

Is Science Me? High School Students' Identities, Participation and Aspirations in Science, Engineering, and Medicine

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Received 18 March 2009; Accepted 28 October 2009

Abstract: This study follows an ethnically and economically diverse sample of 33 high school students to explore why some who were once very interested in science, engineering, or medicine (SEM) majors or careers decided to leave the pipeline in high school while others persisted. Through longitudinal interviews and surveys, students shared narratives about their developing science identities, SEM participation and aspirations. In analysis, three groups emerged (High Achieving Persisters, Low Achieving Persisters, and Lost Potentials), each experiencing different interactions and experiences within science communities of practice in and outside of school and within the extended family. These different microclimates framed students' perceptions of their SEM study, abilities, career options, and expected success, thereby shaping their science identities and consequent SEM trajectories. School science was often hard and discouraging; there were very few science advocates at school or home; and meaningful opportunities to work with real science professionals were scarce, even in schools with science or health academies. Students expressed positive attitudes toward science and non-science pursuits where they experienced success and received support from important people in their lives. Results underscore the key role communities of practice play in career and identity development and suggest a need for interventions to help socializers better understand the value and purpose of science literacy themselves so as to encourage students to appreciate science, be aware of possible career options in science and enjoy learning and doing science. © 2009 Wiley Periodicals, Inc. *J Res Sci Teach* 47: 564–582, 2010

Keywords: identity; attitudes and achievement; diversity; secondary

Science understanding is an increasingly precious resource throughout the world. Despite reformers' vision of science for *all* (American Academy for the Advancement of Science, 1990; National Research Council, 1996), many students (and their parents) consider math and science irrelevant to their personal interests and goals and are unaware of how many jobs require this knowledge (Kadlec, Friedman, & Ott, 2007). In the USA context, women and most minorities continue to be under-represented in the physical sciences, engineering and technology (National Science Board, 2006; National Science Foundation, 2006; U.S. Department of Education, 2006). As science education efforts fail to reach out and invite all students to learn science, the current workforce ages, and fewer native-born science and engineering graduates enter the labor force. Concerns have grown about the nation's ability to remain globally competitive and to retain good jobs and a high standard of living (Business Roundtable, 2005; National Academies, 2007). Engaging more students in learning science, particularly under-represented females and minorities, could not only increase the talent pool but also lead to more equitable economic opportunities, wider utilization of science understandings in people's lives, and new viewpoints in the practice and teaching of science. Newcomers to the discipline could influence the goals, knowledge, and culture of science as well as challenge narrow assumptions about who is capable of learning and doing science in a field historically dominated by white middle-class males (and recently Asian males) sometimes referred to as the "culture of power" (Calabrese Barton & Yang, 2000; Harding, 1998; Schiebinger, 1989).

Contract grant sponsor: National Science Foundation (NSF); Contract grant number: REC0231878.

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DOI 10.1002/tea.20353

Published online 4 December 2009 in Wiley InterScience (www.interscience.wiley.com).

There has been considerable research on young people's career interests, interactions with science, and development of confidence in and identification with science, primarily through small case studies, large quantitative datasets, and retrospective interviews of adults (Carlone, 2004; Furman & Calabrese Barton, 2006; Hanson, 1996; Seymour & Hewitt, 1997). Yet there is still much to understand about what invites diverse young people to appreciate, desire to learn, and develop a sense of themselves as someone who does science; how they perceive and pursue their science interests and career options; and why so many young people initially interested in science eventually choose not to continue learning science or pursuing careers involving science. To investigate these issues, the present study uses a longitudinal approach with an ethnically and economically diverse sample to explore family and school factors that may affect the trajectory of high school students' science identity, participation and aspirations. The nature of the sample allows us to examine possible gender, ethnic, and economic interactions seldom addressed in past research, and the longitudinal design allows for cause-effect inferences. A combination of interview and survey data tracks students over time on multiple questions while allowing for deeper probing of key questions to better understand students' perspectives.

This study utilizes and expands the metaphor of the *science pipeline*, used to represent the successive training experiences necessary for students to consider a career in science (Berryman, 1983). Hanson (1996) later distinguished four dimensions or pipelines along which students experience science: access, activity, achievement, and attitudes. In a recent quantitative study (Gilmartin, Li, & Aschbacher, 2006), we drew on Hanson's ideas as we operationally defined the science pipeline for that study to include curricular and extracurricular activities, achievement, attitudes, behaviors and choices that prepare high school students for college and work in the physical sciences and engineering. In the present study, we explore these pipeline dimensions not only in the physical sciences and engineering, but also biological and environmental sciences, medicine, and other science-related careers such as nursing, lab technician, and science teacher. We use an inclusive pipeline definition here for several reasons. Workforce concerns exist not only for who will be the next generation of research scientists but also for who will have desirable middle class jobs applying scientific knowledge and practices, and which also suffer shortages and high turnover (Buerhaus, Auerbach, & Staiger, 2007; Ingersoll, 2007). Such jobs may also be more accessible to low income and minority students. Defining the pipeline to include medicine and health-related jobs also allows us to study students who are drawn to the life sciences but have little knowledge of careers options and precursor college-majors, or who may change goals within the field over time.

Research Question

Recent quantitative research found that 10th graders' interest in a physical science or engineering career was correlated with family and science class variables (Gilmartin et al., 2006). We delve deeper here to explore how relationships and interactions with family, teachers and other important socializers in students' different communities of practice influence science identity, activities, and aspirations in science. Our major research question is: Why do some students interested in science during middle and early high school decide to leave the science, engineering, and medical (SEM) pipeline by the end of high school while others opt to persist? To understand students' perspectives on their science trajectories, we examine factors that they describe as influencing their movement towards or away from an SEM college major or career.

Conceptual Framework

In trying to understand students' point of view on studying science and considering SEM careers, we utilize the concept of *identity*, informed by situated learning, a model of practice theory that sees learning as taking place through everyday social interactions within "communities of practice," such as those found at school, home, or work (Lave & Wenger, 1991; Wenger, 1998). Students are active participants and learners in many different communities of practice, in which they have formal and informal apprenticeship opportunities to learn the common language, conventions, rituals, stories and histories valued within each community (Charney et al., 2007; Hsu & Roth, 2009; Lave & Wenger, 1991). Lave and Wenger stress the social nature of learning and knowing, which develops through meaningful student engagement, experience, and practice within their social communities. As students develop knowledge, competence, and meaning from these social

interactions, they begin to construct their identities, or who they are and wish to be, in relation to these communities.

Science identity is 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, 2001). Within a situated learning framework, science identity is informed by students' lived experiences and social interactions at home, in school, and in the larger world. It is based on how students view themselves and believe others view them as they participate in scientific endeavors. Students may participate in multiple social communities where they must negotiate their identities back and forth along the rules and values set up by these communities (Furman & Calabrese Barton, 2006; Lave & Wenger, 1991). Thus a student's science identity likely changes and evolves over time. This framework inspired our development of instruments to track students' social interactions and experiences involving science at home, at school, and outside school over time, and to link them to the trajectory of students' aspirations. For example, survey and interview protocols address student perceptions of what science entails, their interactions with others in science communities of practice such as science classes and clubs, and how and why learning or doing science is (or is not) meaningful and comfortable to them.

Our notion of science identity is also informed by the realization that science is a social construct shaped by human endeavor and therefore prone to the biases inherent to any human activity (Calabrese Barton & Yang, 2000; Brickhouse & Potter, 1999; Brickhouse, Lowery, & Schultz, 2000; Harding, 1998). Modern science as we have come to know it, and as it is viewed in many families and schools, has been and still is largely shaped by the ideas, experiences, and biases of European middle class males. Thus, we recognize that student science identity involves how one sees oneself in relation to this culturally based and biased science, which is generally accepted and reproduced in schools and society. In studying the roots of diverse students' science career paths, we consider how participation, identity, and aspirations may be influenced in complex ways by students' gender, ethnicity, and economic background.

Our approach to this study was also influenced by Eccles et al. (1983) expectancy-value model of achievement-related choices, linking students' educational and career decisions to their expectations for success and the value they ascribe to the options they perceive as available. We value the model's emphasis on the important role of socializers, such as teachers, parents, and peers, in shaping how students access, interpret, and evaluate their lived experiences, in turn affecting their short- and long-term goals, attitudes, values and priorities. Daily social interactions with parents and extended family, peers, teachers and counselors in various communities of practice convey their beliefs about what science entails, its value, and whether students are capable of and "should" engage in science. Influenced by these interactions, students judge the viability of their science identities and aspirations against the reactions of others. Students' sense of self-efficacy in science seems particularly important, as it affects their persistence in the face of obstacles as they pursue their goals (Bandura, 1997; Betz, 2004).

That interactions with families and schools influence students is hardly debatable. Families and teachers are often cited as significant forces in students' lives, serving as role models and socializers (Case & Katz, 1991; Dick & Rallis, 1991; Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; Seymour & Hewitt, 1997). Studies suggest that families play an important role in encouraging students' interest and decision to pursue science coursework and careers, and some have found that parental effects differ by race/ethnicity for science achievement, attitude, and interest (Ferry, Fouad, & Smith, 2000; Gilmartin et al., 2006; Huang, Taddese, & Walter, 2000). Existing research points to teacher feedback, expectations, and encouragement as influencing student attitude and motivation, confidence, perception of competence and ability, as well as science career motivation (Chouinard, Karsenti, & Roy, 2007; George, 2000; Stake & Mares, 2001). Other studies have uncovered positive relationships between classroom experiences and student science attitude (Hall & Sandler, 1982; Papanastasiou, 2002; Simpson & Oliver, 1990). Research has also found peer attitude and interest in science to be a significant predictor of student attitude and enjoyment of science (Fraser & Kahle, 2007; George, 2000; Simpson & Oliver, 1990), and having peers with whom to share science interests enhances students' vision of themselves as future scientists (Stake & Nikens, 2005). The literature provides little doubt that students are influenced by their relationships and daily social interactions with important people around them. This study looks more closely at students' descriptions of their daily experiences, looking at communities of practice where family or educators may support student participation in science

and where they support other endeavors. We listen particularly to underrepresented students to learn from them whether and how families and other important socializers provide support for science, how this support is manifested and how it affects students' science identity development. Learning from students' stories about their daily lived experiences, we hope to better understand the challenges students face as they develop a sense of who they are and want to be in relation to science. We also consider implications for how the broader science education community, schools and families might make studying and appreciating science a more welcoming and rewarding experience.

Methodology

This study examines the science identity development of 33 diverse high school students, including the trajectory of their interest in SEM college majors and careers. The students were a purposeful sample (described below) of participants in a larger longitudinal, mixed-method study titled "Is Science Me?" funded by the National Science Foundation (Gilmartin et al., 2006; Gilmartin, Denson, Li, Bryant, & Aschbacher, 2007). At the beginning of 10th grade the students were all "in the SEM pipeline," defined by their enrollment in a science course as well as survey responses indicating they were "very interested" in one or more SEM college majors or careers. Using data from two interviews supplemented by three surveys over a 3-year time period, we explore their identities, participation and aspirations in SEM and present our findings by describing three groups that emerged with distinct characteristics and trajectories (High Achieving Persisters, Low Achieving Persisters, and Lost Potentials). Pseudonyms are used throughout for students, adults, schools, and districts.

Participants

Students attended six public high schools in four California districts selected for ethnic and economic diversity, including African American, Asian American, Latino, and non-Latino White students from low to high economic backgrounds (see Table 1). Three of the schools had science- or health-related academies, which 7 of the 33 students attended. In the larger study, all 10th graders except special education classes were invited to participate in three annual written surveys; 1,247 (34%) received parental permission and participated in the first survey and nearly 900 also had permission to participate in interviews. Based on their 10th grade survey demographics and stated SEM interest, we selected 145 to also be in the initial interview cohort. We used a stratified sampling plan with a 48-cell design ($2 \times 3 \times 4 \times 2$) that included gender, economic level, ethnicity, and SEM interest. To focus on students under-represented in science and engineering, we slightly over-sampled Latino and African Americans, girls, and students with a strong interest in SEM. Students self-reported gender and race/ethnicity; we assigned multi-ethnic students to the ethnic group with which they most identified. As in prior analyses for the larger study (Gilmartin et al., 2006, 2007), students were assigned to "low," "medium," or "high" socioeconomic categories (SES) based on responses to a set of survey items commonly associated with economic status (mother's college attendance, father's college attendance, number of home computers, English as primary home language, and living in a

Table 1
*School Demographics and Proficiency on State Tests as Percent of Student Body**

High schools	Asian	Black	Latino	White	FRL ^a	ELL ^b	Math ^c	Language ^c
Sycamore	41	4	15	31	6	5	88	70
Treadwell	54	1	14	30	32	12	83	55
Century ^d	7	24	35	34	33	9	38	35
Valencia ^d	6	21	39	33	38	14	20	34
Pasa Flores	5	25	47	23	46	16	33	28
Mayflower ^d	1	46	44	8	53	18	NA	20

*Ed-Data, statewide database on public schools, 2003–2004.

^aFRL = students qualified for federal free/reduced price lunch subsidy (indicates low income).

^bELL = students designated by district as English Language Learner.

^cPercent "proficient" on CA grade 10 exams.

^dSchool had a health or science academy at time of study.

single parent home headed by the mother). Assignment to categories was corroborated by district data on free lunch eligibility where available. Of the 145 students interviewed and surveyed as 10th graders, we re-interviewed 58 of them in 12th grade (the rest had changed schools, dropped out, were absent or unavailable on interview days despite multiple attempts, or chose not to be re-interviewed). Of these 58, 33 had said in 10th grade that they were “very interested” in one or more SEM majors and/or careers, as noted above; the other 25 never showed a strong interest in SEM during high school on any of our measures. This study explores what happened to the 33 students who began 10th grade with a strong interest in an SEM major and/or career.

Procedures and Instruments

The primary data for this analysis come from personal interviews with students in grades 10 and 12, supplemented by their responses to annual surveys in grades 10–12. Instruments are available from the authors. We developed two 45-min semi-structured interview protocols drawing on science education and pipeline literature (e.g., Hanson, 1996; Seymour & Hewitt, 1997) and ongoing discussions with a diverse national advisory group; we then piloted them with comparable students in participating schools, and extensively trained researchers in standardized interview procedures. Interviews, which were audio-taped and later transcribed for analysis, began with a discussion of the student’s current science and math courses and segued into questions about past and present science experiences and attitudes in and outside of school; social networks, hobbies and activities; peer and family expectations and actions related to SEM involvement; perceptions of science/engineering and scientists; sense of self learning and doing SEM; influence of gender and ethnicity on their lives, particularly as related to SEM opportunities; and their dreams and plans for the future. A set of core questions appeared on both interviews, but the second included additional questions reflecting new evidence of teachers’ and families’ influence on science identity development (Gilmartin et al., 2006, 2007). When students entered college, we posed several questions by email to those we could reach about their freshman year science experiences, and 10 students responded. To provide context to better understand students’ stories, we also interviewed a sample of each high school’s science teachers and guidance counselors about courses, policies, and practice.

Seven researchers coded the 145 tenth grade transcripts using an initial coding scheme derived from interview protocols. The coders tested and refined the scheme using a sample of eight transcripts; once consensus was reached for all codes, the team coded the remaining transcripts. To monitor inter-coder reliability, 30% of the transcripts was independently coded by two researchers, who then compared coding. They reached exact agreement 80% or more of the time for each major code. When they disagreed, they discussed their views to reach consensus and revised previous coding. Coding of 12th grade interviews proceeded along similar lines.

As part of the larger study *Is Science Me?* we developed three annual surveys drawing from existing scales and questions on related surveys (e.g., McCoach & Siegle, 2003; Phinney, 1992), science education and pipeline literature as noted, and input from advisors; we pilot tested them in participating schools and debriefed students to maximize item comprehensibility and sensitivity of Likert scales to the range of students’ intended responses. The second and third reflected item characteristics and new insights from the previous year. The 10-page surveys addressed: perceptions of science and scientists; interest in SEM, SEM-related, and other popular college majors and careers; family and peer expectations related to science interest and activities; perceptions of science classes and teachers; grades, courses and self-confidence in science and math; science-related activities and behaviors in and outside of science class since childhood; and demographics. To identify constructs underlying groups of items, principal components factor analyses were conducted using varimax rotation techniques (Gilmartin et al., 2006), and items with poor reliability were omitted.

Analysis

To explore the trajectories of students who were ever “in the pipeline” during high school, we examined the data from the three surveys and two interviews for the 58 students with full data sets, and, as mentioned above, identified 33 who had expressed a strong interest in SEM at least once in the five data points during

high school. No students were found who developed a new strong interest in science *after* 10th grade. To explore students' own meanings and purposes in relation to their participation, identity development, and aspirations in science in various communities of practice, we used the general codes described above and the qualitative software package Atlas to discuss initial coding for the 33 students and create a summary matrix of the data. We extended the matrix with survey data to corroborate some variables and add new information, such as courses, grades, confidence learning science, and priorities when considering a career. Open to other themes that might emerge, we looked into students' interview data more deeply—such as how they spoke about their lived experiences in school, family, and extracurricular communities of practice, including encounters with teachers and counselors related to science and math classes, their extracurricular SEM experiences, relationships with people they saw as role models or mentors, and family expectations, pressure or support towards or away from SEM and non-SEM areas. We also looked at how they described the influence of their gender or ethnicity on their lives and aspirations, and the language used when imagining themselves as scientists, engineers or other SEM professionals. We created new, higher inference codes and subcodes, compared and contrasted comments within subcodes, and constantly checked and countered our interpretations (Miles & Huberman, 1994). As we attempted to identify relationships and triangulate emerging ideas across data points, and to accurately reflect students' meaning, our team revisited the interview data many times, rereading and discussing student responses and listening to audiotapes. We also systematically looked within and across trajectory categories for possible relationships between science identity and performance, demographics (gender, ethnicity, SES) and school/academy attended. We were able to discern three distinct student trajectories, as noted above, and collaboratively wrote group summaries, comparing and contrasting them as a way to explore and clarify group characteristics and boundaries. Our results draw from those summaries.

Results

What Kind of Students Left the SEM Pipeline in High School and Why?

Of the 33 students who expressed a very strong interest in an SEM major or career in grade 10, 15 (45%) no longer wished to pursue an SEM major/career by 12th grade. We refer to this group as the Lost Potentials for that reason. They came from every school in the study, although the majority were from schools with a large proportion of students eligible for free lunch. As Table 2 shows, it was a fairly diverse group, with five Latino, five African American, and five White students (no Asian Americans left the pipeline). They were mostly from mid-SES families headed by two working parents. Boys tended to leave the pipeline at a slightly higher rate than girls. Only two, a Latino male and a Latina female, belonged to their school's Science, Engineering, and Technology (SET) Academy.

Student Interests and Ambitions Reflect Key People and Experiences. In 10th grade, the Lost Potential students all described interests in several different careers, both science and non-science. As they explained

Table 2
Percentage of Each Demographic Subgroup for Each SEM Trajectory Group

Subgroup (n)	Lost potentials % (n)	Low achieving persisters % (n)	High achieving persisters % (n)
Ethnicity			
Af Amer (8)	63 (5)	37 (3)	0 (0)
Asian Amer (7)	0 (0)	0 (0)	100 (7)
Latino (8)	63 (5)	13 (1)	25 (2)
White (10)	50 (5)	20 (2)	30 (3)
Gender			
Female (20)	40 (8)	25 (5)	35 (7)
Male (13)	54 (7)	8 (1)	38 (5)
SES			
Low (10)	40 (4)	40 (4)	20 (2)
Med (15)	60 (9)	7 (1)	33 (5)
High (8)	25 (2)	13 (1)	62 (5)

what interested them and why, common themes began to emerge and it was clear that experiences and people mattered greatly to them. Many could trace their career interests to positive experiences in activities they saw as relevant to these jobs or that important people in their lives had encouraged them to explore. For example, Adrianna (Latina female) explained that she enjoyed fixing appliances at home with aluminum foil and thought she might like to be an electrical engineer. Four students with family members in medicine expressed interest in medical careers. Several other students, who said they were considering marine biology or veterinary science, linked their interests in animals to enjoyable visits to aquariums, zoos, and similar sites. Michelle (White female) is a good example.

My uncle used to have a boat, and we always used to go out in the boat and go fishing and stuff, and like one time they took me to Sea World, and ever since I was little I just loved Sea World. I love touching the stingray and watching the seals and stuff like that. I don't know, it's just so fun . . . It's so entertaining and interesting how they act like people, but they're little animals.

At the same time, students were also considering non-science careers, interest in which also developed through the influence of real life experiences and people. Chrissy (White female), a student who had expressed interest in becoming a doctor (her grandfather was a pathologist), shared that she was also seriously considering becoming a teacher, like both her parents. Adrianna, the aspiring electrical engineer, was also very interested in the culinary arts. She explained that she was from "a very long line of cooking people" and that becoming a chef was a priority for her. A number of students interested in business careers said they were inspired by family members who had started their own businesses, such as Kevin (African American male).

Kevin: Most of the women I ever came across were the women in my life that they really know what they're doing and they are really far in business . . . My mother is really high up . . . She's a business administrator. And then my aunt has her own clothing line. She made her own woman's clothing line.

Interviewer: Do they ever tell you anything about it?

Kevin: Just follow them and do what they do and learn from them.

Like other students, Kevin's admiration for his family members is evident in his words and suggests the strong role his mother and aunt played in shaping his perspectives and values about a career as well as his belief that he can achieve in business if he follows in their footsteps.

Despite strong initial science interest, by the end of high school, every Lost Potential student decided they were *not* going to pursue an SEM major/career. Several influential factors emerged in students' narratives, as discussed below, including generally poor interactions and experiences related to science within communities of practice at school, which seemed to color students' perceptions of science and erode their career interests. During 12th grade interviews, the majority explained that they had had few if any science-related extracurricular experiences and no strong science mentors or role models in their lives, while a number had had strong experiences or interactions with key people leading them toward non-science alternatives.

Poor School Science Experiences. By high school, many of the Lost Potentials perceived school as their only access to science and only window on the world of scientists. Unfortunately, they said school experiences failed to encourage or support their science interests, and teachers and counselors did not seem to consider science learning a high priority even at schools where a science or health academy existed. Many students cited poor instruction, lackluster curriculum with few hands-on inquiry activities or meaningful projects, and little encouragement to study or do science from teachers, counselors, and administrators alike. For example, Angela (African American female) stated that she did not know there was a science club at her school until she read about it in her yearbook; Joseph (White male) was angered by the administration's refusal to create an AP chemistry class despite a sufficient number of students. At several schools, students described frustrations with multiple substitute teachers for science.

In the beginning of the year, I didn't really like [biology], 'cause, the first semester, we had like four teachers. Four different teachers! And we never got to like actually settle down and get something

done and get something learned. (Teresa, Latina female in a Science, Engineering and Technology Academy)

Students with permanent science teachers did not always fare better. They often complained that teachers tended to be authoritarian and did little to help willing but struggling students.

She [chemistry teacher] didn't really teach. She just let the book teach us, and that's not fun. I don't know. I'm the kind of kid who needs a good teacher to get ahead. She just didn't teach. She gave us notes once in a while, but she's just like, "Read the chapters, answer the questions and there will be a test tomorrow." (Thomas, Latino male)

Mr. Peters kind of expected us to memorize the book and when . . . you're like, "I don't know what this means," he'll be like, "It means this." I'm like, "Well why doesn't it just say that?" and he's like, "Now you're supposed to use this kind of language." And I'm like, "Can you break it down for me?" and he was like "No, just read the book," and I'm like, "I don't *understand* the book . . . Instead of like, 'It was recessive and dominant'," I was like, "Why can't it just say 'stronger or weaker'?" (Debbie, African American female)

Debbie faced disapproval from her teacher when she asked for help and questioned the terminology and process of conventional science. This situation seems similar to that found by previous research in which teachers can reject unconventional science identities and marginalize students who are otherwise interested in science (Brickhouse, 2001; Brickhouse & Potter, 1999).

School counselors were also a source of discouragement in science. Several Lost Potentials told us their counselors described science as "hard" and "not for everyone," from which students inferred that science is an elite subject and that, despite their interest, they "did not measure up." Two Latinas said their counselors overlooked or overruled them by not enrolling them in desired ninth grade science classes. This phenomenon also occurred in college, where Angela, a Lost Potential Latina student who communicated with us as a college freshman, told us she was advised away from a desired chemistry course and towards meteorology, a "less demanding class" that her advisor reportedly felt was "better suited to a business major."

Perception of School Science as "Hard" Undermines Identity. The idea of science as hard and only for certain people seemed to permeate 12th graders' interviews. Students shared stories of being frustrated and discouraged to pursue science as it became harder to earn good grades. Diana (White female) provides a poignant example.

"I was *very* like frustrated . . . I had a ton of homework, and I wouldn't go to sleep until like one [o'clock] . . . And I just was really struggling. I was fighting to keep my grade as a 'B.' Honestly, like my whole school life I've gone through science pretty easily, and this year was the first year that I actually needed to put extra effort into it and work hard for it. And still, I'm working for a 'B!' You know, usually, I'm working for an 'A' . . . And the pressure of the AP exam, I hated that."

Diana's experiences in this class were significant to her, marking the first time she struggled in an academic subject. Her confidence was shaken by the experience, and she told us that was a turning point in her interest in science.

Diana: Last year [chemistry] I understood everything. This year, like, at a few points during the day, I would just think, 'Is this lady speaking the same language that I speak?! Some of these words are just clueless.' And I couldn't get over how people just automatically understood 'em, like they were born with the biology gift in their brain or something . . . I felt like, "Wow, I do *not* belong here."

Interviewer: Did that sort of make you like science less?

Diana: Yeah. Because I . . . this sounds really bad. I like things that I'm good at, I guess. Because I see no point to working hard if you know that other people have an upper hand over you. So, like they have, they have a certain benefit over you. So, I just don't bother. I'd rather stick to what I like doing.

Joseph, a White male, also began to experience science as hard. An avid and ambitious science student in middle and early high school, he described wanting to work in robotics or at NASA. He stated that he began to

question his role in science when he came across increasingly difficult science classes and his grades began to fall. Unlike Diana, Joseph discovered he was good at something else—graphic arts. As he began to spend more time involved in graphic arts activities, he gained recognition from his peers and this seemed to motivate him further in these endeavors.

I used to want to be like a scientist, like for NASA or something. I wanted to build robots and stuff to go into space, but I just got out of it . . . I think I just started to realize what I like more, and I started learning how to use PhotoShop and InDesign and stuff on the computer. And then my aunt has a photography studio and she wanted me to do like photography touch-up stuff for her. So, I started messing with that, and I really like it. Then I started doing designs and all that stuff. Now I do it for everyone.

Neither Joseph nor Diana was used to struggling in their classes. Both high achieving students, they were surprised to find themselves no longer at the top of their science classes. Diana's statements in particular suggest important relationships between student science identity, self-confidence, and perceived ability in science. For Diana, it was easier to see herself pursuing a science career when she was doing well in science and when others acknowledged and encouraged her ability and interest. When she was struggling in AP biology, her perceptions of herself as a good student and as a scientist began to erode. This was confirmed in her mind, she said, when her counselor, who once thought her capable enough for advanced science classes, signed her up for regular rather than AP physics the following year. Diana's experiences illustrate a simplistic binary view of some students and counselors that science is something students are either good at or not, ignoring differences between fields or due to learning contexts. While Joseph also struggled with science classes, he did not attribute his decision to drop his science aspirations to a lack of ability and did not express a loss of confidence even though his grades were dropping. He explained that finding another interest in which he could excel (graphic arts) and having the support of others in this endeavor shored up his confidence.

Perception of Science Careers as Too Difficult. Some 12th graders complained less about their science classes being difficult and more about their belief that science is a difficult major or career and would require more effort than they were willing to exert, so they had begun to view science careers as less appealing.

[Astronomy] feels like a little unreachable . . . I'd have to work like ten times harder to get there . . . I enjoy it and I like it. I know I'm still young and I still could get there if I wish, but I think that during high school I've come to see myself like procrastinate and be lazy, and I feel like—not that another major I wouldn't have to work hard in, but I feel that in NASA and astronomy and stuff you have to work harder I guess. (Jessica, Latina female)

I personally am like a really lazy person . . . I could be a 4.0 student in this school, but I'm not because I'm lazy. I'm happy with like a 3.4 . . . I don't expect much of myself I guess. And then to be a scientist I think I would have to expect a lot of myself. (Thomas, Latino male)

Such statements might suggest these students were not motivated or ambitious. However, as a group, they earned mostly B's, were involved in non-science extracurricular activities or had jobs that required much of their time and energy after school. Some served as officers in clubs, two launched new programs at their schools, and another started his own t-shirt company. Several students initiated these activities on their own. However, these students did not question the quality of their school science experiences; instead, they were self-critical and attributed their problems in science to a personal deficit, to being "lazy." Many said they began to doubt the value of persisting when high school science became challenging and frustrating. They came to view their SEM career interests as impractical or risky, as they considered the long years of difficult study with no guarantee of a job afterwards.

If I was to get out of college and there's no type of job for a Marine Biologist I would probably feel like it was a waste of the past four years. (Kevin, African American male)

So my career choice right now, because I am safe, is being a teacher, an English teacher, because when you go to school you're given a job. But when you study science or whatnot it seems like you're out there. (Michelle, White female)

With limited and/or distorted information about SEM careers from school, home, and popular media, and no extracurricular opportunities to participate in real science where they could obtain more accurate information about options, many remained naïve about SEM career practicalities.

Other Interests and Priorities Compete With Science. As science careers lost their luster, many Lost Potentials, like Joseph, could easily turn to alternative interests since most were involved in multiple activities. As they got older, some of these communities of practice demanded more time from students, who then had to decide which interest to pursue. For example, four African Americans and one Latino student admitted they had less time for science activities in high school because their interests in sports or music required practice before and after school and during summers. Chrissy became heavily involved in math tutoring and explained this took time and focus away from science; Debbie was involved with the French club and learning more about business; as mentioned above, Joseph chose to seriously pursue his interest in graphic arts. As each of these students spent less time thinking about and taking part in science, they identified less with science, and their interest waned. They began to value and prioritize other activities they enjoyed and found satisfying. By 12th grade, their view of science had changed from an exciting interest to merely a school requirement.

When it comes to science . . . it's more of just a school thing . . . It's required for school. It was a thing for fun . . . But, now, it's kind of, it's not a priority. It's just something for school, basically. (Charles, African American male)

Lack of Compelling Extracurricular Science Activities. Only three Lost Potentials (20%) were involved in extracurricular science programs. Diana and Teresa were in the science clubs at their respective schools, where they had opportunities to participate in science fairs and research projects. Jessica took part in a summer research project at a local university where she collected data in a laboratory. Each student seemed to appreciate these science experiences and felt they learned a lot about science and/or scientists. Jessica said working in a real laboratory helped break her “stereotype that only certain kinds of people could become scientists” (an important realization with potential to impact her science identity). Teresa was enthusiastic when she described her involvement in projects such as building and programming a robot. These experiences, however, failed to ignite deep interest, and each girl eventually left the pipeline. Diana's and Teresa's science club experiences were not enough to overcome successive negative classroom experiences and subsequent loss of self-confidence. Jessica confessed that while she liked seeing “real scientists” in a lab setting, her work was not very stimulating and she was told little about the project rationale. She described taking notes and measurements, but she had little opportunity to discuss and see the relevancy of her work. These potentially promising extracurricular experiences were reportedly not sufficiently compelling to ignite passion and balance negative school science experiences.

Family Focus on Other Priorities. Many students described their initial interest in science beginning when family members encouraged activities and engagement in science-related activities. However, by high school, less than half reported that family members were still encouraging such activities. Most Lost Potential students said their families were now far more focused on their completing high school and going to college than on science learning, interests or careers. Predominantly mid-SES, parents of Lost Potentials reportedly spoke often to their children about the importance of getting a college degree for a good job. Some offered specific advice, suggesting students should volunteer or join a club to bolster their resumes, but students said they never suggested SEM activities. Boys described strong messages from their families to focus on college.

I've always told them I wanted to be a veterinarian, but they're not really encouraging me to do it . . . Just get to college first, and see what I want to do later. (Michael, African American male)

Interestingly, the boys were all doing fairly well in school, with little apparent danger that they would fail to graduate due to poor grades. Parents of minority boys in particular reportedly advised them to stay away from neighborhood gangs and avoid any negative influences that might distract them from going to college.

Many boys had obviously internalized this message, frequently making statements such as they were “going to college no matter what.”

According to students, parent expectations and goals for daughters varied more than for sons. Some girls’ said their parents encouraged them to attend college, but three of the eight Lost Potential girls (one White and two Latinas, from low- to mid-SES families) said they received little encouragement for college let alone an SEM career. One said she planned on attending the local community college as no one in her family had ever gone to a 4-year college, and her family did not expect her to do more. Two Latinas, who described their families as “traditional,” shared feeling pressure throughout high school to take care of and be cultural (as opposed to academic or career) role models for younger siblings or cousins. The two girls described their parents as uninvolved in their academic careers, and said they were left with the responsibility for their own educational choices and problems. Neither girl said she felt encouraged by her parents to work toward ambitious college or career goals. Instead, each said her parents would be satisfied with community college or trade school. These girls’ grades were only slightly lower than other Lost Potential students, so it was not lack of ability driving low family expectations. Rather, the girls reported different expectations and priorities in their families, and an SEM major or career was not a high priority. As they attempted to compose a life that would accommodate family members’ needs and expectations, the girls generally restrained their SEM ambitions.

What Kinds of Students Persisted in the SEM Pipeline and Why?

A little over half (18, or 55%) of the 33 SEM-interested 10th graders still desired an SEM college major or career by the end of high school. We refer to these students as SEM Persisters. They were found in five of the six schools. Asian American students in the sample had the highest rate of persistence by far (all of them remained committed to SEM goals). Girls were slightly more likely to persist than boys overall and particularly among African American students. Low- and high-SES students were more likely to persist than mid-SES students.

By 12th grade, two subgroups of Persisters emerged with different high school SEM experiences and trajectories: (1) “high achievers” ($n = 12$), who came mostly from Treadwell and Sycamore Highs (one from Mayflower’s science academy), did well in school, participated in extracurricular SEM activities, applied to 4-year colleges, and continued to aspire to careers such as doctors, research scientists, or engineers; and (2) “low achievers” ($n = 6$), who all came from Century High (four of six came from its health academy), had poor academic records, did not participate in extracurricular SEM activities, and modified their originally high SEM aspirations towards SEM-related jobs, like nursing, that they could access through community college or trade school. The two groups also differed demographically, as shown in Table 2. High Achieving Persisters included all seven Asian American students in the sample as well as three Whites and two Latinas (one in the SET academy), both genders in similar proportions, and more mid- to high-SES students than in the sample of 33. Low Achieving Persisters included three African-Americans females, one Latina, one White female, and one White male; four were from low-SES families and in the health academy. The two groups described different economic circumstances, experiences, and interactions in communities of practice at home, school, and elsewhere that influenced their different trajectories as described below.

Persisters’ Interests and Ambitions. In 10th grade, most Persisters (in both groups) showed a sense of passion and purpose towards an SEM career and said they had always liked science, were good at it, and wanted to use it to help people. While a few had been devoted to a particular career since childhood, most 10th graders described uncertain but high aspirations including both science and non-science fields (“math professor, journalist or engineer”). Medicine, a familiar, concrete and altruistic goal, was very popular: eight students wanted to become doctors; four others aspired to pharmacist, dentist, or nurse. Four considered research in life science, and three considered engineering. Two were interested in being math or science professors, and two in teaching science.

By 12th grade, High Achieving Persisters had earned A’s and B’s in honors/AP math and science classes and were focused on high SEM goals. Several showed new interest in physical sciences such as aeronautics and chemistry. All applied to competitive universities with strong SEM programs; most aspired to advanced degrees. While they acknowledged science could be “hard,” “boring,” and “time-consuming,” they were

twice as likely as Lost Potentials to have an altruistic interest in science (“Helping people is very appealing to me”) and three times as likely to enjoy understanding the world scientifically (“Figuring things out, revolutionizing the world, knowing about the things around you or going on inside you appeals to me”).

Low Achieving Persisters continued to aspire to SEM careers but displayed a disconnect between their lofty career aspirations and their academic choices, that is, low grades (mostly C or below), poor science class participation, and avoidance of hard science courses. By the end of high school, some had become discouraged academically and wanted jobs that required little further schooling while others finally realized they could only get into community college or trade school and thus tended to shift their aspirations accordingly. Zandra (African American female), who long aspired to be an obstetrician and researched prestigious medical schools in hopes of attending one, told us in 12th grade, “I’m going to [local community college] ‘cuz of their nursing program, to see if I would want to do that first and then become a doctor.”

Mostly Positive Perceptions of School Science. Persisters were interested in the natural world since childhood and several proudly recalled winning a science fair. By middle school, most of them told us, it was their science teachers who most inspired their interest in science. Only a few reported having had a particularly poor middle school science teacher, but even in those situations, Persisters said they did not lose confidence as science learners since they saw that others suffered similarly, and the troublesome class was the exception, not the norm for them. But in high school, the two subgroups of Persisters with rather different experiences and characteristics began to diverge.

Students who would become High Achieving Persisters attended high schools that offered advanced science and math courses, which they took advantage of, earning A’s and B’s. Most Asian American Persisters, however, felt opportunity was mixed with stereotypical pressure from administrators, teachers, peers, and parents to take multiple AP classes and earn top grades in science and math. Some said they did not want to take so many difficult classes but complied in order to satisfy their teachers and parents and to get into good colleges.

Despite challenges, High Achieving Persisters valued their science courses, such as Cameron (White female) who felt that her classes and labs gave her “a small taste of what college science would be like.” The high achieving students recounted few bad experiences with high school science, although they could still be slightly critical of their classes as too easy or too limited, and teachers as not always enthusiastic enough. For the most part, however, these students appreciated their teachers’ attitudes, instructional skills, and encouragement, and the negative aspects of school science did not deter their enthusiasm or persistence in learning science. Suzie (Asian American, female) remarked, “I didn’t really like my biology teacher but he really *taught* well, which is rare, so I liked that and I learned a lot. I had to work hard to get an A.” Kelly, another Asian American female, showed mature insight as she compared her “easy” teacher to a friend’s more demanding one:

I didn’t have a lot of work to do. A lot of people had another teacher who, she’s crazy and super hard, but at least the thing is, they learned a lot. And I think I learned a lot, but I think I could have learned a lot more if I had a different teacher.

Some students, like Steve (Asian American male) lauded their teachers for inspiring them.

She made it really comfortable for us to ask questions. She was the best teacher I’ve ever had . . . A lot of high school teachers, they’re really bad, and they’re just there to teach the material; they don’t wanna talk to students. But the few teachers that are really good, they inspire me . . . She inspired me to become a chemistry teacher.

Students who became Low Achieving Persisters all attended Century High, which seldom offered advanced science courses. It has a health academy, described by a counselor as “not a vocational track.” She noted students are free to take regular or advanced science classes outside the academy, but none of the four academy students in our sample did so. These students, both the four in and two outside the academy, tended to describe more negative high school science experiences and appeared more affected by them than High

Achieving Persisters. Like many of the Lost Potentials, the Low Achieving Persisters had to cope with many substitute teachers as well as teachers who reportedly did not care if students had problems understanding science. These students were less likely than others to say their teachers saw them as capable of being a good scientist. As with many Lost Potentials, over time their negative school science experiences started to weigh on several Low Achieving Persisters, and they described beginning to like science less, avoid hard classes, and downshift college and career goals. Rather than leave the pipeline, however, these students shifted their aspirations *within* SEM by the 12th grade towards jobs like pharmacy assistant, forensic technician, or nurse, that were within the health academy focus, accessible through community college, and entailed fewer years of school.

For each subgroup of Persisters, their peers generally mirrored their own academic orientation and reinforced their career direction. High Achieving Persisters described their school friends as interested in science, planning to attend college, caring about studying, attending class regularly, and getting A's and B's. Low Achieving Persisters said their friends shared their interest in science and in health careers, but both they and their peers were less committed to taking hard classes and studying diligently and were more likely to view C's as "good grades."

Compelling Extracurricular Science Opportunities. Most High Achieving Persisters took part in extracurricular hands-on experiences in real science labs, hospitals, or zoos, where they had opportunities to see the work being done, participate in doing it themselves to some extent, and interact with scientists, doctors, or vets. In these communities of practice, they discovered some passion and ability in these scientific activities, raising their sense of self-efficacy in science, as Haley (White female) explained.

I spent a lot of time at [noted research hospital] over the summer—so it just kind of helped me to realize that like it was what I want to do. I want to go into like research, medical research and that type of stuff . . . I think just like figuring out that I really did like science and I was good at it. And it's something like, if you find something that you're really good at and that you like and you can do it, why not do it, you know? I eventually want to do some type of like pharmaceutical, like I want to work more with developing the actual drug itself. So I think biochemistry kinds of leads into that.

Low Achieving Persisters, on the other hand, tended to come from low- to mid-SES families. They were more likely than their high achieving counterparts to have jobs after school, and their jobs were less likely to support their academic skills and identities (such as waitress versus tutor). Their work schedules, sometimes 30 hours/week, left little time or energy for tackling the hard courses and extracurricular activities in which high achievers engaged.

Different Patterns of Family Support and Extracurricular Opportunities. The two groups of Persisters described different patterns of academic and career support from families. Most of the High Achievers described immediate or extended family members who were doctors, pharmacists, scientists, or engineers who helped shape the family community of practice in science in a variety of ways, such as serving as role models and providing advice, information, and ongoing conversations about what such careers and their pathways entail. Parents also facilitated extracurricular experiences by seeking opportunities, encouraging participation, paying expenses, and providing transportation.

The Asian American parents stood out as providing strong expectations and support for *SEM careers in particular*, which students said their parents viewed as offering desirable status, remuneration, and stability. The parents also reportedly had high expectations for effort, grades, advanced courses, and extracurricular activities in preparation for college and careers in general. More than in other families, Asian American students saw their immediate or extended family members as *proactive* SEM role models who provided extensive connections, information, and coaching for succeeding in high school and college math and science courses and becoming scientists, doctors, and engineers. Follow-up email interviews with several high achievers during their freshman year in college revealed the continuing strong expectations and guidance for SEM majors and careers provided by extended Asian American families compared to others. While these students sometimes complained about the pressure and acknowledged it as different from other students' experience, our sample seemed to accept it as an integral part of their lives.

Low Achieving Persisters described their families as having few role models in SEM careers other than nursing, and little knowledge about possible science-related jobs, appropriate preparation, or career paths. Families offered generic support and encouragement for going to college and getting a good job, but far less pressure than high achievers described receiving from their families to work hard and get top grades in school, develop academic skills in their out-of-school time, and attend good universities. For example, Patrick (White male) said his mother's career advice was "Do whatever you want; just make sure you have a good life." Heather (White female), who lived with her single mother, described her dad being "harder on us than my mom" yet his expectations did not seem all that high. "We get our report cards and he's like, 'There better not be any D's on there'." In some Low Achieving Persisters' families, however, an older sibling who majored in science was a critical source of inspiration and guidance. However, according to students, many families did not give advice on the courses, grades, and experiences needed to become scientists, engineers, doctors, or dentists. These students more often than others cited television programs like "ER" or "CSI" as a major source of career information. With little effective support from families, teachers, or school counselors, most of the low achievers were amazingly committed to but unfortunately naïve about their SEM career paths.

Influence of Economic Level, Race/Ethnicity, and Gender

While family socioeconomic level was not a predictor of science interest for 10th graders in a previous quantitative study (Gilmartin et al., 2006), our longitudinal results suggest that it appears to be linked to students' high school science experiences and 12th grade college/career plans. Over half of those from high-SES families became High Achieving Persisters; about two-thirds of mid-SES students became Lost Potentials, with a third becoming High Achieving Persisters; and most low-SES students became either Low Achieving Persisters or Lost Potentials in equal proportions (although two girls did beat the odds to become High Achieving Persisters). Except for Asian-Americans in our sample, low-SES students said their science interests faced serious challenges both at home and at school with the result that those at Century High lowered their aspirations, and most of the others dropped out of the pipeline. By definition, their parents had reportedly limited financial resources. According to students, most of these parents also had little familiarity with science or with SEM careers, tended not to recommend them to students, and had lower expectations than higher SES families for their children's academic achievement. Both low- and mid-SES students in the Low Achieving Persisters and the Lost Potentials recounted disheartening school science experiences in and outside the classroom, including many substitutes, science teachers perceived as uncaring, and curriculum experienced as boring and divorced from their lives. It was they who told stories of counselors portraying science as something "hard" to "avoid if you don't have to take it." Counselors explained they attempted to minimize student failure and maximize graduation and college entry, but possibly their advice also reflects a limited background in science themselves. In any event, their guidance reportedly dissuaded some students from taking science courses they wanted to attempt, often as early as ninth grade, thus preventing access to some communities of SEM practice. This not only deprived students of the opportunity to study science at a time they were motivated to do so, but also, according to students like Diana, undermined their emerging science identities by implying they were not smart enough to learn science.

Patterns by ethnic/racial group were apparent in regards to family and school support for SEM learning. While most students said their parents wanted them to go to college to get good jobs, the Asian American students in the sample described their parents as viewing SEM careers in particular as tools to gain access to status, income, stability, and success. These families had members in the sciences who gave science-targeted support to their youth. Most other students described their families as giving no specific support for SEM majors/careers, as less controlling of their career paths, and more focused on graduating high school or applying to college.

Students spoke frankly about ethnic/racial biases they faced at school. Asian American students tended to feel their science teachers and administrators were supportive and had high expectations, while African American and Latino students tended to feel educators had lower expectations of them than of others and were unwilling to adjust their teaching to accommodate students' learning needs. Teresa, a Latina girl who was in an SET academy, Puente college prep classes, and Upward Bound, yet become a Lost Potential by shifting her aspirations from science to elementary teaching, reveals how she perceived being Latina affected her science class experiences.

Society wise, or at least in this community, we're [Latinos] known to be bad people. Not really bad, bad people but people that don't really, aren't dedicated to achieve our goals. And a lot of times, not to put any teacher out, but sometimes they tell us that we're not capable of doing much. And maybe I would understand why, 'cause a lot of the students here are kind of rude and disrespectful. And sometimes a lot of our students do think we know everything, and I know we don't 'cause we haven't had that much experience. But besides all that, I think maybe sometimes it has to do with people telling us that we can't do it. Maybe that kind of, it kind of doesn't motivate me to do something.

Later, Teresa told us that she believes she can be a good teacher because she understands the problems many young Latinos face struggling to learn in a new language and country.

Gender, sometimes interacting with ethnicity and SES, seemed to play a role in under-represented minority students' aspirations and pipeline participation. According to Latinas in our sample, their parents valued college and careers less for girls than boys, and girls felt more pressure to conform to traditional Latino family patterns of staying close to home to care for and interact with family members. These expectations decreased Latinas' opportunities to participate in extracurricular science activities and to attend colleges not proximal to families, thereby reducing the pool of science programs to which they might apply. African American girls in our sample, who often expressed a strong desire to help others or give back to their communities, were more likely than boys to enroll in health academies and to pursue their science interest throughout high school. Both African American and Latina girls tended to believe their ethnicity was more important than gender in their lives to date, but as they begin to envision having families of their own, they felt their gender will more strongly shape their future opportunities and choices. Girls from low-income families were more likely than more affluent girls to say they saw limited choices for their identities and future goals. The Latino and African American boys in our sample told us their parents and counselors tended to focus strongly on making sure the boys avoided trouble and remained engaged in school, and they tended to support the boys' engagement in compelling and socially desirable activities such as sports rather than science.

Discussion

Students' stories about their school, family, and extracurricular lives underscored the significant role that communities of (science and non-science) practice, key socializers, and students' gender, ethnicity, and socioeconomic status played in the development or dissipation of their identities, participation, and career goals in science. The three groups whose paths diverged over time each encountered a different microclimate—a combination of communities of practice at home, at school, and outside of school—characterized by different counseling, science courses and teaching, peer academic attitudes, access to real scientists and their work, and family support for science. These microclimates provided different resources, experiences and interactions, challenges and opportunities, as well as expectations, feedback and advice from significant others, which helped frame students' perceptions of SEM study, their own abilities, choices and career options, and chance to succeed. In the process, these perceptions influenced the way students consciously or unconsciously considered the questions: What is science? How important is it to me? Am I good at it? Is science me?

Students who participated in and found solid support for science in multiple communities were more likely to consolidate their science identities and persist in their SEM aspirations, becoming High Achieving Persisters, than students with less breadth and depth of support. They were buoyed by perceived strong and aligned support for their science identities at home, at school, and in extracurricular activities (Schneider & Stevenson, 1999). They felt high expectations from their mostly middle to high SES, mostly Asian American families for courses and grades, and their science identities benefited from family SEM role models, tutoring, information, and coaching. Their schools reportedly had science-supportive teachers, counselors and administrators and offered advanced courses, which the students utilized while investing considerable time and effort to maintain their identities as good science students. When students encountered problems, the broad support they enjoyed reportedly contributed to their resilience and confidence in facing challenges. Facilitated by parents, many participated in compelling extracurricular opportunities where they apprenticed with SEM professionals, described as inspiring role models who helped students find their strengths in

science while practicing authentic work, and influenced their judgments about the extent to which learning and doing science could be enjoyable, relevant, feasible, and desirable.

Low Achieving Persisters (mostly low-income females who wanted to become doctors or dentists) described communities of practice with far fewer positive elements and seemed to lack the network of knowledge and contacts, the cultural capital, of the High Achieving Persisters' families and social class. They mentioned no extracurricular activities in which to learn about and practice authentic science, and often had the additional responsibility and distraction of a non-science job. Perceiving family and school norms as accepting lower academic performance and with frustrating counseling and learning experiences in school communities of science practice, as well as some reported bias against minorities, they did less well academically than others. Still, they managed to negotiate continuing science identities through support from siblings or non-parent adults, a strong altruistic commitment to help their communities through medical careers, and/or consistent focus on SEM goals through a healthy academy.

Students who perceived little if any support for their science identities in multiple communities of practice—nearly half the sample—eventually dropped out of the SEM pipeline, becoming the Lost Potentials, despite the fact that most were capable and hard-working. During high school, these mostly middle-class and ethnically diverse students perceived significant challenges in their school communities of practice involving science: teachers they perceived as uncaring or poorly skilled; instruction that failed to help them appreciate the discursive practices of science or the rationale for how science is done, despite the importance of such fundamental understandings for science literacy (Duschl, 2003); classrooms where they felt they had little voice and no personal connection between the curriculum and their daily lives and dreams (Furman & Calabrese Barton, 2006); and counseling to avoid “hard” science courses, from which they inferred that science was not meant for them. Those like Thomas and Debbie who dared to question the norms and values of school science, felt teachers saw them as deficient and unworthy (Harding, 1998; Furman & Calabrese Barton, 2006), and this negative social persuasion undermined their sense of self-efficacy in science (Britner & Pajares, 2006). As their grades slipped and their identity or status shifted, it is not surprising they lost confidence in themselves as science learners and began to doubt their chance to succeed in science careers. Lost Potentials' families, with modest means, few apparent connections to SEM professionals, and non-science priorities, were reportedly unable to counter the schools' negative science messages and stress, provide SEM career models and information, or help students connect to inspiring extracurricular science opportunities. Motivated to achieve and to attend a 4-year college, some students, like Joseph in graphic arts and Chrissy in tutoring, shifted identities when they discovered an alternative community of practice in which they felt competent, could imagine an attainable and rewarding career, and were encouraged by family more familiar with the alternate area than with science.

The fact that the three groups of students were not evenly distributed over the six schools invites future research to investigate the degree to which system-level factors may affect students' identity development and SEM trajectories. In our study, all the students in the sample at Pasa Flores become Lost Potentials; all the Low Achieving Persisters came from another school, Century High; and High Achieving Persisters came mainly from Treadwell and Sycamore. Our students' experiences suggest that the value of communities of science practice lies partly in the depth and personal meaning of the activities and interactions there, and that identity within a community is deepened by competence and positive assessments by self and others. How might the culture of a district/school/academy affect the kind of teachers and counselors hired, the kinds of curriculum and learning activities implemented, which students are allowed access to which communities of science practice (courses, tracks, academies, activities), how much space for student voice and participation in authentic inquiry the teachers are allowed/encouraged to provide? As our findings indicate and Brotman and Moore (2008) suggest, systematic research is needed on how the overall culture of a district, school or academy constrains or enhances development of students' identities and the depth of learning that occurs.

This study's definition of the science pipeline to include the many medical/health careers and science-related jobs accessible through community college pathways revealed the phenomenon of the Low Achieving Persisters—primarily low-income females in our sample—who are strongly interested in science-related jobs but by the end of high school would appear to have dropped out of the pipeline under a more traditional academic-science definition. The fact that all these students came from one high school (and most were from its health academy), raises additional questions about the academy/school: who they attract or recruit, what

identities are promoted there, who does well in this setting, how the observed disconnect between aspirations and performance occurs, and how well students are prepared to pursue their ambitions. Given the rise of biotechnology and many science-related jobs requiring less than a 4-year degree, and economic pressures inducing many students to seek cheaper college/career paths, an inclusive definition of the pipeline is useful to explore the trajectories of a diverse population towards a broad array of careers.

Compelling apprentice or intern opportunities facilitated by supportive parents set High Achieving Persisters apart from the other groups. To provide accessible opportunities for more students to experience doing SEM in authentic and exciting communities of practice, *regularized* partnerships could be developed to link schools to places of SEM practice like community colleges and universities, hospitals, museums, and technical laboratories. Such programs could allow students to explore identity connections to science in their own individual ways. Research on how such informal, active learning settings help students discover their abilities and options and perhaps develop a sense of themselves as people who enjoy learning/doing science and engineering would contribute to a growing and important body of literature to guide policy and practice in this area (Hsu & Roth, 2009; Tal & Morag, 2007).

While our findings reinforce the research on communities of practice and their important role in student identity development, our results also highlight how few adults at home or school enthusiastically invite students to learn about science or engineering, to value scientific ways of knowing, or to pursue an SEM degree or career. High Achieving Persisters tended to have parents, teachers, or scientists who filled this role, but other students found fewer science guides. While academies might seem to offer access to professional knowledge, contacts and mentors many families lack, students' stories lead us to question how well they deliver on this promise and whether their efforts are effective. Our study underscores the need for programs to help educators, families, students, and others appreciate and value science while at the same time transcend the narrow vision of the culture of power in science education that alienates or counsels too many youth away from learning and enjoying science. We are not advocating that all students should major in science in college or aspire to become scientists and engineers. We do support reformers' suggestions that scientific literacy is useful to individuals and society (AAAS, 1990; NRC, 1996), and we assert that more students might be interested in careers involving the study of science if they were aware of them and if the learning process were more personally meaningful, acknowledged what they bring to science, and provided the chance to enact who they might want to be. To this end, better informed and science-comfortable adults in families, schools, and communities could more effectively invite students to learn science, develop confidence, and better align their choices and ambitions.

This material is based upon work supported by the National Science Foundation (NSF) under grant REC0231878. Any opinions, findings, and conclusions or recommendations expressed here are those of the authors and do not necessarily reflect the views of the NSF. We thank the members of our extended research team and our advisory panel for their efforts in conducting the study, and we thank the students for making the study possible.

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