A CASE STUDY: Science Identity Formation of Mexican American Females in High School Chemistry

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Mexican Americans are noticeably underrepresented in physical science fields. The purpose of this study was to explore the possible association between Mexican American female high school chemistry students' social and educational experiences in chemistry and science and their development (or rejection) of a science identity, that is, seeing themselves as future scientists. The all-encompassing theoretical frameworks were mestiza/o psychology, multicultural feminism, Chicana feminism, and identity based upon situated cognition. The researchers used in-depth interviews, classroom observations, and a focus group. From the data, five important identities emerged: ethnic, gender, college, science, and student. These identities influenced how the students conceptualized their social and educational experiences in chemistry and science. Regarding attitudes and aspirations in science, there was a relationship among college, science, and student identities. Having a personal connection to a successful member within a science community of practice was paramount to the young women's self-perception as potential members of the science community.

The population of the United States is becoming increasingly multiethnic and multilingual. Latinas/os are the fastest growing ethnic group but are underrepresented in science careers and in secondary and post-secondary preparation science courses (The Education Trust 2003). Differences between Latina/o and Anglo students' achievement in science begin in the elementary school years. Fourth-grade Latina/o students who took the Trends in International Mathematics and Science Study (TIMSS) test in 2003 scored an average of 498 on the science test, in comparison to an average of 565 for Anglo students (Gonzales et al. 2005). In the eighth grade, the TIMSS science scores for Latina/o students averaged 482, versus 552 for Anglo students (Gonzales et al. 2005).

In addition to differences in science achievement, Latina/o students are less likely than Anglo students to take higher-level science courses in high school (Gonzales et al. 2005; Llegas 2003). They are also more likely than Anglo students to plan on withdrawing from mathematics and science courses as soon as possible (NACME 2001). Along with students of all ethnicities, Latina/o students appreciate the value of mathematics and science; however, few find these subjects relevant to their own lives (Kadlec, Friedman, and Ott 2007). There is an increasing body of literature pertaining to students of color in science. However, few studies have focused specifically on Mexican American female students and examined how these women perceive the world through their particular gendered and cultural lenses. In fact, there is a paucity of research focusing on Latinas in any educational setting (González, Stone, and Jovel 2003; Zambrana 2002).

Despite the scarcity of research, a large number of factors have been identified that may contribute to the lower achievement and enrollment in science for Mexican American girls (Barba and Reynolds 1998; Rakow and Bermudez 1993). Factors include fewer culturally meaningful science experiences at school (Frau-Ramos and Nieto 1993), science teachers who are less qualified than those in schools serving majority populations (Von Secker and Lissitz 1999), and fewer science role models with whom they can identify (Barba and Reynolds 1998; Muller, Stage, and Kinzie 2001; Rawis 1991). These factors, combined with social expectations that scientists are traditionally middle-to-upper class Anglo men (Fung 2002; Schiebinger 1987), may make some lower-income Mexican American females believe that they do not belong with the group of students who excel in science. This feeling of belonging is important and is related to identity, that is, who students think they are and who they want to become (Stryker and Burke 2000). Students will not be interested in science if doing so conflicts with their views of who they are and what is expected of them (Lee 2002).

The theory of identity based on situated cognition and communities of practice (Wenger 1998) has been applied to studies in science education with an emphasis on how gender and/or ethnicity influence students' sense of self (Brickhouse 2001; Brickhouse, Lowery, and Schultz 2000; Brickhouse and Potter 2001; Carlone 2004). Moreover, Brickhouse, Lowery, and Schultz (2000) stress the importance of understanding how girls construct their identities—as females, as daughters, as students, as members of an ethnic community—and how these identities overlap with their view of scientists.

In this study, the operating science community of practice is defined as that cadre of students and teachers interested in science and science careers, similar to previous definitions of science identity used by Brickhouse (2001) and Aschbacher, Li, and Roth (2010). Recently, models of science identities within communities of practice have been developed for African American females in high school (Brickhouse, Lowery, and Schultz 2000) and in graduate school (Malone and Barabino 2009), high school students of color (Aschbacher, Li, and Roth 2010), middle school Latinas/os (Furman and Barton 2006), and undergraduate women of color (Carlone and Johnson 2007). This study adds to existing understanding by building a model of science identity for young Mexican American women.

Purpose of the Study

This article reports on a qualitative study of nine Mexican American female high school students enrolled in a chemistry course. The research question guiding the design of this study was: How does the development (or rejection) of a science identity for Mexican American females in high school chemistry relate to their self-image as future scientists? Early in the study, the data revealed that several identities, besides science identity, were relevant to the research question. Therefore, these additional identities were also examined. Past studies

have shown that social encounters and experiences are influential for identity formation in a general population of students (Aschbacher, Li, and Roth 2010; Lave and Wenger 1991; Lee 2002) and so it was of interest to find how social interactions affected the participants' identities relevant to views of science.

Theoretical/Conceptual Framework

Historically, research paradigms have misrepresented or overlooked Chicanas' experiences (Bernal 1998). Therefore, the perspectives of Mexican Americans and other scholars of color are used as theoretical frameworks for the present study. These frameworks address use of theory, methods, data collection and interpretation, as well as formulation of conclusions. Specifically, these theoretical and methodological approaches are mestiza/o psychology (Ramirez 1998, 2004) and multicultural feminism (Landrine 1995; Landrine, Klonoff, and Brown-Collins 1995). A discussion of these scholars' recommendations and their implementation in the present study follows.

First, researchers who study Mexican Americans must necessarily rely on theories and methodologies that critically consider Mexican American culture, value heterogeneous voices (Ramirez 1998, 2004), and examine the impact of culture across cultural groups (Landrine 1995; Landrine, Klonoff, and Brown-Collins 1995). Thus, we create a model to explain the data from participants' responses rather than imposing hypotheses based on theory developed for Anglos. Furthermore, procedures throughout the study show respect for the cultural values of the young women. The first author spent considerable time getting to know the young women to establish rapport with them. She also chose a less structured interviewing technique, which approximated life history and story-telling—two methods that Ramirez listed among data collection procedures consistent with Mexican American cultural values. Second, rather than adhere to traditional models of inequitable power

distribution between participant and researcher (Landrine, Klonoff, and Brown-Collins 1995; Ramirez 1998, 2004), we made an effort to embrace a "person-centered approach" in which we inquired about participants' own interpretations of their behavior (Vera and de los Santos 2005). In our attempt to emulate this protocol, we encouraged participants to provide their input regarding accuracy and completeness of data and initial data interpretation. Lastly, we acknowledge that the lead researcher does not have the same cultural background as the participants and that the study would benefit from the cultural competence of two Latinas. The third author is a bilingual/bicultural Mexican American who assisted with the research design and final interpretation of results. Also, a Puerto Rican chemistry graduate student assisted with data collection during a focus group with the participants.

In this study, particular attention is placed on the contextual setting of class, ethnicity, and gender. Researchers have concluded that the socioeconomic status of a student's family is the most common and important correlate of academic achievement for students of color (Alnabhan, Al-Zegoul, and Harwell 2001; Barba and Reynolds 1998; Battle 2002; Hampton, Ekboir, and Rochin 1995; Horn 1998; Rakow and Bermudez 1993; Vasquez 1982). This has major implications for Latinas, where "educational disadvantage is more directly associated with family economic disadvantage than cultural disadvantage or lack of aspirations of parents" (Zambrana 2002, 46). Ethnic influences include some culturally unique background knowledge and "ways of knowing" (Barba 1993), degree of students' comfort with their ethnic identity, experiences of discrimination, and bilingual ability. Gender is also a critical component in identity formation due to the perception of science as masculine (Vockell and Lobonc 1981), fewer science experiences and lower teacher expectations for girls (Jones and Dindia 2004; Kahle and Lakes 1983; Owens and Waxman 1998), and the conflict between Mexican American

gender roles and pursuit of a science career (Alva 1991). Ethnic, gender, and class identities are not experienced in isolation; rather they are informed by each other (Bettie 2003).

As ethnic identity figures importantly among the participants' identities, the work of Vera and de los Santos (2005) is presented in detail in the following paragraphs because of their extensive analysis of how identity theories—traditional, feminist, and even ethnic identity—must provide a valid conceptualization of the identity development of Chicanas and Mexican American females. Examples of how the present investigators made use of concepts from Chicana feminist scholars' formulations of Chicana ethnic identity development are included. Vera and de los Santos traced the development of major theories of identity development in the history of psychology. Erickson's 1959 theory (as cited in Vera and de los Santos) postulated that identity formed during eight stages over an individual's lifetime, beginning in infancy. His theory relied solely on data from Anglo males and did not consider culture or the interaction among identities, including ethnicity, race, gender, sexuality, and socioeconomic status.

Marcia (1966, as cited in Vera and de los Santos) extended Erickson's theory by adding the concepts of exploration and commitment to address individual differences in achieving an identity. Neither Marcia nor Erickson included females in their investigations of identity. Vera and de los Santos next presented the work of Gilligan (1982) and Josselson (1987). These feminist scholars questioned the validity of traditional theories of identity development for women, highlighting the importance of a greater emphasis on the centrality of relationships and connections to others for women's identity formation. For further positive impact on such theories, both scholars needed to address the various oppressions encountered by Mexican American

females, the impact of the dominant culture on the identity formation of people of color, and differences in power between the dominant society and Chicanas/os. They also needed to call for the inclusion of women of color as research participants. Finally, Vera and de los Santos examined ethnic identity theory through the work of Berry (2003) and Segura and Pierce (1993). In these theories there was no examination of the impact on Chicanas' identity development of daily encounters with the dominant culture; in addition, the processes of identity development were described as occurring within Mexican American culture only.

According to Vera and de los Santos, Chicana feminists maintain that Chicanas have experiences that are unique to them and that are absent in the daily lives of Anglo women and other women of color. Furthermore, these unique experiences, as well as the voices of Chicanas, have been missing in past theories proposed to capture the processes of their identity development. Vera and de los Santos urged theorists to use concepts created by pioneering Chicana scholars expressly for Mexican American female participants, based on their daily, lived experience. Some of these concepts are mestiza identity (Anzaldúa 1987), pláticas (González 2001), and the ideas of "belonging" and "not belonging" (Elenes 1997, 363).

Mestiza identity refers to an identity that is neither Anglo nor Mexican; rather, it is a synthesis of identities created from the two cultures but distinct from either—a Chicana identity. In the present study, the concept of mestiza identity is acknowledged in the inclusion of comments from the participants, describing negotiations between their inner worlds, their identities, and the dominant society—for example, the low expectations that some teachers conveyed about the young women's abilities. Another Chicana feminist concept, pláticas (González 2001), refers to informal conversations between

investigator and participant. The less structured interviewing technique mentioned earlier makes use of this concept. In addition, including the impact of gender and ethnic identities in data analysis acknowledges the importance of the intersectionality of identities.

Stryker and Burke (2000) emphasize the importance of social influences on developing and maintaining an identity. Having more people who expect a student to behave in a certain manner makes it more likely that the student will adopt that role. This is also true in science; Lee (2002) found that when more people supported young women in science they were more likely to maintain a scientific identity.

Family relationships are particularly important for Mexican American students (Chin and Kameoka 2002; Koballa 1988; Pong, Hao, and Gardner 2005). In comparison to Anglo families, Mexican Americans have, on average, larger family networks and higher levels of exchange and interaction among family members. They also rely on family members more for help with problems and remain closer to family members throughout their lives (Vega 1995). Mexican American females in college often refer to the importance of the support given to them by their families (Brown 2002; Taxis 2003). Mexican American youth appear more inclined to adopt the occupational preferences of their parents compared to Anglo youth (Solis 1995), including science fields (Gilmartin, Li, and Aschbacher 2006).

Within school, interactions with teachers and school counselors are important. Previous qualitative studies that focused on Latinas who were successful in science found that the women identified a teacher who encouraged them and supported their interest in science (Brown 2002; O'Halloran 1994; Taxis 2003). Past studies have also shown peers to be important socializers for

inclusion in a community of practice for a diverse student population (Fraser and Kahle 2007; NACME 2001; Stake and Nickens 2005) and for Mexican American females (O'Halloran 1994; Taxis 2003). For these reasons, this study examines family, school personnel, and peers as possible social influences on science identity formation. However, we were careful during data collection not to limit the possibility of other experiences having an effect on the young women's formation of a science identity.

Methodology

This study examines the science identity development of nine Mexican American females in high school chemistry. The design was selected to create boundaries and structure for the investigation, while still allowing for rich description and the inclusion of context (Stake 1997). Participants were purposively sampled after students in the chemistry class completed a demographic questionnaire and from that group three individual interviews were conducted using Seidman's in-depth interviewing technique (Seidman 1998) and an additional questionnaire—the Multigroup Ethnic Identity Measure (Roberts et al. 1999)—was administered. In the spring, participants were involved in a focus group and teachers were interviewed. These methods provided data from different perspectives that were analyzed for central themes. Thus, as the study progressed, data were triangulated by the use of data from multiple sources (Lincoln and Guba 1985).

Setting and Participants

The project took place in a large midwestern urban high school near an industrial area that divided the inner city and suburban communities. A large Latina/o community had formed in the area within the last fifteen years. At the time of the study, the total enrollment in the school was approximately 1,300 and the ethnic makeup was 47.1 percent Latina/o, 25.7 percent African American, 22.4 percent Anglo, and 4.7 percent other. Seventy-three percent of

students at this school qualified for a free lunch program. Only 73.2 percent of teachers were fully licensed and in the sciences, 73.1 percent of teachers were ranked as highly qualified. The students in the school scored below state averages on standardized exams in mathematics and reading in eleventh grade.

The nine young women in the study were selected because they self-identified as Mexican American or were Mexican American but self-identified as Latina or Hispanic on a demographic questionnaire, and they were enrolled in high school chemistry. Prior to any data collection, participants signed an assent form and returned a consent form signed by a guardian. Teacher participants and the high school district also gave their consent. To ensure confidentiality, pseudonyms were used in data collection and reports. Sociodemographic information for each participant appears in Figure 1.

Four teachers participated in the study: Ms. Washington (African American), Mr. Miller (Anglo), Mr. Anderson (Anglo), and Ms. Clark (Anglo). Ms. Washington taught three of the classes in which Mr. Miller did student teaching in the spring. Mr. Anderson taught one of the classes but resigned in mid-fall for health reasons; Ms. Clark replaced him in the spring.

The teachers used a variety of teaching methods. Ms. Washington had students complete inquiry-based group activities as well as bookwork. Although she sometimes asked the students to take notes, she preferred not to lecture. Ms. Clark also had an inquiry-based teaching style, with some lecturing, but mostly hands-on activities. The majority of the time, Mr. Anderson had the students complete worksheets, which they discussed at the end of the period. Mr. Miller showed PowerPoint slides, often interacted with the students, used clicker-response activities, and had students conduct experiments at their desks. None of the teachers assigned homework because

Figure 1
Participant Demographics at Time of Study

Pseudonym	*Place of Birth*	*Time in U.S.*	*First Language*	*Highest Parental Education Level*	*Career Interest*
Nancy	Mexico	15 years	Spanish	Mom – 3rd grade	Computers
Catherine	U.S.		English	Grandma – some college	Real Estate Agent, Scientist
Esmeralda	U.S.		Spanish	Mom – 5th grade	Uncertain
Clarissa	Mexico	13 years	Spanish	Mom and dad – college degrees	Pediatrician, Nurse
Monica	Mexico	4 years	Spanish	Mom – high school graduate	Immigration Lawyer
Miriam	U.S.		English	Mom – high school graduate	Culinary Artist
Nallely	Mexico	4 years	Spanish	Mom and dad – high school graduates	Uncertain
Maria	Mexico	7 years	Spanish	Mom – high school graduate	Interior Design
Mia	U.S.		Spanish	Mom – 6th grade	Mechanic

there were not enough textbooks for every student. At the end of the year, the teachers had covered less than half of the content specified in the district-wide course syllabus.

Data Collection and Analysis

The primary source of data for this analysis came from in-depth interviews of the participants using Seidman's interview technique—in-depth interviewing that combines life history and phenomenology so as to connect

stories to context (Seidman 1998). With this technique, the interviewer uses a few primary, open-ended questions and builds upon these as the interviews progress. In the fall, each participant engaged in three thirty- to seventy-five-minute individual interviews that were recorded with a digital audio recorder. The interviews were transcribed in full and reviewed by the participants. Each of the three interviews had a different focus. The first interview established a life history by focusing on past science experiences in and out of school. The second interview focused on the present reality of the student, with particular attention to the social influences in the student's life. Finally, the third interview drew from the first two interviews and addressed the meaning the student had attached to being a chemistry student and how she made sense of her science identity in the context of her life experiences.

After the initial student interviews, three of the teachers (Ms. Washington, Mr. Miller, and Ms. Clark) were interviewed about their perceptions of the participants. In the spring, the students participated in a focus group conducted by a female chemistry graduate student from Puerto Rico. Activities in the focus group included individual and group rankings of themes that emerged from the individual interviews and discussion of the chemistry class. Participants were given a blank sheet of paper and asked to draw a chemist (activity modified from Draw-A-Scientist test, Chamber 1983). After their drawings were complete, the ethnicity and gender of their chemists were discussed as a group. At the conclusion of the focus group, the graduate research assistant and the primary researcher shared their science stories. The research assistant was able to ask questions in a style that differed from that of the primary researcher and the young women were able to ask her questions about her experiences as a Latina in chemistry.

Throughout the study the first author was involved in participant observations of the chemistry classes (Merriam 1998) and kept a reflective journal. She

was an active member of the chemistry classes, building rapport with the participants, and giving them an opportunity to develop trust in her. The young women were encouraged to review their interview transcripts and participate in a focus group to discuss results from preliminary data analysis. Such collaboration is consistent with multicultural feminism's emphasis on the promotion of egalitarian rather than hierarchical relationships between researcher and participants. The first author was very open with the participants about the goals of the project and strove to give them extra assistance with school and college preparation.

The transcripts of the interviews were coded and analyzed using a constant comparative method (Glaser and Strauss 1967), in which main themes emerged from the data rather than from the interviewer's preconceived categories. Triangulation involved examining the other sources of data (reflective journal, student questionnaires, focus groups, teacher interviews, and observations) to ensure that the data confirmed the emerging themes. From these themes, a theory of identity formation related to science for the participants emerged.

Results: Identities That Influenced Views of Self as a Scientist

Originally we sought to explore the social interactions and experiences that influence science identity for Mexican American females. However, early into the study, it became apparent that it was not solely the students' self-perceptions as potential members of a science community that influenced the viability of a science career. Five identities were found to have an impact: ethnic, gender, student, college, and science identities.

Ethnic identity, which we defined as "knowledge of membership in a social group together with the value and emotional significance attached to that membership" (Phinney 1992, 156), was an important factor in defining the

Figure 2
Patterns of Ethnic Identity and Identification

Strong Ethnic Connection	***Weak Ethnic Connection***
• Strong connection to Mexican heritage • Displayed comfort and pride in culture • Formed groups based on ethnic identity • Presented evidence of pride in various personal and social ways • Spoke Spanish to signify social solidarity	• Lack of Spanish language skills marginalized the one member who did not display ethnic identification • Ethnic identity differed from Mexican American and was a source of discomfort • Affirmation and belonging scores much lower • Third generation in the United States • Showed confusion and isolation pertaining to ethnic identity

participants in this study. Individually we defined ethnicity as a "reference to groups that are characterized in terms of a common nationality, culture, or language" (Betancourt and López 1995, 92). Through the Multigroup Ethnic Identity Measure (MEIM) differences in ethnic identification surfaced among the girls in the extent to which they felt they belonged within the Mexican American community. Patterns that emerged are illustrated in Figure 2 above.

In addition to exploring their ethnic identity, participants talked freely about what it meant to be female. Although all used the term *girls* as a self-descriptor, they differed in their self-image as female. Two participants had self-images that were more masculine than those of the other participants.

Figure 3
Characteristics of Participatory, Borderline, and Non-Participatory Student Identities

Participatory	***Borderline***	***Non-Participatory***
• Capable learners • Proud of their school accomplishments • Liked school • Enjoyed learning • Felt a sense of belonging in school • Described by teachers as good students	• Showed peripheral or marginalized student identity • Uninterested in school or believed they do not belong • Viewed school as important, something to complete as future provider • Wished to do well, but teachers/ students conveyed message of inability to succeed • Had lower grades and lower confidence	• Believed school did not apply to real life and questioned why in school • More likely to consider leaving school, did not see it as a place for them • Displayed negative school behaviors such as: disruptive in class, getting in trouble, or skipping school • Ability to succeed in school did not reflect capacity

They thought they acted and dressed more like "guys;" they were more comfortable having male friends. The other participants considered their manner of dress and behavior as more feminine and more consistent with stereotypes of Mexican American female students—for example, being quiet and listening to the teacher (Alva 1991). Clarissa said, "I always had the tendency to [be] smiling, so I was the nice girl." Monica liked being a girl because "girls have more fun because they get to do their hair, do make-up, all that stuff…nails." The patterns that surfaced for student identity are shown above in Figure 3.

Figure 4
Participatory and Non-Participatory College Identities

Participatory	***Non-Participatory***
• Believed that going to college was in their futures • Had access to college information and support • Excited about going to college	• Did not see college in their futures • Did not believe they could succeed in college • Knew little about college admission or where to find information about college • Did not think they would enjoy going to more school

These student identities were fluid; in fact, several of the participants discussed how their identities had changed. For example, Monica described how she went from having a non-participatory student identity to having a participatory student identity: "…before, I used to fight everybody just for nothing, just looking at them and saying thing[s] to them. But when I came back, I was, like, a different girl. I try to do my best in all my classes." On the other hand, Miriam experienced a gradual shift away from a participatory student identity: "I can see the change within elementary school, middle school, and high school. In sixth grade, I was doing good and everything…like eighth grade, that's when I was starting to get discouraged."

For this study, a college community of practice was defined as those students preparing to attend college and the teachers who supported them. Five of the participants planned to go to college or had already been accepted into a college. Characteristics of college participatory and non-participatory identities are shown in Figure 4.

Figure 5
Characteristics of Participatory and Non-Participatory Identities in Science

Participatory	*Non-Participatory*
• Envisioned a possible career in science	• Had little connections to science
• Thought science was important to learn and applicable to everyday life	• Felt science was "out there" and could not imagine becoming scientists
• Tended to have more positive views about learning science	• Did not enjoy learning science and found science classes boring
• Thought they would prove something to society if they succeeded in science	

The science community of practice was defined as consisting of students who could imagine a future in which they developed into scientists. Only three participants had participatory science identities.

All of the participants thought that there were few Latinas/os in science. For example, Catherine defiantly stated, "If I did become a scientist…I would be, like, the first person, probably the first Hispanic person to be a scientist and stuff." A summary of the participants' identities is shown in Figure 6.

Relationships Among the Five Identities Related to Science
Consistent with the literature (Roth et al. 2004) the participants' identities were not expressed in isolation. A schematic of how these identities may work together is shown in Figure 7. Ethnic and gender were found to be pre-existing stable identities that interacted with the other identities; the young women had ethnic and gendered views of their participation within the student, college, and science communities of practice. Participatory science,

Figure 6
Summary of Participant Identities

Participant	*Ethnic Connection*	*Gender*	*Student*	*College*	*Science*
Nancy	Strong	Strongly feminine	Peripheral	Non-participatory	Non-participatory
Catherine	Weak	Strongly feminine	Marginalized	Participatory	Participatory
Esmeralda	Strong	Mildly feminine	Non-participatory	Non-participatory	Non-participatory
Clarissa	Strong	Strongly feminine	Participatory	Participatory	Participatory
Monica	Strong	Strongly feminine	Participatory	Participatory	Non-participatory
Miriam	Strong	More masculine	Non-participatory	Non-participatory	Non-participatory
Nallely	Strong	Strongly feminine	Participatory	Participatory	Non-participatory
Maria	Strong	Strongly feminine	Participatory	Participatory	Non-participatory
Mia	Strong	More masculine	Non-participatory	Non-participatory	Participatory

student, and college identities were needed in order for the student to see science as a feasible career path. Although these are separate identities, they overlapped and influenced one another. At the root of the figure are factors that influenced the development of the science, student, and college identities; these factors will be described later.

Being female was an important identity for the participants; however, gender was viewed through an ethnic identity lens. When the participants were asked what their experiences were as a female, they commonly responded "as

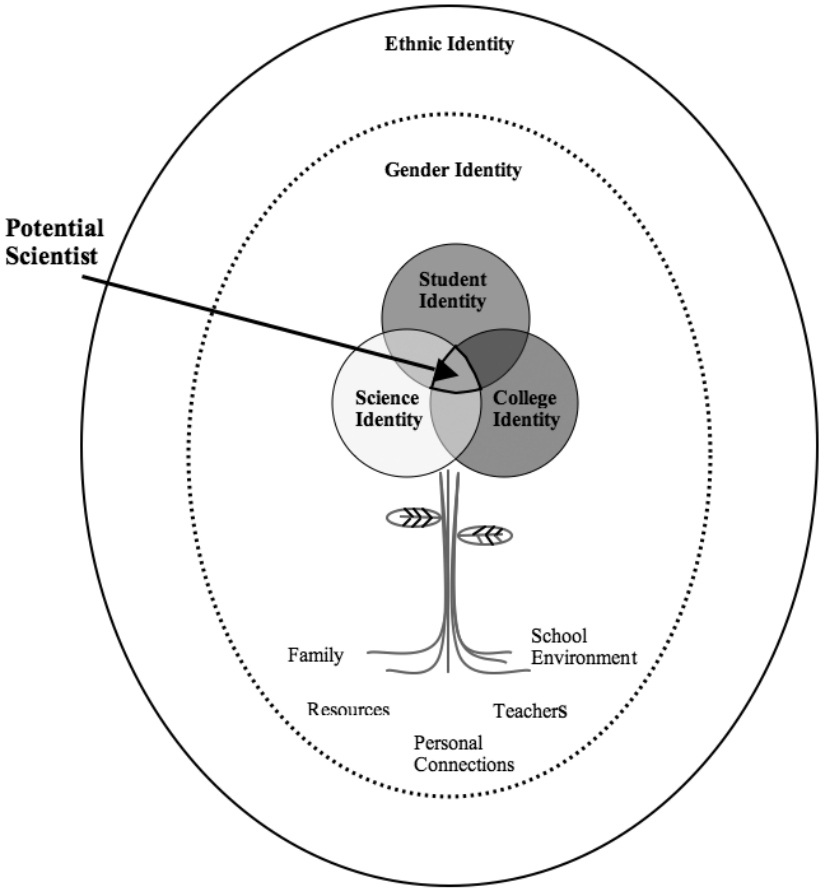

Figure 7
Theory of Mexican American female students' identities with respect to science

a Mexican American female" or "as a Latina." For these young women, the majority of their closest friends were Mexican American females and, in school, they socialized with Mexican American classmates if possible. The participants spoke often about traditional Mexican gender roles and expectations and did not often separate their ethnic identity from their gender identity.

Being a Latina influenced how the participants viewed other people's expectations of them and they were aware of differences in opportunities for males and females and for people of color. This was particularly pertinent for the science community of practice. Several of the young women talked about how Mexican gender roles, such as being expected to stay at home to cook and clean, may influence Latinas in science. Mia commented that Hispanic men do not want Mexican American women to do science because then the women would be more successful and would make more money than they did. When the girls were asked to draw a picture of a chemist, only one participant drew a female and only one drew a Latino. When the young women were asked why they drew Anglo men, they said that is who they thought most chemists were. Maria added that it was the "history of science" and that all the scientists she had seen were white men. Mia expressed that there is not "any Hispanic person that really is into science and wants to go ahead and be a scientist."

There were definite interactions between the student, college, and science identities. These interactions are summarized in Figure 8. Even though there were many overlaps between these communities of practice, they were still distinct and participation in one did not mean participation in the others (refer to Figure 6).

Of the three young women with participatory science identities, Clarissa was the only one who had a participatory identity in the science, college,

Figure 8
Interactions Between Student, College, and Science Identities

Interactions	***Characteristics***
Student x College Identities	• Good students were more likely to believe they were going to go to college and more likely to be encouraged by parents and teachers to go to college • Other factors, such as monetary resources or citizenship, prevented good students from going to college
Student x Science Identities	• Science class achievement and attitudes overlapped with school grades and attitudes • Attitudes about the chemistry class and teacher were more related to school identity than science identity • Grades earned in the chemistry class were not related to science identity • Science teachers were not able to distinguish between students who had participatory science identities and those who did not.
College x Science Identities	• Participants recognized that college was required for a science career • Factors that prevented college attendance prevented access to science careers

and student communities of practice. She was also the only participant who planned to study in a science field after high school. The other two girls were participatory in only one or two of the science, college, and student communities of practice. Catherine had participatory science and college identities, but was marginalized as a student. Although she had aspirations of attending college and pursuing a career in science, it is likely that her poor record in school and lack of solid study skills would make that goal a difficult one. By the end of the study, she reported being encouraged to take a job that required less rigorous schooling, such as becoming a real estate agent. Finally, Mia had a participatory science identity, but was non-participatory in the other two identities. She admitted in the interviews that she could see herself being a scientist, but it was not something she would realistically pursue because she did not like school and was not planning to attend college. The year after the study, she was taking classes at a technical college to become a mechanic.

Influences on Identities

There appeared to be several influences on the participants' school, college, and science identities. The majority of these influences were specific people with whom the young women interacted regularly; however, other factors, such as financial resources and educational environments, were also cited as influences. These influential "roots," as shown in Figure 7, were embedded within the gender and ethnic identities of the participants; that is, these identities influenced how the students interpreted and internalized social encounters. The more positive the roots the young women had for an identity, the more likely they were to participate within a community of practice.

Lee discussed how social interactions help to shape a person's self-image and behaviors: "Within social structural boundaries, social interactions lead to social positions with attached behavior expectations and meanings

that are called *roles*," (2002, 352). An implication of this behavior is that the more social support there is for a role, the more likely it is that someone will maintain that identity. This connection was particularly evident for the science identity; because many of the participants had few connections to anyone within the science community of practice, science was something that was unknown to them.

Family, particularly the mother, was one of the most influential social connections to student, college, and science identities. When asked who encouraged them the most to do well in school, all the participants mentioned family, in general, or a specific family member. This finding is consistent with results from other studies indicating that Latinas view their mothers as the most credible source of information about schooling and future careers (Cardoza 1991; Koballa 1988). When Nancy felt discouraged about school she talked to her mother: "She'd be like, 'No, you have to go to school, you have to have a good life.' And she would encourage me again to get up every morning and come to school." Other family members were also a source of support. When Miriam told her father that she would rather find a job than go to school, her father told her, "No! I would rather you go to school than work right now, because you know, now you have the opportunity to be in school; you can do it." Mia, Nallely, and Monica had older siblings who encouraged them to attend school.

Family could also be a source of discouragement from school. Miriam, Esmeralda, Mia, and Catherine had brothers, sisters, cousins, or young aunts and uncles who were negative influences. Miriam was the youngest child in her family, but would be the first to graduate from high school because her two older brothers had dropped out of school. Esmeralda had a large extended family living close by, with many cousins, aunts, and uncles who had left

school. She said, "I have some younger uncles, the one that's thirteen, he used to never go [to school] either. Then, my other uncle, the one that's fourteen, he dropped out. Then my other uncle, that's seventeen, he dropped out."

Students experienced different types of family encouragement to attend college. Only Clarissa and Maria's parents expected and encouraged them to go to college and these two had strong participatory college identities. Clarissa said that her dad "always expected me to go…it's when, not if," and she thought this viewpoint was different from that of many of her peers' families. In contrast, Mia described her mother's attitude toward college as, "She'll just tell me, try to be like your sister [who had an associate's degree]…but make it only to high school and I'll be proud." Mia had a non-participatory college identity.

The level of education achieved by the participants' family members differed. Clarissa's parents were the only ones who had college degrees; some of the other parents had only attended elementary school. Since most of the participants' parents had not gone to college, they did not have the experience to help their daughters in school and with college preparation. Having fewer years of school also meant that parents had less experience with science and so were less likely to model an interest in science.

Family was the primary source of early gender expectations. Many participants spoke about family expectations to be a "good daughter." For example, Nallely commented that her grandmother told her "to take care of myself…to be a good daughter." Nancy felt that she had let her mother down when she got pregnant. "I feel like I've failed and I didn't do what I'm supposed to…[my mom] said I was a bad daughter." Several of the young women also felt that they were given fewer privileges compared to

their brothers. Nallely thought that her young nephew was smarter than her sister and her because "he's a boy and we are girls." The participants were asked whether they thought that their families would be happy if they went into science and although none of them thought that their parents would disapprove of a science career, only Clarissa, Nallely, and Catherine's family encouraged them to take science courses or participated with them in science activities at home or in a school setting.

Personal connections to family members or family friends with different careers seemed to have a large impact on what careers were viewed as accessible by the participants. In fact, all three participants who could envision themselves as scientists had a family connection to science. Clarissa's parents were engineers when they lived in Mexico, Mia's brother was a pre-med student in college, and Catherine's grandmother was interested in nursing. Friends of the family also had influence. Monica wanted to be an immigration lawyer and talked about having met her mother's friend who was an immigration lawyer and how she regarded this person as a role model.

In contrast to the findings of other studies on the importance of peer influences on Latina/o students (O'Halloran 1994; Taxis 2003), peers did not appear to be an important factor in student, college, or science identity formation for this group of young women. Each participant reported having friends who often matched her own student and college identities. This may have strengthened her place within that community of practice; however, they gave examples of picking their friends to reinforce views of themselves. This particular group of young women was fairly transient; many of the participants moved often and/or talked about changing friends over the years to fit better with the community of practice to which they wanted to belong.

The participants mentioned little peer support for science, even for the three young women with participatory science identities. When the participants were asked what their friends thought about the chemistry class and science in general, the most common response was a blank stare. It seemed that science was a topic that did not commonly come up in conversation. Nancy's friends questioned why she was taking the chemistry class. So, there seemed to be very little peer support for the development and maintenance of a science identity.

Opinions of and experiences with teachers and administrators varied drastically with student identity. Those with participatory student identities liked all their teachers, thought they were helpful and nice, and gave examples of how teachers had encouraged them. For example, Clarissa commented, "I get along with all my teachers, they're really nice." Nallely said about one especially supportive teacher: "She always was helping me when I don't understand and when I was writing a big paragraph about my life…to tell me what words are wrong and if I spelled them wrong." Nancy also described a teacher who encouraged her, "She made me feel like I could. She would teach for people to understand, and really well."

The participants who had marginalized or non-participatory student identities predominantly gave descriptions of teachers who did not care, were out to get them, had low expectations, made them feel uncomfortable, and cared more about rules than learning. Catherine felt that teachers often ignored or punished her unfairly. One teacher had helped her with mathematics. "To me she was the only teacher that really helped me out with my work and stuff. Out of all the years I had, she was the only teacher that really helped." Esmeralda made many comments about feeling that teachers did not care about students, such as, "I really think that teachers are here just to get paid.

Most of them are. They just don't care. I remember this one teacher, she said that even if we do learn or not, she still gets paid."

Since only two of the young women had family members with a college connection, schoolteachers and counselors were their main source of information about college. Seven of the nine participants viewed their teachers as the most credible source of information about how to get into college, because their mothers, normally viewed as the most trusted source of information, had little experience with college. Students with participatory college identities talked with teachers and counselors more often about college; however, even participants who had non-participatory college identities, such as Miriam and Mia, mentioned discussions with teachers about which college they should attend and what they needed to do in order to attend college.

Several of the young women, especially the ones who had non-participatory student identities, often judged how well they liked a subject based on how well they liked the teacher as a person. No pattern of gender or ethnic preference in a teacher emerged; rather they connected with teachers who respected them, were less stringent with rules, and seemed to care about them. Science teachers, and the way the class was taught, made a difference in whether the participants liked science. For the chemistry classes in this study, the participants enjoyed doing hands-on activities, but felt that the activities were pointless if the teacher did not explain them. Several of the young women said that they liked Mr. Miller, the student teacher, because he was young and they thought he was attractive. Mia and Esmeralda did not like Ms. Clark; Esmeralda said that she was her least favorite teacher.

> She's kind of getting on my nerves. Just by the way she's acting. Every little thing that she doesn't agree with is just all like, "Go to

> the office" or "I'm not going to argue with you"…or sometimes she gets really mad. I can't stand that.

In addition, participants brought up wanting a teacher who made science interesting and was knowledgeable on the subject. They communicated dissatisfaction over not having a certified science teacher and having many substitute teachers who knew little about science. Mia said the main reason that she did not enjoy science was the poor teachers she had had in the past. Maria explained why she stopped liking science in middle school, "In middle school I didn't learn no science…I didn't learn nothing because the teacher we had, she didn't really teach us."

Most of the young women had an example of at least one science teacher whom they thought made the class interesting and revived their interest in science. Maria, who had lost interest in science in middle school, started liking science again when she was in ninth grade. "I had the best teacher. He was really young. Everybody liked him…he was a really good teacher. That was biology, I think. …I learned a lot. He just made it fun and interesting." Nallely and Clarissa both had middle school science teachers whom they had liked and who had actively encouraged them to get involved with after-school and summer science programs. Clarissa explained that her middle school science teacher "opened up the door to science" and stimulated her interest in science careers. The participants, with the exception of Clarissa, did not consider their science teachers to be "real" scientists and there did not seem to be much of a connection between teachers and science identity. These results are consistent with findings from a large science attitude survey (Gilmartin et al. 2007), in which students were found not to view teachers as science role models.

As mentioned previously, availability of resources was one of the main factors in college identity and, therefore, also science identity. Participants had a hard time imagining going to college to become a scientist because they did not have the financial resources to pay for a college education. Also, some institutional practices at the school may have marginalized participants from the student community of practice. The atmosphere of the school was focused on discipline and made students with non-participatory student identities feel that the teachers did not care about them. They were also marginalized by other practices, such as not being able to choose their own classes or not having access to after-school activities. In this study, only four of the participants, Nancy, Catherine, Clarissa, and Nallely, chose to take the chemistry class, the rest were just placed in classes without their input. Esmeralda believed that they were placed in particular classes because there was nowhere else to put them.

The overall environment of the school was not conducive to learning. Many students at the school came from poor families and had serious problems at home. The participants thought that most of the students at the school did not care about learning. Some of the other students were disruptive in class and learning time was lost when teachers had to discipline them. Also, many resources were used to raise the grades of lower achieving students. Consequently, higher-level courses, such as AP courses or calculus, were not offered at the school, preventing higher achievers, such as Clarissa, from taking them.

Discussion and Conclusions

The purpose of this study was to understand how the identities of Mexican American females and their views of and aspirations in science related to their educational and social experiences. Several identities were found to influence

the participants' self-image as scientists. These main identities were: ethnic, gender, student, college, and science identity. Self-perceptions as students, potential college attendees, and scientists were influenced by ethnic and gender expectations.

Personal connections to someone with a participatory identity appeared to be important to gain access to a particular community of practice. A personal connection did not have to mean daily interaction, but did need to involve a person with whom these young women had a bond and with whom they interacted sometimes. For instance, several of the young women mentioned meeting scientists on field trips who were all Anglo men. The participants did not consider meeting them to be equivalent to knowing a scientist. None of the participants specified that these personal connections had to be with Latinas; however, it seemed that connections were made more easily when the person was similar in gender and ethnicity.

The young women who had a participatory school, college, or science identity also knew someone with that same participatory identity. This was especially apparent when talking about future careers. For the participants, the majority of these personal connections were found within their families. These findings correspond to earlier studies on the importance of family on the school achievement of Mexican American females (Brown 2002; Taxis 2003; Vega 1995). Other people also influenced specific identities. For many of the participants, teachers were the main personal connection to college. Still, most of the participants with participatory college identities had family members with some connection to college. Teachers did not serve as personal connections to the science community of practice for any of the participants—except perhaps Clarissa—because the young women did not view their teachers as scientists.

To encourage more young Mexican American women into science careers it may be necessary to provide them with more personal connections to scientists; many of these young women did not have such connections and believed that there were few Latinas/os in science fields. Planning field trips to science research institutions and industrial plants and inviting scientists to speak to the class are good ideas, as long as there is diversity among the scientists. Otherwise these meetings may further marginalize the students from feeling that they belong in a group of scientists. A field trip to a chemical plant where the students listened to Anglo American male scientists explain their job made science seem less accessible to Maria. It may be more helpful to give small groups of students a chance to interact with an ethnically diverse group of male and female scientists or to set up mentorship opportunities that would be likely to build personal connections. The GK-12 program is an example and may be useful in building these types of personal connections. This program puts science graduate students into K-12 classrooms (for more information go to http://www.gk12.org/). These graduate students provide students with connections to both science and college.

Classroom activities that highlight the accomplishments of diverse scientists may also be helpful in promoting a participatory science identity. For example, the participants noticed that textbooks and videos shown in class focused only on Anglo men. The only scientists they knew of were the ones that they had read about in their science textbooks. Since many of the famous chemists who are included in textbooks are white men, it would be beneficial to highlight influential female chemists from different ethnic backgrounds. Several professional organizations have biographical sketches of ethnically diverse scientists that could be used to supplement textbooks. Examples of this are the Adelante Project (Cantú 2006, 2008), the SACNAS Biography Project (http://bio.sacnas.org/biography/default.asp), and the Biographical

Snapshots of Famous Women and Minority Chemists from the *Journal of Chemical Education*.

Valenzuela (1999) notes that educación incorporates the foundation of all learning in that it includes the family's role in teaching moral, social, and personal responsibility. "Though inclusive of formal and academic training, educación additionally refers to competence in the social world, wherein one respects the dignity and individuality of others" (Valenzuela 1999, 23). Thus, Valenzuela concludes that educación is both the means and product of academic achievement and is characterized by respectful and authentic, caring relationships. The participants in this study often mentioned that they learned more in classes when they thought the teacher cared about them and respected them. Educación is embedded in the nurturing relationship of the family and stresses teaching to the whole child (Eggers-Piérola 2005; Reese et al. 1995).

Several of the participants, particularly the ones with marginalized and non-participatory student identities, felt that the teachers in the school did not care about them. Pearl (2002) describes an optimum learning environment for Mexican American students as one in which the concepts students learn are immediately useful; teachers emphasize creativity, excitement, and hope; and students have ownership in what they learn, experience encouragement to risk, and obtain a sense of competence and a feeling of belonging. In other words, an ideal learning environment helps Mexican American students believe that they belong in the school community of practice. Such a learning environment is ultimately beneficial for all students. (For examples, see Lambert and McCombs 1998; McGilly 1994.)

Barba and Reynolds (1998) and Rakow and Bermudez (1993) identified variables that contributed to the underrepresentation of Latinas/os in the

sciences. Many of the same variables were found to affect the student, science, and college identity formation of the participants in this study. For example, few role models in science, low awareness of science careers, few relevant science experiences, views of chemistry as a white male profession, lack of funds for higher education, and low expectations from parents and teachers may be barriers to the formation of a participatory science identity in some of these young women.

Having a personal connection to science alleviates some of these barriers by providing a role model and access to information about science careers and science experiences. The participants were not discouraged from going into science by family or teachers, but nor were they actively encouraged. Personal connections were found to be very important to the development of science identities. However, since science identity is interconnected with school and college identities, the school environment in which these students were exposed to science was crucial in developing their appreciation for science and a self-image as a scientist.

The schooling conditions of the students in this study were not vastly different from those of the majority of Mexican American students. Valencia (2002a) gave an overview of schooling conditions and outcomes for the majority of Latina/o students in the United States. He pointed out fifteen realities that Mexican American students face, such as segregated schools, language and cultural exclusion, low academic achievement, more frequent grade retention, lower school financing, low school holding power, tracking, unqualified teachers, overrepresentation in special education and underrepresentation in gifted programs, low Latina/o teaching force, and school stress related to racism.

The inequitable conditions that Mexican American students face can have direct economic impacts on their futures. Pearl (2002) stressed that schooling has become society's "gate keeper" and controller of status flow between rich and poor. During the 1990s, the number of "good" jobs has increased, along with the number of "bad" jobs; few jobs remain in the middle to make "upward mobility a realistic aspiration for working-class and immigrant populations" (Pearl 2002, 337). Education is a key qualification for high paying jobs in which upward mobility is possible, such as those in science (Pearl 2002). The good jobs go to people with college degrees. So, now, more than ever, future prospects are determined by how well a person does in school.

The results of this study suggest that to increase the interest that Mexican American females have in science, more personal connections need to be developed and schooling conditions for Latinas need to be improved. Improving school conditions is not an easy task because Latina "school failure and school success are inextricably linked to larger, complexly interrelated social issues" (Pearl 2002, 361). This change will require a "deep-rooted systemic reform" (Valencia 2002b, 365) with vast changes in the context of schooling—economic, political, and cultural—along with changes in the ways which teachers disseminate information. The quality of life and the number of students interested in science for the next generation of Mexican American females may rest on greater access to positive personal connections and role models and the improvement of school and economic conditions.

Limitations and Future Research

This study was limited to the information given by participants and analyzed through the cultural lens of the researchers. The impact of culture on interpretation was demonstrated during the teacher interviews. Two teachers

gave a description of the same student, Miriam. One of the teachers was a young Anglo male who described Miriam as loud and disruptive during class. He viewed these as negative actions. However, the second teacher, an African American female, had an opposing view of Miriam's actions. She described Miriam as being an assertive young woman who could do anything if she put her mind to it. These interpretations of the same behavior may have been influenced by cultural norms for discourse. Anglos tend to praise quiet and attentive behavior in the classroom, whereas studies have shown that some African Americans value a louder, more responsive form of discourse (Kunjufu 2002; Lee and Fradd 1996). This difference in interpretation of the same actions demonstrates how our culture influences our views of others and it reminded us to be cautious in describing the participants. However, even with care and consultation with the young women and our Mexican American co-researcher, there is the potential for misinterpretation in the analysis of the data.

This study is a step toward understanding how Mexican American female identities form and interact with their views of themselves as scientists. It would be helpful to examine how different contexts affect identity formation for Mexican American females. It might give further insight to explore the science identity of rural students, students in more or less diverse schools, and students with families that have been in the United States for three or more generations. It would also be interesting to study a group of Mexican American females from different socioeconomic backgrounds to see whether class is a defining identity, along with language of origin and generational patterns.

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