Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytic Lens

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Abstract:
In this study, we develop a model of science identity to make sense of the science experiences of 15 successful women of color over the course of their undergraduate and graduate studies in science and into science-related careers. In our view, science identity accounts both for how women make meaning of science experiences and how society structures possible meanings. Primary data included ethnographic interviews during students' undergraduate careers, follow-up interviews 6 years later, and ongoing member-checking. Our results highlight the importance of recognition by others for women in the three science identity trajectories: research scientist; altruistic scientist; and disrupted scientist. The women with research scientist identities were passionate about science and recognized themselves and were recognized by science faculty as science people. The women with altruistic scientist identities regarded science as a vehicle for altruism and created innovative meanings of "science," "recognition by others," and "woman of color in science." The women with disrupted scientist identities sought, but did not often receive, recognition by meaningful scientific others. Although they were ultimately successful, their trajectories were more difficult because, in part, their bids for recognition were disrupted by the interaction with gendered, ethnic, and racial factors. This study clarifies theoretical conceptions of science identity, promotes a rethinking of recruitment and retention efforts, and illuminates various ways women of color experience, make meaning of, and negotiate the culture of science.
Keywords: general science; diversity; equity; sociocultural issues

Article:

Undergraduate science majors often must negotiate a culture characterized by white, masculine values and behavioral norms, hidden within an ideology of meritocracy (Eisenhart & Finkel, 1998; Johnson, 2001; Nespor, 1994; Seymour & Hewitt, 1997; Traweek, 1988). In their study of science majors at seven different U.S. colleges and universities, Seymour and Hewitt (1997) noted specific features of science departments that aligned with masculine norms and values, particularly the competitive nature of weed-out courses and unfriendly professors. The researchers also found that many students of color manifested values at odds with those expected in science departments. Thus, students of color and white women had more difficulty thriving in undergraduate science than did white men. This was despite preparation; all participants in the ethnographic study scored higher than 650 on the mathematics portion of the Scholastic Aptitude Test (SAT). Several biographical accounts similarly describe the setbacks and successes of women scientists of color (Ambrose, Dunkle, Lazarus, Nair, & Harkus, 1997; Chinn, 1999, 2002; Manning, 1989; Sands, 1993).

Despite these difficulties, many women of color persist and, at times, thrive in science. For example, in 2001, Asian American women were the most well-represented science graduates compared with their showing among all college graduates: 3.3% of all college graduates, and 5.2% of science graduates. Even black, Latina, and American Indian women, whom one might predict would find the most difficulty persisting, were only moderately underrepresented: 10.3% of all college graduates in 2001 compared with 8.3% of science majors (NSF, 2005).

The obvious question, then, is how do women of color experience, negotiate, and persist in science? The existing literature is silent on this question, although there has been some recent attention to related questions. For instance, in their study of 11 successful African American undergraduate seniors (eight women and three men) in a biology degree program at a predominantly white institution, Russell and Atwater (2005) found that strong pre-college science experiences, family support, teacher encouragement, intrinsic motivation, and perseverance were all critical factors in students' success. In a study of 22 Hispanic engineering majors (12 women, 10 men), Brown (2002) found nearly identical results. In addition, she found that growing up in small, supportive communities benefited students.

These studies provide starting places to understand barriers for women of color in science and mechanisms that help students of color persist in science, but there are further gaps to address. For example, the factors outlined in the Russell & Atwater (2005) and Brown (2002) studies might describe any successful student in science; how do race, ethnicity, and/or gender complicate those factors? Do women of different ethnicities have different experiences in science? Lewis (2003) asked a similar question: "What it is about being African American" that can explain why African Americans are underrepresented in science?" Further, students' agency is underexamined in these studies; factors that explain success are fairly static. For instance, one either has had parental support or strong pre-college science experiences or she has not. Such explanations position the student as a passive recipient of her life's conditions with little consideration for how she might creatively position herself within and against those conditions. Finally, existing literature provides mostly snapshot accounts of women of color's science experiences. We need better understandings of how their meanings of science and of themselves as budding science professionals evolve over time.

In other words, the literature about successful women of color in science needs a richer theoretical lens that takes into consideration the complex interplay between structure and agency and the ways these tensions play out over time. The construct of identity holds such explanatory potential. Identity accounts for "individual agency as well as societal structures that constrain individual possibilities" (Brickhouse, 2000, p. 286). It allows for nuanced consideration of race and gender—that is, for race and gender to be something we do rather than something we are (Brickhouse, 2000). Finally, the notion that identity is not predetermined and fixed lets us study someone's identity across time and in different contexts (Brown, Reveles, & Kelly, 2005; Gee, 1999, 2000–1; Holland, Lachiotte, Skinner, & Cain, 1998; Lemke, 2001).

A primary purpose of this study is to contribute to science educators' contemporary theoretical discussions about science identity. Although the concept of "science identity" is receiving growing attention in science education literature (e.g., Brickhouse, Lowery, & Shultz, 2000; Brickhouse & Potter, 2001; Eisenhart & Finkel, 1998; Hughes, 2001; Tan & Calabrese Barton, 2007), the concept is slippery and difficult to operationalize in a way that provides solid methodological and analytic direction. Our dissatisfaction with the amorphous nature of the concept led us to develop an initial model of science identity (described in what follows, in the Conceptual Framework section) to make sense of the science experiences of 15 successful women of color through their undergraduate and graduate studies in science and into the beginnings of their science-related careers. We used our initial model as a flexible guide, one that informed but was also informed by the data. In doing so, we ultimately developed a more grounded, fleshed-out science identity model, which we present in the Discussion section.

Our study has theoretical, methodological, and practical implications. We expect that our grounded model of science identity will provide a theoretical and methodological springboard for other researchers who concern themselves with identity and the problem of underrepresented groups in science. The women's stories, interpreted through the science identity lens, will inform those who want to understand the multiple ways women of color experience, make meaning of, and persist in science. Finally, we expect that the successful and problematic cases we present here will inform those who develop science, technology, engineering, and mathematics (STEM) programs and curricular innovations aimed at recruiting and retaining diverse populations.

Conceptual Framework

The Science and Mathematics Education Literature on Identity Scholars in science education have posed three main arguments for emphasizing identity as an analytic lens. First, those who utilize social theories of learning, such as situated cognition (e.g., Brickhouse & Potter, 2001), cultural historical activity theory (e.g., Lemke, 2001), and practice theory (Carlone, 2003, 2004; O'Neill & Polman, 2004), argue that identity opens up a new way of viewing teaching and the science learning environment. The identity lens allows us to ask questions about the kinds of people promoted and marginalized by science teaching and learning practices; the ways students come to see science as a set of experiences, skills, knowledge, and beliefs worthy (or unworthy) of their engagement; and the possible ways that students' emerging identities in science might eventually involve changes in their more enduring sense of who they are and who they want to become (Cobb, 2004).

A second, related argument for including identity as an analytic lens involves new ways of viewing the process of learning, as the socialization of students into the norms and discourse practices of science (Brown, 2004; Kelly, 2007; Varelas, House, & Wenzel, 2005; Warren, Roseberry, & Conant, 1994). Mathematics educators make a similar argument, explaining that, as students engage in relevant disciplinary practices, they begin to develop stronger mathematical identities (Boaler, 2002; Nasir, 2002). If we view science as a community of practice (Lave & Wenger, 1991; Wenger, 1998) into which aspiring members must be enculturated, it is essential that we understand how neophytes affiliate with, become alienated from, and/or negotiate the cultural norms within these communities.

Third, the lens of identity aids in the quest for a more equitable science education. Traditional school science practices imply that science consists of narrowly defined tasks and emphasize science as a finished body of knowledge. This promotes narrow science identities that do not appeal to a broad range of students (Calabrese Barton, 1998; Eisenhart & Finkel, 1998; Gilbert & Yerrick, 2000). Broadening students' participation in science requires close attention to the kinds of people we ask students to become as they participate in science activities, and to the ways girls, women, and students of color embrace and resist these promoted science identities (Brickhouse & Potter, 2001; Carlone, 2003, 2004; Eisenhart & Finkel, 1998; Hughes, 2001; Olitsky, 2006). For example, Carlone (2003, 2004) found that, in a traditional physics curriculum (emphasizing lectures and verification labs), girls embraced the certainty of knowledge because it appealed to their good student identities (i.e., allowed them to earn good grades). However, they did not develop science identities because the nature of the tasks deemphasized scientific thinking, talking, and tool use (Carlone, 2003). Cultivating short-term knowledge and interest are not enough to develop sustained interest in science; we need to look beyond achievement and interest to understand how and why some students persist in and others opt out of science. We need a better understanding of how students develop science identities.

An Initial Science Identity Model

In this section, we describe our initial science identity model, developed to provide analytic direction for our data analysis and interpretation. Due to the concept's unwieldy nature, we had to make choices about what counted as "identity" in our model; it was impossible to include every possible aspect of identity. Our model is informed by both practical and theoretical sources (Maxwell, 2005). First, we considered a prototype—how would we describe a person who has a strong science identity?[1] She is competent; she demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world scientifically. She also has the requisite skills to perform for others her competence with scientific practices (e.g., uses of scientific tools, fluency with all forms of scientific talk and ways of acting, and interacting in various formal and informal scientific settings). Further, she recognizes herself, and gets recognized by others, as a "science person." Our model captures these aspects of science identity in three interrelated dimensions: competence; performance; and recognition (Figure 1).

This model is also informed by Gee's theory of identity (1999, 2000–1). Gee defined identity, in part, as "the 'kind of person' one is seeking to be and enact in the here and now" (1999, p. 13). Yet, one cannot claim an identity all by oneself; being "somebody" requires the participation of others (Buxton, Carlone, & Carlone, 2005; Carlone & Webb, 2006; Gee, 1999, 2000–1; Holland et al., 1998; Wenger, 1998). One cannot pull off

being a particular kind of person (enacting a particular identity) unless one makes visible to (performs for) others one's competence in relevant practices, and, in response, others recognize one's performance as credible. For example, a scientist presenting her work at a conference must use language according to prescribed norms, dress and interact in certain ways, and demonstrate that she thinks in certain ways for others to recognize her performance as appropriately "science-like" if she wants to be considered a scientist. The criteria for credibility shift depending upon context. For instance, performing and being recognized as a scientist is subject to different norms depending on whether one is in a lab with one's graduate students, at a dinner party with other professionals, or in a classroom as a guest speaker. Our model accounts for the socially constructed nature of science identity. Lewis (2003) makes a similar point in his critique of studies of the underrepresentation of African Americans in science, which, he argues, overlook how "science career attainment is a social process, and the desire of an aspirant is only one factor in this process. An aspiring scientist relies on the judgment and invitation of practicing scientists throughout every phase of the educational and career process" (Lewis, 2003, p. 371).

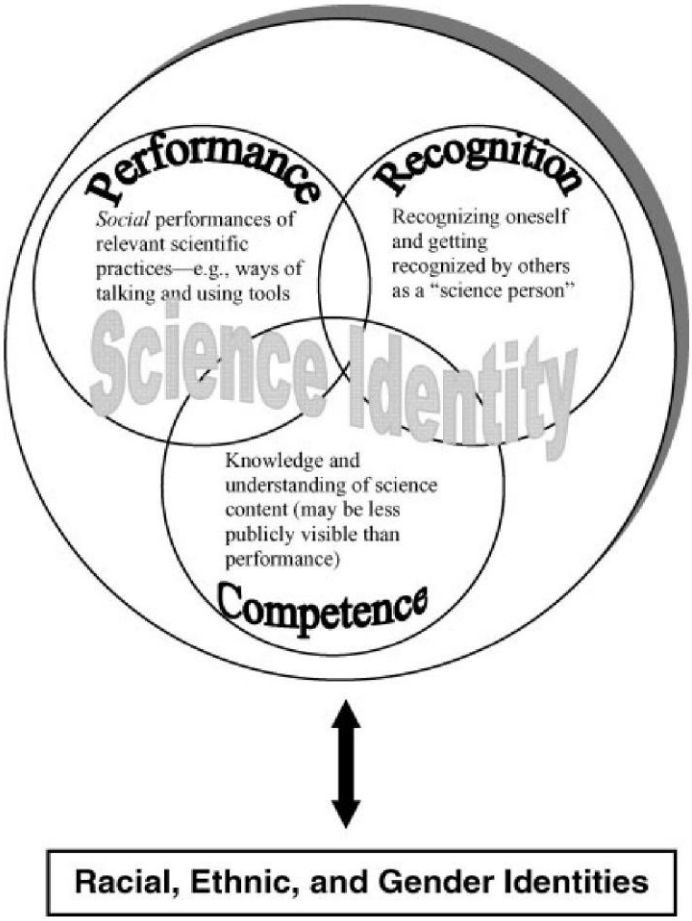

Figure 1. Model of science identity that guided our initial analysis.

The model illustrates that the three dimensions of science identity—competence, performance, and recognition—overlap. Someone with a strong science identity would rate themselves highly and be rated highly by others in each of these dimensions, but one can envision various degrees and different configurations of science identity. For example, someone might be able to perform relevant scientific practices (e.g., communicate and use tools within designated scientific norms), recognize herself as a "science person," and get recognized by others as a "science person," but may not have a deep and meaningful understanding of the science content (i.e., she might have low competence). Tonso's (1999, 2006) ethnographic studies of a relatively elite U.S. engineering program provided examples of such students. Tonso found that high-status engineering students (i.e., those who receive the greatest recognition) were sometimes the least skilled (i.e., had the lowest competence). In another scenario, we can envision someone who might be very competent in her understanding of science content and may be able to adequately perform scientific practices, but, for one reason or another, may not recognize herself or get recognized by others as a science person. For example, Tonso

(1999, 2006) found women in the engineering program she studied who were extremely competent and excellent performers of engineering practices in small group settings, but who were rarely recognized as legitimate engineers by their professors or with potential future employers.

Our science identity model is based on an assumption that one's gender, racial, and ethnic identities affect one's science identity, a connection hinted at, but not made explicit, in previous literature. For example, numerous studies have indicated women pursue science for different reasons than men (Huang, Taddese, & Walter, 2000; Leslie, McClure, & Oaxaca, 1998; Sax, 1994) and that their success in science is associated with different factors (Farmer, Wardrop, & Rotella, 1999; Fenske, Porter, & DuBrock, 2000; Sax, 1994; Wyer, 2003). Yet, the relationship between one's racial, ethnic, and gender identities and one's science identity warrants further study.

Identity is not simply what an individual says about her relationship to, abilities in, or aspirations regarding science; it is not purely an emic construct (see also Tan & Calabrese Barton (2007), who demonstrated the personal and social nature of identity). Identity arises out of the constraints and resources available in a local setting. Identity is not just something an individual feels; it is not even what an individual does, although both feelings and actions are components of identity. A science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person.

In our conceptualization, science identity is both situationally emergent and potentially enduring over time and context. Although we recognize that identities get formed in practice (Holland et al., 1998; Lave & Wenger, 1991; Rahm, 2007), we also take into consideration that, over time, people's performance, participation patterns, and expectations become patterned and habitual. Through their years of science education, students learn to participate in similar practices in similar ways and often get recognized (or not) in similar ways. We see science identity as fragile (contingent, situationally emergent) and, if habitually accessed, performed, and recognized, as stable, carried across time and context (Elmesky & Selier, 2007; Roth, 2006).[2]

Cultural Production

The study of identity demands consideration of "cultural production," a construct from educational anthropologists defined as "meanings developed by groups in their everyday activities" that reflect or counter-meanings implied by larger social structures (Eisenhart & Finkel, 1998, p. 44). Cultural productions allow us to study the ways sociohistorical legacies (i.e., the way white men predominate among practicing scientists) are reproduced in local practice and how groups (e.g., women of color majoring in science), in their everyday practice, might contest legacies to create novel meanings (Carlone, 2003; Carlone, 2004; Eisenhart, 2001). This construct is helpful in understanding identity development because it focuses on articulations between local meanings of an activity or phenomenon and global contexts that enable and constrain those meanings. For example, a typical undergraduate introductory chemistry class is sometimes considered a weed-out course where only the most competent students excel. Those who excel come to be known as "science people." The cultural practices of the weed-out course perpetuate powerful, historically enduring meanings of "science people"; for example, students are spectators in class, exams are graded on a curve, and the professor teaches a standardized curriculum that may seem irrelevant. Yet, different cultural practices might promote more inclusive meanings of "science people." Cultural production reminds us that the women in our study were not free to develop any kind of science identity. Their choices were shaped by: (1) larger and more pervasive meanings of "science people" derived from sociohistorical legacies of science; and (2) historical and political meanings of being a woman of color. Still, cultural production allows for the possibility of the women transforming meanings of "science people" and what it means to be a woman of color in science. Cultural production reminds us that the outcome of a situation, or the meaning produced in a setting, is never determined or fixed; it is always in question (Eisenhart, 2001).

Research Questions

The research questions for this study were: (1) How do successful women of color negotiate and make meaning of their science experiences? (2) How do women of color develop and sustain their science identities throughout their undergraduate and early science careers? (3) What is the relationship between the women's science identities and racial, ethnic, and gender identities?

Further, we were interested in testing out our initial model of science identity. What aspects of our a priori definition of science identity were relevant for these women's developing science identities? How might our findings inform the science identity model? In other words, we were interested in adding depth and texture to our model by grounding it in our empirical findings.

Methods

Participants and Data Collection

This study is part of a larger ethnographic study of women science students of color at a large, public research university (Johnson, 2001). The university is located in a small, predominantly white city in a mostly rural state. The university is also predominantly white, although it is more diverse than the city or the state overall. The area is good for science; besides the university, this city is home to numerous public and private science and engineering entities, and there are several Nobel Prize–winning scientists on the university faculty. The science faculty is around 25% female and 10% nonwhite; over half of the nonwhite faculty are Asian American. Although the university is well-ranked and attracts many out-of-state students, it primarily serves in-state students and is relatively affordable.

Participants for our study included 15 women (see Table 1): 4 Latinas (Mexican American and Southwestern Hispana); 4 black women (3 African Americans and 1 African immigrant); 3 American Indian women (all raised on or near their respective Nations); and 4 Asian American women (Taiwanese, Filipina, and Indian, all raised since birth or infancy in the U.S.). The women in this study all identify themselves as women of color, a term with both ethnic and racial components. By ethnicity, we mean systems of meaning shared among a group. By race, we mean what students, at first glance, "look like." For some of the Latinas in this study, being a woman of color is more a matter of ethnicity; they are all Mestiza, but some are light-skinned enough that they are sometimes assumed to be white. For all the Asian American, American Indian, and black women in the study, and some of the Latinas, being a woman of color entails both ethnicity and race. The women in particular categories do not necessarily share the same ethnicity; among the black women, for instance, three are ethnically African American and the fourth is an African immigrant. The American Indian women come from several different nations, and the Asian Americans from a variety of nations of origin. To further complicate matters, several of the women are actually ethnically or racially mixed; we classified them according to their individual preference. To protect the women's confidentiality, we used only broad categories when describing particular students (for the American Indian women, omitting references to particular Nations; for immigrants and children of immigrants, not specifying nation of origin). Again, for confidentiality reasons, we used black rather than African American to avoid uniquely identifying the African woman. The diversity in our sample allowed us to explore not only the similarities of these women's experiences but their differences as well.
Informants were recruited through an academic enrichment program for high-achieving students of color in the sciences. One of us, Angela, was an instructor in this program from 1997– 2001, and knew almost all of the informants prior to the study. Her work with this program gave informants an opportunity to judge her trustworthiness and build a rapport with her before agreeing to participate in the study. To protect informants from conflicts of interest or coercion, she interviewed only women who had already completed her course, gave them the opportunity make corrections and deletions to interview transcripts, invited their comments on all writing that grew out of the study, and invited them to public presentations of all findings. Twelve women were juniors or seniors at the time of the initial interviews; three more were interviewed at the end of their sophomore year. Thirteen of the women graduated with science majors; one graduated in another field but with extensive upper-level coursework in science; and one had not yet graduated during the writing of this manuscript. All 14 graduates pursued advanced degrees in science-related fields and are currently pursuing science-related careers.

Table 1

Research participants, ethnicity, major, and current occupation by science identity trajectory

Participant	Ethnicity	Major	Current Occupation		
			Life Sciences	Health Practitioner	Social Sciences
Research scientist identity					
Chris	Latina	Molecular biology	Doctoral student		
Nancy	Latina	Molecular biology	PhD		
Jaya	Asian American	Molecular biology	PhD	Medical student	
Mariah	Asian American	Biochemistry	Doctoral student		
Altruistic scientist identity					
Jackie	Black	Psych/population bio		MD	
Magdalena	Latina	Biochemistry		Doctoral student	
Evonne	American Indian	Molecular biology		MD	
Xiao-Ling	Asian American	Kinesiology		Physical therapist	
Monica	Pacific Islander	Anthropology		Medical student	
Disrupted scientist identity					
Alethia	Black	Molecular biology			MPH
Conchita	Latina	Kinesiology	Physiology research		Public health PhD student
Kathy	American Indian	Molecular biology		PharmD	Epidemiology research
Crystl	American Indian	Chemistry	Undergraduate		
Chanda	Black	Population biology	Master's student		
Merima	Black	Molecular biology		PharmD	

This study draws on data collected via ethnographic interviews that took place in 1999 and 2000 and follow-up e-mail interviews in Winter 2005–6. Initial interview questions centered on the women's experiences as science majors in a predominantly white setting. They included whether students wanted to persist in science and why, whether they felt they had been successful science students, and their perceptions about how their ethnicity shaped their experiences. Most interviews took about 1 hour; actual times ranged from 40 minutes to 2 hours. The university's office of institutional research supplied students' predicted first-year and graduation grade point averages (GPAs).

We are currently in contact with 13 of the informants, and have been in contact with 1 more within the past 2 years. In November 2005, we e-mailed the 13 women, asking about their current career status. All 13 responded. We e-mailed each of them at least once more, asking focused interview questions (Spradley, 1980) to clarify their earlier e-mail responses. These questions ranged from the specific (asking particular informants why they chose, for instance, to pursue graduate school—information beyond the scope of the original interviews which took place while they were undergraduates) to the theoretical (asking participants to comment on our developing theoretical insights). In February 2006, we sent 13 informants an earlier draft of this article. Seven responded. Five responses were entirely positive; two included suggestions for improving the article, which we incorporated.

Data Analysis

We analyzed data by using Spradley's (1980) method of semantic structure analysis. First, using our science identity model as a guide, we searched for the patterns in the data, developing categories of cultural meaning, or domains. Each domain consisted of a cover term (the name of the domain; for instance, "recognition by meaningful scientific others"), a list of included terms (the examples we found which fit into the cover term; for instance, "receiving an assistantship," "being put on the spot during office hours") and a semantic relationship (which described the relationship between the included terms and the cover term; for instance, "is a kind of").

Next, we used a taxonomic analysis, which involved looking for relationships among included terms and, once individual domains were organized, among domains. This involved looking primarily at domains associated with competence, performance, and recognition and with students' cultural, ethnic, and gender identities. Taxonomic analysis allowed us to resolve the participants' experiences into three main categories: those who formed research scientist identities; those who formed alternative (but effective and satisfying) scientist identities; and those whose science identity formation was disrupted by others. Central domains for this analysis, for example, were "recognition of self as scientist" and "science recognition by others." The latter domain was broken down into subdomains including "recognition by meaningful scientific others," "recognition by others outside of science," and "disrupted recognition."As the analysis progressed, we looked at all included terms under each of the major domains and categorized them into increasingly finer-grained categories. For instance, "recognition by meaningful scientific others" was subdivided into positive, neutral, and negative. See Appendixes A and B for sample domain and taxonomic analyses related to "recognition." As our analysis progressed, it was clear that the "recognition" component of the model was the most helpful in making sense of the distinctive experiences and meanings for women in the different trajectories as well as the interactions between gender, race, ethnicity, and science identities. In foregrounding recognition, we note here that the use of interviews as our primary data source meant that we relied on the women's reports of positive or negative recognition and our member-checking strategies. We did not directly observe the incidents we describe in what follows; in fact, some of them were quite intimate, occurring between students and professors in the privacy of offices and labs. The "meaningful others," whom our informants believed had failed to recognize them, might interpret the events quite differently. For the purposes of our analysis, we assumed that if a student felt negatively recognized, it was irrelevant to her science identity development whether an outside observer would have agreed on her interpretation or whether or not a negative recognition was intended. Our interpretations of the data were guided by our commitments to interpretivistic and critical research paradigms. Our privileging of the women's meanings stems from interpretivism, which implies that the primary goal of research is to understand the participants' realities (Crotty, 1998; LeCompte & Shensul, 1999). At the same time, our critical research lens meant that we also took seriously the influences of social structures like race and gender in structuring the women's experiences, meanings, and identities.

Once we identified initial domains, we conducted various componential analyses, which involved selecting the domains of greatest relevance to our emerging assertions (Erickson, 1986) (i.e., those dealing with recognition) and examining their included terms to determine their relevance for women in different groups. For example, we examined the ways "recognition by others" was similar and different for women in different groups. These analyses allowed us to explain the different science identity trajectories that, after a process of validation, became our major findings.

Both of us are white women. Because we both have undergraduate degrees in science (A.J. in physics, H.B.C. in biology), we came to this study with a degree of familiarity with the setting. However, our experiences as white women allowed us only very partial insight into our informants' experiences. Because of this, we were particularly rigorous in our validation procedures, which included triangulation and, most importantly, member checking. We placed more trust in findings that emerged from several different data sources (formal interviews, e-mail interviews, participants' current occupation). For instance, as we describe in what follows, we had already tentatively grouped students into identity categories when we discovered that all women in the research scientist identity category were pursuing PhDs in science research, whereas none of the other women in the study were doing so; this provided strong support for our groupings.

Results

Our initial science identity model included three components of science identity: competence; performance; and recognition. When we examined GPAs, we found no robust patterns regarding the competence across groups. The women in the research scientist identity group had the highest mean GPAs at graduation (3.53); the women in the altruistic group were next in GPAs (3.30); and the women in the disrupted group were lowest (3.10). However, there was wide variation within each group, and all these averages compare favorably with the college-wide average of all the students who matriculated between 1995 and 1998 and graduated in science (3.12), and the average of students of color in this group (3.02).

Because this study draws on interview data rather than observation data, we cannot draw any conclusions about the women's public performances of scientific practices. Thus, this study foregrounds recognition (of self and by others) as a key component of science identity development for women of color because we found that this dimension of the model most critically explained the differential experiences for women in the three identity groups—research, altruistic, and disrupted (see Appendix B). In addition, the recognition dimension of the science identity model made most visible the interactions between the women's science identity trajectories and their race, ethnicity, and gender. Our labels for different science identity groups highlight an identity as a path or a trajectory (Wenger, 1998). We do not want to imply that the trajectory has a fixed course or destination, but rather that it "has a coherence through time that connects the past, the present, and the future" (Wenger, 1998, p. 154).

All the women in the research scientist trajectory are currently working as research scientists; all have completed or are in the process of completing doctorates in research science; and among them they have five peer-reviewed publications and hold three patents. All the women whom we classified as altruistic scientists are health practitioners or are near completion of pre-professional programs, including three doctors, an audiologist and a physical therapist. The professional patterns for women in the disrupted trajectory are less clear. Although none of them entered a doctoral program in the sciences, three of them maintained, nonetheless, a strong orientation toward research. One works as a public health researcher; a second has just received her master's degree in public health but financed her education by working in a kinesiology lab (and has coauthored three peer-reviewed publications as a result), and a third became a pharmacist and is currently conducting epidemiology research. Three more are still in school, including one finishing her undergraduate degree in biochemistry, one who (as of March 2000) was in a master's program in the life sciences with hopes of pursuing medical school, and one who is a pharmacist. Our label of "disrupted scientist identity" represents the following unifying pattern: All women in this group expressed dissatisfaction about how they were positioned in science and felt their goals to become scientists and doctors were disrupted. Although they were able to persist in the face of these disruptions, their trajectories were rockier, more unstable, and less satisfying. That their current occupations have not fallen into the simple patterns of the women in the other two trajectories is consistent with their sense that their initial career goals to become doctors or research scientists were disrupted (see Table 1).

In the remainder of our discussion, we focus on each identity trajectory in more detail. In doing so, we make the argument that developing a satisfactory science identity hinges not only upon having competence and interest in science, but also, critically, upon recognition by others as someone with talent and potential in science. Our

focus on women of color, those who have not been recognized historically as "science people," brings into relief the importance and problematic nature of recognition by others in cultivating satisfying science identities.

Research Scientist Identities

Recognition of self as scientist. Nearly every woman in the study recognized herself as a "science person" to some degree or another. They expressed enthusiasm for science's practices, subject matter, or career possibilities. The women in the research scientist trajectory, however, were particularly focused on prototypical aspects of science. They saw science as an exciting way of knowing, expressed the importance of science for science's sake, and conveyed an interest in studying the natural world. Nancy said about her experiences working in a research lab:

> I like working in the lab because I get to go in there and I get to do all this stuff that you have no idea what you're doing—because you work with things that you can't see, right? And so you do a lot of stuff, ...you don't know if it's going to work or whatever, and then you find out that it works, and you're just kind of like "Wow, I did that, and it worked! And now I know that this species is not related to this species..." It was just all this work on trying to find out [using DNA sequencing] if some species were related, and how closely they were related. It was just learning—learning about things that you can see by using things that you can't see. (Interview, 13 August 1999)

Later in the same interview, Nancy was asked what she wanted to do next, and she said:

> After I graduate, I want to come back and do a doctorate, probably in genetics, some kind of genetics. And then I want to do research. Because I just find it fascinating! You're always learning! That's what I like—I like learning. (Interview, 13 August 1999)

Chris talked about the pleasure she derived from employing the logical processes of science:

> I like the fact that I get to think about a lot of things at once, and try and figure out what's going on and stuff like that. Whenever you set up reactions, you have to think about all the factors that are happening at once, and try and figure out which ones you're going to change and which ones you'll leave the same, and I like to do that kind of stuff, set up experiments and figure out what's wrong. (Interview, 27 August 1999)

Each woman in this group described herself as a "science person" or "scientist," highlighting the ways she saw her interests and ways of thinking connected with science. For example, Jaya echoed Nancy's emphasis on the value of evidence and Chris's pleasure in science's intellectual processes, presenting this as a way of thinking that made her more of a "scientist":

> I guess I'm more of a scientist. I like the whole intellectual aspect of it. I really like to think that way. Many things, like psychology and religious studies and things like that, you don't have physical evidence of some things, and I like to have the evidence in front of me. I guess that's what makes me a scientist, in a way. (Interview, 2 September 1999)

Finally, each woman aligned herself with a research scientist identity by pursuing work in a research laboratory early on in her undergraduate career. Chris and Nancy sought out paid positions in research labs, Jaya and Mariah received research fellowships and funding, and, as juniors and seniors, Mariah and Chris served as teaching assistants and tutors. This behavior implies different "modes of belonging" (Wenger, 1998) than other participants in the study. Wenger (1998) outlined three modes of belonging (engagement, imagination, and alignment) as important sources for identity formation. These women created a meaning of their undergraduate science experiences that was distinct from the women in other groups. Their engagement in the laboratory at an early stage of their undergraduate careers allowed for greater opportunities to create shared histories of engagement with other, more senior members of the field. In addition, although their initial reasons for

choosing to work in a lab may have centered on building their resume´s, with increased engagement as lab assistants, they began to imagine themselves fitting into this community of practice. Imagination involves "the creative process of producing new 'images' and of generating new relations through time and space that become constitutive of the self " (Wenger, 1998, p. 177). The women's choice to continue working in the lab throughout their undergraduate careers was a way of aligning their actions and energies with others further along the research scientist trajectory. Mariah, for instance, said "I saw my research as a 'practice run' for my future career" (e-mail, 8 March 2006). For the women with research scientist identities, lab work was an apprenticeship for their future professional selves.

However, access to the research scientist identity would not have been possible without the recognition from meaningful others within their major departments. The "recognition of self as scientist" was strongly influenced by recognition by meaningful scientific others.

Recognition by others. Every woman in this category received consistent and repeated recognition from established members of the scientific community, or "oldtimers," in Lave and Wenger's (1991) terms. Jaya was awarded four summer research fellowships, both Chris and Nancy were included as authors on published papers, and Mariah presented her research at several undergraduate research forums. This recognition by others led to their own stronger identification with research science. As Mariah put it, reflecting on her undergraduate career:

> I think what gave me my sense of success wasn't the tangible receiving of awards, but rather that professors would say, wow, she's really a top student, I think it's worthwhile to be a mentor to her, or I value her opinion and ideas enough to hire her for this job, etc. Or at least they gave the feeling that I was something special. (e-mail, 18 November 2005)

This recognition did not happen just once; it happened repeatedly. Furthermore, this external recognition shaped their own self recognition as scientists. Chris, for example, worked in three different research labs as an undergraduate. Each of the labs focused on environmental biology. Because Chris majored in molecular biology, she became recognized in her labs as the molecular specialist, the person in the lab who spent time looking through a microscope and studying DNA. A publication on which she was third author grew out of this role and, along with it, a sense of self as a content/research specialist in what was becoming "her" field.

Altruistic Scientist Identities

Although the women in the research scientist trajectory recognized themselves and were recognized by others as "science people" in prototypical terms, the women in the altruistic scientist trajectory created their own definition of science, redefined whose recognition mattered to them, and, in some cases, redefined what it meant to be a woman of color in science. In short, they engaged in successful cultural productions. We argue that these cultural productions enabled the development of strong, and redefined, science identities.

Redefining recognition of self as scientist. The women in this group redefined what they meant by science. They saw scientific knowledge and skills as deeply tied to their altruistic values. When asked why they majored in science, all five gave answers that incorporated two aspects: (1) an interest in humanity, including both human behavior and human physiology; and (2) altruistic career goals that necessitated scientific competence. Their reasons for pursuing science, then, were less about science itself and more about science as a vehicle for altruistic ambitions. This cultural production of science allowed them to have a place in science and to view themselves as science people, albeit different kinds of science people than implied by those in the research scientist identity group.

Although women in all the groups expressed altruistic values and saw science as a way to express those values, the women in this group saw themselves using science in direct service of humanity. Three of the women in this group are now conducting research that can improve people's lives, including ways of minimizing organ

transplant rejection and pharmaceutical research. The women in this group wanted to "give back to others," as Jackie put it, in more immediate, personal ways. Altruism was their primary reason for pursuing science. Jackie's quote below is typical; it illustrates these themes of personal experiences, altruism, and an interest in science only as it relates to humanity. She said:

> I carry the trait for sickle cell anemia... [W]hen they first started telling me about that and I learned about it, I thought it was like the most interesting thing ever—I don't really care for chemistry too much, don't care for physics [laughs, as her interviewer was her physics instructor], but biology, for some reason, I just really have always liked it. I've had a lot of people go through different aspects of needing medical help, and I think it's just a way for me to make a place in the world where I feel like I'm making a difference for other people, which is important for me. I feel like, even though I've had a lot of hard times, I've been given so much, and I've been so lucky to have so many wonderful people—I would say that I've been blessed a lot of the time, for all the hardships and all that, and by being a doctor, it's my way of giving something back to others. (Interview, 9 September 1999)

Xiao-Ling's quote demonstrates the same themes of personal experiences, altruism, and science as it relates to humanity:

> I chose kinesiology because I knew I needed to do some kind of science, and it would help with the pre-req's for med school. But I didn't want to do detailed molecular biology, and environmental was pretty much plants and animals, so ... I really wanted to work with human beings, and I really liked the course load of kines[iology], where—it was one of the only majors that required human anatomy and human physiology, and they also included psychology. It's like the body and mind as a whole, and I liked that more than looking into a microscope. [Angela: Why do you want to go on to med school?] I just want to heal people. I don't like to see people in pain, and I really don't like to—I want to fix them up. So, I thought med school would be the logical path to take. (Interview, 30 August 1999)

All of the women in this group planned to become doctors. Their expressed motives were to serve people rather than to gain status or make money. Magdalena, as we discuss in what follows, wanted to become a medical missionary. Jackie, after saying that she saw medicine as a way to give back, ended with, "It was doctor or teacher"—a choice that certainly suggests she was not in it just for the money. Similarly, Monica talked about "not just being a doctor. Like [being a] teacher, [or a] counselor" (Interview, Spring 2000). Because these women saw majoring in science as a fundamental aspect of their commitment to serving others, their recognition of self as scientist did not hinge on recognition by meaningful scientific others. Thus, their meaning of science may have been a resource for their persistence in science. This finding extends the work of Lewis and Collins (2001), who discussed an African American man whose "perception of science resonates so well with his activism and idealism [that] he is better equipped to persist in a science career" (p. 617).

Redefining meaningful others. These women, for the most part, did not receive, and did not necessarily pursue, the kind of recognition from established members of the scientific community that the women with research scientist identities did. Yet, this lack of recognition did not hinder their satisfaction and sense of belonging in their science majors, nor did it interfere with their career goals, because it was more important to them to receive recognition from meaningful others who shared their altruistic commitments or others whom their altruism would benefit. These women valued meaningful altruistic others more than meaningful scientific others.

Evonne talked eloquently about the people she turned to for recognition of her success in science: the members of her community and other people of color:

> We have the pressure from our communities, so it's really hard for me to go home with bad grades. And that's the pressure people of color have, is we have to bring something back to our community that will be helpful.... And I come home and half the community knows what I've been up to. I'm like, "Where'd

> you hear that from? My mom?" And they're like, "No. Someone else, your grandma, someone in the church." They're watching us. We have that pressure to do well. And that's good pressure. (Interview, 8 June 2000)

Evonne underscored that she was looking to the people of her home community for recognition instead of her science professors:

> So I don't really have a feel for the science department. But working with other people, and being active with other communities of color, you learn about their struggles and this or that, and so when you apply both of them together—biology and working with people—I can see that medicine is one way to connect them all. (Interview, 8 June 2000)

Magdalena looked to her family for recognition of the importance of her science studies. She had already, with her in-laws, traveled to several impoverished locations to provide health care, and wanted to dedicate her life to a health profession as part of her missionary work. That kind of experience, she said, "really changes you" (interview, 1 November 1999). She was a deeply committed science student. For example, she considered taking "only" 24 credits to be a light load. But, she was committed because of this dream, not because of any intrinsic interest in science (which is not to say that she did not find science interesting). Because her deep religious beliefs shaped her professional goals and resulting commitment to humanity, science department values or expectations were almost incidental.

Evonne and Magdalena's cases are typical of women in the altruistic trajectory in that they were driven to pursue science because of their altruistic ambitions and were given fuel to persist in science by redefining whose recognition mattered to them. In doing so, the women in this trajectory had an alternative set of experiences and meanings to draw on as resources, enabling their construction of satisfying science identities. Redefining what it means to be a woman of color in science. For two of the women in this group—a black woman and an American Indian woman—developing a satisfying science identity involved a further cultural production. They put forth innovative interpretations of how membership in a group regarded as historically low-performing in science helped them to succeed. Jackie explained the potential for her professors to see her as a black student or as a woman, and to see those characteristics as conflicting with her scientific competence:

> I went up to go see my biology teacher and he's making us do all this stuff with statistics, and I took statistics like in 1996. Excel's so different now, everything's so different, and I can't remember what I took back then, and I'm just like, "Ah! This sucks"! And so I went up to go talk to him, and I wondered, like, how someone might look at you and be like—I wonder if he's thinking, "Ah, this poor girl," or, "This stupid student," or, "She doesn't know it," you know. How is he like perceiving me? (Interview, 9 September 1999)

Jackie's reflections arose from how the professor might respond upon looking at her—in other words, how his seeing her as a black woman might affect his interpretation of her difficulties. But, instead of feeling paralyzed and defined by historically oppressive meanings of being a black woman in science, Jackie reported that being of color was an advantage to her, making it easier to succeed in science. She was explicit in saying that the assumption that she would not be as academically successful as white students aided in her persistence:

> Definitely the way the world reacts to me has a large influence, I would say, on me, and maybe like the types of things that I will do. But at the same time, maybe I don't feel like I'm so confined—like this is going to sound really contradictory, but in a way, I'm confined by the labels of being black and being a woman, but in a way I'm also freed by being black and being a woman, because—I mean, I'm not the normal, so therefore just because I'm not the normal, I can deviate from the normal easier than someone who is exactly what normal is supposed to be, if that makes sense. (Interview, 9 September 1999)

Evonne reported similar advantages to being a woman of color in science. She saw being American Indian as raising her own performance and that of her white classmates; she believed that this happened because her success defied racist expectations:

> Science-wise, I'm not expected to know what I know. And so I went and talked to the physics professor about a 70 I got on an exam, and the previous time I'd gotten a 100. I told him, "I don't know how I could go from a good grade to a 70." He was like, "What was your grade?" I was like, "I had a 100." His face dropped. He looked at me like that never happened before. And so I'm not expected to know that. So in a sense, if I do really well in science, people look up to me—like, "She's smart" type of thing. And so it's easier both ways. It's a lot easier for them [white students], too. Because [as things stand now, with few academically successful people of color in their classes] they don't have competition. Like they compete against themselves. White people. But when they see a colored person doing really well, they have to beat that [laughs]. That's the way I see it. It's like we're the ones pushing everyone to do better.... So that in a sense, we have it easier, because we don't have the pressure on us. (Interview, 8 June 2000)

In the next section, we discuss examples of this phenomenon of negative recognition. These are cases where the women were recognized not as competent science students but as women of color incapable of learning and doing science, that is, as members of a stigmatized group. Jackie and Evonne, however, were able to blunt the effects of negative recognition by a dual cultural production: redefining whose opinion about their success mattered to them and redefining the implications of negative recognition. Their doing so points to the way individuals can maneuver within and change culture. It also points to a failure in the culture of science if dark-skinned or culturally different individuals must be able to engage in sophisticated levels of cultural production to find a peaceful niche for themselves within science.

Disrupted Scientist Identities

Women in this final group reported disruptions in their pursuit of a science identity. When we describe their identities as disrupted, we do not mean that they could not form science identities, but rather that, when they talked about themselves as science students, they focused on experiences where they felt overlooked, neglected, or discriminated against by meaningful others within science. They told us about instances where they felt that established members of their science departments recognized them not as science people but, instead, as representatives of stigmatized groups. They perceived that their behaviors, or even just their appearance, triggered racial, ethnic or gender recognitions that overwhelmed their chances of being recognized as good science students.

There are six women in this category, including all of the black and American Indian women in the study except Evonne and Jackie, whose cultural productions are have been discussed. Three are black, two are American Indian, and one is Latina. Of the five whose whereabouts are known, all are still pursuing science-related careers. Two are pharmacists, two have completed master's degrees in public health (one of whom is now pursuing a doctorate), and one is completing an undergraduate degree in science. The disrupted recognitions we describe in what follows did not derail them from science. Nonetheless, their perceptions of negative recognition and of feeling invisible were significant aspects of their undergraduate science studies, aspects which some of them still dwell on with bitterness.

Recognition of self as scientist. These women's recognitions of themselves as scientists, especially early on in their undergraduate careers, align with the research scientist identity group (e.g., love of science as a way of knowing, inherent interest in research) and/or the altruistic scientist identity group (e.g., all considered medical school at some point during their high school or college careers). For example, Kathy talks about her interest in molecular biology in ways that align with the ways the women in the research scientist group talked about science:

> I like biology, I like learning about cells, the body, the mechanisms of cells, and cell signaling, all that stuff. I thought it was the coolest thing. Because to me, everything comes down to a cell... I just like biology. I couldn't see myself doing anything but biology. (Interview, 6 October 1999)

Like the women in the research scientist trajectory, Crystl related her choice to major in science to their preference for theorizing from evidence:

> Just give me the facts. You need that proof, you just need physical something—because I can't just be taking something as fact [when people say] "We really don't have any concrete evidence as to why this is the way it is, this is how we think it might happen, or might have happened." (Interview, 6 October 1999)

Although they began their undergraduate careers with interest in and affiliation with science, over time, the women in this category felt more and more disconnected from science. Of all the participants in this study, Alethia reported the most disillusionment and anger about her science experiences; she spoke repeatedly about a feeling of disconnection. For example:

> It sort of seems like the other white students in the class were the over-achievers, the type who challenge the professor, who work in the lab. [Professors] seem to, not welcome them as their peer, but their soon-to-be peer. With other students of color, it's kind of like, I get the feeling I do when I walk through somebody's house with shoes on. Like I'm in somebody else's home and I'm improperly walking, when I'm in science. (Interview, August 1999)

Conchita, Chanda, Merima, and Kathy reported similar feelings of alienation and invisibility. Kathy said that her first big introductory science classes reminded her of going to a play or movie rather than any sort of meaningful learning experience. Chanda, as a senior, believed she would have received better grades and would have gotten into medical school had she attended a historically black college. While women in every trajectory reported some negative experiences in science, all the women in this trajectory described experiences where they could have been, and wanted to be, recognized as research science students, but did not feel this occurred.

Disrupted recognition. The women in this group sought recognition from meaningful scientific others in the same ways the women in the research scientist trajectory did; some worked as members of a research lab and almost all tried to interact with their professors and graduate student instructors. Yet in these encounters with meaningful scientific others, they sometimes perceived that recognition of their gender, race, or ethnicity got in the way of professors recognizing their science abilities.

Gendered failures of recognition. Two of our examples involve black women who mentioned gendered encounters with established members of science departments as particularly frustrating, off-putting, and fueling a sense of disconnection in science. The first story is Alethia's account of working in a research lab as an undergraduate. For her work, she had to kill mice, a task she found unpleasant:

> I remember (a graduate student who worked in the lab) who ...would be like, "Why don't you just kill them? Just do it." And I always felt like I wasn't living up to these standards because I couldn't kill these mice. But then later I would be like, "Why can't they just understand that it's difficult?" I mean, this is not something normal people can do, just walk in and take a mouse out with their bare hands. (Interview, August, 1999)

When Alethia read an earlier draft of this account, she made the following addendum:

> When I started telling Derartu [a science colleague] about how we killed mice—I guess she did it before too—she's all, "With chloroform?" I guess she would put the mice in a bowl with a paper towel on top—spray the towel with chloroform—and they suffocated. But NO! We had to put a sharpie behind

> their neck, pull their tail and break their neck!! ... I have a snake, so you think I would be immune to seeing frequent mouse death, point being, there is a humane way, sorta, to do this, but they tripped on me like this shit was normal, and I was the freak for having problems with it. (e-mail, Spring 2000)

Eventually, when Alethia was having difficulty getting her assigned procedures to work right, her supervisor came in to help her out, was unable to get them to work either, and then fired her over e-mail. Alethia interpreted her difficulties by saying that her trepidation about killing mice "resonate[d] with stereotypes of squeamish, timid, "pretty" girls who don't want to get dirty; and who are therefore "incompatible" with the 'get in and get your hands dirty' kind of mentality that is valued in a lab setting" (e-mail, 22 March 2007). Alethia's interpretation makes this story an example of the more subtle ways that gendered factors can prevent women being recognized as scientists. Alethia did not experience overt sexism; in fact, the person who fired her was another woman. Rather, she did not conform to one of the cultural norms of her workplace—a willingness to kill mice without emotion. Because emotionlessness is strongly associated with masculinity (Aristotle, 1962; Bem, 1993), when she failed to conform to this norm, she felt established members of the lab were judging her for failing to be masculine enough. This interpretation is supported by Alethia's academic performance; she had one of the highest GPAs of all the women in the study and was very successful in other lab settings, and yet in this situation was summarily fired as a lab assistant. Although she had the necessary competence and performance skills, she perceived that her colleagues failed to recognize them, focusing instead on how she did not fit into the cultural norms of the lab, norms aligned with masculine practices. Thus, this experience of working in the lab, the same experience that formed the basis for a successful research scientist identity for students like Nancy and Chris, disrupted Alethia's development of a satisfying science identity and fueled her sense of alienation. We note here that we are not attributing this experience to the fact that she is a woman, but rather, her failure to conform to masculine norms. A man with similar squeamishness may have been experienced similar, or even worse, difficulties.

Merima, another woman with an outstanding GPA, told a similar story in which her substantial science talents were not recognized because her professor structured a meeting with her around masculine behavior norms. One day, after visiting one of her professors, she bitterly announced that out of the five professors she had studied with in her major, she had had bad experiences with three of them. The conversation that ensued took place between Merima, Monica (from the altruistic scientist group), Chris (from the research scientist group) and Angela:

> Merima: Whenever I go talk to molecular biology professors, they make me feel, I don't know—he's a nice teacher, but they make me feel stupid. [Chris & Monica: Uh-huh.] I couldn't even divide ten thousand by ten—I was so nervous. One time he said, "Did you understand what I just said?" I said "Uh-huh," so he said, "Repeat in your own words," and I couldn't. The hard thing is that for med school, they want you to have two science
> recommendations. This summer I'm going to work with somebody, but I don't know who else I could get a recommendation from...
>
> Angela: What are they doing that makes you feel stupid?
>
> Monica: They put you on the spot.
>
> Merima: And they're not too friendly. If you don't know the answer, they just wait.
>
> Chris: It's like they expect you to know the answer. And then, if you don't, they just wait. They don't tell you the answer.
>
> Merima: And I can tell you a lot of molecular biology students feel like this. It's not just me or Chris. (interview, spring 2000)

Scholarship on gender and communication provides evidence that the kind of interactions Merima just described are imbued with masculine norms. For example, a common pattern in women's talk is affirmation-seeking and giving; when women do not receive affirmation, interaction may become strained, uncomfortable, and/or alienating (Eckert & McConnell-Ginet, 2003; Tannen,1994). In these situations, the professors' silence, whether intended or not, could be interpreted as a masculine test, requiring credible performance in the absence of this feedback or affirmation. Research on cross-gender communication supports this notion of silence playing a masculine testing role (Glenn, 2004; Hopper, 2003).

Merima's superb academic competence made her more than up to the tasks asked of her; it was not the task's difficulty but the way in which the interaction was structured that disrupted her recognition. Merima herself realized her professor's failure to recognize her as a promising science student and knew its career implications: no recommendations for medical school. That Merima mentioned "a lot of molecular biology students feel like this" suggests that these kinds of masculine interactional norms have the potential to negatively affect both men and women.

Ethnically disrupted recognition by others. Kathy is a traditional member of her American Indian community, practicing her traditional religion and embodying a value and belief system that is quite different from that of most scientists. This value system brought her into conflict with powerful members of her department. In her case, she reported that not only was her interest in science unrecognized, she was discouraged from pursuing a science major.

Kathy's community has a strong taboo against dead bodies and dissection. "My grandma had taught me over and over again, you don't go out of your way to hurt an animal, to take apart an animal." When the department of molecular biology insisted that Kathy participate in dissections to major in the field, Kathy first asked the lab coordinator about alternatives to dissection, then the department chair, and finally, the dean of the college. Even after intervention from the dean, the lab coordinator insisted that she actively participate in dissection. The situation got worse when Kathy became pregnant while enrolled in a class with a required dissection lab. The taboo against dissection is particularly intense during pregnancy: "I was crying when I was pregnant, when they kept telling me I had to dissect, because like I can't do that, I can't do that. They were like, 'Well, maybe you can change your major"' (interview, 6 October 1999, her emphasis).

In Kathy's case, she felt she had to fight for the most minimal level of recognition from her science department—being allowed to continue her major. To maintain that slender recognition, she had to, in her worldview, subject her pregnancy to mortal danger. As in the case of Alethia, Kathy's difficulties did not hinge on her performance or competence. Instead, she, with her non-mainstream beliefs, had to fight for recognition in ways that mainstream students did not. That she held such reverence for the fundamentals of molecular biology was irrelevant. Angela witnessed, during her participant observation in undergraduate labs, numerous students who were not active participants in labs, serving as recorders for lab groups or simply not pulling their weight in lab groups. That the lab coordinator would choose to take such a strong stance against a student with a genuine ethnic proscription against dissection, in the face of widespread nonparticipation in labs, speaks to the ethnic aspects of these failures of recognition.

Racially disrupted recognition by others. Our examples of racially disrupted recognition are less explicit, but as science education scholars have recently argued (Lewis, 2006; Parsons, under review; Parsons & Mutegi, 2007), we need to be continuously mindful of the ways race structures and denies opportunities for people of color, especially African Americans, in science. We distinguish between racially and ethnically disrupted recognitions as follows: Racially disrupted recognitions occur in response to a student's appearance; ethnically disrupted recognitions occur in response to a student's ethnic beliefs and behaviors. Alethia strongly believed there was a racial component to her experiences in the mouse-killing story, and Chanda contended that she would have been more successful at a historically black college (it is hard to know whether these experiences were more closely aligned to Alethia's and Chanda's race or ethnicity; in the case of black women, the two are often closely entwined). Conchita also told us about being accused of stealing:

> I would go to the professor in charge of the lab [where she was a research assistant] with intent of getting course advice or help as far as what else my biology degree would get me. I was expecting a mentor, but that didn't happen. He was too busy for little 'ol me. Also one of his grad students accused me of stealing his favorite pen, which ended up being in his lab pocket the whole time and eventually apologized. That is why I switched my major. (e-mail, 2 June 2000)

Conchita interpreted this accusation of theft as a response to her race. Her failed bid to gain recognition from her professor led to her decision to switch majors. As of December 2006, Conchita was a coauthor or first author on three publications in science journals. As in the case of others in this trajectory, her professor and the graduate students in his lab misjudged her potential in science. In November 2005, Conchita e-mailed an update about her career and included a story of running into a former professor at a conference. Although her professor still failed to recognize her as a scientist (and this still stung), the recognition she since received in other settings led her to fully claim her scientist identity, labeling herself "a mad scientist":

> I went to [an experimental biology conference]...ironically enough I ran into the chair of the dept. of physiology from [her undergraduate university]. He just couldn't believe that I was first author of my project. He was in such dismay that I actually worked in physiology...b/c remember he is the one that suggested I go into communications in order to graduate. It was a GREAT feeling to shove his stupidity in his face! It's funny b/c I am learning procedures here that I remember hearing about in undergrad. I remember studying about genetics and the base primers and blah, blah, and here I am, doing it in real life...like a mad scientist. (e-mail, 10 November 2005)

Conchita, along with the four other women in this trajectory whose whereabouts is known, managed to stay in science, despite the failure of science professors, lab directors, and teaching assistants to recognize them as legitimate science people. That they have done so is a testament to their own persistence and points to the evolving nature of identity. Yet, that most of the black and American Indian women in this study reported experiences where their recognition as science people was disrupted also suggests that processes of recognition within science institutions may be more shaped by race and ethnicity than we would like to admit.

Discussion

In this investigation, our goal was to develop a science identity model. We used the data collected from women science majors of color to test and refine our model and used the model to better understand the women's experiences. In this discussion, we first discuss how the women's experiences helped us refine our model. Next, we explain how our model helped us better understand the science experiences of these women of color.

A More Grounded (and Still Evolving) Model of Science Identity

In our science identity model, recognition was problematic for the women in this study because it hinged so crucially on an external audience. The composition of this audience, mostly white males, along with the institutional and historical meanings of being a scientist (being a white male), complicated their bids for recognition. Recognition can thus be viewed as a mechanism for reproducing the status quo in science. It is much easier to get recognized as a scientist if your ways of talking, looking, acting, and interacting align with historical and prototypical notions of scientist. This, of course, makes it more likely that members of the discipline will keep reproducing members who look, talk, act, think, and interact like they do. So, how do people from groups underrepresented in science get recognized as scientists? This study is significant because it highlights the different ways women of color made successful bids for recognition, redefined what it meant to be recognized, and sometimes were disrupted in their bids for recognition. Science education scholars are just beginning to include recognition in their discussions of identity (Moje, Tucker-Raymond, Varelas, & Pappas, 2007; Tonso, 2006). One of this study's primary theoretical contributions, then, is to unpack this notion of recognition and its importance in identity development. We provide our fleshed-out, grounded model of science identity in what follows (Figure 2).

The model elaborates on previous findings about successful students of color in science. For example, we can re-examine Russell and Atwater's (2005) and Brown's (2002) findings that critical factors for successful students of color in undergraduate science were strong pre-college science experiences, family support, teacher encouragement, intrinsic motivation, perseverance, and growing up in small, supportive communities. Three of the six factors (family support, teacher encouragement, and supportive communities) deal with recognition by others. A fourth factor (intrinsic motivation) aligns with the ways we defined recognition of self. It appears that these previous studies' findings align with our own; recognition is a key influence on students' science identities. Further, our model implies a relationship between these factors described discretely in the previous studies. Strong pre-college science experiences help build students' competence in understanding science content and, likely, their skills in performing relevant science practices for others. Coupled with the meaningful recognition they received from family, teachers, and their communities, it is understandable why these students were able to persist in science; they were developing strong, satisfying science identities.

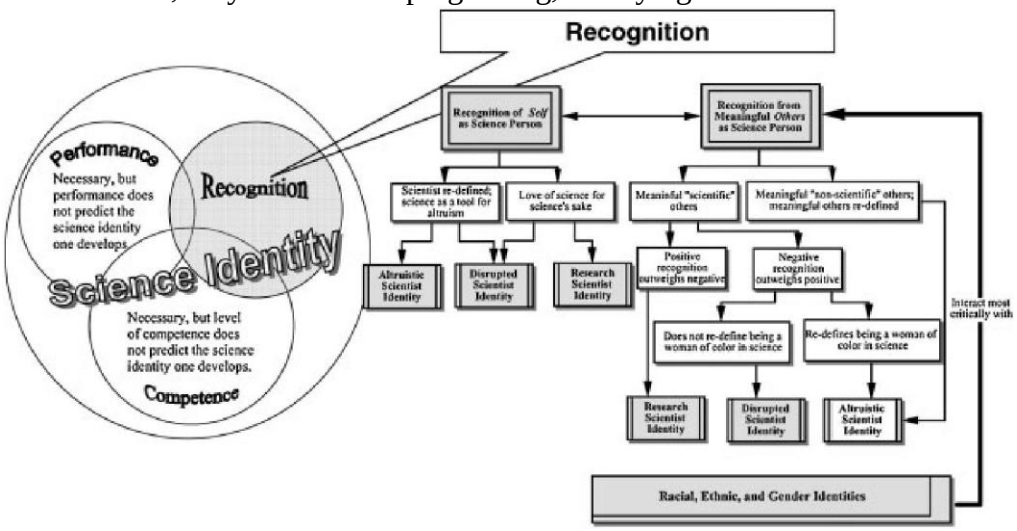

Figure 2. Grounded model of science identity, informed by our findings.

Our study also illuminates the ways one's racial, ethnic, and gender identities interact with that process of recognition and complicate the development of science identity. Seymour and Hewitt (1997), Brown (2002), and Russell and Atwater (2005) used ethnicity as a filter, selecting successful science and engineering students from particular ethnic groups and exploring what other factors those students had in common. They used ethnicity as a static variable. Like them, we used ethnicity and gender as selection filters, but our conceptual framework allowed us to also treat race, gender, and culture as dynamic variables with ongoing effects in students' lives.

Persistent Gaps

Our study leaves critical dimensions of science identity still underexamined. For example, we need further study about the performance dimension of the model. We need to understand better the ways and contexts in which students take up, reject, and/or transform specific scientific practices, and how those performances mutually impact science identity (see Tan & Calabrese Barton (2007) for an example of this kind of work). Further, despite the fact that our data cover a 6- year span, the fluid and unstable nature of the science identity trajectories is underexplored in this study. Our study may imply that these women's current science identities are fixed, that they have "achieved" a particular science identity. We have mentioned in passing some women in the disrupted scientist identity groups who were able to work themselves into new trajectories, but the analysis needs further fleshing out. We also understand that, in reality, these women have to fight for their identities, performing, developing, and achieving them again and again in different contexts and across time (Roth, 2006). Complementing the aforementioned contributions are further theoretical and practical insights garnered by drawing out lessons learned from our participants' stories. We address these lessons in what follows.

Learning From the Women's Experiences and Stories

The women in this study found ways to negotiate the rigors of majoring in science. Not all were happy with their experiences, but almost all graduated with science majors, even those whose bids for recognition were disrupted. All the women who formed research scientist identities are working on or have completed doctorates in science; all those with altruistic scientist identities are working on or have completed graduate work in health professions; and even those whose recognition as scientists was disrupted are pursuing degrees or careers in science-related fields. What can we learn from their stories?

Rethinking recruitment and retention efforts. The women in this study almost uniformly expressed a strong connection to science. Other researchers have documented the enthusiasm about science of girls and women, and the importance of this enthusiasm to women's success in science (Davis, 1999; Gornick, 1983; Kubanek & Waller, 1995). A few researchers have confirmed similar findings for girls and women of color (Brickhouse, Lowery, & Schultz, 2000; Fadigan & Hammrich, 2004; Johnson, 2006; Patterson, 1989). Thus, these findings call into question a common strategy for drawing women of color into science: stimulating their interest. The women in this study did not need any support for their interest in science; on the contrary, in some cases they steadfastly maintained that interest despite the discouragement they received.

Almost every woman in this study made statements associating her interest in science with her altruistic career goals. Previous research has documented the relationship between science and altruism (or a desire to work with people) for women (Kubanek & Waller, 1995; Scholer, 1998), girls (Baker & Leary, 1995), and for girls and women of color (Brickhouse et al., 2000; Johnson, 2006; Seymour & Hewitt, 1997). Emphasizing the relationship between altruism and science could encourage more women of color to enter health and public health professions, as it did for all of the altruistic scientists and four of the disrupted scientists in this study. Further, attention to the altruistic aspects of science may also recruit more women of color to become research scientists. Three of the four research scientists expressed a strong sense of the connection between science and altruism (protecting endangered species, preserving the environment, and working on a cure for cancer).

Lessons about the culture of university science and women of color interested in science. The main factor that differentiated these women's pathways through science was not competence in or commitment to science but recognition by others. From this we can learn both about the culture of university science and about women of color who are interested in science. The women who formed research scientist identities were able to locate professors who recognized them as capable science students and gave them access to relevant scientific activities. Their trajectory through science matched the legitimate peripheral participation described by Lave and Wenger (1991). They were drawn ever more centrally into their community of practice, recognized as increasingly competent science students. Perhaps the most important thing we can learn from this is that there is room within university science for women of color to be recognized as science people. Their success, particularly that of Chris and Nancy, who do not come from families with rich educational histories, is remarkable.

More remarkable, perhaps, are the experiences of the women whose science identities were disrupted; remarkable because, despite the failure of their professors to recognize them as promising or legitimate science students, they are all still pursuing science-related careers or study. What we learn from this group is that discrimination is not destiny. Yet there are important, lingering questions with implications for the culture of university science. Why did these women persist despite humiliation, frustration, and even encouragement to change majors? Was it their commitment to science? Was it the presence of others' support or recognition that we were unable to document in this study? Was it positive experiences with science outside the university? Their stories, particularly that of Conchita, who went from being a marginal science student to attaining an impressive publication record, indicate that the role of sheer persistence in science is not well understood and merits further study.[3]

Most remarkable is the group of women who formed altruistic scientist identities and their thorough and successful cultural productions. What we learn from this group is that women of color can persist in science

without either gaining or being denied recognition from meaningful scientific others, but instead by redefining their understanding of what it means to be in science and whose recognition is important to them. Although pre-health trajectories through science majors already exist, a focus on medical school did not, by itself, help all the women in this study to persist in science. Kathy, Crystl, and Alethia (from the disrupted trajectory) also had aspirations for medical school during their undergraduate careers, and Alethia, at least, expressed a strong altruistic component to this aspiration (with a plan to establish a health clinic in an underserved community). They did not, however, have the same success in redefining meaningful others or the meaning of being a woman of color in science as did the women with altruistic scientist identities. The women who formed altruistic scientist identities engaged in two and, in some cases, three interrelated cultural productions. They all redefined the meaning of science as an interesting vehicle for expressing altruism. They each defined their own group of meaningful others to whom they turned for support for this new definition and recognition of themselves as successful within it. Also, at least two of them redefined the meaning of being a woman of color in science, arguing that they benefited by coming from groups who are not expected to succeed in science. Other researchers have documented similar cultural productions. Davidson (1996) wrote about a girl who maintained, despite being pushed to the margins of the school community, that working hard in school was part of being Mexican. Hughes (2001) quoted a Vietnamese woman studying science who said, "I think when it comes to like...if you're...a race not living in your own country you wanna do better than the people who live there so that you can show that you...like worthy to be there" (p. 282).

On Agency and Structure

Agency. These women's stories indicate that there is room for individual agency and cultural production at the university level. Hughes (2001) makes a similar argument, that "dominant discourses of science as abstract and inflexible are open to reformulation and reinterpretation, offering possibilities for widening the range of scientist subjectivities available and creating new identity positions for those often excluded from science" (pp. 278–9). Despite the culture of science, which other researchers have argued is masculine (Eisenhart & Finkel, 1998; Harding, 1991; Keller, 1985; Noble, 1992; Scheibinger,1989; Seymour & Hewitt, 1997; Tuana, 1993) and white (Campbell, Denes, & Morrison, 2000; Harding, 1993,1998; Seymour & Hewitt, 1997), all of the women in this study persisted in the study of science and are now pursuing science-related careers.

Structure. The women in this study who were the most ethnically or racially different from the norm in the sciences were also the most likely to end up with disrupted scientist identities. Among the women who achieved research scientist identities, the two Latinas are both lighter-skinned and periodically taken for being white. The other two women in this group are Asian American, the most well-represented racial group in science. This is not to say that it was easy for them to be recognized as research scientists; Chinn (1999, 2002) documented the cultural difficulties that Asian American women face in the sciences, despite their strong representation. Nancy and Chris told us about their own struggles as science majors. These four women in the research scientist trajectory, however, eventually prevailed and earned external recognition as "science people." Meanwhile, all but one of the black women in this study, and two of the three American Indian women, fell into the group whose scientist identities were disrupted; no Asian American women were in this group. Jackie, the only black woman in the study not to fall into this group, and Evonne, the only American Indian woman, both engaged in remarkable acts of cultural production, redefining their membership in stigmatized groups as an advantage.

This pattern suggests that a kind of subtle racism was at work when these women were bidding for recognition as science students. We have described how some participants' bids for recognition were disrupted when they were recognized not as science students but, instead, as representatives of their racial or ethnic groups, or as women. Treisman (1992), in his study of why mathematics professors thought that African American students underperformed Chinese American students in calculus, found that professors put the blame for this phenomenon on the students, arguing that they must be less interested, or less motivated or less well-prepared. Contrary to the beliefs of the professors Treisman surveyed, we found that the women in this study had strong interest and preparation in science; their difficulties came into play when they encountered the supposedly meritocratic culture of science. Our findings suggest that the difficulties some scientists have in recognizing

darker-skinned or more ethnically different students as capable science students may explain some of the under-representation of women of color in the sciences (see Bertrand & Mullainathan (2004) and Nosek, Banaji, & Greenwald (2002) for studies supporting the institutionalized, unconscious nature of racism).

Conclusions

Previous approaches to the study of successful students of color in science have examined antecedent factors (Brown, 2002; Russell & Atwater, 2005) or the culture of science (Seymour & Hewitt, 1997). Although both approaches yielded rich results, gaps remained. The studies of successful students of color in science have treated ethnicity as a static variable and university science as a black box, examining what factors its survivors shared before entering the box. We have designed a science identity model that allowed us to look at what happens within the box. The recognition components of our model allowed us to pinpoint specific ways that women of color get recognized, or fail to get recognized, as science people, highlighting the complex ways race, ethnicity, and gender complicate that recognition.

In examining the culture of science, Seymour and Hewitt (1997) concluded that all science students face similar unpleasant conditions, that those who persist are more willing to tolerate the conditions, and that the difficult conditions are congruent with white male norms and thus it is easier for white male students to survive. This cultural approach left open the question of how this culture could be changed and how some women of color persist despite these unpleasant, culturally asynchronous conditions. Our model of science identity allowed us to maintain a dual focus on both the agency of those striving to build a science identity and the constraints on that process due to the structures within which that identity is being constructed. Our approach incorporated the agency of students and professors. It allowed us to look not only at pre-college factors but also at students' daily interactions and experiences, and how these, over time, accrete until particular students have either worked themselves into established trajectories (research scientists), somehow persisted despite being pushed out of those trajectories (disrupted scientists), or created new trajectories (altruistic scientists). Also, in accounting for agency, we have developed powerful new understandings of the culture of science without seeing that culture as monolithic or eternal.

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Notes

[1]We understand the limitations of using an a priori definition and prototype of a person who has a "science identity." There are many ways of being a "science person" and defining one prototype may reproduce status quo and overly narrow conceptions of what counts as a science person. However, because our study examines women who were largely pursuing science degrees and science-related careers, we argue that they had to confront, in some way, the historically enduring "science identity" prototype. Thus, we argue that it is appropriate to clearly define this prototype to make sense of the ways the women accepted, rejected, and/or transformed it.

[2]Although they may not agree with our reconciliation, we gratefully acknowledge Colleen Fairbanks and Gregg Solomon for helping us think through the potentially conflicting aspects of our science identity model.

[3]Alethia, on reading a draft of this manuscript, said that "it seems like those who are adept at constructing identities (purporting a racial/ gender identity) would be able to transfer those skills to help them successfully construct a science identity. It stands to reason that those who (for whatever confluence of factors) think about

race and define an identity daily, would be more successful at defining themselves within a new culture of science and, thus, be more successful at constructing a science identity." She goes on to call this phenomenon "the protective factors of the marginal experience in the U.S" (e-mail, 13 March 2006).

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Appendix A

Sample Domain and Taxonomic Analyses Associated with "Recognition"

Table 2
Ways to recognize self as scientist

Ways to Recognize Self in Prototypical Science Terms	Ways to Recognize Self in Altruistic Terms
Enjoy working in research labs (7 students)	*Using science to help people* (12 students)
Enjoy scientific ways of thinking (e.g., logic, problem-solving, evidence-based reasoning) (9 students)	• Examples include: "Anything I can do to help people would really make me feel good"
• Examples include: "I like to... set up experiments and figure out what's wrong"	*Using science to help the environment* (2 students)
Enjoy the subject matter of science (4 students)	• Examples include: "I've always been interested in... helping the environment"
• Examples include: "I have always been intrigued with science"; "Biology is cool"	*Using science to help animals* (2 students)
	• Examples include: Conducting research on endangered species

Table 3
Kinds of meaningful others

Kinds of *Scientific* Meaningful Others	Kinds of Meaningful Others from *Outside of Science*
Scientific others in science classrooms and Departments • Examples include: Professors; Department Chair; teaching assistants	Meaningful academic others from outside of science • Examples include: Professors in non-science majors; professors at other colleges
Scientific others in science labs • Examples include: Lab directors; scientists in research labs	Meaningful others from home • Examples include: Parents; home community
Scientific others in professional organizations and award committees • Examples include: Journal editors; internship and fellowship selection committees	Meaningful others who might benefit from woman's scientific/academic efforts • Examples include: Recipients of missionary work; an imagined "public"

Table 4
Kinds of recognition from meaningful scientific others

Positive Recognition	Little to No Recognition	Negative Recognition
Honors (Being singled out) (12 instances) • Examples include: Receiving research fellowships; selected as teaching assistant	*Feeling invisible* (6 instances) • Examples include: Can't get to know professors because classes are so large	*Having bad experiences in office hours* (5 students cited) • Examples include: Feeling "dumb" or "put on the spot"
Professional recognition (Being recognized as a budding scientist) (18 instances) • Examples include: Awarded grant funding; co-authoring publication or presentation; being hired as a research assistant	*Feeling as though you are not worthy of professor's time* (4 instances) • Examples include: Professors are too busy and uninterested/ uninvolved	*Being challenged because of ethnic religious beliefs* (2 instances) • Examples include: Required to participate in dissection, despite ethnic religious restrictions
Recognition from professor as someone worthy of his/her attention (4 instances) • Examples include: Welcomed during office hours; getting the feeling that the professors thought "I was something special"	*Feeling out of place* (3 instances) • Examples include: "feeling so out of place in that damned lab"; Noticing the professors and graduate students are "all White"	*Being misjudged (interpreted by women as racially/ ethnically-motivated)* (4 instances) • Examples include: Accused of stealing; Professor surprised that you earned a 100 on test *Being avoided (interpreted by women as racially/ethnically motivated)* (5 students cited) • Examples include: Difficulty finding lab group because they are racially segregated

Appendix B

Componential analysis comparing recognition and science identity trajectory

Participants	Recognition of self as[1]		Kind of recognition from meaningful others[2]			
	Prototypical scientist	Altruistic scientist	Positive from scientific others	Negative from scientific others	Felt invisible to scientific others	Positive from outside science
			Research Scientist Identity			
Chris	X	X	XX	X	X	
Nancy	X	X	XX			
Jaya	X	X	XX		X	
Mariah			XX			
			Altruistic scientist identity			
Jackie	X	X		X		X
Magdalena	X	X				X
Evonne		X	X	X		XX
Xiao-Ling		X	X		X	
Monica	X	X		X		X
			Disrupted scientist identity			
Alethia	X	X	X	XX	XX	
Conchita	X		X	XX	X	
Kathy	X			XX	X	
Crystl	X					
Chanda				X		
Merima		X		X		

[1](. . .)Marks indicate which students cited prototypical and altruistic motivations for studying science.

[2]One X indicates that students reported this form of recognition. Two Xs indicate that students emphasized, in interviews, the importance of this form of recognition to their experiences as science majors.