade, this gap was found to be statistically significant in both ability and interest. This coincides with students' own SE and STV ratings of science, to an extent; whereas the gap in teacher ratings between boys and girls was only statistically significant in 6th grade, boys' science SE and STV scores were statistically significantly higher than girls' SE and STV scores in 4th, 5th, and 6th grades. This can be seen in Technical Appendix II.

Teacher ability and interest ratings of students were generally moderately to strongly correlated with student self-efficacy and subjective task value ratings.

Teacher ratings of ability and interest among their students were compared with students' own SE and STV scores in STEM areas and skills. Across all three waves, teacher ratings of math ability correlated strongly and positively with students' SE ratings in math (ρ_{W3}= .56, $p < .01$) and teacher ratings of interest in math correlated strongly with students' STV ratings in math, as well (ρ_{W3}= .35, $p < .01$). Students who had high SE and STV ratings in math tended to have high teacher ratings of ability and interest in math, on average.

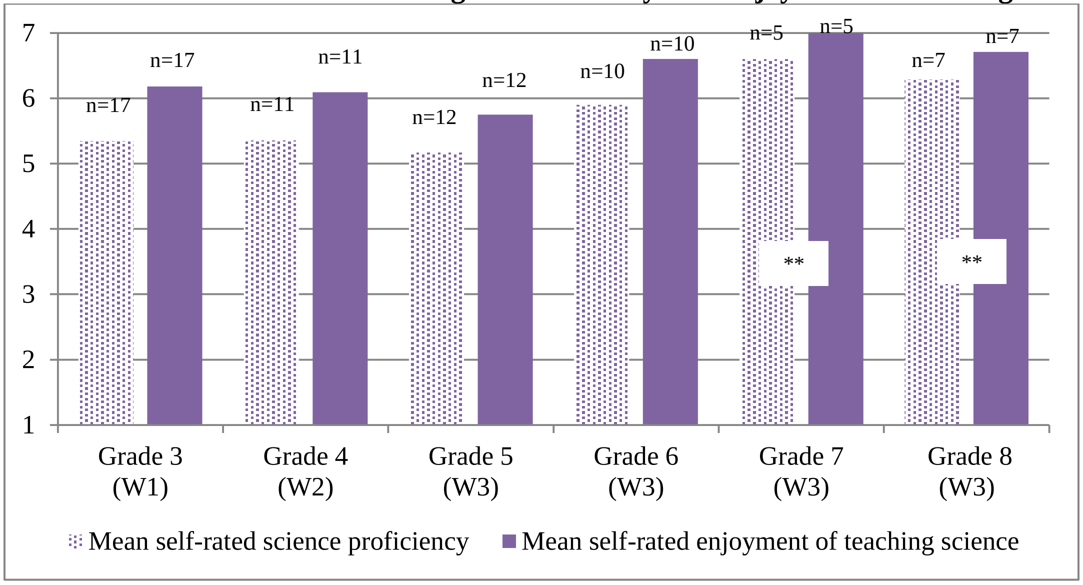
In Waves 2 and 3, teacher ratings of interest in science were moderately correlated with students' science STV ratings (ρ_{W3}= .20, $p < .01$) and teacher ratings of ability in science were more strongly correlated with students' science SE ratings (ρ_{W3}= .30, $p < .01$). Students who had high SE and STV ratings in science tended to have high teacher ratings of ability and interest in science, on average.

As with parents, correlations between teacher ratings of ability and interest in computers and students' ratings were not as strong. They were not statistically significantly correlated with students' ratings of SE and STV in computers in Wave 1, and were weakly correlated in Waves 2 and 3. There was no relationship between students' SE and STV ratings in computers and their teachers' ratings of them on ability and interest in computers, on average.

Educators across all grades (3rd-8th) who teach science consistently rated their enjoyment of teaching the subject higher than they rated their proficiency.

Teachers were asked to rate themselves on their own proficiency in science by answering the question: "How would you rate your own knowledge in [Subject or Skill]?" They were also asked to rate how much they enjoyed teaching each subject. Average responses to these items are shown in Exhibit TI-11.

Exhibit TI-11: Teachers' Self-Ratings of Proficiency and Enjoyment in Teaching Science



Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); * = $p < .05$, ** = $p < .01$
Note: Calculated using most recent wave of data collection (W1, W2, or W3)

Subjective Task Value (STV)

On the student survey, we measured subjective task value (STV) using six questions, each asked on a scale from 1 ("Not at all") to 7 ("Extremely"):

7. *Utility*: How useful is what you learn about [subject/skill]?
8. *Utility*: How important is it to you to be good at [subject/skill]?
9. *Interest*: How much do you like [subject/skill]?
10. *Interest*: Not counting homework, how often do you do an activity with [subject/skill] outside of school?
11. *Interest*: When you are older, how likely are you to choose to take classes in [subject/skill]?
12. *Interest*: When you are older, how much would you like to have a job that uses [subject/skill]?

Exhibit TI-12 shows the mean calculated utility and interest item scores for the M-LEAP student survey at each data collection point, as well as a composite STV score in each area, which was calculated as the average of all students' scores on the two utility and four interest items. Further breakdown of STV scores in each area by cohort, grade, and gender can be found in Technical Appendix II.

Exhibit TI-12: Subjective Task Value Indicator Means on the Student Survey, Waves 1-3

		Utility		Interest				Composite Subjective Task Value
		4. How useful is what you learn about…?	5. How important is it to you to be good at…?	6. How much do you like…?	7. Not counting homework, how often do you do an activity with … outside school?	8. When you are older, how likely are you to choose to take classes in …?	9. When you are older, how much would you like to have a job that uses …?	
Reading/ELA	*W1*	5.82	6.15	5.30	4.75	5.01	4.33	**5.24**
	W2	5.56	6.16	5.14	4.68	4.97	4.22	**5.15**
	W3	5.83	6.08	5.08	4.40	5.01	4.32	**5.12**
Math	*W1*	6.20	6.45	5.37	4.64	5.61	4.86	**5.48**
	W2	6.15	6.46	5.19	4.59	5.43	4.69	**5.41**
	W3	6.08	6.34	4.94	4.22	5.38	4.59	**5.25**
Science	*W1*	5.57	5.97	5.48	3.76	5.42	4.79	**5.14**
	W2	5.48	6.00	5.34	3.65	5.33	4.74	**5.08**
	W3	5.53	5.94	5.35	3.51	5.29	4.65	**5.04**
Computers	*W1*	6.02	6.06	6.06	5.55	5.79	5.50	**5.79**
	W2	6.00	6.06	5.76	5.69	5.38	5.11	**5.66**
	W3	5.96	5.91	5.62	5.63	5.29	5.07	**5.58**
Teamwork	*W1*	5.92	6.05	5.68	4.61		5.38	**5.17**
	W2	5.89	6.05	5.65	4.84		5.4	**5.67**
	W3	5.94	6.02	5.59	4.92		5.35	**5.58**

Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); $N_{W1} = 667$, $N_{W2} = 1,128$, $N_{W3} = 1,327$
Note: Results are shown disaggregated by school and wave in the Technical Appendix II.

Students found STEM areas to be more useful than interesting.

Students in the M-LEAP sample gave generally strongly positive assessments of the utility of each academic discipline and skill on the survey, while interest ratings tended to fall more toward the middle of the 1-7 scale, but were still generally positive.

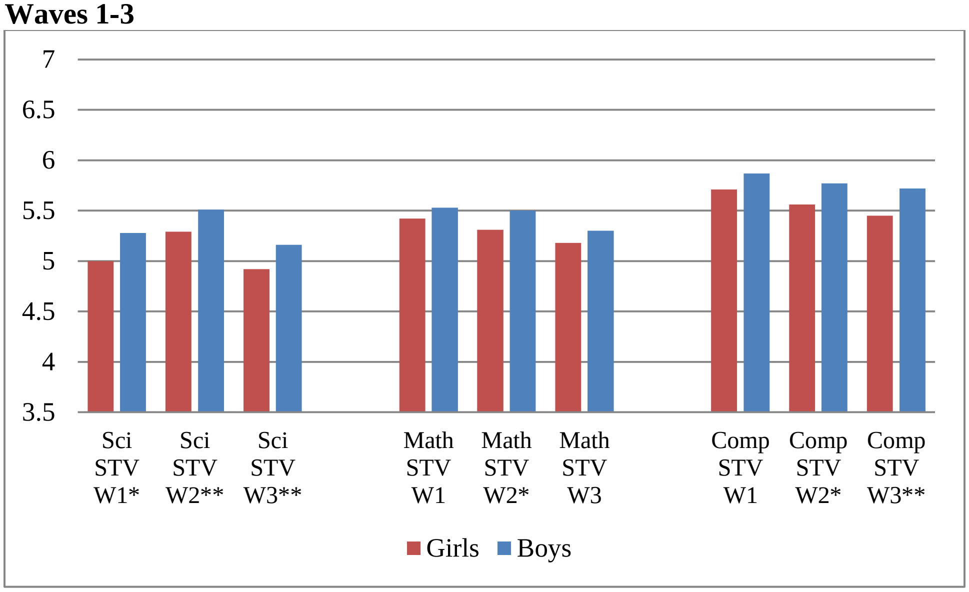
Each wave, for each academic discipline and skill, the mean utility value was statistically significantly higher than the mean reported interest level at $\alpha = 0.05$, meaning that students believed these areas were more useful than interesting. For example, the mean utility value for math in Wave 3 (6.18) was statistically significantly greater than the mean reported interest level in math in Wave 3 (4.78) ($t = 42.44$, $df = 1326$, $p < 0.001$). These statistically significant differences indicate that students in the M-LEAP sample believed that each of these areas and skills is more useful than it is interesting.

The mean STV score for the STEM areas of math, science, and computers as a whole was not statistically significantly different from the STV score for the non-STEM areas of reading/ELA and teamwork in Waves 1 and 2. In Wave 3, however, the mean STV score for STEM areas (5.47) was statistically significantly different from the mean STV score for non-STEM areas (5.37) (t = 2.59, df = 666, $p \approx 0.01$). This suggests that the sample of students in 5th-8th grades viewed the STEM areas and activities, as a whole, as being slightly more useful and/or interesting than reading/ELA and teamwork.

Boys' subjective task value ratings were generally higher than were girls', except in ELA/reading.

We conducted independent samples t-tests to explore differences in mean STV scores by gender at each wave of data collection. As shown in Exhibit TI-13, boys' mean STV ratings in science were statistically significantly higher than girls' mean STV ratings in science during each wave of data collection. The size of this difference in means ranged from 0.24 to 0.27, an effect size that was calculated to be relatively small (d'_{W1} = 0.22, d'_{W2} = 0.18, d'_{W3} = 0.2). Girls' STV ratings for reading/ELA (not shown in Exhibit TI-13), however, were statistically significantly higher than boys' STV ratings for reading in all three waves by approximately half a point on a scale of 1-7. There was not a statistically significant difference between the genders in teamwork STV in any wave.

Exhibit TI-13: Mean Subjective Task Value Ratings on Student Survey for STEM Subjects, Waves 1-3



Note: The vertical axis is truncated to a range of 3.5 to 6 in order to highlight the findings. True range was 1-7.
* = p < .05, ** = p < .001; N_{W1} = 326-341, N_{W2} = 523-557, N_{W3} = 590-678

Boys' mean STV ratings in math were statistically significantly higher than girls' mean STV ratings in math during the second wave of data collection, only. The size of this difference in means (0.19) was smaller than it was in any wave for science STV, and a sensitivity analysis confirmed that this effect size was small (d'_{W2} = 0.16). In Waves 2 and 3 of data collection, boys' mean STV ratings in computers were statistically significantly higher than girls' mean STV ratings in computers by 0.22 and 0.27 points, an effect size that was calculated to be small at each point (d'_{W2} = 0.18, d'_{W3} = 0.24).

Students' subjective task value ratings dropped in science and math over the three waves, while ratings for reading/ELA, computers, and teamwork remained constant.

As with SE, we were interested to see if students' STV scores changed over time as the as the mean age of the sample went up and the students moved up in grades, especially with regard to STEM areas. Descriptively, students STV composite scores for each discipline dropped between 0.12 and 0.23 points between Waves 1 and 3, with the exception of teamwork, which increased from 5.17 to 5.58, an increase of 0.41 points on a 7-point scale.

A repeated-measures ANOVA with a Greenhouse-Geisser correction conducted with students with a complete three -year record (n = 390) determined that the mean STV score did differ statistically significantly between time points in math and science. For students who took the student survey during all three waves, STV ratings in math dropped from 5.50 to 5.34, on average, and STV ratings in science dropped from 5.21 to 5.04 between Waves 1 and 3. In other words, evidence suggests that these areas slightly became less interesting and/or useful to students over time.

Exhibit TI-14: Results of Repeated-Measures ANOVA on Student Subjective Task Value Scores

Subject		Test of Within-Subjects Effects	N	F	Sig.	Interpretation
Math	STV	Greenhouse-Geisser	390	5.066	0.008**	Significant change over time.
Science	STV	Greenhouse-Geisser	390	3.146	0.045*	Significant change over time.
Computer	STV	Greenhouse-Geisser	390	2.791	0.064	No significant change over time.
Teamwork	STV	Greenhouse-Geisser	390	2.118	0.123	No significant change over time.
Reading	STV	Greenhouse-Geisser	390	2.618	0.077	No significant change over time.

* = $p < .05$, ** = $p < .01$

We were also interested in whether or not changes in STV scores occurred disparately for girls and boys. A repeated-measures ANOVA with a Greenhouse-Geisser correction conducted with students who had a complete three-year record determined that there was no statistically significant interaction between gender and time in terms of STV scores. While these scores may have changed in some areas, the evidence suggests that, on the whole, any changes in STV scores in 3rd-8th grade were not related to gender.

Parents rated each area and skill as having high utility value.

Parents were asked similar questions about the utility of each academic area and skill, and their responses were used to calculate a composite utility score for each area. The items which formed the utility subscale of the parent survey are shown in Exhibit TI-15, along with average scores for parents from each wave of data collection.

Exhibit TI-15: Utility Indicator Means on the Parent Survey, Waves 1-3

			Utility			
			1. How important is it for your child to do well in…?	2. When your child is in high school, how much would you like him or her to take elective classes or advanced courses in…?	3. When your child is an adult, how much would you like for him/her to have a job that uses…?	**Composite Utility Rating**
Reading/ELA	*W1*	*MOTHER*	6.63	6.24	6.21	**6.36**
		FATHER	6.67	6.29	6.17	**6.38**
	W2	*MOTHER*	6.56	6.09	6.05	**6.23**
		FATHER	6.64	6.06	5.98	**6.23**
	W3	*MOTHER*	6.67	6.03	6.03	**6.24**
		FATHER	6.61	6.10	5.81	**6.17**
Math	*W1*	*MOTHER*	6.59	6.34	6.19	**6.37**
		FATHER	6.66	6.34	6.14	**6.38**
	W2	*MOTHER*	6.63	6.20	6.07	**6.30**
		FATHER	6.68	6.27	6.10	**6.35**
	W3	*MOTHER*	6.60	6.09	6.06	**6.25**
		FATHER	6.52	6.23	5.72	**6.16**
Science	*W1*	*MOTHER*	6.49	6.37	6.27	**6.38**
		FATHER	6.61	6.36	6.13	**6.37**
	W2	*MOTHER*	6.53	6.21	6.08	**6.27**
		FATHER	6.54	6.30	6.26	**6.37**
	W3	*MOTHER*	6.44	6.08	6.05	**6.19**
		FATHER	6.35	6.19	6.01	**6.18**
Computers	*W1*	*MOTHER*	6.50	6.21	6.35	**6.35**
		FATHER	6.55	6.21	6.27	**6.34**
	W2	*MOTHER*	6.61	6.16	6.25	**6.34**
		FATHER	6.56	6.29	6.35	**6.40**
	W3	*MOTHER*	6.61	6.17	6.34	**6.37**
		FATHER	6.54	6.26	6.16	**6.32**
Teamwork	*W1*	*MOTHER*	6.58		6.28	**6.43**
		FATHER	6.47		6.00	**6.24**
	W2	*MOTHER*	6.52		6.14	**6.33**
		FATHER	6.49		6.11	**6.30**
	W3	*MOTHER*	6.47		6.05	**6.26**
		FATHER	6.34		5.99	**6.17**

Scale: 1 (Not at all), 4 (Ok), 7 (Extremely); N_{W1} = 124-384, N_{W2} = 140-339, N_{W3} = 99-301

While the trend was for mothers to give slightly higher utility ratings than fathers, paired-sample t-tests comparing mean utility ratings from pairs of parents who both rated the same student showed that there were no statistically significant differences between mean utility ratings assigned by mothers versus those assigned by fathers. In other words, mothers and fathers tended to agree with one another on the importance of doing well in each area and continuing to take classes in those areas.

Students and parents did not agree as strongly about utility as they did about self-efficacy.

Because parents were not asked about interest (a sub-construct of student STV) we did not compare students' STV ratings with the utility scores of parents. Instead, correlations were calculated between parents' and students' utility ratings in order to examine the concordance between these two measures. The correlations between students' utility scores and their parents' utility scores are shown in the Technical Appendix II, for mothers and fathers, respectively.

Overall, correlations were positive, moderately strong, and statistically significant at $\alpha = 0.05$; however, they were also smaller than correlations between students' and parents' SE ratings. The strongest correlations were exhibited for both parents in science, and then math. Mothers' ratings correlated statistically significantly with students' ratings at more points in time than fathers' ratings, but the number of observations was also greater for mothers. For example, there were moderately strong and positive correlations between mothers and children on the utility of teamwork, but no statistically significant correlations between students and fathers in any wave on this measure.

Parent ratings of the utility of STEM areas remained mostly stable over time.

Parent utility ratings were examined for change over time and for gender interactions. Three statistically significant findings were observed: (1) for mothers' ratings of teamwork utility, (2) for mothers' ratings of reading/ELA utility, and (3) for fathers' ratings of reading/ELA utility.

A repeated-measures ANOVA assuming sphericity conducted with mothers with a complete three-wave record (n = 107) determined that the mean composite teamwork utility score for mothers differed statistically significantly between time points ($F = 3.6$, $df = 2$, $p < .05$), although there was not a statistically significant interaction effect with gender. The mean teamwork utility score for mothers with a complete three-wave record fell from 6.45 in Wave 1 of data collection to 6.26 in Wave 3, but this trend in ratings was not different for boys and girls. This indicates that mothers viewed teamwork as being slightly less useful as time progressed for both groups of students.

A repeated-measures ANOVA assuming sphericity conducted with mothers (n = 107) and fathers (n = 37) with a complete three-wave record determined that the mean composite reading/ELA utility score for both mothers and fathers differed statistically significantly between time points ($F = 4.12$, $df = 2$, $p < .05$ and $F = 3.4$, $df = 2$, $p < .05$, respectively), although there was not a statistically significant interaction effect with gender. Mean reading/ELA utility scores for mothers with a complete three-wave record fell by .16 points, and these scores fell by .21 points for fathers over the course of the three wave study, and this trend was exhibited in both boys' and girls' ratings. Both mothers and fathers reported that they viewed reading/ELA as being moderately less useful over time, and expressed this view when rating both boys and girls.

The Relationship between Student Self-Efficacy and Subjective Task Value

Student self-efficacy and subjective task value scores were highly correlated.

Student SE and STV scores were compared to examine the relationship between how students felt about their ability and expectations for success in each area and how interested and useful they found each area and skill to be. Correlations between student SE and STV scores, as calculated based on their responses to the student survey, are presented in the Technical Appendix II. Overall, correlations between these two constructs were strong, positive, and statistically significant at $\alpha = .05$ for each area and each of the three waves of data collection, that is, having a higher self-rating in one was associated with having a higher self-rating in the other.

STUDENT OUT-OF-SCHOOL ACTIVITIES

The M-LEAP study was focused not just on measuring SE beliefs and STV beliefs through survey and interview instruments with students, parents, and teachers, but also the context for these beliefs. Student experiences (the "E" in science beliefs, experiences, and aspirations, or SBEAs) outside of school were measured on the student survey with questions regarding their frequency of participation in numerous out-of-school (OOS) activities related to STEM. This included reading STEM-related literature, watching STEM-themed TV and movies, visiting informal science learning institutions, and participating in other activities. Their responses were used to calculate a composite score of STEM-related activity level with a scale of 1 to 7, as shown in Exhibit TI-23; means are shown for girls and boys at each wave, as well as the results of independent samples t-tests comparing boys' and girls' mean participation level during each wave.

Exhibit TI-16: Mean Self-Reported Participation Level in STEM-related OOS Activities

	Wave 1			Wave 2			Wave 3		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
Girls	3.19	1.29	341	2.88	1.32	557	2.68	1.18	678
Boys	3.47**	1.36	326	3.08*	1.40	523	2.92**	1.32	590
All	3.33		667	2.98		1,128	2.80		1,327

Scale: 1 (Never or almost never), 2 (a few times/year), 3 (about every other month), 4 (about once/month), 5 (every week or every other week), 6 (a few times/week), 7 (Every day or almost every day)
* = $p < .05$, ** = $p < .01$

Students did not frequently participate in STEM-related out-of-school activities, and participated in fewer activities over time. Boys participated in these activities more frequently than did girls.

Given a scale of 1 to 7, mean scores were relatively low, overall, with all scores falling well below the possible midpoint. Students reported engaging in STEM-related activities at an average rate of approximately one time every two months. Furthermore, these scores decreased over time. A repeated-measures ANOVA assuming sphericity conducted with students with a complete three-wave record (n = 390) determined that the mean activity level score differed statistically significantly between time points ($F = 36.16$, $df = 2$, $p < .001$). There was a mean drop overall of .33 points between Waves 1 and 2, and a further drop of .25 points between Waves 2 and 3. This corresponded to a drop from participating in STEM-related OOS activities "about every other month" on average to participating "a few times per year." The interaction term between gender and the activity variable was not found to be statistically significant ($F = .56$, $df = 1$, $p \approx .46$), indicating that this change did not occur differentially for boys and girls and both experienced this decline. There was also no interaction between the activity variable and selection of a STEM career in W3 ($F = 1.06$, $df = 2$, $p \approx .35$), indicating that students who selected in STEM career in the final wave of data collection and those who did not experienced a similar decline in frequency of participation in OOS STEM activities.

There were, however, statistically significant differences between boys and girls on their self-reported frequency in engaging in a STEM-related activity outside of school at each time point. Boys reported engaging in more STEM-related activities outside of school than girls during each wave of data collection. The effect sizes (*d'*) reflected in these independent samples t-tests comparing means were small and ranged from .15 to .21.

Students who participated in more STEM-related activities also believed they were better at STEM areas (SE); this was particularly true for science.

In order to explore the relationship between engaging in activities and SE beliefs, correlations were calculated between students' self-reported frequency of engagement with such activities and their SE scores. These correlations are presented below.

Exhibit TI-17: Non-Parametric Correlation Matrix Comparing Students' Frequency of Participation in OOS STEM Activities and SE Beliefs

		Mean Frequency of Participation in STEM Activities: W1	Mean Frequency of Participation in STEM Activities: W2	Mean Frequency of Participation in STEM Activities: W3
Math SE: W1, W2, W3	ρ	.16**	.16**	.14**
	N	667	1,128	1,327
Science SE: W1, W2, W3	ρ	.18**	.24**	.23**
	N	667	1,128	1,327
Computers SE: W1, W2, W3	ρ	.13**	.19**	.19**
	N	667	1,128	1,327

** = $p < 0.001$

Students' mean self-reported frequencies of engaging in OOS activities related to STEM were statistically significantly positively correlated with their SE beliefs in those subject and skill areas across all three waves. In each STEM area and skill, engaging in more STEM activities was associated with higher SE beliefs, on average. Overall, correlations were small to moderate according to conventions of sensitivity analyses, with *d'* statistics of .26 to .48. SE scores correlated most highly with STEM activity level for science, indicating that what students believed about their ability and expectations for success in science was tied more closely to their frequency of engagement in out-of-school STEM activities than it was for any other area. The results of multivariate HLM models predicting student SE and STV in STEM areas, discussed in a later chapter, revealed that students who participated in fewer STEM OOS activities had higher math SE scores, a finding which contradicts what was found here.

Students who participated in more STEM-related out-of-school activities also thought that STEM areas were more interesting and useful (STV).

As with SE, correlations were calculated between students' self-reported frequency of engagement in STEM-related activities outside of school and their STV beliefs. This was done in order to explore the relationship between engaging in activities and students' level of interest and utility beliefs with regard to STEM areas. These correlations are presented below.

Exhibit TI-18: Non-Parametric Correlation Matrix Comparing Students' Frequency of Participation in OOS STEM Activities and STV Beliefs

		Mean Frequency of Participation in STEM Activities: W1	Mean Frequency of Participation in STEM Activities: W2	Mean Frequency of Participation in STEM Activities: W3
Math STV: W1, W2, W3	ρ	$.34^{**}$	$.31^{**}$	$.33^{**}$
	N	667	1,128	1,327
Science STV: W1, W2, W3	ρ	$.38^{**}$	$.42^{**}$	$.43^{**}$
	N	667	1,128	1,327
Computers STV: W1, W2, W3	ρ	$.19^{**}$	$.32^{**}$	$.29^{**}$
	N	667	1,128	1,327

** = $p < 0.001$

Students' mean self-reported frequencies of engaging in OOS activities related to STEM were statistically significantly positively correlated with their STV beliefs in those areas and skill areas across all three waves. In each STEM area, engaging in more STEM activities was associated with higher STV beliefs, on average. These correlations were stronger than they were between SE beliefs, indicating an even closer relationship between participation in STEM activities outside of school and interest and utility beliefs. Overall, correlations were moderate to very large according to conventions of sensitivity analyses, with *d'* statistics ranging from .40 to 1.05. Again, STV scores correlated most highly with STEM activity level for science, indicating that the extent to which students believed science is interesting and useful was tied more closely to their frequency of engagement in out-of-school STEM activities than it was for any other area.

During each of the three survey waves, students who engaged in more OOS STEM-related activities were moderately more likely to say they wanted a STEM job when they're adults.

Across all three waves of the M-LEAP study, girls and boys who self-reported engaging in more STEM-related out-of-school activities were also more likely to present a STEM-related career choice when asked about what job they would like to have when they grow up. When their career choice was coded as "non-STEM" or "STEM", where the latter category included only foundational STEM jobs like engineer or scientist, then reporting engaging in more STEM-related OOS activities was statistically significantly positively correlated with picking a STEM job. As shown in Exhibit TI-19, the correlation between these two measures was slightly higher for girls than it was for boys in Waves 1 and 2 of data collection, while in Wave 3 it was stronger for boys.

Exhibit TI-19: Non-Parametric Correlation Matrix Comparing Students' Frequency of Participation in OOS STEM Activities and Dichotomous STEM Career Choice

		Mean Frequency of Participation in STEM Activities: W1	Mean Frequency of Participation in STEM Activities: W2	Mean Frequency of Participation in STEM Activities: W3
Girls' STEM career choice: W1, W2, W3	ρ	.19**	.22**	.11**
	N	333	526	539
Boys' STEM career choice: W1, W2, W3	ρ	.18**	.16**	.22**
	N	313	495	457

** = $p < 0.01$

Independent samples t-tests confirmed that the difference in mean frequency of participation in OOS STEM activities was statistically significant between students who selected a STEM career and those who did not in all waves ($p < .01$ in all cases). Students who selected a STEM career reported participating in OOS STEM activities more frequently than those who selected a non-STEM career, on average. The size of this difference was large (approximately .60 of a point on a 1-7 scale during each wave). In Wave 1, the mean for students who selected a STEM career that wave was 3.89, roughly corresponding to participation in OOS STEM activities "about once a month," while for those who did not select a STEM career it was 3.22, approximately corresponding to "about every other month." In Wave 2, these means declined somewhat but remained in the same categories, and in Wave 3 the mean for students who selected a STEM career fell to 3.28 (just above "about every other month") and for non-STEM careers to 2.68 (just below "about every other month").

Parents' ratings of their own proficiency in science and math were positively correlated with participation rate in STEM-related out-of-school activities amongst students in Wave 3.

Spearman correlations between parents' own ratings of their own proficiency in science and math were moderately positively associated with students' reported frequency of participation in STEM activities, in Wave 3. Students whose parents felt confident about their own abilities tended to report participating more frequently in extracurricular STEM activities than students whose parents did not feel confident about their own abilities, on average. This relationship was stronger for fathers ($\rho_{science}$ = .28, $p < .01$; ρ_{math} = .25, $p < .01$) than mothers ($\rho_{science}$ = .17, $p < .01$; ρ_{math} = .15, $p < .05$) but while the relationship also appeared in Wave 2 for mothers ($\rho_{science}$ = .15, $p < .01$; ρ_{math} = .14, $p < .05$), it did not emerge in any other wave for fathers.

STUDENTS' PERCEPTIONS OF THEIR PARENTS' ATTITUDES TOWARDS SCHOOL SUBJECTS

On the M-LEAP survey, students were asked to identify the parent or adult with whom they spend the most time and then to consider their relationship with this adult. In the sample as a whole, 72% of students identified a female adult — typically a parent — and 28% chose a male adult, also typically a parent. We asked: "How important is it to this adult that you do well in… [school subject or activity]?" Likewise, we also asked parents how important it was to them that their children do well in certain school areas. Below, we present student and parent responses side by side, divided by gender.

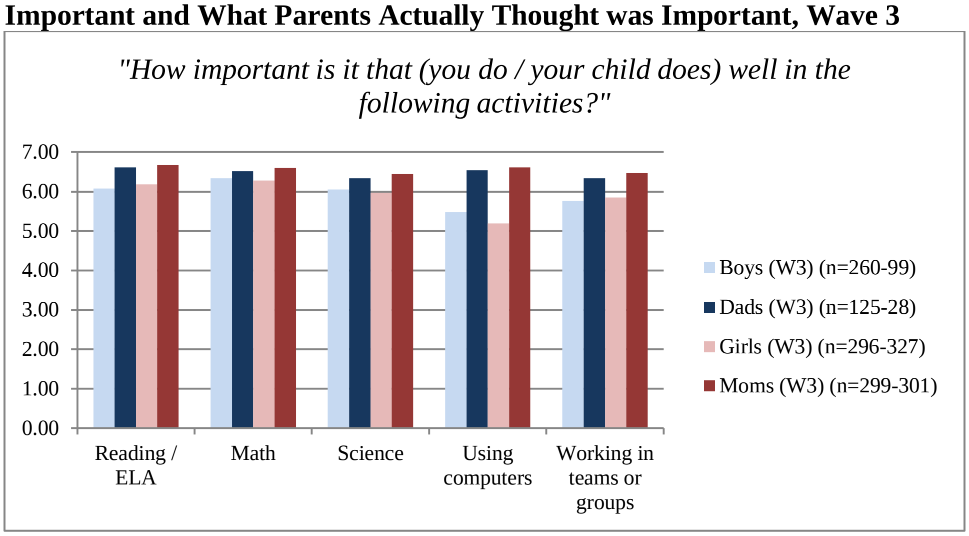
Students' ratings of how important it was to their parents to do well in certain areas remained stable over time.

Results are presented for Wave 3 of data collection, only, as a repeated-measures ANOVA assuming sphericity conducted with students with a complete three-year record (n = 192-271) determined that the perceived parents' importance of doing well in these areas did not differ statistically significantly between time points in any area at $\alpha = 0.05$. Furthermore, there were no statistically significant gender interactions with time, suggesting that perceived importance of doing well in areas did not change differentially between genders over time. Given this finding, Exhibit TI-20 presents student and parent responses side by side, divided by gender, for Wave 3 only.

Students believed their parents think it is slightly more important to do well in math and reading/ELA than in science.

On average, the students in Wave 3 of the M-LEAP study rated each discipline as holding moderate to high importance in the view of the adult with whom they spend the most time. Students believed that their parents think it is important for them to do well in reading/ELA, math, and science, and working in groups. The area rated as most important to do well in in the overall student sample was math, which had an average rating of 6.30, followed by reading/ELA (6.10) and science (5.99). "Using computers" received a score closer to the midpoint of the scale, with average ratings of 5.25 out of 7.00. These results remained relatively stable when students were asked to reflect on the beliefs of a second parent or adult.

Exhibit TI-20: Comparison Between What Children Believed their Parents Thought was Important and What Parents Actually Thought was Important, Wave 3



Scale: 1 (Not at all important), 7 (Extremely important)

Parents thought it was important for their children to do well in all five areas and skills, but students did not perceive that their parents assigned such importance to these; the gap was especially large for computers.

As shown in Exhibit TI-20, parent ratings of the importance of their students doing well in various areas differed somewhat from what students predicted their parents would say. For each core class and skill, parents rated the importance of doing well higher than their students thought they would. A paired-samples t-test comparing student ratings with those of their mothers and fathers showed that this difference was statistically significant at $\alpha = 0.05$ for each class, as shown in Exhibit TI-21. Although the table reflects analysis done on Wave 3 data, this same pattern of results was seen in all three waves of data collection.

Exhibit TI-21: Results of Paired-Samples T-Test Comparing Parent Ratings on Importance of Doing Well in Certain Areas with Perceived Parental Importance Ratings of Students in Wave 3

		Mean Difference (Parent - Student)	Pairs (n*)	Std. Error Mean	t	df	sig (2-tailed)
Reading/ELA	MOTHER	0.53	247	0.09	6.11	246	0.00
	FATHER	0.54	106	0.13	4.16	105	0.00
Math	MOTHER	0.40	252	0.08	4.76	251	0.00
	FATHER	0.39	110	0.14	2.79	109	0.01
Science	MOTHER	0.47	236	0.10	4.62	235	0.00
	FATHER	0.45	106	0.17	2.70	105	0.01
Computers	MOTHER	1.57	234	0.13	11.85	233	0.00
	FATHER	1.38	98	0.17	7.90	97	0.00
Teams	MOTHER	0.67	234	0.11	6.05	233	0.00
	FATHER	0.57	99	0.16	3.49	98	0.00

*Note: as a paired samples t-test, means for each comparison reflect scores only for those who had matched parent/student surveys.

These results show that there was a misalignment between the level of importance in doing well that parents assigned to each area and the level of importance that students thought their parents would assign. This gap was smallest in the STEM areas of math and science, and somewhat larger in reading/ELA and teamwork. Interestingly, this difference was roughly three times larger for computers than any other area, with a difference in means of 1.38 between students and fathers, and 1.57 between students and their mothers. Parents thought that doing well in computers is as important as doing well in any of the other areas, but students did not perceive this.

Students who perceived that their parents thought it was important to do well in an area gave that area higher utility and interest ratings, on average.

Students' ratings of their perceived importance of doing well in various areas to their parents were also statistically significantly correlated with their STV ratings within each area at $\alpha = .05$ for each wave of the study. All correlations were strong and positive (0.3 or above in nearly every case) indicating that there was a relationship between perceiving that their parents thought it was important for them to do well and the utility and interest value that students assigned to each area.

In general, students who chose a STEM job and those who chose a non-STEM or allied health job did not differ in terms of how important they thought it was to their parents to do well in STEM areas.

Independent t-tests of differences in mean ratings of perceived importance to adults between students who chose a STEM job and those who did not showed that, on average, this difference was not statistically significant in almost all cases and waves. By and large, students who picked a STEM career did not perceive it as being more or less important to their parents to do well in STEM areas. Correlations between the job selection variable and the various measures of perceived parental importance were also not significant in almost all cases and waves.

The exception to this trend was in Wave 1, where there was positive association between perceiving it as important to parents to do well in science (t = -3.1, $p < .01$) and selecting a STEM job, where students who perceived it as important to their parents to do well in science tended to select a STEM job more often than those who did not, on average. Statistically significant spearman correlations between this measure of perceived importance and mean rate of STEM job selection were also found ($p < .05$).

GENDER STEREOTYPES

We asked students, parents, and teacher each a variation of the following question: “In general, do you think that boys or girls are better at these subjects and skills?” For each of five subject and skill areas, they were able to indicate the degree to which they thought girls were better, that boys were better, or that boys and girls were about the same. Percentages of students, parents, and teachers selecting each response during Wave 3 of data collection are presented below, separated by gender. Note that all graphs total 100% except in cases of rounding error, and that the sample of male teachers responding is relatively small.

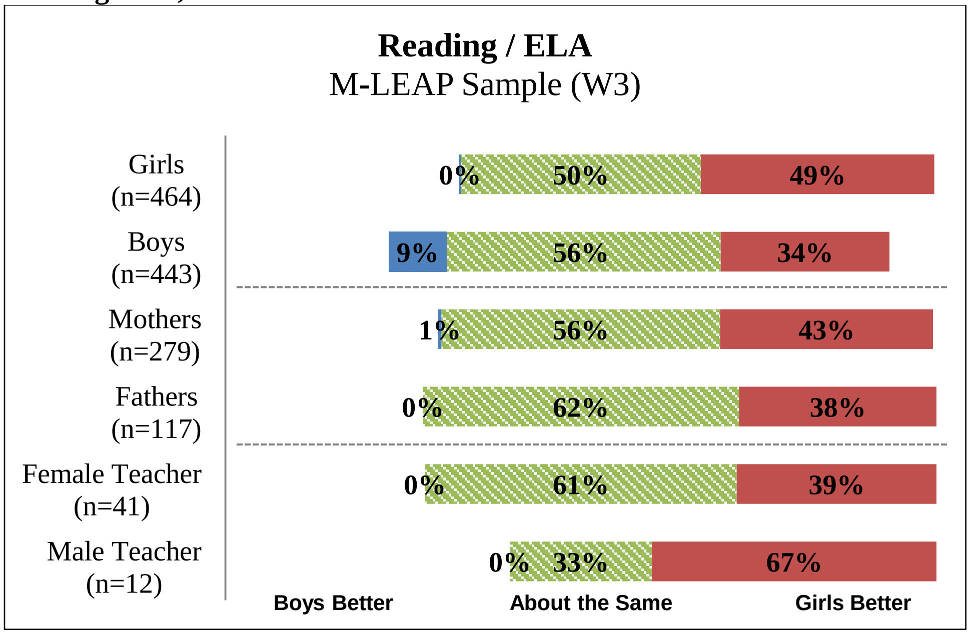
Reading/ELA

All groups thought that girls do better in reading/ELA than do boys.

In the overall M-LEAP sample, approximately half of both girls and boys said that both genders are about the same in ability when it comes to reading/ELA. Yet for both girls and boys, there was a pronounced skew toward rating girls as better at reading/ELA, and almost no girls indicated that boys were better. Responses from parents followed a similar pattern. However, while 9% of boys said that boys were better at reading/ELA, no fathers said this, and instead a greater percentage of fathers said both genders were about the same or that girls were better.

A large percentage of both male and female teachers said that girls were better at reading/ELA, while none said that boys were better. Approximately 60% of female teachers said that boys and girls were about the same, while two-thirds of male teachers said that girls were better.

Exhibit TI-22: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Reading/ELA, Wave 3



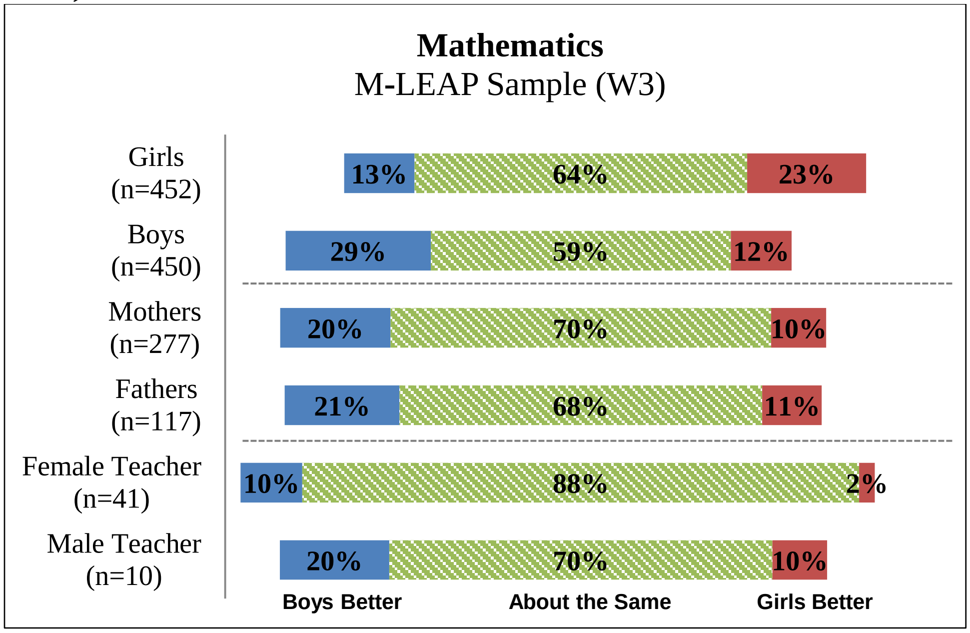
Mathematics

Most students and adults believed boys and girls are about the same in mathematics ability. While traditional math stereotypes favoring boys persisted among a fifth of adults and a quarter of boys, about a quarter of female students favored their own gender.

In math, the majority of girls and boys in the M-LEAP sample said that both genders are about the same in ability, although about a quarter of respondents from each gender gave the nod to their own gender. Responses from mothers and fathers lined up more closely with one another than the two sets of student responses, but mothers did not exhibit the same tendency to favor their own gender in math as much as female students did. The majority of parents said that both genders are about as good at math as one another.

The overwhelming majority of both male and female teachers said that boys and girls are about the same in terms of ability when it comes to math. Most of the remaining male and female teachers favored boys.

Exhibit TI-23: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Math, Wave 3



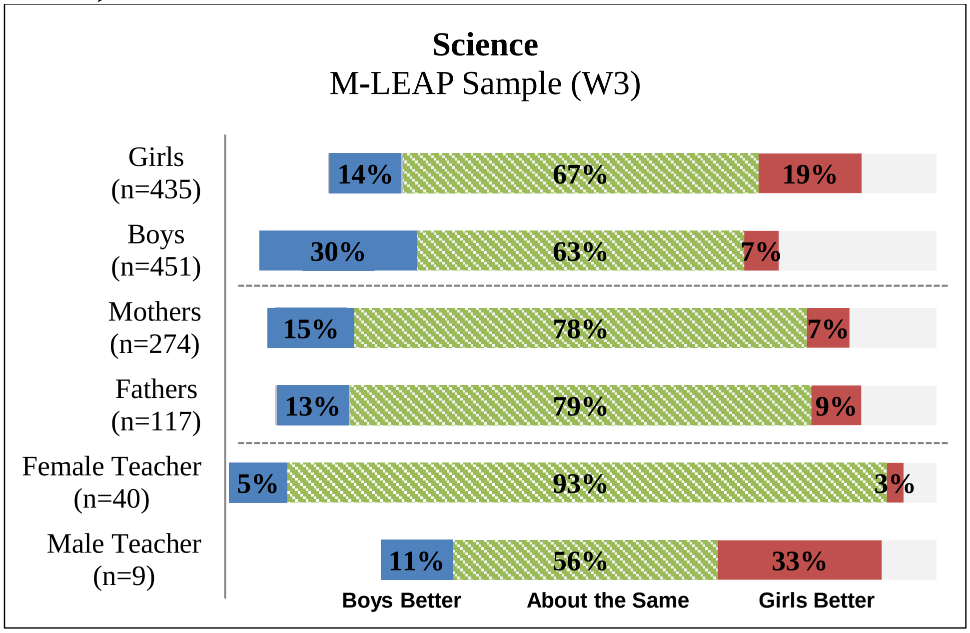
Science

Girls thought they are as good as, or better than, boys at science.

Among students, approximately two-thirds of respondents from each gender said that boys and girls are about as good as one another at science, with the remainder of girls split roughly evenly between seeing girls as better and boys as better, and with the remaining boys tending to favor their own gender. Once again, the two sets of parental responses lined up more closely than did the student responses, with a greater proportion of mothers and fathers saying that boys and girls are about the same in terms of science ability and the remaining respondents giving a slight edge to boys.

Female teachers, by and large, said that boys and girls were about the same in terms of ability in science. In comparison to students and parents on this and any other area, this was the largest instance of a group converging on this option. In contrast, a far smaller majority of male teachers said that both genders were about equal, with one third of male respondents giving the edge to girls.

Exhibit TI-24: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Science, Wave 3



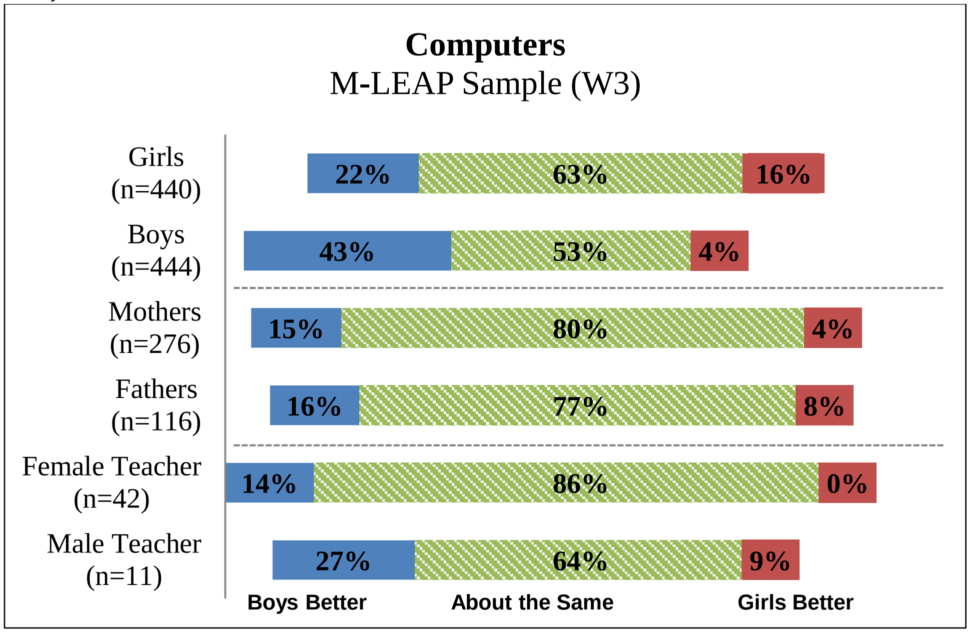
Computers

Students, teachers, and parents all had different views on computer ability stereotypes.

Regarding computer ability, the majority of girls said that both genders are about the same in ability, with the remaining female respondents giving a slight edge to boys. In contrast, about half of boys said that both genders are about as good as one another at computers, but the remaining male student respondents skewed heavily toward seeing boys as better. Parents, on the other hand, seemed to agree more with each other that boys and girls have the same ability with computers, with the remaining parents favoring boys over girls.

The vast majority of female teachers said that both groups of students were about the same in terms of ability in computers, with a small percentage giving the edge to boys. No female teachers said that girls were better at computers than boys. Over a quarter of male teachers favored boys when it came to computers.

Exhibit TI-25: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Computers, Wave 3



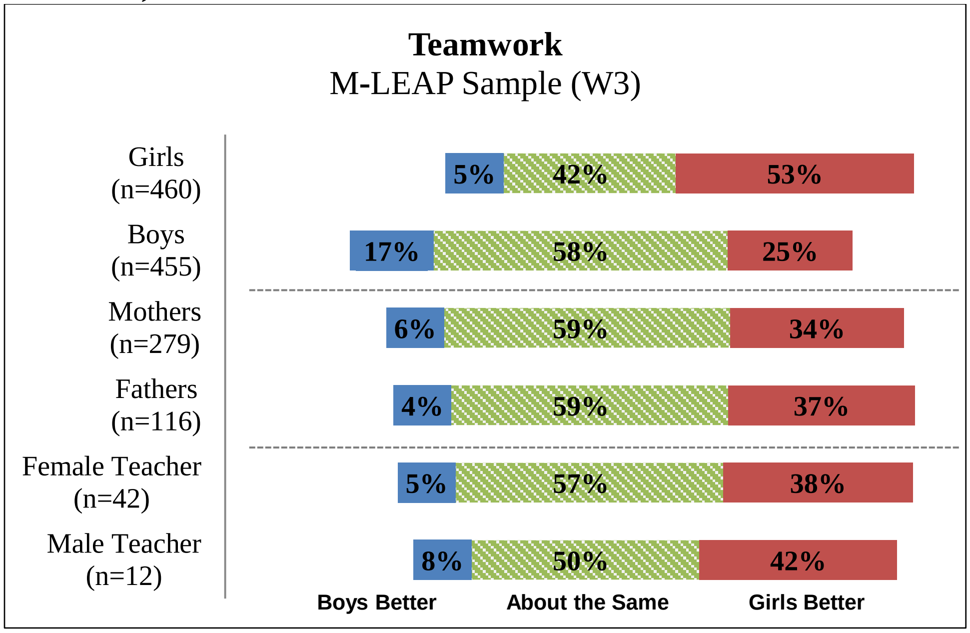
Teamwork

When it came to teamwork, students, parents, and teachers all said that girls are as good as, if not better than, boys.

The majority of girls said that girls are better than boys at working in teams. In contrast, the majority of boys said that both genders were about the same in terms of teamwork ability, with the remaining male respondents giving the edge to girls. As with the other areas and skills, the two sets of parents were in closer alignment with one another than their children were with one another, with the majority of both mothers and fathers saying that boys and girls had the same aptitude for teamwork, and approximately a third saying that girls are better.

Around half of teachers from each gender said that boys and girls were about the same, while the vast majority of the remaining percentage of both groups said that girls were better

Exhibit TI-26: Gender Stereotype Ability Beliefs of Students, Parents, and Teachers for Teamwork, Wave 3



Relationship of Gender Stereotypes to Student Outcomes

We explored the relationship between holding stereotypes that favor one gender or another and outcomes relevant to the M-LEAP study, especially for girls who hold stereotypes that are unfavorable to girls in regard to STEM areas (e.g., that girls are not as good in science as are boys). To do this, we created a variable that measured the extent to which students endorsed a boy-favoring stereotype in STEM areas on a 0 to1 scale, with 0 representing no boy-favoring stereotypes in these subject areas, 0.33 representing holding a boy-favoring stereotype in one area, 0.66 corresponding to holding this stereotype in two areas, and a 1 representing holding a boy-favoring stereotype in all three STEM subject areas and skills. The distribution of boy-favoring stereotypes across these areas among girls for each wave is presented in Exhibit TI-27, which shows that most girls held boy-favoring stereotypes in either no area (67-73%) or only one area (19-25%). An identical variable was computed for mothers and fathers and is discussed below.

Exhibit TI-27: Distribution of Boy-Favoring Stereotypes Among Girls

Number of STEM areas in which holding boy-favoring stereotypes	W1		W2		W3	
	Girls (n)	%	Girls (n)	%	Girls (n)	%
0	235	69%	372	67%	492	73%
1	83	24%	140	25%	128	19%
2	21	6%	36	6%	46	7%
3	2	1%	9	2%	12	2%

In Wave 1, 3rd-6th grade girls who held more pro-boy gender stereotypes also had moderately lower self-efficacy and subjective task value beliefs in STEM areas, but this effect did not hold over time.

Pairwise correlations between this boy-favoring stereotype variable and female student SE and STV scores yielded insights into the relationship between gender stereotypes and how students felt about their abilities in and about the value of STEM school areas. In Wave 1, holding a boy-favoring stereotype in one or more areas was statistically significantly negatively related to SE and STV scores for girls in each STEM area at $\alpha = 0.05$. Correlations ranged from -.16 to -.21, indicating that girls who thought that boys were better at STEM areas also tended to feel moderately worse about their own abilities in those areas and saw them as less valuable.

Interestingly, most of these significant correlations became insignificant in Waves 2 and 3, with some notable exceptions. In Wave 2, holding a boy-favoring stereotype was statistically significantly negatively associated with SE scores in computers, for girls ($r = -.09$, $n = 557$, $p < .05$). In Wave 3, the negative association between boy-favoring stereotypes and STV in science for girls re-emerged ($r = -.11$, $n = 678$, $p < .01$), as it did for STV in computers ($r = -.10$, $n = 678$, $p < .05$). Girls who held boy-favoring stereotypes in more areas felt that science was less useful or interesting, on average, in two of the three waves of data collection.

Holding more gender stereotypes was unrelated to participation in STEM activities or selecting a STEM career, on average.

Other outcomes that were analyzed for potential relationships with holding boy-favoring stereotypes as a girl included the average frequency of participation in out-of-school STEM activities, and STEM career aspirations. These analyses revealed no statistically significant correlations between holding a boy-favoring stereotype in STEM areas and participation in STEM activities in any area in any wave. The only exception was that, for girls, endorsing boy-favoring stereotypes was statistically significantly negatively correlated with participating in STEM activities in Wave 3 ($r = -0.1$, $n = 678$, $p \approx .01$). This indicated that girls who endorsed boy-favoring stereotypes in STEM areas participated in fewer STEM activities outside of school in Wave 3 of data collection. Analyses further revealed no statistically significant correlations between holding a boy-favoring stereotype in STEM areas and selecting a STEM-related career.

Students who held more gender stereotypes tended to have mothers who also held more gender stereotypes.

Students' frequency of STEM areas in which they hold boy-favoring stereotypes was not statistically significantly correlated with parents' holding boy-favoring stereotypes in any wave when both genders of students were grouped together. However, when boys' and girls' frequency of holding boy-favoring gender stereotypes were compared with mothers and fathers, separately, a few significant correlations emerged. For girls, in Wave 1 of data collection, holding more gender stereotypes was statistically significantly correlated with mothers' number of gender stereotypes held ($r = .19$, $n = 201$, $p < .01$). Girls who held more gender stereotypes tended to have mothers who held more gender stereotypes, as well. This correlation remained statistically significant in Wave 2 ($r = .13$, $n = 138$, $p < .05$), but was not significant in Wave 3. For boys, holding more boy-favoring stereotypes was statistically significantly associated with having a mother who holds more gender stereotypes, as well, but only in Wave 1. The association between student and parent stereotypes was stronger for boys in Wave 1 than it was for girls in Wave 1 or Wave 2 (r = .31, n = 177, p < .001).

Parent gender stereotypes generally did not correlate with student outcomes.

Parents' holding boy-favoring gender stereotypes of ability in STEM areas was not statistically significantly correlated with students' SE or STV beliefs, or their career aspirations. The exception was that for both boys and girls, having a father who holds more boy-favoring gender stereotypes was statistically significantly negatively correlated with math STV in Wave 3 of data collection (ρ_{GIRLS} = -.21, p < .05; ρ_{BOYS} = -.22, p < .05). In Wave 3, boys and girls whose father held more boy-favoring gender stereotypes tended to have lower STV scores in math, on average.

Also:

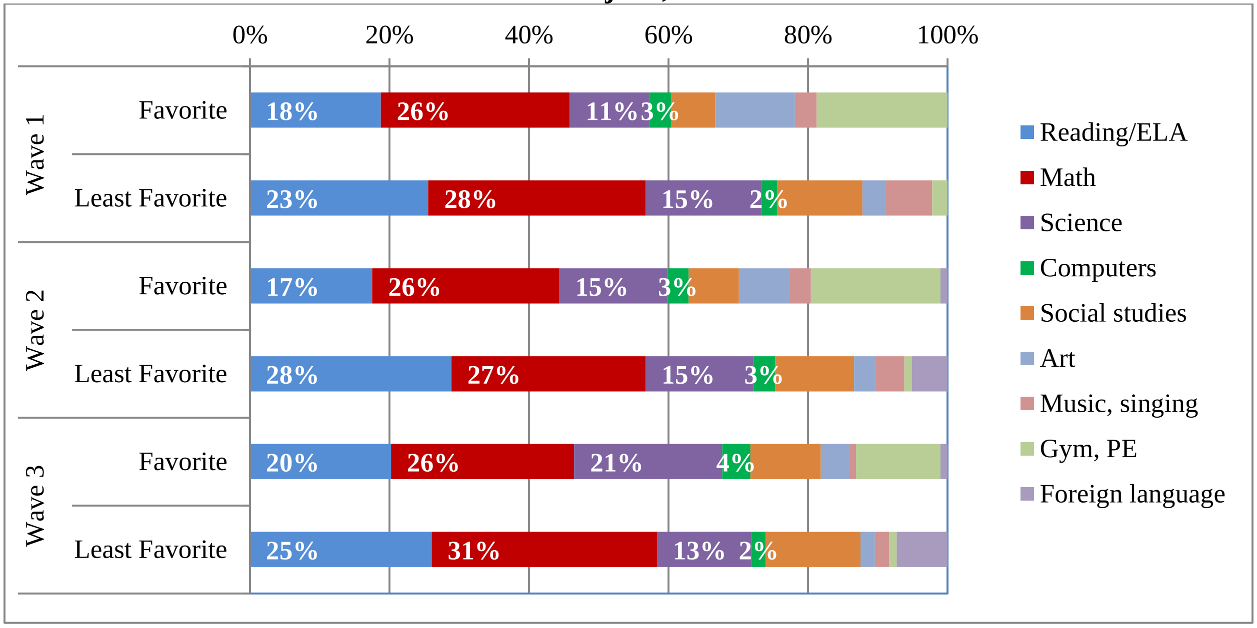
- In Wave 2, there was a positive association between having a mother who holds more boy-favoring stereotypes and selecting a STEM career, for girls (ρ = .15, p < .05), where girls whose mothers held more boy-favoring stereotypes tended to select a STEM job slightly more often.
- In Wave 2, there was a negative association between having a father who holds more boy-favoring stereotypes and selecting a STEM career, for boys (ρ = -.20, p < .05), where boys whose fathers held more boy-favoring stereotypes tended to select a STEM job slightly less often.

The results of HLM models predicting student SE and STV scores in STEM areas discussed in Chapter 7 revealed relationships between parental stereotype endorsement and student outcomes not found here. These included the findings that boys whose parents endorse more boy-favoring gender stereotypes have higher science, math, and computers SE and lower math STV, whereas girls whose parents endorse more boy-favoring gender stereotypes have lower science, math, and computers SE, but higher math STV.

FAVORITE AND LEAST FAVORITE SUBJECTS

Students were asked to write down both their favorite and least favorite subject in school. The percentages of students selecting each subject are presented below (n = 625-1,142). Wave 1 represents 3rd-6th graders, Wave 2 is 4th-7th graders, and Wave 3 is 5th-8th graders.

Exhibit TI-28: Favorite and Least Favorite Subjects, Waves 1-3

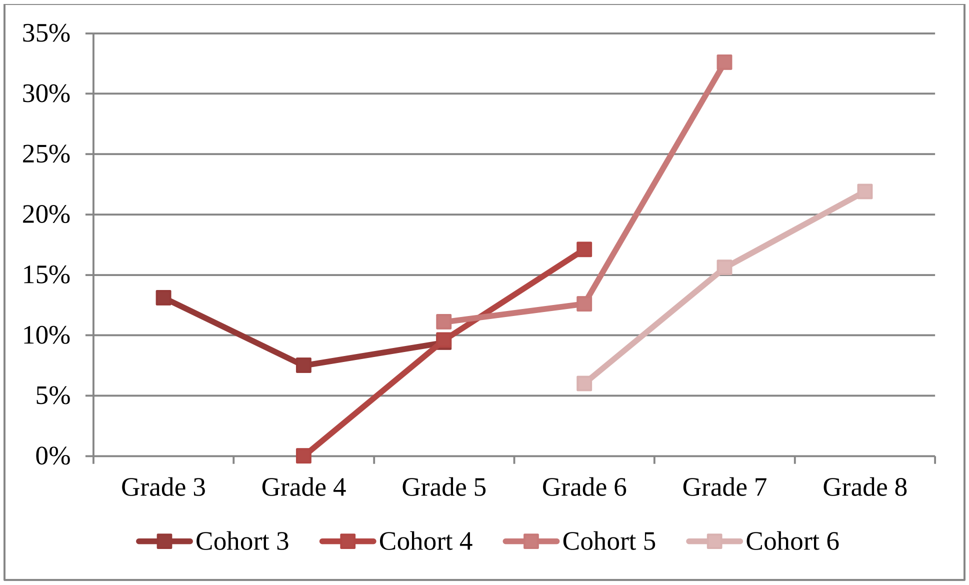


Most of the favorite and least favorite class selections involved core areas, like reading/ELA, math, science, and social studies; however, gym/PE was also a popular selection for favorite class. The percentage of students who responded with "None" or "Don't have one" was nearly zero.

The percentage of students selecting science as a favorite subject increased as they moved into higher grades, and this increase was more dramatic for girls than it was for boys.

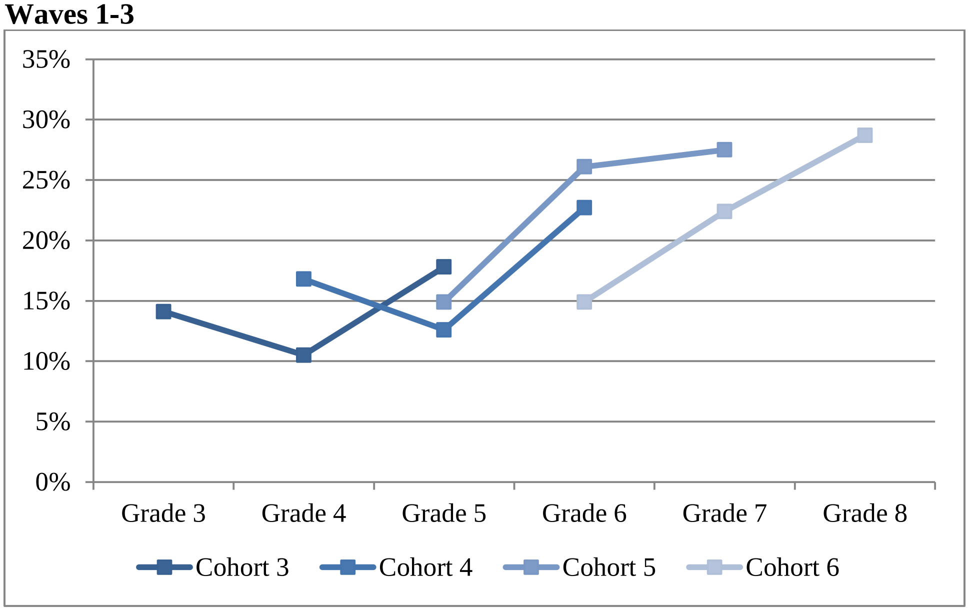
A few notable trends emerge from the data regarding the core areas. In science, the distribution of favorite versus least favorite showed an interesting reversal, with a greater percentage of students in Wave 1 disliking science than liking it and a greater percentage of students in Wave 3 liking science than disliking it. For girls, specifically, this change was even more dramatic: in Wave 1, only 7% of girls (*n* = 335) said that science was their favorite class, with 20% selecting it as their least favorite, while in Wave 3, 20% of girls (*n* = 438) said that science was their favorite subject and 15% said that it was their least favorite. This trend is illustrated in Exhibits 5-29 and 5-30, broken down by cohort, and Exhibits 5-31 and 5-32, which shows the trend in selecting science as a least favorite subject.

Exhibit TI-29: Percentage of Girls Selecting Science as a Favorite Subject, by Cohort, Waves 1-3



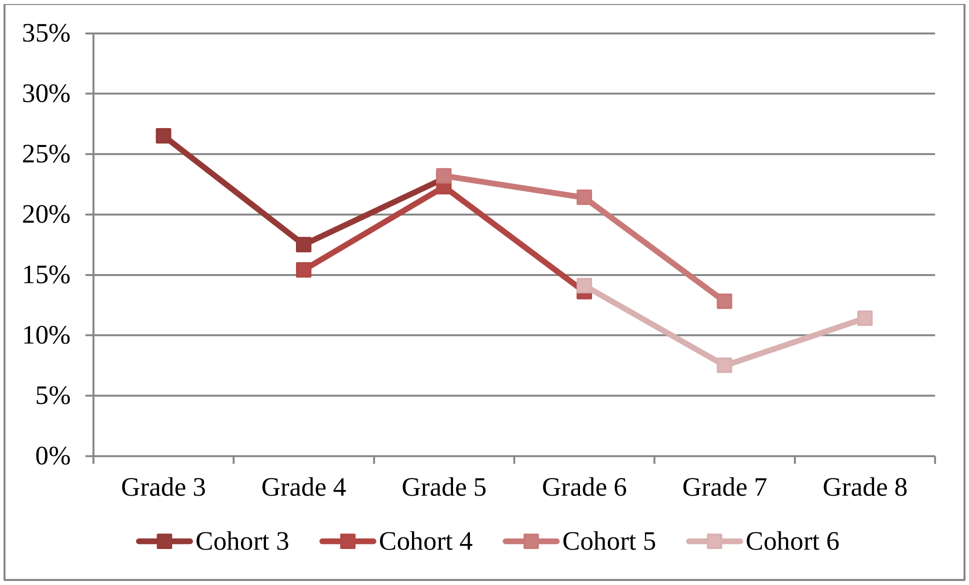
N = 72-123 per data point (for example, 84 3rd grade girls in Cohort 3 surveyed in Wave 1 responded to this item)

Exhibit TI-30: Percentage of Boys Selecting Science as a Favorite Subject, by Cohort, Waves 1-3



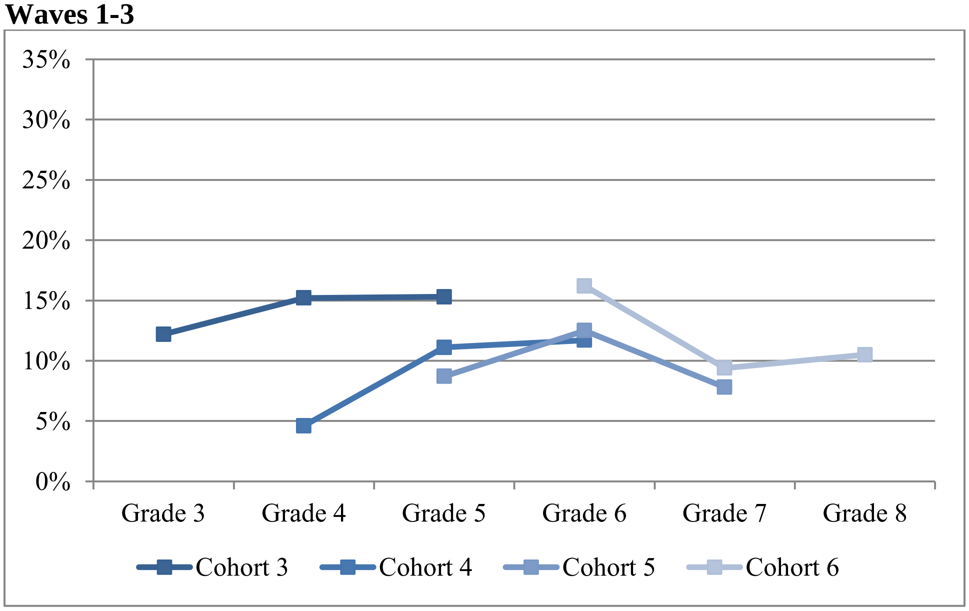
N = 74-105 per data point (for example, 89 6th grade boys in Cohort 5 surveyed in Wave 2 responded to this item)

Exhibit TI-31: Percentage of Girls Selecting Science as Least-Favorite Subject, by Cohort, Waves 1-3



N = 69-118 per data point

Exhibit TI-32: Percentage of Boys Selecting Science as Least-Favorite Subject, by Cohort, Waves 1-3



N = 69-99 per data point

For the M-LEAP sample as a whole, the ratio between favorite and least favorite for math stayed relatively constant, with "least favorite" edging out "favorite" slightly each wave. Again, though, the gap between these two options was greater for girls than it was for the sample as a whole: the average percentage of girls selecting math as their favorite subject over the three-wave period was 23% while the average percentage of girls selecting math as their least favorite subject over the same period was 32%, and this ratio stayed relatively constant over all three waves.

Students who picked a STEM area as their first or second favorite class had higher self-efficacy and subjective task value scores in STEM areas than those who did not, on average.

Whether or not a student selected a STEM area such as science, math, or computers as their first or second favorite class was related to their composite SE and STV scores in the STEM areas and skills, in the present sample. Independent samples t-tests showed that for each wave of data, the mean composite SE and STV scores for students who selected a STEM area as their favorite were statistically significantly higher than for those who did not select a STEM area ($p < .01$ in all cases). The size of this difference was large, averaging approximately half a point on a scale of 1-7 in the case of science SE and STV, slightly above 0.7 of a point for math SE and STV, and just over 0.3 of a point for computer STV. Students who picked a STEM class as their favorite had moderately higher SE and STV scores in STEM areas, on average.

The exception to this pattern was the relationship between selecting a STEM area and computers SE, where the difference in mean SE scores between students who selected a STEM area as their first or second favorite and those who did not was smaller than it was for the other areas — approximately 0.17 on a 1-7 scale - and only statistically significant in Wave 1 ($p < .05$) and Wave 2 ($p < .01$), but not Wave 3 ($p \approx .05$). Students who picked a STEM class as one of their favorites had slightly higher SE scores in computers, on average, but this difference was not as large as it was in other subject areas. The results of the multivariate HLM models predicting student SE and STV scores in STEM areas discussed in a later chapter showed that students whose favorite subject is non-STEM actually have higher computer STV scores.

Students who picked a STEM area as their first or second favorite class chose a STEM career at twice the rate of those who did not choose a STEM area.

Exhibit TI-33 shows the mean percentage of students selecting a STEM career disaggregated by whether or not they chose a STEM area as their first or second favorite class and the results of independent samples t-tests for differences in means between these two groups. Across all three waves, the percentage of students who chose a STEM career versus a non-STEM career differed statistically significantly between students whose first or second favorite class was STEM-related and those who favored another class ($p < .01$ in all cases). The mean percentage of students who selected a STEM career was higher among students who chose a STEM area than it was among those who did not choose a STEM area.

Exhibit TI-33: Results of Independent Samples T-Tests of Differences in Percentage of Students Selecting a STEM Career Between Those Whose Favorite Class was STEM and Others, by Gender, Wave 3

		1st or 2nd Favorite Subject was STEM (W3)	
		No	*Yes*
All	N	423	535
	Mean	0.13	0.29
	t	-5.83	
	df	965	
	p	< .01	
Girls	N	256	245
	Mean	0.09	0.18

	t	-3.12	
	df	499	
	p	< .01	
Boys	N	165	259
	Mean	0.21	0.39
	t	-4.03	
	df	422	

EDUCATIONAL AND CAREER ASPIRATIONS

Educational Aspirations

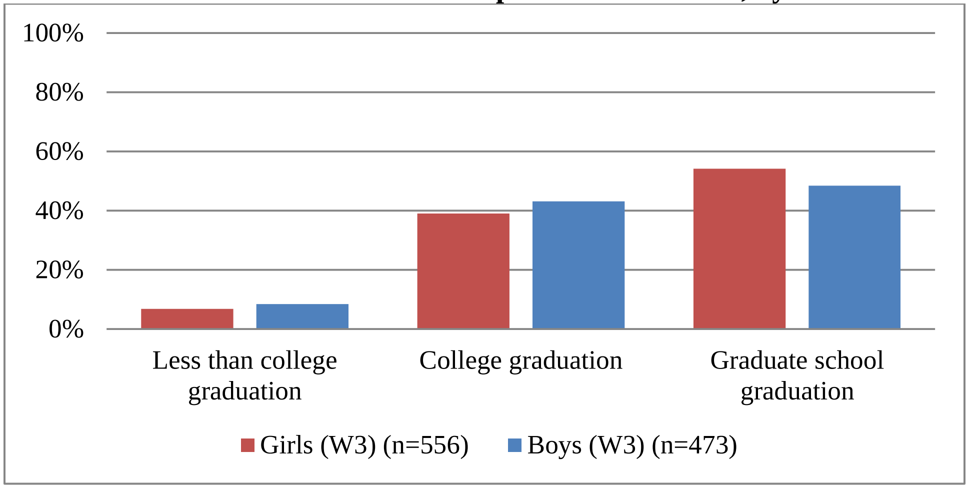
Students self-reported how far they thought they would advance in school, choosing from: "Some high school", "High school graduation or G.E.D.", "Some college", "College graduation", "Graduate degree (medicine, law, or advanced study of any subject)", and "Some other school or training program". To simplify our analyses and zero-in on the outcomes most relevant to this study, we collapsed students' responses to this question into a variable with the following three categories: "Less than college graduation," "College graduation," and "Graduate school graduation." In some analyses we use the term "underrepresented minority" to refer to African American, Latino, American Indian, Pacific Island and Hawaiian students in the sample.

According to U.S. government statistics, of the 3.2 million youth aged 16 to 24 who graduated from high school between January and October 2012, about 2.1 million (66.2%) were enrolled in college in October 2012 (Bureau of Labor Statistics, 2013) (This rate was slightly lower than the October 2011 rate of college entrance of 68.3%.) For 2012 graduates, the college enrollment rate was 71.3% for young women and 61.3% for young men. The college enrollment rate of Asians (82.2%) was higher than for recent white (66.6%), black (58.2%), and Hispanic (70.3%) graduates.

A large percentage of both girls and boys aspired to a graduate degree.

A slightly greater proportion of girls than boys in the M-LEAP sample expected to obtain a graduate school degree in Wave 3, with a greater percentage of boys indicating that they expected to advance as far as a college degree or somewhere less than college graduation. A chi-squared test with two degrees of freedom revealed that there was not a statistically significant relationship between gender and educational aspiration in Wave 3 of data collection (χ^2 = 3.56, $p \approx 0.17$).

Exhibit TI-34: Student Educational Aspirations in Wave 3, by Gender



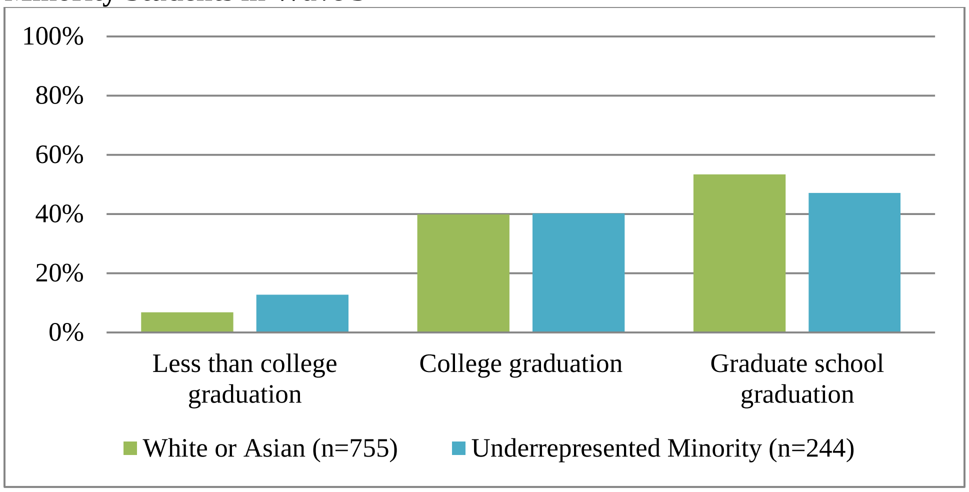
Both genders aspired to higher levels of education as they progressed into higher grades.

Exhibit TI-33 shows the percentage of boys and girls who selected each level of education in the final wave of data collection. A repeated-measures ANOVA with a Greenhouse-Geisser correction conducted with students with a complete three-year record (n = 288) determined that the mean educational aspiration score differed statistically significantly over the three waves ($F = 14.53$, $df = 1.97$, $p < .001$). The mean for students included in this ANOVA in Wave 1 on the educational aspiration trichotomous variable was 2.34, which corresponded to the average student selecting "College graduation" and above. In Wave 2, the mean was 2.48. In Wave 3, the mean for this set of students on the *EDUCASP* variable was 2.56, which corresponded to the average student selecting "Graduate school graduation" or below. Students educational aspirations rose over time; however, this same analysis revealed that there was no statistically significant interaction between this variable and gender ($F = 0.85$, $df = 1.97$, $p \approx 0.43$), meaning that both genders experienced a similar growth pattern over time.

There was a small but statistically significant difference between underrepresented minorities and white and Asian students in educational aspirations in Wave 3.

A chi-squared test with 2 degrees of freedom showed that there was a statistically significant difference in the distribution of formal academic aspirations among the two groups in Wave 3, with white and Asian students being slightly more likely to aspire to graduate school, on average, and underserved minority students being slightly more likely to aspire to "less than college graduation" ($\chi^2 = 9.35$, $df = 2$, $p<.01$).

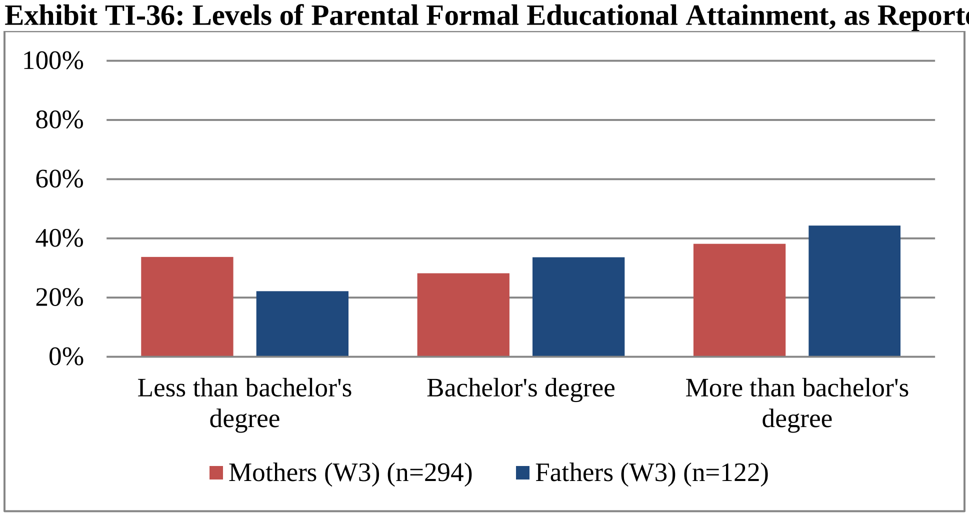
Exhibit TI-35: The Distribution of Formal Academic Aspirations for Minority and Non-Minority Students in Wave 3



The more education a mother had, on average, the higher her daughter's own educational aspiration.

Parents also reported their own level of educational attainment. Responses from Wave 3 are presented below by parent gender. The proportion of male parents who have at least a bachelor's degree exceeded that of female parents, while a greater proportion of mothers reported an education level below bachelor's degree. The difference is shown in Exhibit TI-35.

Exhibit TI-36: Levels of Parental Formal Educational Attainment, as Reported in Wave 3



Parents' reported education levels were compared with students' educational aspirations. Mothers' (but not fathers') education level was positively linearly associated with students' academic aspirations in Waves 2 and 3 of the study, when boys and girls were compared as one group (r_{Wave2} = .25, p <.01; r_{Wave3} = .17, p <.01). Students whose mothers had advanced farther in formal education tended to hold higher academic aspirations for themselves, on average.

This finding was then examined for differences by gender, and while this relationship between student aspirations and mothers' attainment strengthened slightly when the comparison group was girls (r_{Wave2} = .33, p <.01; r_{Wave3} = .19, p <.01), it dropped and became non-statistically significant for boys (r_{Wave2} = .14, p = .14; r_{Wave3} = .17, p = .09). Girls whose mothers had higher educational attainment also held higher educational aspirations, themselves, in Waves 2 and 3, but this association was not found to be statistically significant for boys in any wave.

Career Aspirations

Students wrote down the jobs that they would like to have as adults. We coded their responses into the following categories: science, technology, engineering, and math (STEM) jobs versus non-STEM jobs. At this level of analysis, "STEM" jobs included those that match the NSF definition of a STEM career. The most commonly selected STEM jobs were engineer, architect, and marine biologist. "Non-STEM" jobs included allied health careers and other jobs. The three most popular non-STEM jobs were lawyer, teacher, and artist. Exhibit TI-36, below, shows the percentage of boys and girls selecting a STEM job or a non-STEM job during each wave of data collection.

Exhibit TI-37: Percentage of Male and Female Selecting Non-STEM and STEM jobs

		Non-STEM	STEM	N
Girls	W1	89%	11%	333
	W2	88%	12%	526
	W3	88%	12%	539
Boys	W1	71%	29%	313
	W2	74%	26%	495
	W3	69%	31%	457

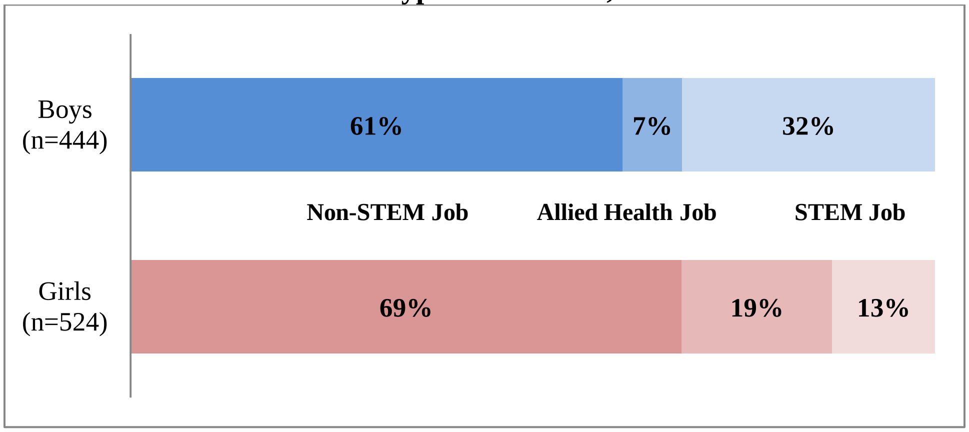
While the majority of students in both genders preferred non-STEM careers, boys selected a STEM career with greater frequency than did girls during all three waves of data collection.

A chi-squared test with one degree of freedom showed that the distribution for career preference (i.e. STEM or non-STEM) was statistically significantly different for boys and girls in all three waves of data collection (p <0.001 for all waves). This suggests that whether or not students selected a STEM job or a non-STEM job depended on whether or not they were a boy or a girl, with boys selecting STEM jobs more frequently.

More girls than boys aspired to work in allied health.

In order to get a more fine-grained insight into the kinds of careers that students wanted to pursue, non-STEM jobs were further divided into "allied health" jobs versus regular non-STEM jobs. The most popular "allied health" jobs were doctor, veterinarian, and nurse. Here, we present the results of this additional level of coding for the sample as a whole, separated by gender

Exhibit TI-38: Preferred Job Type for Students, Wave 3



Note: STEM job choice results are shown disaggregated by school and wave in Technical Appendix II.

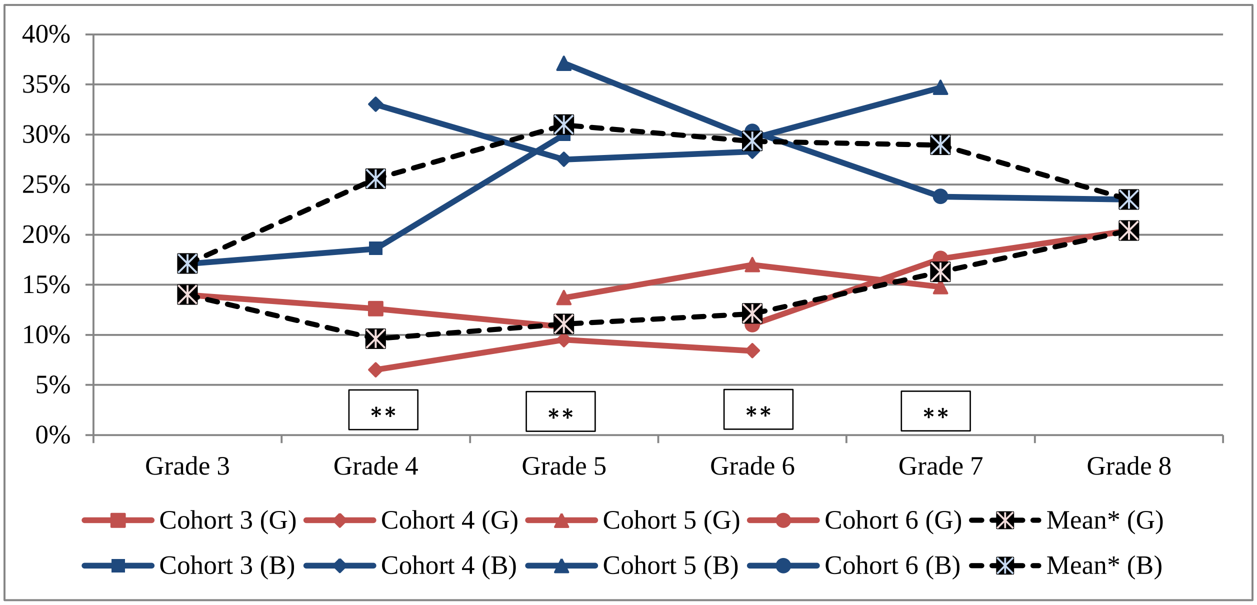
A chi-squared test with two degrees of freedom showed that the distribution of career choices (i.e., non-STEM, allied health, or STEM) in the final wave of data collection was statistically significantly different for boys and girls (χ^2 = 63.87, p <0.001). This indicates that there was a relationship between student gender and career choice, with boys being more likely to select a STEM job and less likely to select a non-STEM or allied health job.

Wave 3 results are relatively similar to the findings from Waves 1 and 2. For instance, the percentage of girls selecting a STEM career was 11% in Wave 1 and 13% in Wave 3. A repeated-measures ANOVA with a Greenhouse-Geisser correction conducted with female students who had a complete three-year record (n = 165) determined that this was not a statistically significant change. For boys, 31% in Wave 1 and 32% in Wave 3 selected STEM careers. Surprisingly, a repeated-measures ANOVA with a Greenhouse-Geisser correction conducted using male students who had a complete three-year record (n = 134) determined that for boys who filled out a survey every wave, the percentage selecting a STEM career actually dropped from an average of 34% to 29% over the three waves, and this result was statistically significant.

Boys and girls exhibited opposite trends in the rate of selecting a STEM career over the course of school. After 3rd grade, the percentage of boys selecting a traditional STEM job went up and then back down, while girls went down and then up.

About 15% of boys and girls in 3rd grade chose a STEM career, such as engineering, but the general trend after this grade was for a higher percentage of boys than girls to select a STEM job. Exhibit TI-41 shows the percentage of students selecting a STEM job during each wave of data collection by gender, grade, and cohort.

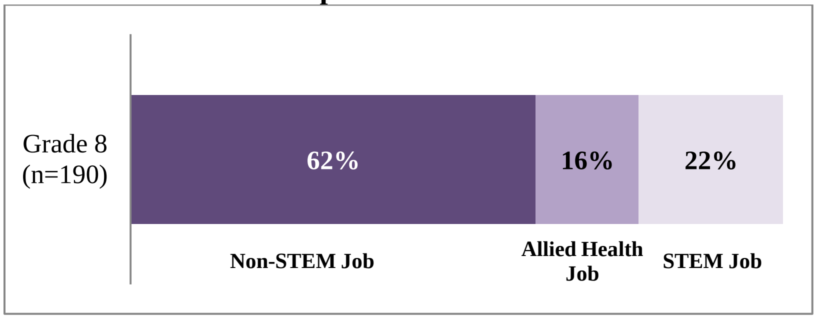
Exhibit TI-39: Percentage of Boys and Girls Selecting a STEM Career in Waves 1-3, by Grade



N = 68-108 per data point (for example, there were 86 3rd grade girls surveyed in Wave 1)
*Note that due to the study design, the number of data points being averaged within each gender per grade ranges from one to three. This mean represents a weighted arithmetic mean. ** = $p < .01$ in two-tailed z-test of difference in proportions between two groups.

Exhibit TI-40 shows the percentage of students in our sample selecting a non-STEM job, allied health job, and STEM job at the end of 8th grade.

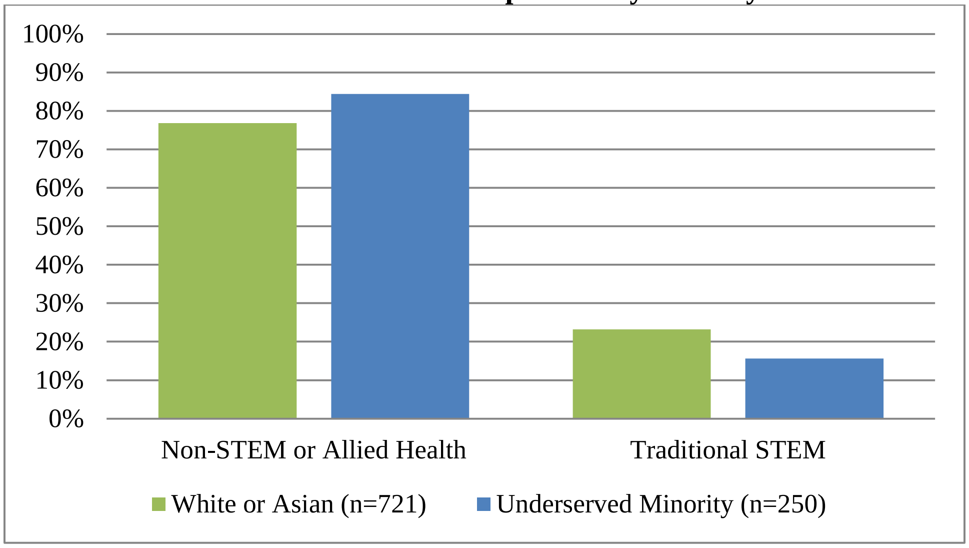
Exhibit TI-40: Career Aspirations of 8th Grade Students in Wave 3



Underrepresented minority students were moderately less likely to aspire to a STEM career than white or Asian students.

A chi-squared test with 1 degree of freedom showed that there was a statistically significant difference in the distribution of career aspirations among the two groups in Wave 3, with white and Asian students being slightly more likely to aspire to a traditional STEM career, on average, and underrepresented minority students being slightly more likely to aspire to a non-STEM or allied health career ($\chi^2 = 6.35$, p<.05).

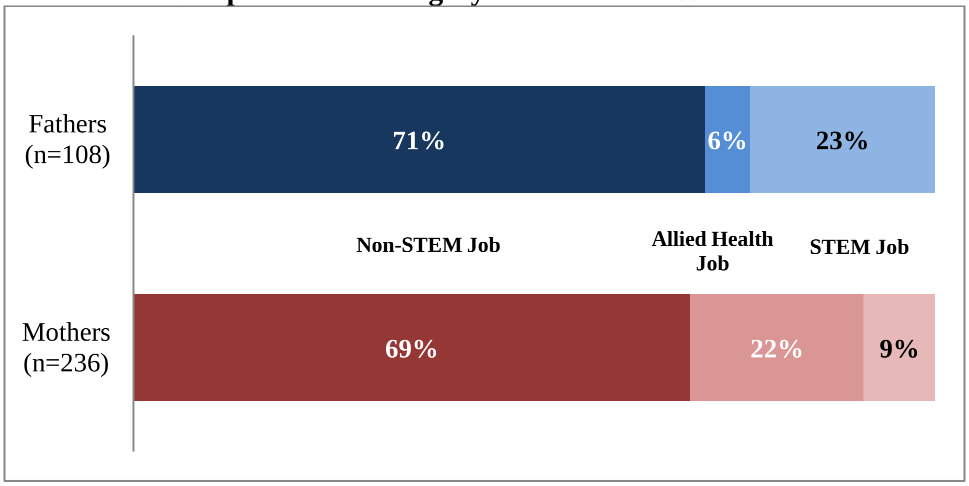
Exhibit TI-41: Distribution of career aspiration by minority status in Wave 3



There was no correlation between parent STEM job status and student job choice.

Parents who completed the parent survey also self-reported their career, which was similarly coded. Results of this coding for parents who submitted a survey in Wave 3 of data collection are presented below.

Exhibit TI-42: Reported Job Category for Parents in Wave 3



A chi-squared test with 2 degrees of freedom showed that the distribution of parental job status was not statistically significantly different for students who selected a STEM career versus those who selected a non-STEM or allied health career ($\chi^2 = 3.34$, p ≈ .19). In other words, the parents of students who selected a STEM job or a non-STEM job had a similar job distribution, indicating that there was not a heavy skew toward parents having a STEM job amongst students who chose a STEM job or a skew toward parents not having a STEM job amongst students who selected a non-STEM job.

This was also confirmed by testing for Spearman correlations between parents' job status (non-STEM vs. STEM) and students' job choice (non-STEM vs. STEM), which showed no statistically significant relationship between these two variables, or any gender differences in this trend. Children of parents who worked in a STEM field were not statistically significantly more or less likely to choose a STEM job, on average, and this trend was seen in both genders.

There was generally no statistically significant relationship between parents' STEM job status and students' gender stereotypes in STEM areas.

No statistically significant correlations were found between parent STEM job status and students' gender stereotypes, except for a moderately strong correlation in Wave 3 between mothers and female students where female students whose mothers worked in a STEM field also tended to hold boy-favoring stereotypes in more STEM areas, on average ($\rho = .21$, $n = 126$, $p < .05$).

The relationship between career aspirations and student self-efficacy and subjective task value

Students who hold a STEM career aspiration tended to have higher self-efficacy and subjective task value beliefs in STEM areas.

We examined whether or not students who aspired to a STEM career tended to have higher SE and STV ratings in STEM areas. When boys and girls were compared as one group, there was a small but statistically significant Spearman correlation between the career aspiration variable and SE composite means which gradually grew stronger over the three waves ($\rho_{W1}= .08$, $p < .05$; $\rho_{W2}= .13$, $p < .01$; $\rho_{W3}= .18$, $p < .01$). Holding a STEM career aspiration was associated with higher SE beliefs, on average. The same was true for Spearman correlations between the career aspiration variable and STV composite means, where holding a STEM career aspiration was associated with having higher STV beliefs, on average; however, this relationship was even stronger than it was for SE beliefs ($\rho_{W1}= .15$, $p < .01$; $\rho_{W2}= .22$, $p < .01$; $\rho_{W3}= .23$, $p < .01$). Additional analyses revealed that the strengths of these relationships were not statistically significantly different by gender, suggesting that students from both genders who held a STEM career aspiration tended to have higher SE and STV beliefs in STEM areas.

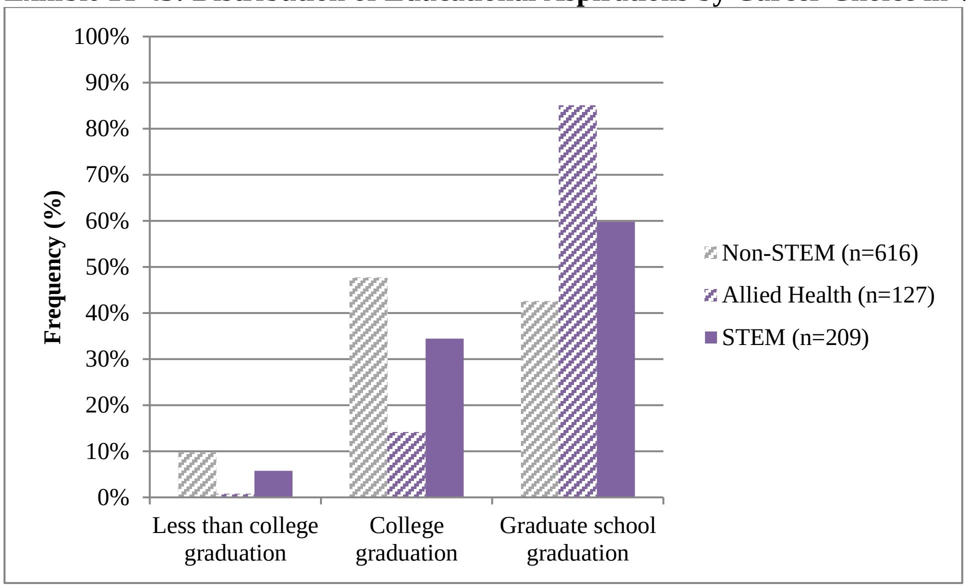
The relationship between educational aspirations and career aspirations

We examined whether or not students who held higher aspirations for advancement in formal education were also more likely to self-report wanting a STEM job when they grew up.

Students with STEM career aspirations envisioned getting more formal schooling than students who aspired to a non-STEM career.

Correlations between our measure of academic aspirations and our various measures of STEM career aspiration consistently hinted toward a positive association between selecting an advanced academic degree and aspiring to hold a STEM job. Across the three waves, correlations between the trichotomous career choice variable and the trichotomous education aspiration variable were statistically significant at $\alpha = .01$ and ranged from .23 to .25, suggesting that students who held STEM career aspirations also tended to hold higher aspirations for formal education. The following figure shows the distribution of educational aspiration for students dependent on their career choice. A chi-squared test with four degrees of freedom confirmed that the distribution of educational aspiration differed across the career choices (χ^2 = 83.72, p<0.001).

Exhibit TI-43: Distribution of Educational Aspirations by Career Choice in Wave 3



H. **TECHINCAL APPENDIX II**

STUDENT OUTCOMES BY SCHOOL

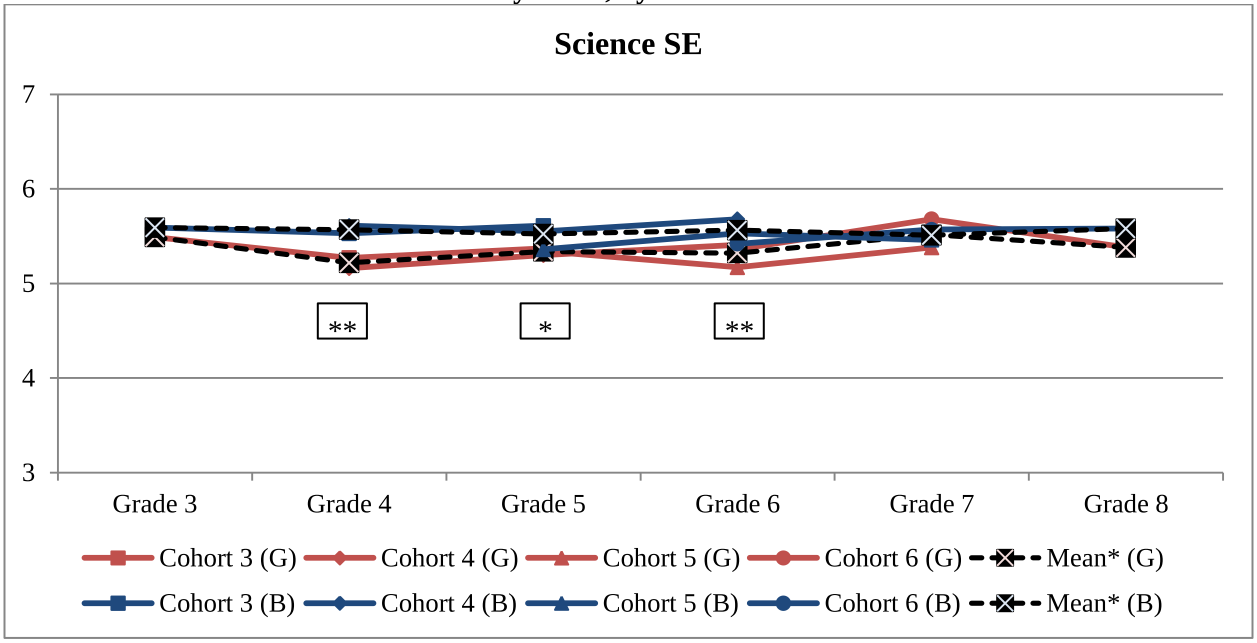
Exhibit TII-1: Mean Self-Efficacy Scores, Subjective Task Value Scores, and STEM Career Choice Selection on Student Survey in All Three Waves, by School

School		SCIENCE		MATH		COMPUTERS			
		Mean SE	Mean STV	Mean SE	Mean STV	Mean SE	Mean STV	n	% STEM career choice
Winship	*W1*	5.35	5.14	5.48	5.44	6.15	6.20	106	13%
	W2	4.99	4.57	5.50	5.34	6.30	6.08	72	10%
	W3	5.24	4.97	5.37	5.29	5.81	5.71	65	12%
Prescott	*W1*	5.31	4.97	5.40	5.25	5.43	5.54	136	26%
	W2	5.43	4.92	5.45	5.30	5.43	5.36	249	29%
	W3	5.31	4.75	5.31	5.12	5.38	5.34	273	25%
Beaufort	*W1*	5.29	4.88	5.55	5.29	6.15	5.96	48	21%
	W2	5.27	4.75	5.13	4.87	5.66	5.35	57	19%
	W3	5.56	5.02	5.32	4.95	5.34	5.20	35	23%
Pace	*W1*	5.29	4.84	5.73	5.41	5.91	5.90	80	19%
	W2	5.24	4.82	5.57	5.42	5.80	5.79	126	14%
	W3	5.23	4.92	5.35	5.32	5.70	5.63	116	22%
Girton	*W1*	5.70	5.64	6.13	5.98	6.13	5.86	73	18%
	W2	5.76	5.60	5.95	5.80	6.06	5.93	146	15%
	W3	5.93	5.48	5.92	5.55	6.06	5.89	125	20%
Allentown	*W1*	5.60	5.23	5.77	5.60	5.68	5.53	101	24%
	W2	5.71	5.31	5.58	5.48	5.74	5.66	67	22%
	W3	5.60	5.03	5.23	5.18	5.51	5.40	66	27%
Davison	*W1*	5.41	5.25	5.60	5.48	5.69	5.71	102	18%
	W2	5.36	5.18	5.58	5.50	5.86	5.82	179	16%
	W3	5.51	5.23	5.57	5.37	5.83	5.79	200	16%
Heybridge*	*W2*	5.34	5.22	5.13	5.36	5.70	5.52	169	19%
	W3	5.43	5.14	4.90	5.11	5.79	5.56	161	22%
Total	*W1*	5.42	5.14	5.64	5.48	5.82	5.79	646	20%
	W2	5.40	5.08	5.50	5.41	5.77	5.66	1065	19%
	W3	5.45	5.04	5.37	5.25	5.68	5.58	1041	21%

* Note: This school entered the sample in Wave 2.

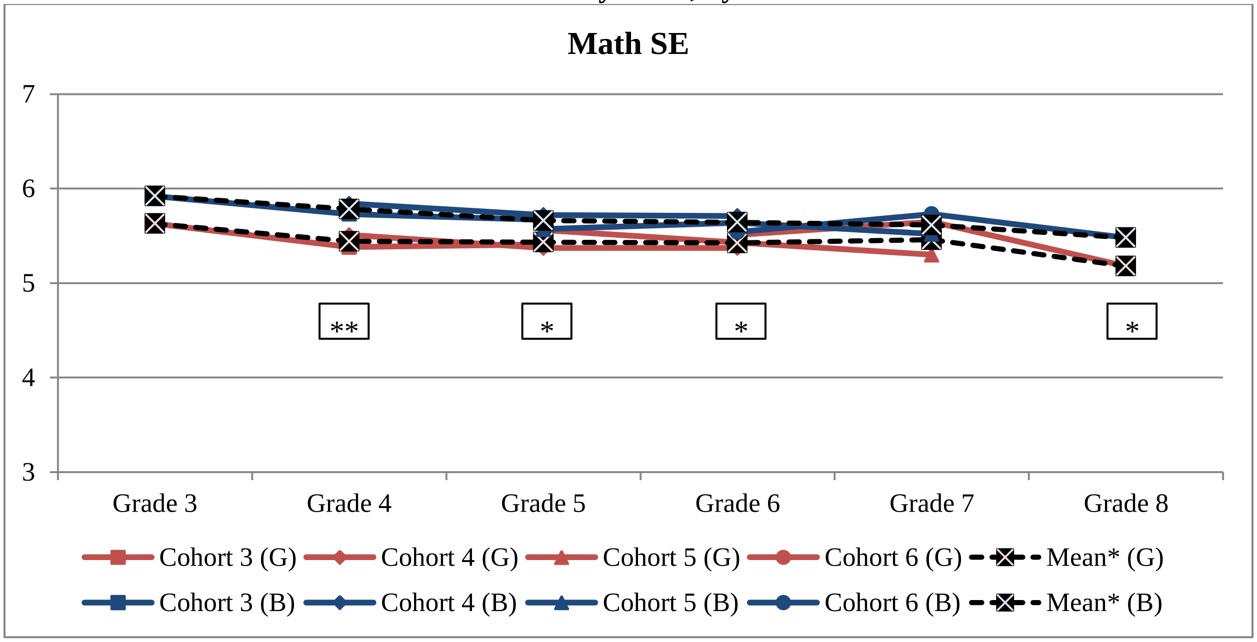
SELF-EFFICACY (SE)

Exhibit TII-2: Mean Science Self-Efficacy Score, by Gender and Cohort



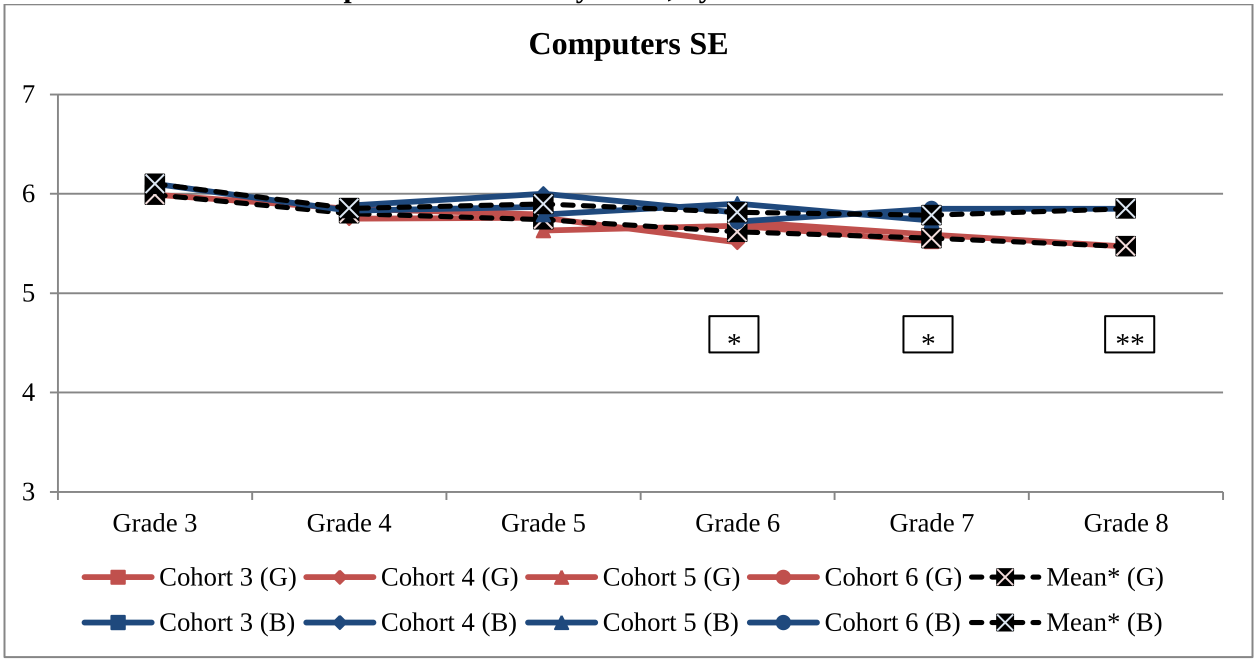
N = 74-142 per data point (for example, there were 87 3rd grade girls surveyed in Wave 1)
*Note that due to the study design, the number of data points being averaged within each gender per grade ranges from one to three. This mean represents a weighted arithmetic mean. Truncated: true range 1-7.
* = $p < .05$, ** = $p < .01$; represents results of 2-tailed independent samples t-test assuming equal variance.

Exhibit TII-3: Mean Mathematics Self-Efficacy Score, by Gender and Cohort



N = 74-142 per data point. Truncated: true range 1-7.
* = $p < .05$, ** = $p < .01$; represents results of 2-tailed independent samples t-test assuming equal variance.

Exhibit TII-4: Mean Computers Self-Efficacy Score, by Gender and Cohort



N = 74-142 per data point. Truncated: true range 1-7.
* = $p < .05$, ** = $p < .01$; represents results of 2-tailed independent samples t-test assuming equal variance.

Exhibit TII-5: Correlations Between Students' and Mothers' Self-Efficacy Ratings (Both Rating Child)

			Mothers														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Students	Reading	W1	.387**														
		W2		.473**													
		W3			.478**												
	Math	W1				.513**											
		W2					.547**										
		W3						.579**									
	Science	W1							0.227**								
		W2								.448**							
		W3									.330**						
	Computers	W1										0.04					
		W2											.248**				
		W3												.284**			
	Teamwork	W1													.264**		
		W2														.266**	
		W3															.276**

n = 282-283, * = $p < 0.05$, ** = $p < .01$

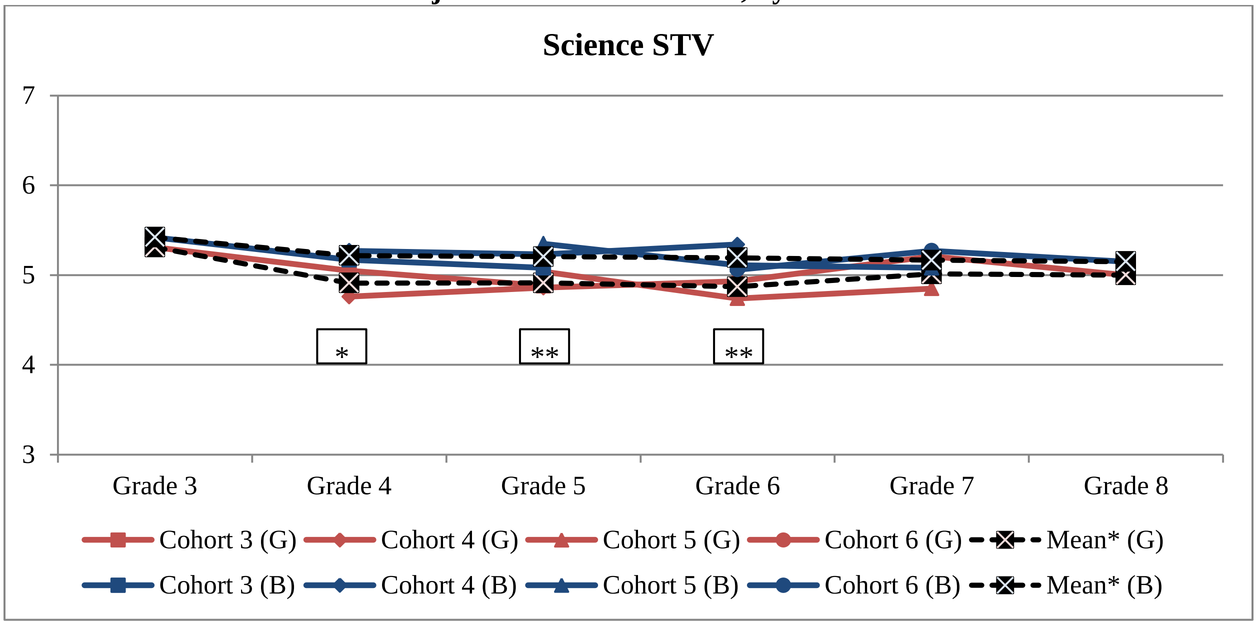
Exhibit TII-6: Correlations Between Students' and Fathers' Self-Efficacy ratings (Both Rating Child)

			Fathers														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Student	Reading	W1	.258**														
		W2		.369**													
		W3			.438**												
	Math	W1				.356**											
		W2					.589**										
		W3						.488**									
	Science	W1							0.203								
		W2								.274**							
		W3									.233*						
	Computers	W1										0.097					
		W2											0.108				
		W3												0.172			
	Teamwork	W1													.369**		
		W2														.324**	
		W3															.181*

n = 122-167, * = $p < 0.05$, ** = $p < .01$

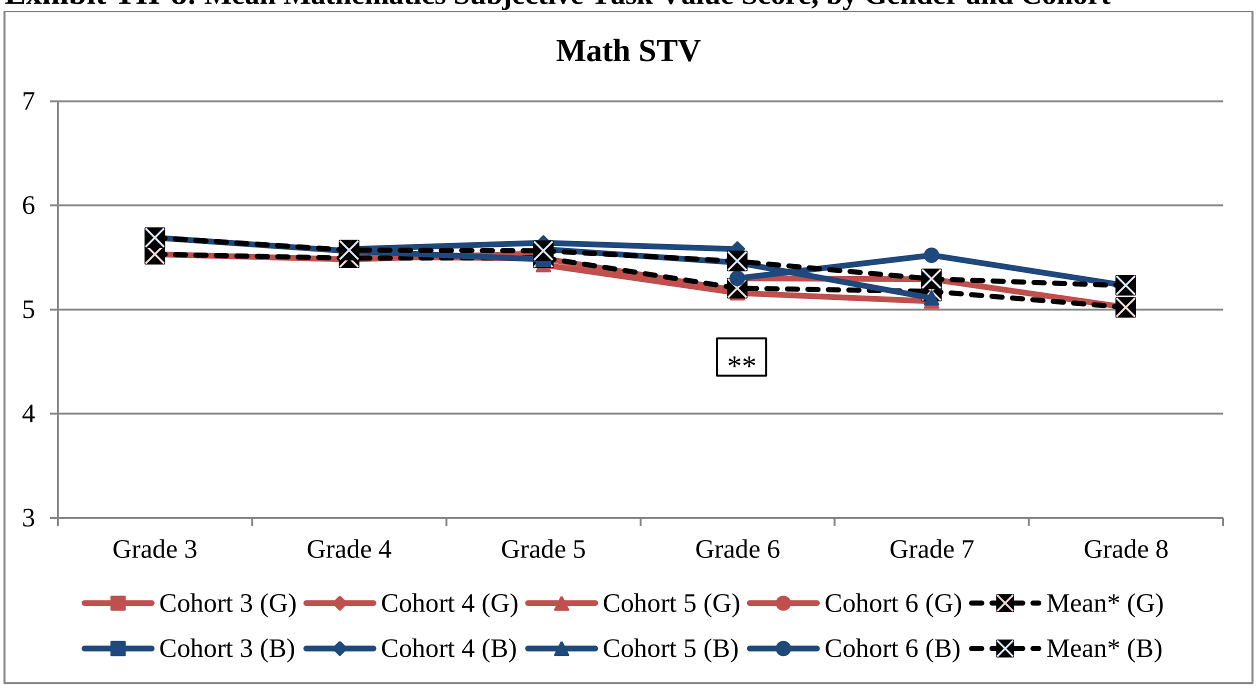
SUBJECTIVE TASK VALUE (STV)

Exhibit TII-7: Mean Science Subjective Task Value Score, by Gender and Cohort



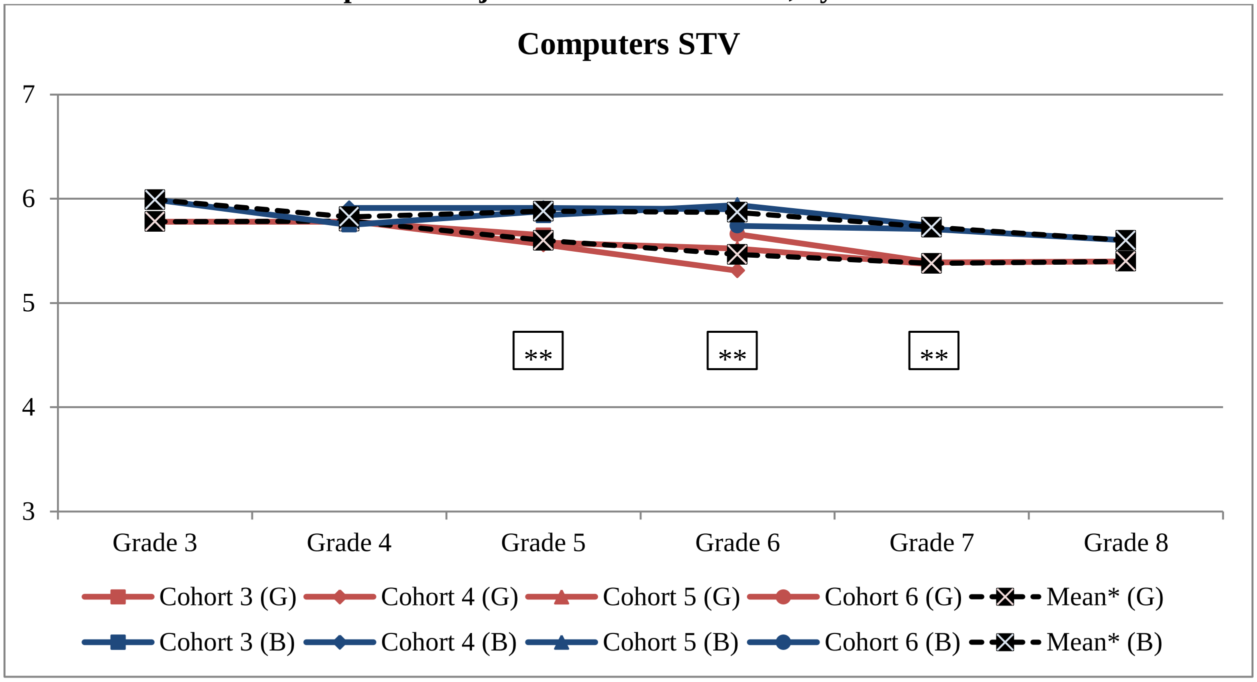
N = 74-142 per data point. Truncated: true range 1-7.
* = *p* < .05, ** = *p* < .01; represents results of 2-tailed independent samples t-test assuming equal variance.

Exhibit TII-8: Mean Mathematics Subjective Task Value Score, by Gender and Cohort



N = 74-142 per data point. Truncated: true range 1-7.
* = *p* < .05, ** = *p* < .01; represents results of 2-tailed independent samples t-test assuming equal variance.

Exhibit TII-9: Mean Computers Subjective Task Value Score, by Gender and Cohort



N = 74-142 per data point. Truncated: true range 1-7.
* = $p < .05$, ** = $p < .01$; represents results of 2-tailed independent samples t-test assuming equal variance.

UTILITY RATINGS

Exhibit TII-10: Correlations Between Students' and Mothers' Utility Ratings

			Mothers														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Students	Reading	W1	.138*														
		W2		.151**													
		W3			.148*												
	Math	W1				.146**											
		W2					.189**										
		W3						.177**									
	Science	W1							.253**								
		W2								.174**							
		W3									.271**						
	Computers	W1										.126*					
		W2											0.101				
		W3												.141*			
	Teamwork	W1													.168**		
		W2														.184**	
		W3															.189**

n = 284-320, * = $p < 0.05$, ** = $p < .01$

Exhibit TII-11: Correlations Between Students' and Fathers' Utility Ratings

			Father														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Student	Reading	W1	0.090														
		W2		.199**													
		W3			.232*												
	Math	W1				.257**											
		W2					0.084										
		W3						.189*									
	Science	W1							.250**								
		W2								.189*							
		W3									.230*						
	Computers	W1										.172*					
		W2											0.059				
		W3												.196*			
	Teamwork	W1													0.096		
		W2														0.040	
		W3															0.104

n = 122-167, * = $p < 0.05$, ** = $p < .01$

STUDENT SE AND STV RATINGS

Exhibit TII-12: Correlations Between Student Self-Efficacy and Subjective Task Value Scores

			STV														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
SE	Reading	W1	.645**														
		W2		.624**													
		W3			.614**												
	Math	W1				.693**											
		W2					.654**										
		W3						.640**									
	Science	W1							.644**								
		W2								.607**							
		W3									.627**						
	Computers	W1										.672**					
		W2											.608**				
		W3												.642**			
	Teamwork	W1													.600**		
		W2														.624**	
		W3															.660**

n = 667-1327, ** = $p < .001$

STUDENT AND TEACHER RATINGS OF ABILITY AND INTEREST

Exhibit TII-13: Correlations Between Students' and Teachers' Ability Ratings (Both Rating Students)

			Teachers														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Students	Reading	W1	.300**														
		W2		.440**													
		W3			.384**												
	Math	W1				.363**											
		W2					.514**										
		W3						.552**									
	Science	W1							.149**								
		W2								.290**							
		W3									.285**						
	Computers	W1										-0.009					
		W2											.102*				
		W3												0.052			
	Teamwork	W1													.218**		
		W2														.211**	
		W3															.172**

n = 351-1094, * = $p < 0.05$, ** = $p < .01$

Exhibit TII-14: Correlations Between Students' and Teachers' Interest Ratings (Both Rating Students)

			Teachers														
			Reading			Math			Science			Computers			Teamwork		
			W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
Student	Reading	W1	.313**														
		W2		.330**													
		W3			.305**												
	Math	W1				.203**											
		W2					.290**										
		W3						.359**									
	Science	W1							.108*								
		W2								.103*							
		W3									.233**						
	Computers	W1										0.049					
		W2											.125**				
		W3												.140**			
	Teamwork	W1													.119**		
		W2														.182**	
		W3															.233**

n = 356-1091, * = $p < 0.05$, ** = $p < .01$

MULTIVARIATE MODELS PREDICTING STEM BELIEFS AND ATTITUDES: SCHOOL AND COHORT RESULTS

	Time Invariant	Time Varying	
	On average, who scores higher on the outcome across time?	*Whose scores on the outcome increase over time?*	*As outcome scores increase over time, what other variables change along with them?*
SCIENCE			
STV	▪ Students in Girton, Davison, and Heybridge (vs. Winship)	▪ DECREASES for students in Heybridge (vs. Winship) ▪ Cohorts entering in later grades	
SE	▪ Cohorts entering in earlier grades	▪ DECREASES for students in Pace (vs. Winship)	
MATH			
STV	▪ Students in Allentown and Heybridge (vs. Winship) ▪ Cohorts entering in earlier grades		
SE	▪ LOWER scores for students in Heybridge (vs. Winship)	▪ DECREASES for students in Pace (vs. Winship)	
COMPUTERS			
STV	▪ Students in Davison (vs. Winship)	▪ Students in Pace, Girton, Davison (vs. Winship)	
SE	▪ LOWER scores for students in Prescott, Pace, and Allentown (vs. Winship)	▪ Heybridge (vs. Winship)	

MULTIVARIATE MODEL PREDICTING JOB ASPIRATIONS: SCHOOL AND COHORT RESULTS

	Time Invariant	Time Varying	
	On average, who scores higher on the outcome across time?	*Whose scores on the outcome increase over time?*	*As outcome scores increase o time, what other variables change along with them?*
STEM	▪ Students at Prescott and Heybridge (vs. Winship)		
Allied Health	▪ Students at Girton and Davison (vs. Winship)		

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