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Profiles of Urban, Low SES, African American Girls' Attitudes Toward Science

A Sequential Explanatory Mixed Methods Study

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The purpose of this study was to increase the science education community's understanding of the experiences and needs of girls who cross the traditional categorical boundaries of gender, race and socioeconomic status in a manner that has left their needs and experience largely invisible. A first of several in a series, this study sought to explore how African American girls from low SES communities position themselves in science learning. We followed a mixed-methods sequential explanatory strategy, in which two data collection phases, qualitative following the quantitative, were employed to investigate 89 African-American girls' personal orientations towards science learning. By using quantitative data from the Modified Attitudes toward Science Inventory to organize students into attitude profiles and then sequentially integrating the profile scores with year-long interview data, we found that the girls' orientations towards science were best described in terms of definitions of science, importance of science, experiences with science, and success in science. Therefore, our mixed method analysis provided four personality orientations which linked success in school and experiences with science to confidence and importance of science and definitions of science to value/desire. In our efforts to decrease the achievement gap, we concluded there should be more emphasis on conceptual understanding and problem-solving skills, while still being cognizant of the danger of losing the connection between science and society which so often plagues achievement-focused efforts. Our continued efforts with this group of girls will center on these instructional techniques with the goal of addressing the needs of all science learners.

Keywords: *gender; feminist research; science*

The increasing diversity of the school-aged population coupled with differential science performance among demographic groups makes the goal of science education for all children a major challenge. The number of students whose personal circumstances cross and confound categorical boundaries, such as gender, race, ethnicity, and socioeconomic status (SES) is greater than ever and will no doubt continue to increase. As we

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struggle to identify the needs of the students in our schools, student identities are being theorized in increasingly sophisticated ways—as are the social forces, processes, and practices that shape students' educational experiences (Levinson, Foley, & Holland, 1996). As these theoretical approaches evolve by challenging underlying assumptions (e.g., questioning where the diverse individual lies in a demographic grouping), so must our methodological approaches (e.g., questioning how to meet the needs of the many while coming to understand the uniqueness of the individuals among the many).

The pur of our research is to increase our understanding of the needs of girls who cross the traditional categorical boundaries of race and socioeconomic status in a manner that will allow us to meet the needs of all the girls with whom we work, while also adhering to the uniqueness of the individual girls. We acknowledge that we have become feminists critiquing feminism and the dominant methodological approach within our line of inquiry. It is a place at which we have arrived as a result of our presence in the schools and the lives of girls and their teachers. With this study, we sought to explore the science attitudes, as well as the experiences and understandings that helped shape them, of African American girls from urban, low SES communities. Our work was informed by quantitative studies that sought to identify the attitudes toward science and science education of a large demographic group (Carpenter, Ramirez, & Severn, 2006; Catsambis, 1995; Weinburgh & Engelhard, 1994; Weinburgh & Steele; 2000) and the more recent work of qualitative researchers who strived to enhance our understandings of individual cases within those groups (Brickhouse, Lowery, & Schultz, 2000; Calabrese Barton, 2007; Calabrese Barton, Tan, & Rivet, 2008; Tan & Calabrese Barton, 2006, 2008).

Through the analysis of the modified Attitudes Toward Science Inventory (mATSI; Weinburgh & Steele, 2000), we identified four attitudes toward science profiles among the girls. Through the analysis of in-depth focus-group interviews, we came to understand how these girls' position themselves toward science, what the experiences were that led to this positioning, and if these experiences were positive or negative. Ultimately, through a mixed method approach, we gained an insightful look into a seemingly homogeneous group of girls to demonstrate the vast differences, as well as similarities in these girls' profiles to understand how they orient themselves as learners of science.

Theoretical Framework

As feminist researchers in science education celebrate the fact that our work has contributed to an improved situation for girls in science classrooms overall, we must also ask ourselves—who have we excluded? In reality, our research over the past several decades has too often explored how to better meet the needs of White, middle-class females. Although our concerns have pushed the science education community to ask more useful questions with regard to what we believe about students, schools, and science, they were too narrowly focused and biased (Kahle & Meece, 1994; Krockover & Shepardson, 1995; Scantlebury & Baker, 2007). It is essential that feminist researchers now take a critical look at our own perspectives much in the way that we have taken a critical look at the biases in other perspectives (Butler, 2004; Crawford & Unger, 2000; Donovan, 1996; hooks, 1990; Lather, 2007; Luttrell, 1989; Qin, 2004; Stewart & Ostrove, 1993; Wilson, 1998).

Contemporary feminists continue to question political and social inequalities in society, but are increasingly turning their critiques back on feminist theory itself. These critical feminists seek to challenge what feminism has come to portray as the universal female identity; noting that although early feminisms sought to eliminate the political and social inequalities that affect women, it was often the White, middle-class females that were at the center of the plight (Butler, 2004; Crawford & Unger, 2000; hooks, 1990; Lather, 2007; Luttrell, 1989; Qin, 2004; Stewart & Ostrove, 1993; Wilson, 1998). Critical feminists seek to eradicate the further marginalization of working-class minority women by questioning whose interests and perspectives are being pursued by the feminist movements (Donovan, 1996). They argue that women's construction of self is influenced by not only gender but also race, ethnicity, class, power, and sexuality (hooks, 1990; Luttrell, 1989; Stewart & Ostrove, 1993). In light of these concerns, critical feminist researchers seek to deconstruct cultural feminists' theories on "womaness" (Qin, 2004). They propose that by putting one's categories in crisis, we can see what is excluded (Butler, 2004). The effects in science education emerging from this approach include a questioning of the lack of gender research involving girls from non-White, middle-class populations; as well as challenges to the very practice of creating dichotomous boundaries with gender and race.

We question not only what it means to be a girl in science, but also what it means to be an African American girl in science. Furthermore, we embrace the complication of differences within the construct of African American female science identities. As critical feminists, we examine the diversity within gender and race groupings and attempt to work against polarizations of stereotypical categorization. Thus, we further challenge a practice of exploring attitudes of African American girls as a universal whole by exploring the homogeneity and heterogeneity found within a group of urban, low SES, African American girls. By doing so, we endeavor to further situate our practice within a feminist approach that seeks a "faithful transgression that is not so much self-correction as negotiation with complexity" (Wilson, 1998, p. 65) by allowing our research in gender and science education to actively and continually rewrite itself.

Relevant Research

The 2005-2006 American Association of University Women (AAUW, 2006) reports made the following claims: (a) girls fall behind boys in science and mathematics; (b) girls participate less than boys in class, or are "silenced" in the classroom. These are concerning claims that warrant response by the professional field, but the claims do not go far enough in determining how we should respond. For example, are these claims true for girls of all races and socioeconomic situations? Will the problems be addressed by responding with strategies that have been shown to improve the situation for girls from middle class, White populations? As we sought to define the perimeters of our efforts to address the needs of the girls with whom we were working, we reviewed research that explored students who crossed categorical boundaries of race, gender, and SES status. We have come to understand that African American females are facing a "two-tiered dominating patriarchy" that consists of race and gender (Fordham, 1993, p. 5). For these women to be participating members of the scientific community, they often feel the need to be silent or invisible. This transition into the culture of science can cause distress and serve to alienate African American females from science (Fordham, 1993). This silencing has not been greatly explored in the literature, as most of the research focuses on reducing the achievement gap of African American males or White females (Rollock, 2007).

Britner (2008) demonstrated that attitudes are a crucial link in understanding girls' voices and how they position themselves in science. Thus, to understand the voices of African American girls, their attitudes about science need to be considered. Catsambis (1995) studied the attitudes toward science of African American students. The quantitative findings from this study revealed that these students' attitudes were often positive despite low achievement. It was suggested that this attitude–achievement paradox may be related to factors external to the classroom (e.g., family, community, school), but this was not explored with the quantitative data collected for this study. Weinburgh and Steele (2000) also argued that students' attitudes toward science are important because they are believed to influence the course selection of African American females and ultimately their achievement in science-related fields. Using the mATSI to explore student attitudes in science, Weinburgh (2003) investigated gender and attitudinal differences of fifth graders because of systematic reform. There was a large disparity in attitudes toward science among racial groups. In addition, the negative attitude on the mATSI showed that African American girls experienced overall less value of science to society and reduced motivation to engage in science that African American boys.

Further complicating the boundaries of gender and science, some science education research encourages us to question whether addressing African American girls as a homogeneous group ignores important values and propensities unique to the individuals within the group. Carpenter et al. (2006) used National Education Longitudinal Study data to examine within-group differences and compare those across various minority populations. Though factors such as qualified teachers, urbanicity, and public versus private schools have long been held as major predictors of achievement, the most significant predictors appear to be rooted in the home, including language, parental involvement, SES, and homework. These researchers point out that accurately defining these gaps is essential as these issues influence public understanding of them, the policies crafted to support them, and how that success is assessed. Results question the singular view of the categorical boundaries often used in discussing achievement gaps, and suggest that current policies may miss the mark in raising achievement levels between and within demographic divides.

Brickhouse et al.'s (2000) study of African American girls highlighted the need to explore identities. They asserted,

> What we do know is that when teaching girls science and trying to explain why it is they are or are not doing well in science, we need to know more than that they are girls. We need to know what kinds of girls they are. (p. 457)

They stress that we must understand learning as a cognitive, emotional, personal, social, and cultural experience for each student. This qualitative work explored the different personal factors that can be found within a classroom and their influences on teaching and learning. Through the use of case studies, these researchers created profiles of students. The four cases they described, chosen because they represented diversity in girls' identities, deviated from the stereotypical stories often heard about African American girls in science. Through reading these cases, we learn about how the girls' personal identities do or do not overlap with school science identities. This research helped promulgate an understanding of the diversity within both gender and race categories. Our understanding into the heterogeneity of this population is further enhanced by the work associated with the "The Inquiry School" (Calabrese Barton, 2007; Calabrese Barton et al., 2008; Tan & Calabrese Barton, 2006, 2008). With this project, these educators expanded the work to account for the fluid nature of identities-in-practice. Overall, these in-depth cases help us to understand how girls' science identities are developed within school science. These identities are both fluid and multiple in nature.

In conclusion, science education research on minority girls in science demonstrates our universal understanding of attitudes toward science has been too narrowly defined. Most of the quantitative research in this area explored African American girls as a population with external heterogeneity from other student populations and internal homogeneity within the population (Catsambis, 1995; Fordham, 1993; Weinburgh, 2003); the exception to this being the quantitative research completed by Carpenter et al. (2006), which demonstrated within group differences. These differences were further explored by a growing number of qualitative studies that fractured the boundaries of gender even further (e.g., Brickhouse et al., 2000; Calabrese Barton, 2007; Tan & Calabrese Barton, 2006, 2008; Calabrese Barton et al., 2008). From this qualitative research, we came to understand that there are multiple identities among this group of girls that shape their science identities. Our study expanded this literature by exploring the differences within the science attitudes of African American girls from low SES and urban environments in a manner that allowed us to develop an educational initiative that will foster greater engagement for a greater number of these girls. This study goes beyond looking at African American girls as a whole by further exploring the heterogeneity within the group. As well, this study goes beyond looking deep into a few individuals within the group by seeking broad patterns within the heterogeneity in a manner that would allow us to develop an educational approach that would better fit the needs of all girls within an entire school.

Context

In the summer of 2007, the first author developed a collaborative action research group with the principal and teachers at an all-girls elementary academy in a large urban district in the Midwest. The majority of the approximately 350 girls at this school lived in one of two public housing developments within four blocks of the school. The student population of the school was 99% Black and 1% Multiracial. Additionally, 88% of the students qualified for free lunch. The all-girls academy was in its second year of operation and was seeking to initiate a science focus for their academy.

Purpose

The overall efforts of our collaborative action research group were guided by the identification and monitoring of the girls' engagement in science and how this engagement influences and was influenced by science teaching and learning. The purpose of this initial study was to explore the attitudes toward science of urban African American girls from low SES communities using a mixed methods sequential explanatory design. In the first phase, quantitative questions addressed what profiles emerged from the scores of 89 African American girls on the mATSI. Information from this first phase was explored further in a second qualitative phase. In this phase, interviews were used to probe significant themes by exploring aspects of the profiles with 30 of the girls at the academy. The reason for following up with qualitative research in the second phase was to better understand and explain the reasons for the differences in profiles.

Research Questions

In light of the fact that the phenomenon we were studying was so complex, we needed to use different kinds of methods to understand the complexities (Greene & Caracelli, 1997). Mixed methods research was necessary. This approach offered us the ability to develop a deep knowledge of a small number of minority girls in science, while simultaneously expanding our understanding by looking at a larger number of girls at our school site. Our exploration was guided by the following research questions.

Quantitative Research Questions

1. Did the students in the sample score differently on the scales of the attitudes toward science survey?
2. What attitudes-toward-science profiles emerge from the scores on the attitudes toward science survey?

Qualitative Research Questions

1. What are the urban, low SES, African American girls' attitudes toward science and science learning?
2. What aspects of their experiences and understandings contribute to differences in attitudes?

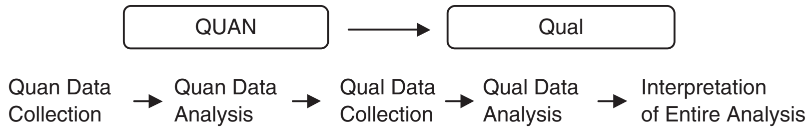
Mixed Methods Question

1. How can the understandings that emerge from the qualitative data be used to provide a deeper understanding of the attitude-toward-science profiles?

Method

This study followed a mixed methods sequential explanatory strategy (Creswell & Plano Clark, 2007). Two data collection phases, one following the other, were used in this approach. The two methods were integrated during the interpretation phase. By using this

Figure 1
Explanation of Mixed Methods Analysis



approach, we were able to use qualitative results to assist in explaining and interpreting quantitative findings. A model of this approach is given below.

Participants

All students in the school were invited to participate in this study. Of the 89 responding student participants, 33 were from the fourth grade, 16 were from the fifth grade, and 40 were from the sixth grade. All participating girls were given the research survey. We used a purposeful sample of girls ($N = 30$) from each of the three grade levels and from the various academic achievement levels (low, average, high) to participate in the group interviews. The academic achievement on the statewide standardized test of the participant group (22% high, 52% medium, and 26% low on the English portions and 22% high, 42% medium, and 36% low on the math portions) was representative of the entire school (24% high, 50% medium, and 26% low on the English portions and 23% high, 45% medium, and 32% low on the math portions). The purposeful subsample for interviews included 30 girls, 10 from the fourth grade, 10 from the fifth grade, and 10 from the sixth grade with representative academic achievement as mentioned above. All girls in the study came from similar socioeconomic situations (they all lived in a housing project and qualified for free lunch) and were members of the majority racial make-up of the school (African American).

Quantitative Data Collection and Analysis

Quantitative data collection. The girls completed the mATSI (Weinburgh & Steele, 2000). The original 48-item instrument was first adapted to be used with science attitudes instead of mathematics attitudes (Gogolin & Swartz, 1992) and later shortened by Weinburgh and Steele (2000). This 25-item questionnaire is designed to measure fifth-grade African American girls' and boys' attitudes toward science. The adjusted/shorter version maintained the validity of the original questionnaire (see Validity section). The questionnaire contains five subgroups of items: "perception of the teacher," "anxiety toward science," "value of science to society," "self-confidence in science," and "desire to do science." A 6-point Likert-type scale, ranging from 1 (*strongly agree*) to 6 (*strongly disagree*), is used. We reversed the scales so that positive answers received higher scores and negative responses received lower scores. We then recoded the "anxiety" subgroup as "antianxiety" because we considered low anxiety a positive response. We also chose to

Table 1
Factor Loadings of Summary Scale Scores on Desire and Value and Confidence and Nonanxiety

Summary Scale Scores	Desire and Value	Confidence and Nonanxiety
Desire	.843	
Value	.869	
Confidence		.832
Nonanxiety		.869
Cronbach's alpha	.763	.746

Note: Factor loadings of less than .2 are excluded.

omit the survey questions on "perception of the teacher" from the analysis because we were interested in the girls' general perceptions of science, rather than their views of their teacher. An African American teacher that was part of the research team administered the survey.

Quantitative Analysis. A summary score was created for each of the four remaining subgroups by averaging the items for each category of questions, with some questions reverse coded. Considering the complementary nature of the constructs of desire and value and antianxiety and confidence, we theorized that those four scales could be condensed into two. To explore this possibility, we conducted a two-factor confirmatory factor analysis with varimax rotation on summary scale scores for Desire, Value, Nonanxiety, and Confidence. We extracted a two-factor solution that accounted for 75.6% of the total variance. Scale reliability measures show items in these two factors, Desire and Value and Confidence and Nonanxiety, are highly reliable, with Cronbach's alpha values of .763 and .746, respectively (see Table 1). By averaging the summary scores for Desire and Value and Confidence and Nonanxiety, we assigned each student two new scores that simply and effectively summarized their attitudes toward science as evaluated by the survey.

Finally, to understand the varying types of students in our population ($N = 89$), the students were divided into four groups based on their two new scores. The Desire and Value scale and the Confidence and Nonanxiety scale were each split at the midpoint of the scale (3.5 on the 6-point Likert-type scale) to differentiate students who were "high" and "low" on each scale. Four profile groups were then created with those that were high on both, low on both, or high on one dimension and low on the other.

Qualitative Data Collection and Analysis

Qualitative data collection. We conducted group (three or four girls at a time) interviews for the data collection procedure. Interviewing offered us access to the girls' ideas, thoughts, and memories in their own words. This attribute is particularly important for the study of girls and minorities because this way of learning from them is an antidote to centuries of ignoring their ideas altogether (Reinharz, 1992). In addition, the group-interview format allowed for representation of a larger number of girls to look for attitude-toward-science profiles that describe more than one student within the population. In light of the type of information we sought to explore, we used open-to-semistructured group interviews as the source of qualitative data collection. We selected group interviews because they are (a) socially oriented and a more comfortable arena for talking about perceptions, as well as conducive to reflection on the ideas of others (Reinharz, 1992); (b) a safe environment where students can share ideas, beliefs, and attitudes in the company of people from the same socioeconomic, ethnic, and gender backgrounds (Madriz, 2000); and (c) inclusive in that they limit the powerful voice of the researcher (Wilkinson, 1999).

The foci of the interview included science experiences outside of school, experience inside of school science, perceptions of science, perceptions of science as a school subject, the relative importance of science (as an area of study and school subject), and favorite science lessons. Sample questions included (a) Do you feel that you do well in science at school? What would help you do better? (b) Is it important for you to do well in science at school?, Why/why not?, What is as important as studying science?, What is more important than studying science?; and (c) Tell me about your favorite science topic. Do you explore this topic on your own? The interviews were based on consent and availability during the school day. The researcher who conducted the interviews was a Caucasian female and former science teacher with training in conducting focus-group interviews. We took steps to assure that the girls' were familiar with this interviewer by having her introduce herself to the girls and make several initial visits to the school prior to the interviews. We maintained the same interviewer throughout the study.

Qualitative analysis. We analyzed the database using traditional qualitative procedure for coding and developing themes (Creswell, 2003; Creswell & Plano Clark, 2007; Miles & Huberman, 1994). One member of our research team transcribed the audiotapes verbatim. All members of the research team then reviewed the transcriptions. We coded the data using an in vivo coding technique to represent the girls' words as closely as possible. We refined the codes throughout the coding process as new ideas emerged, and similar codes were ultimately grouped together into broader themes (e.g., definitions of science, importance of science, experiences with science, and success in school science). Each theme was discussed and clarified until a final set of four major themes emerged that best represented the positions of the participating girls.

Validation. Lather (1986) discussed the importance of assuring the validity of research committed to improving social and educational practice. She established guidelines to follow within openly ideological research. The following guidelines were used to develop our study.

Triangulation. Our study was triangulated through the use of multiple methods, data sources, and theoretical schemes. The use of different methodological approaches was obvious by the inclusion of both quantitative and qualitative approaches. In addition, we used multiple data sources through the use of numerous group interviews and a survey instrument. The individual perspectives of the research team members further strengthened our study by assuring that different theoretical constructs came together throughout the study. Our five-member research team included science education researchers and teachers/former teachers. Four of the team members were Caucasian female university personnel with social science research experience, teaching experience, and strong science backgrounds. The first author had completed prior studies on gender and science, as well as urban education. To assure the team included the theoretical construct associated with being an African American female, a teacher was recruited from the school. The teacher was selected due to the fact that she was an African American female in the community and desire to become more involved in our efforts. Also, as a result of the participatory nature of the inquiry, another critical criteria used in the selection process was our favorable assessment of this teacher's ability to see herself as a member of the research team.

Construct validity. To assure that we were measuring what sought to measure (attitudes toward science), we used a validated survey. The mATSI maintained the validity of the original questionnaire, ATSI (Weinburgh & Steele, 2000). To ensure this, we conducted a factor analysis to select an appropriate subset of items to form the shortened versions and administered this shortened version to a pilot group of African American fifth graders in an urban district. It retained alpha coefficients on all scales above the .50 level. Weinburgh and Steele (2000) identified groups of items that were empirically distinct and had a maximum internal consistency with a Cronbach's alpha of .7. As we administered the adjusted survey, the statistical analysis was previewed and reviewed by a professional statistician. In addition, initially analyzing the quantitative data provided by the survey and adjusting the qualitative interview protocols in light of the emerging findings further enhanced construct validity.

Face validity. Face validity seeks to assure that the findings are representing the experience of the participants. It is often operationalized by recycling the emerging findings and conclusions back through the research team and at least a subsample of respondents. Peer debriefing, during which the project researchers critiqued the method and checked the interpretations emerging from the data, was employed. As noted earlier, this debriefing was critical in that it assured responses from an African American female and teacher. In addition, input from African American girls from low SES populations was invited. This was accomplished by providing an open forum within the group interviews in which the girls could provide the information they felt was necessary for us to know in completing member-checks with the girls.

Catalytic validity. Finally, our research had a reality-altering impact (catalytic validity). As is explained over the course of this article, our research provided our research group with a greater understanding of the various needs included within this population. This understanding prohibited us from treating these girls as a heterogeneous group, and provided us with profiles that would be used to guide the science education efforts aimed at enhancing the levels of engagement of a greater number of girls. A more accurate understanding of the needs of these girls ultimately will lead to a better science education for all. In addition, this study, along with the subsequent work that explored the use of the profiles to improve science education for urban, low SES, African American girls, provides a possible approach that serves to both fracture the categorical boundary of girls and find patterns within the heterogeneity of a population that can be used to meet the needs of a larger student population.

Table 2
Descriptive Statistics From the Modified Attitudes Toward Science Inventory

	N	Minimum	Maximum	Mean	Standard Deviation
Value	89	1.80	6.00	4.5579	0.95747
Anxiety	89	1.00	5.25	2.6049	1.08203
Confidence	89	1.40	6.00	4.0848	1.06971
Desire	89	2.14 6.00	4.4454	0.94810	
Valid *N* (listwise)	89				

Findings

The quantitative data from the mATSI survey revealed significant variances within the surveys that the descriptive statistics did not explain and showed that those differences could be categorized to create profiles. We used descriptive statistics to further analyze the data into four attitude-toward-science profiles, which are listed below:

Quantitative Results

1. *Quantitative Research Question 1:* Are there significant differences within the surveys that descriptive statistics do not explain?

The descriptive statistics show the girls surveyed were moderately high (4.5579) in value, confidence (4.0848), and desire to do science (4.4454). The average for anxiety was moderately low (2.6049) on the Likert-type scale ranging *low* to *high* from 1 to 6 (see Table 2). The overall mean statistics suggest that the girls have generally positive attitudes toward science; however, they do not highlight the specific differences among the girls surveyed nor the combinations of constructs each individual possess. By further analyzing the data into profiles, we accounted for this variance.

2. *Quantitative Research Question 2:* Are there differences that can be categorized to create attitude-toward-science profiles?

Using the two categorizations of desire/value and confidence/nonanxiety, four profiles emerged: high desire/value and low confidence/antianxiety, high desire/value and high confidence/antianxiety, low desire/value and high confidence/antianxiety, and low desire/value and low confidence/antianxiety. To define each category, we computed a mean score for each student of desire and value items (desire/value) and confidence and antianxiety items (confidence/antianxiety). Because 3.5 is the center point of the 1 to 6 Likert-type scale, we chose to use this measure instead of the median of the group. Therefore, this is a generalizable measure that can be used regardless of population studied. We then assigned individuals to groups by setting limits for group membership where a high category mean was ≥ 3.5 and a low category mean was < 3.5 (3.5 being

Table 3
Profile Statistics

Profile	Individuals ($N = 89$)	Percentage
High desire/value High confidence/anti-anxiety	62	69.7
High desire/value Low confidence/anti-anxiety	15	16.8
Low desire/value High confidence/anti-anxiety	9	10.1
Low desire/value Low confidence/anti-anxiety	3	3.4

the midpoint of the scale). The majority of girls (69.7%) fit the profile of high desire/value and high confidence/antianxiety in science. The second largest group (16.8%) was high in desire/value and low in confidence/antianxiety (see Table 3). Approximately 10% of the girls fit the profile of low desire/value and high confidence/antianxiety, and 3.4% were profiled as low desire/value and low confidence/antianxiety. Whereasthe descriptive statistics showed the general picture of the spread of attitudinal data, grouping of data by profiles illuminated differences in individual girls' attitudes toward science. However, the differences within these profiles are not known. To address this, our qualitative data further delves into the similarities and differences in these girls' attitude toward science gain understanding of which aspects of their personalities attribute to the profiles.

Qualitative Results

From this data, four main themes emerged that demonstrated the differences and commonalities in this group: definitions of science, importance of science, experiences with science, and success in school science. The girls' responses helped to illustrate how personal interests, career aspirations, science content knowledge, engagement and frustrations with science, and previous experience with science shaped their ideas. We attempted to highlight within these categories that there are both similarities and variances among the girls.

Definitions of Science

The first theme that emerged from the data was that there were common ways the girls described science. Within this theme, two major categories emerged. The majority of the girls had very content-driven, specific ideas of science, while other girls described science as more of a discovery process. The girls' definitions of science not only gave insight into their ideas of science, but also how they position themselves with learning science. Therefore, the two categories within this theme of definitions of science are science as specific content and science as a process.

Science as specific content. When the majority (16 out of 30) of the girls described science, many of them used very specific content words to demonstrate their knowledge. However, what is interesting to note is that the content descriptions were extremely varied and covered a wide assortment of science topics.

Several girls listed topics that they thought illustrated science. For example, Ericka responded that science is "our planet Earth," whereas Teona had many ideas about science, each tied to specific content area, and she literally just listed them off when she stated, "Temperature, body parts, lunar energy, and thermal energy." However, some girls included more of a description to these content connections such as Dedra who remarked science is "Cells, the environment, and animals" and then went on to say that science is about, "keeping our body healthy." Xena defined science as both microscopic and macroscopic content topics when she stated, "Science is both particles and plants." As well, Ebony veered from the life sciences toward physical sciences while still drawing the connection of science to content when she described science as "gases and states of matter." As shown by these descriptions, the girls had very specific ideas of how science tied to content and their descriptions included many areas of science including molecular biology, astronomy, health, and environmental biology.

Science as a process. In contrast to science as content, another category to emerge from the data was the description of science as a process. These girls shaped their ideas of this process through personal experience.

Deisha focused on science as a discovery process when she stated, "Science is about learning about . . . science is something that you can discover-that you can learn about in what you make-like you can invent something." From this statement, we can see that she described the connection between science and the quest for discovery to invent something new. Similarly, Ericka also demonstrated that she thought of science as a process of learning about the world around her when she stated, "Science is an adventure of fun about learning things about our planet and Earth." Corine also described science as a process of searching for answers, but highlighted the point that the knowledge gained can offer clues of the past, "Can science help you become a detective. Cause it could help you tell how long it's been there, when it been used, and why." As demonstrated through their descriptions, these girls expressed the connection between science and a quest for knowledge.

Importance of Science

The second theme that emerged from the qualitative data was importance of science. Similar to the descriptions of science, how the girls' viewed the importance of science was varied. Some of the girls placed science as important for their personal needs, whereas others saw it as a way to advance in school. Finally, some girls thought of science as having little importance.

Important for personal need. Some girls stressed science was important in providing them with knowledge they need personally. For example, Corine claimed knowledge of science is important for making everyday decisions. Within this category of science as important for everyday life in the world were how to stay healthy (7 out of 30) and how to be equipped to deal with dangerous situation (5 out of 30). Zahara said, "You have to know what's going on with the body and like how some things you eat can affect you and stuff." Teona also agreed that science is important in knowing about the body and health. She claimed, "Like if somebody tries to give you something you don't know then you can look to tell where they got it so you won't know the wrong thing." Ericka followed "We learn that junk food does not help our body we can learn to eat healthier food." Ericka also discussed how science is important to know for understanding the dangers in nature. She explained, "You need to know about tornados and hurricanes to be safe from them." Teona said, "I learned that you don't mess with the Earth because sometimes the Earth can be dangerous." She discussed how science can help to "Tell which animals are poisonous and how to deal with them." Breeon discussed how "You need to know science if you want to plant like you're out on a nature hike- and can you catch something from it and then you touch it and your skin start breaking out." Through these rich descriptions, the girls illustrate how science is important to them personally in staying safe and healthy.

Science as important for advancement for school. Another category that emerged for some of the girls was that science was important for their advancement in school (5 girls out of 30) and future careers. Aiesha said science is important for her future because "It gives you higher scores." Corine also explained, "Science you need for your GQA (the state graduate qualifying exam)." Deisha explained the importance of knowing science to progress in school. She said, "If you don't get interested in elementary, then going from elementary to high school to college, you can't be in science cause you don't know it, really nothing about science cause you weren't interested in it when you had a chance to get interested in it." Breeon also explained, "You just need to know it before you go to college." Through these descriptions, these girls expressed the need to know science to advance in thinking throughout the grade-levels.

Some girls stressed that science was important for careers in general while others gave examples of science-related careers such as medicine and forensics (7 out of 30). Ericka discussed how science is important if you want to become "an investigator of bodies" or a surgeon. Corine mentioned that science is important for detective work to "Help tell you how long it's been there and when it's been used" and "To uncover fingerprints." Six of the girls also discussed the importance of science for their own future careers. Tisha said, "And when we get older, I want to be a science teacher so I can teach the students how to do work on their bodies and I want to do an experiment with liquid and oil." Yanika also expressed the desire to become a science teacher. She said, "I'll learn how to do experiments and show the class how to do science projects and I'll also learn how to do the technology stuff when I grow up." Necie explained that she will need science as a veterinarian: "I'm going to need to learn science to treat pets and give shots." Here, the girls also thought science was important but thought of it in terms of their future aspirations.

Science is of little importance. These girls did not see science as important in their lives and viewed other subjects as more essential to their learning. Denelle explained that math is more important than science because "You have to do math in like everything." Ebony said language arts and reading were most important because, "When you grow up and you go to college, ready to go and you don't know how to read, and you need language arts and reading." For Ebony, science and math ranked after language arts and reading. Chanise said math and reading are more important than science because "If you have a job you need to know how to read and how to count." Through these descriptions, the girls are positioning themselves outside the realm of science as significant to their personal life.

Experiences With Science

Third, we noticed the experiences the girls had with science were either those in a school setting and/or those, which were natural and prompted by the students themselves in the setting of their home environments. Therefore, the two categories within this theme are science outside of school walls and science as an in-school experience.

Science outside of school walls. As well as referencing in-school labs and activities when asked about their science experiences, girls from this (18 out of 30) group referred to the many experiences they had outside the school walls. Some emphasized familial support and at-home resources for engaging with science. As Teona explained,

> I do science at home with my mom cause she teaches me experiments with water and cornflower and my sister let's me use her science book cause it seems like she never has homework, so she lets me use her science book to look at experiments and other stuff. The experiments that my mom and I do with the cornflower and water, when you put it into the bowl it's hard, and then when you pick it up, it just melts in your hand.

In Teona's case, learning about science was a family-endorsed event in which she engaged in hands-on applications.

Other students conducted experiments at home and inquired about natural phenomena on their own, seemingly out of genuine curiosity. Desiree referenced exploring with household materials, "At home, I got a cup of vinegar and then put a dirty penny in there." Deisha also highlighted how science was related to her everyday life,

> I discovered at home when I had picked up a plant because it's starting to get cold outside—we have to still take care of the plants—so I took it in the house and when I picked it up, little white worms came out and the grass was white.

Ebony attempted to experiment with things she had heard about on television, "Outside one day, I tried outside it was real hot day, I fried an egg outside." These girls identified individual experiences in terms of how they interacted with science in their personal lives, which suggested that the girls saw science as an everyday activity relevant to their world outside of school. They viewed experimenting as a scientific enterprise and one in which they were personally motivated to engage.

Science as an in-school experience. In contrast, a smaller number of girls (10 out of 30) experienced science in the school setting only. For example, when asked to describe their experiences with science outside of school, Queisha said, "No, my teacher just helps us." Several girls were not able to think of any experiences with science in their home environments to share. However, these girls were able to draw on experiences they had had in school with science. Some referenced learning about science in books and from the teacher. They seemed to perceive science as unrelated to their personal lives, but rather as a school-imposed discipline disconnected from their real-world experience. Deisha claimed "Science is like something when you read something out of the science book that people have discovered." The girls perceived the teacher and textbooks as the source of knowledge. As Yanika highlighted, "I just ask the teacher how to do it and the teacher explains it to us and after that, we do a project and learn about experiments."

Experience in the classroom with hands-on activities seemed to bring out the frustrations students had with their exposure to science as a step-by-step process with one correct answer. Teja commented on her anxiety about the tendency to "Mess up things, like blow it up or something or just mix the wrong stuff together." Similarly, Dondrea said she wanted,

> Every time we did we kept on getting- we was getting everything mixed up. And my group kept trying to say no, no that's wrong, but it's right—I said its right, but the secretary was writing everything that's wrong.

In these school-centered experiences, students tended to view science as divorced from self with an external source of power and authority. Their motivation became less about inquiry and more about concern over getting the right answer. Highlighting the differences in these types of experiences illuminated how the girls were or were not motivated to engage with science in their personal lives, as well as shed some light on what types of experiences students regarded as engaging with science.

Success in School Science

The last theme that emerged from the data was the girls' success in school science. The girls varied in their perceptions of success in science, which depended on their previous experiences with science and if they felt they could seek help from the teacher. Therefore, the categories that emerged from the data were, very successful and can succeed with help and too frustrated to succeed.

Very successful and can succeed with help. Some students described themselves as very successful in their abilities with science. They used descriptors such as, "I am good at science." Tisha was so sure of her ability in science that she felt comfortable performing science tasks from books at home. She explained this when stating, "One time I was trying to get an ice cube and I put some salt on it and string, cause I saw it in a science book, and the string got stuck on it." Here her success with school science was demonstrated by her willingness to take science outside the classroom and spend her free time in an environment in which she is comfortable doing science.

Several students demonstrated that they were successful, but a key to this success was that they could succeed with outside help. Yanika clearly explained how her confidence was tied to her ability to ask her teacher for help when she stated, "When we do the experiments by ourselves, when she just explain it out to us, we get it, we just understand it and we do it on our own.'' Ebony expressed this same idea in more detail when she stated,

> Then when you get stuck with something you can ask the teacher. And then, if she says something like if you can't hear it, and then you ask the teacher and she say yes, then I would say you can do it again.

Fawn also linked her confidence to being able to ask for help when she said, ''Asking the teacher, if you say I don't understand, you got to raise your hand and say I don't understand what you're saying and she explain it.'' The students clearly described some frustration with school science, but that they can get beyond those frustrations with the teacher as a guide.

Too frustrated to succeed. Finally, several students described themselves as very frustrated with science, but the reasons for this were diverse. Most girls described frustration with understanding and doing experiments. For example, Abrianna stated, ''Like when we go to the science lab, some of the questions I don't understand . . . like they don't make sense to me.'' Some of the girls linked their frustrations with science to their anxiety to perform scientific tasks. For example, when Tashelle stated, ''I don't like science as much [as other subjects] cause when you do science, it's kind of like math where you have to mix all the chemicals together, and it's messy and it's really irritating.'' Here, the girls are describing the difficulties they have in science and are not able to get beyond the frustration. They therefore position themselves as distant in their relationship with science.

Although the girls in our sample were of the same gender, same race, and similar SES, we saw ranges of differences on their definitions of science, importance of science, their experiences with it, and their confidence of their ability to succeed in science. We believe that understanding and illuminating these important differences and commonalities is a crucial step in understanding these girls and how to help ensure a more inclusive science education.

Mixed Methods Findings and Implications

By linking the quantitative and qualitative data, we were able to further explain the similarities and differences within the profiles that the quantitative data provided. The descriptive statistics revealed four attitude-toward-science orientations: high desire/value and low confidence/antianxiety, high desire/value and high confidence/antianxiety, low desire/value and high confidence/antianxiety, and low desire/value and low confidence/antianxiety. At the same time, the qualitative data provided a rich description of the girls' voices about science including actual descriptions of science, importance, experiences, and success in school science. By combining these data sets, it provided us with an insightful look into this seemingly homogenous group to demonstrate the vast differences and similarities in these urban African American girls' profiles and understand how these girls orient themselves as learners of science. From the themes of the qualitative data, these attitude-toward-science orientations are described in terms of

Figure 2
Quantitative Categories to Qualitative Themes

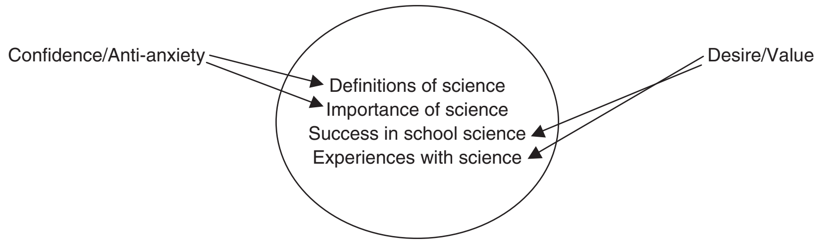
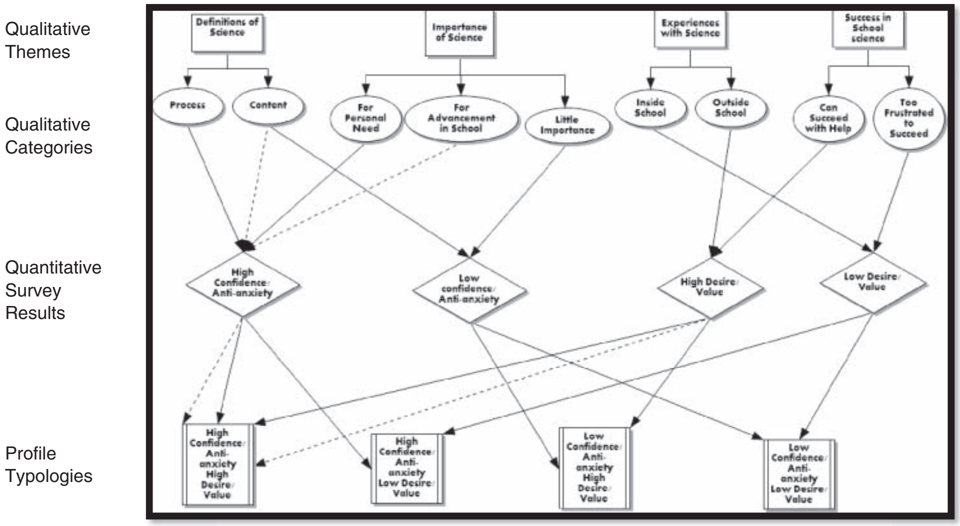


Figure 3
Demonstration of Mixed Methods Findings—Linking Quantitative and Qualitative Data



definitions of science, importance of science, experiences with science, and success in science.

Figure 3 illustrates the emergence of the personal orientations toward science as a result of the linking of the quantitative survey results with the qualitative interview data. The figure is divided into four sections: (a) Qualitative Themes, (b) Qualitative Categories, (c) Quantitative Survey Results, and (d) Profile Typologies. The first level of Figure 3 shows the qualitative themes (definitions of science, importance of science, experiences with science, and success in school science). The second level of Figure 3 demonstrates the corresponding qualitative categories (process, content, for personal need, for advancement in school, little importance, inside school, outside school, can succeed with help, and, too frustrated to succeed). The third level of Figure 3 describes how the categories from the qualitative findings matched up to the quantitative survey results. The dark lines represent the primary explanations from the girls with the dotted lines representing the secondary explanations. The fourth level of Figure 3 provides an explanation for how these survey findings created the profile typologies. In this sense, Figure 3 can be followed from the first level to the fourth level to see how the qualitative findings explain the quantitative typologies.

Our mixed method analysis provided four orientations, which linked success in school and experiences with science to confidence and importance of science and definitions of science to value/desire. These orientations are described below:

High Confidence/Antianxiety and High Desire/Value

Within this profile, our analysis linked all high confidence girls with the ability to succeed in science; however, two personality orientations emerged from the data, which fell into this group for different reasons. Highly confident girls with a high value of science were either intrinsically or extrinsically motivated. The intrinsically motivated girls saw science as a direct connection to their personal life (e.g., to stay healthy or to avoid danger), described science as a process, and experienced science outside of the classroom. For example, Teona's borrowing of her sister's science book to do experiments with her mom indicated that she felt competent enough to introduce concepts she was learning to her mom and expand on what she was learning in the classroom. In contrast, the girls who were extrinsically motivated saw science as important to advance their schooling, described science as content rather than a process, and engaged in science only within the school walls (e.g., next step to college or because it was required). As stated by Corine and others, science can help students to pass the state GQA exams, an indication of their academic success and perceived achievement in school. Xena emphasized the importance of understanding science, as she stated,

> Science is a big part of your life. It's about the world and everything in it. And it's good to know science in the future because you know more from knowing it from the past. So, it would help you even more than it used to and it could tell you like what you want to do.

As discussed previously, research has dispelled the myth that African American girls have poor academic self-concepts and instead highlights the academic perseverance African American students' display despite low achievement (Catsambis, 1995). Our findings underscored these assertions as the majority of girls fell into the profile of possessing affective factors such as motivation and positive attitudes toward science, despite some of them possessing below C averages on the current science grades. The type of girl seen here is ready to learn and be a part of the scientific community. She possesses the confidence in her ability, understands the value of learning science, and is ready to be challenged. Despite these positive attributes, she continues to be low achieving in regards to academic success. It is imperative that we now turn our attention toward reform efforts that are not so heavily laden in affective strategies, but are more focused on achievement gains. Such curriculum has been shown to include a focus on girls' interests and experiences, a prioritization on active participation in long-term and self-directed projects, assessment that is both diverse in form and emphasizes collaboration and communication, and a connection to the real world. These types of efforts can contribute to reducing the achievement gap in minority, urban, and gendered groups.

High Confidence/Antianxiety and Low Desire/Value

In this profile, our analysis continued to link high confidence to their ability to succeed in school, but the difference from the previous profile was that this type of girl saw little value in science. This girl did not experience science except for the activities they performed in school. When defining science, she used content words to describe it and ranked it as of little importance compared with other school subjects. She did not see science as important for her personal life and had low desire to engage with it. Ebony, when asked to rank the importance of science compared with other subjects, said language arts and reading were most important because, "When you grow up and you go to college and you don't know how to read, and you need language arts and reading." Despite seeing science as lower in importance as a discipline, Ebony expressed confidence in her ability to do well in the subject: "Then when you get stuck with something you can ask the teacher . . . and then I would say you can do it again." Asking questions and receiving teacher guidance helped her to succeed in science, though her perceptions of the value of science to her future were less than other disciplines.

This girl needs to see the relevance of science in her personal life. The notion of instructional congruence (Lee, 2006), which aims to link together the cultural norms of the classroom with the students' cultural experiences, is important if we are to help her see this relevance. The materials to which she is exposed should incorporate culturally relevant experiences that can help to foster a positive attitude and personal connection with science (Lee & Luykx, 2007). She would also benefit from instruction that honors and incorporates her "funds of knowledge" (Basu & Calabrese Barton, 2007; Greenberg, 1989; Moll & Greenberg, 1992), thus increasing the likelihood that she will interactively engage in the process of learning.

Low Confidence/Antianxiety and High Desire/Value

In contrast to the previous profile, this girl is frustrated with doing science and not being able to get the right answers and forced to follow a procedure that they do not understand. As previously mentioned, Necie clearly describes her frustrations with doing experiments to read the instructions multiple times and not understanding. As well, Tasha described these frustrations of getting the right answer and becoming "irritated" when not able to do so. Additionally, her experiences in science have been limited to inside the classroom, and she often lacks the confidence to take science home with her. When Quiensha talks of science she described only being able to do science with her teacher, in school. However, these girls do value science and often place it as important as other subjects, calling it essential for her personal life. When Breonna describes the importance of science, she mentioned the practical application for her life. She talked about being outside and being able to identify plants that would be useful or dangerous. The way she describes science is also different from the other personal orientations in that she describes science as a process but is not comfortable performing this process. She describes how science is used to invent things but needs help from the teacher during this process.

Students who have high self-efficacy in science tend to set higher goals, persist longer, expend greater effort, and endeavor to find increasingly better strategies (Koballa & Glynn, 2007). This girl needs short-term benchmarks and regular reward for her performance to help foster higher confidence and less anxiety in the classroom. She should understand the nature of science as being creative and tentative instead of a scripted path to one correct answer (Lederman, 2007). Though much research has described African American girls' tendency toward high academic self-concepts and perseverance despite struggle (Kleinfeld 1999; Marcon, 1999; Signer, Beasley, & Bauer, 1997; Weinburgh & Steele, 2000), this girl displays a lack of confidence, which needs to be addressed in the classroom if she is to effectively, learn science.

Low Confidence/Antianxiety and Low Desire/Value

This girl is frustrated with science. Her experiences in science are inside the classroom and she often lacks the confidence to take science outside the classroom walls. In contrast to the group above with high desire, this girl does not see science as a process but rather as content to be memorized. She ranks science as lower in importance compared with other subjects. For example, when Denelle explained why science was not important to her, she stated, because "You have to do math in like everything." Many of the girls compared science with the other subjects that are more emphasized in school and agreed that reading and math are of more importance to their life beyond school. When Chanise talks of her future, she describes only reading and math.

She needs to experience science as a process of inquiry. As teachers facilitate scientific inquiry in the classroom, they can indentify intersections in her funds of knowledge and scientific practice, and thus use this as a basis for directing instruction and assessment. It is imperative that teachers recognize and encourage the wealth of knowledge she brings into the classroom that can serve as a springboard for science learning. Rather than teaching science as a body of facts disconnected from the students' world, researchers explored "connected science," in which real-life issues and implications were explored in the classroom (Bouillion & Gomez, 2001). Community partnerships were also used to help bridge community-based knowledge to school-based knowledge. Project-based science, which involves finding solutions to authentic questions through extended inquiry, collaboration, and use of technology, allows students to engage with questions that interest them and relate to their lives outside of the school walls. Connecting science to this girl's life, providing space for her voice of experience, and allowing for meaningful opportunities for success in science will allow her to increase her confidence level and value for science. Learning science that is fun and personally relevant can foster her increase in a positive attitude and heightened motivation toward learning science. Positive impacts in standardized achievement tests have also been noted from the use of inquiry-based and technology-rich environments (Lee & Luykx, 2007).

Conclusion

Through interpretation of the entire analysis, we used qualitative findings to provide rich descriptions of the girls' quantitative profiles. These descriptions added to the understanding of the four attitudes toward science orientations that materialized from the quantitative data. The qualitative descriptions highlight the differences and similarities of the girls within a quantitative profile. In our sample, the majority of the girls were high in their confidence and their desire and value to learn science. This further supports the research that has dispelled the myth that African American girls have poor academic self-confidence and are easily discouraged (Signer et al., 1997). Despite these positive affirmations, their achievement in science remains low. Our charge is now to focus on achievement, while being cautious about maintaining and encouraging the positive affective factors that these girls already possess. In our efforts to decrease the achievement gap, we should place more emphasis on conceptual understanding and problem-solving skills, while still being cognizant of the danger of losing the connection between science and society, which so often plagues achievement-focused efforts.

As we have learned from the Brickhouse et al. (2000) case studies, girls are not as engaged in science as they could be. They asserted that though individual student identities were different, they engaged positively with inquiry-based instruction. Furthermore, Weinburgh and Steele (2000) noted, in their initiative to use kit-based reforms to enhance achievement, a decrease in desire to learn science, and suggested that may be due to their instruction being centered on science kits; the connection to society was lost. Though teachers are instructing multiple students with multiple learning styles and interests, we believe there are approaches that may meet multiple needs. Taking these studies and our findings into consideration, we believe our efforts may be enhanced by using legitimate participation, specifically connected-science/project-based instruction in the science classroom (Calabrese Barton, 2007).

Connected problem-based learning (PBL) is a student-centered instructional strategy in which students collaboratively explore real-world issues and reflect on their experiences. In this type of instruction, learning is driven by challenging, open-ended problems, students work in small collaborative groups, and teachers take on the role as "facilitators" of learning. This way, the girls will continue to be positively connected toward science, as well as succeed in learning science. Our continued efforts with this group of girls will center on these instructional techniques with the goal of addressing the needs of science learners.

The increasing diversity of the girls with whom we work and our growing understanding of students' science identities is making our goal of meeting the needs of all girls even more complex. Our theoretical discussions have, for the most part, embraced the complexity. Over the past few decades, gender research has evolved through a series of challenges from feminists; including challenges to feminist theory itself. Our methodological approaches must also evolve through challenging our underlying assumptions. In this mixed methods explanatory sequential design, we (a) elucidated how linking the quantitative results with the quantitative results led to a formation of a typology (Creswell & Plano Clark, 2007), (b) we showed how a quantitative typology was integrated with qualitative themes and visuals (see Figures 2 and 3) to forge this integration, and (c) we illustrated the use of a feminist lens in a study in which specific myths have been dispelled and recommendations for change made.

By bridging the mATSI survey data with the rich interviews of the girls' perceptions of science, we were able to articulate typologies in the form of profiles, which can help educators visualize the specific heterogeneity in their seemingly homogenous group of students. By doing this, we were able to dispel many of the assumptions and stereotypes held about African American girls in science and offer a glimpse into the diversity of students in this urban, low SES community. Finally, these typologies enabled us to offer specific recommendations to educators to help navigate the complexity of individuals with whom they work in the science classroom. As feminist researchers, we place a high value on the voices of the individual; yet we also seek to assure that the needs of all children are being met. Our work contributes to the literature on feminist study by further illustrating that not only is mixed methods a possibility for feminist researchers, but at times, a necessary methodological approach if we are to understand and respond to the complexity of teaching science.

Limitations

Qualitative research has its limitations for advancing grand generalizations (Stake, 1995). Furthermore, quantitative research is limited in providing deep understandings of particular settings or participants. Mixed methods, although used to reduce the limitations of one single approach (Creswell, 2003), also includes the limitations of each of those approaches to a lesser degree. Thus, as we sought to scale up the single in-depth ethnographic case studies created by previous researchers by using methods that allowed for some generalizations to be used to guide daily practice, we acknowledge that we lost some of the in-depth insights into the individual science orientation profiles represented in the population of 89 girls. Likewise, as we sought to gain more insight into the survey data collected by a validated instrument, we acknowledge that we lost some of the strength of the ability to generalize to all African American students as had been previously addressed by this instrument (Weinburgh & Steele, 2000).

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