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Examining the cognitive processes used by adolescent girls and women scientists in identifying science role models: A feminist approach

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Abstract

Women remain underrepresented in science professions. Studies have shown that students are more likely to select careers when they can identify a role model in that career path. Further research has shown that the success of this strategy is enhanced by the use of gender-matched role models.

While prior work provides insights into the value of using role models, it does not explain the cognitive process involved in girls identifying role models from nontraditional careers for women. This feminist study addresses this gap by examining the cognitive process eighth-grade girls use in identifying a person as a science role model and comparing it to the process used by women scientists seeking to serve as possible science role models. Data revealed that the girls' process in identifying a role model involved personal connections and their initial image of a scientist led them to believe they could not have such a connection with a scientist. The initial views expressed by the women suggested they felt pressure to portray "perfect" scientists in order to be a role model. A common understanding of a science role model was realized only after changes occurred in the girls' image of scientists and the scientists' image of a role model. The catalysts for these changes were the relationships that developed between girls and women scientists.

Introduction

Despite increases in the proportions of women in science and engineering occupations over the past 20 years, these populations remain underrepresented (Eisenhart, Finkel, & Marion, 1996; National Science Foundation, 2003, 2006). Women currently account for more than 48% of the U.S. college-educated workforce, but they account for only 25% of the science and engineering workforce (National Science Foundation, 2006). This underrepresentation prevents women's unique points of view and understandings of reality (Belenky, Clinchy, Goldberger, & Tarul, 1997; Gilligan, 1979; Harding, 1991) from being realized in the science and engineering fields (Harding, 1991). Girls' avoidance of the scientific professions when considering their career plans continues despite increases in their participation and achievement in science courses (Gilbert & Calvert, 2003; National Science Foundation, 2003). Researchers have sought to understand why girls are "walking away from careers in science and engineering" (Colwell, 2003, p. 14) (e.g., Baker & Leary, 1995; Furlong & Biggert, 1999; Gilbert & Calvert, 2003; Head, 1997; Jovanovic & King, 1998; Kahle, 1982; Seymour, 1995; Seymour & Hewitt, 1995), and several obstacles have been identified as contributing to the underrepresentation through these investigations. One such obstacle is the sex-stereotypical image of the scientific careers (Baker & Leary, 1995; Head, 1997; Furling & Biggert, 1999; Packard & Wong, 1999). A practice often suggested to address this obstacle is to provide girls with science role models. Indeed, current research does show that students are more likely to enter a profession when they are able to identify a role model in that occupation (Betz, 1994; Hackett & Betz, 1981; Lent, Brown & Hackett, 1994; Zirkel, 2002); however, this research does not further our understanding of the cognitive process students use in identifying a person as a role model (Hackett, Esposito, & O'Halloran, 1989; Nauta & Kokaly, 2001; Pleiss & Feldhusen, 1995). The purpose of this study was to address this gap by enhancing our understanding of the cognitive process used by girls in identifying a person as a science role model.

Background

Sex-stereotypical images of careers are a limiting factor in the career aspirations of women (Greene, Sullivan, & Beyard-Tyler, 1982; Gottfredson, 1981; Hackett et al., 1989; Osipow, 1983; Savenye, 1990). The sex-stereotypical image of science was first identified by Mead and Mattraux (1957). The high school students in their study demonstrated a belief that a scientist is "an elderly or middle-aged man who wears a white coat, works in a laboratory, performing dangerous experiments" (pp. 386–387). These images have persisted over time and have been shown to exist at many levels (Andre, Whigham, Hendrickson,

& Chambers, 1999; Baker & Leary, 1995; Brickhouse, Lowery, & Schultz, 2000; Buck, Leslie-Pelecky, & Kirby, 2002; Chambers, 1983; Cleaves, 2005; Furlong & Biggart, 1999; Kahle, 1983, 1987; Kahle & Meece, 1994; Mason & Kahle, 1989; Mason, Kahle, & Gardner, 1991; Rosenthal, 1993; Stables, 1996). In 1987, Kahle reported the stereotypical image continued to be held by secondary students. Nine years later, Stables (1996) found that those stereotypical views persisted. Chambers (1983) found that this image was formed as early as the second grade. Elementary students also identified scientists as being White male wearing laboratory coats, eyeglasses, and having facial hair. Sixteen years later, Andre et al. (1999) identified many of the same stereotypical characteristics in fourth graders. In 2002, two of the researchers in this current study found that not only did fourth and fifth graders continue to demonstrate a belief that scientists fit this stereotypical image, but that belief persisted despite efforts to broaden the image (Buck et al., 2002). This stereotypical image of scientists has been found to impact career choice negatively when girls' desired images for themselves clash with their sex-stereotypical image of scientists (Packard & Wong, 1999). From their interviews with women, Packard and Wong identified three types of clashes: "(1) type of person; (2) lifestyle choices; and (3) purpose of science work" (p. 12). They conclude that the positive and negative images of science compete as individual women contemplate their future, thereby precipitating the clash of future selves. One often-proposed strategy to broaden students' images of scientists and increase the chances that they will find their desired future self in science is the use of science role models.

The social cognitive theory of sex differences served as the theoretical underpinning to a substantial amount of research we reviewed on using role models as a means to increase the likelihood students will enter a profession (e.g., Betz, 1994; Greene et al., 1982; Haas & Sullivan, 1991; King & Multon, 1996; Karunanayake & Nauta, 2004; Place, 1997; Savenye, 1990). Thus, the insights provided by this theory and subsequent research, as well as the gaps in understanding within them, served as the starting point for our investigation. Social cognitive theory states that behavior, cognition, and other personal factors, along with environmental influences operate as interacting determinants that impact a person's development. In this theory, people are neither driven by inner forces nor shaped and controlled by the environment as assumed by models of human behavior that emphasize one-sided determinism (Bandura, 1989). Instead, a person observes the behaviors of others, codes what they observe, and subsequently performs select behaviors. When the person observes others with similar characteristics perform skills successfully, or act in a manner that produces what they view as desirable results, their expectations about their own ability to perform the task and desire to act in a certain manner are reinforced. Those who are present and observable in children's lives thus "serve as indispensable sources of knowledge that contribute to what and how children think about different matters" (Bandura, 1986, p. 13). In 1981, Hackett and Betz expanded social cognitive theory by relating it to career development. They suggested that people make career decisions and adopt career behaviors by this same social learning process. This research has shown that early experiences with role models that successfully perform skills of a specific occupation can impact a student's future career development (Betz, 1994; Lent et al., 1994). While this and subsequent research has supported this relation to career development, it has also demonstrated that this social learning process has progressive and regressive tendencies in regard to career-related interests. The process supports career-related interests; however, it also deters students from nontraditional careers when those that are present and observable in that career are all of the opposite sex. In light of this, others have further expanded this role-model theory by demonstrating that matching the social class reference group of a role model is effective because children relate to these reference groups when perceiving the occupational world and eval-

uating their career choices (e.g., Betz, 1994; Gottfredson, 1981; Greene et al., 1982; Hackett et al., 1989; Haas & Sullivan, 1991; Lent et al., 1994; Savenye, 1990; Zirkel, 2002).

While social cognitive theory and subsequent research provide some insights into role models, they do not provide an adequate understanding of the cognitive process children use in identifying a person as a role model (Hackett et al., 1989; Nauta & Kokaly, 2001; Pleiss & Feldhusen, 1995). For example, this theory assumes the same cognitive process for both males and females. The gender differences found in role association are prescribed by cultural sex typing (Bandura, 1989). The theory does not lend itself to inquiries about gender differences within the cognitive process. Another example involves the studies reported by Savenye (1990), Greene et al. (1982), and Hass and Sullivan (1991). In these studies, the authors provide quantitative data to support the use of gender or ethnically matched role models through print materials to change a diverse group of students' stereotypical attitudes toward a profession; however, these studies do not provide an understanding into which of the many presented persons they presented as role models were actually perceived as such by the females or the factors associated with such a selection.

Purpose

The primary purpose of this qualitative study was to explore the cognitive process eighth- grade girls use in identifying a person as a science role model. The secondary purpose was to compare the girls' process to the one used by women scientists seeking to serve as possible science role models. The program participants were involved in an outreach program. This program was not designed for this study; however, the representation of women scientists working in a local school district and professional-development efforts to address stereotypical images of scientists revealed it to be a rich context for this study.

Theoretical Perspective

Our inquiry centered on the cognitive processes of adolescent girls and women that would be revealed by allowing them to speak for themselves. At the heart of this inquiry was the social construction of gender. As such, it was a feminist inquiry (Lather, 1987). Cognizant of the history of feminist research (see Calabrese Barton, 1998; Harding, 1991; Lather, 1987) and the dangers of totalizing the female experience within masculine understandings of science education and science professions (see Calabrese Barton, 1998; Harding, 1991), we sought to situate our work in a feminist perspective that would align with contemporary efforts to expand the female voice and the views of the world represented in the science professions. Thus, as explained below, our work was guided by inclusive and critical perspectives within feminist research.

Research on gender differences can be approached from vastly different theoretical understandings. In 1994, Brickhouse grouped these understandings into two broad categories: deficit in girls and children from diverse populations and inequitable treatment in schools. The deficit perspective assumes that underrepresented populations lack the necessary skills and/or knowledge. The inequitable treatment perspective assumes that the schools are not meeting the needs of the underrepresented populations. In 1996, Willis developed a categorization of theoretical perspectives guiding the work on gender which expanded that categorization system. The expansion further defined perspectives in regard to how schools are not meeting the needs of underrepresented populations: an expansion that we found critical in framing a study that reflected our goals. Therefore, it is Willis's system that was used to guide this study. That categorization system included four broad categories: deficit (the problem is the necessary skills, knowledge or motiva-

tion that the disadvantaged children lack), biased pedagogy (the problem is certain pedagogical approaches that advantage or disadvantage certain populations), inclusive (the problem is the sole reliance on curriculum that reflects the interest and experience of one population of students), and critical (the problem is curriculums that work to maintain the interests of the dominant culture within society).

The first category is *deficit*. If we were to approach an inquiry on role models for adolescent girls from this perspective, we would assume that the girls are not able to pursue scientific careers because of the skills, knowledge, or motivation that they lack and seek to understand how to provide role models that would be able to get the girls to successfully do what a scientist does and know what a scientists knows; thereby, showing them they can be a scientist. The second category is *biased pedagogy*. If we were to approach our inquiry from this perspective, we would assume that the pedagogical procedures of the schools are preventing girls from pursuing careers in the sciences (e.g., implicitly or explicitly conveying a belief that the boys are better able to handle the science equipment during laboratory experiences) and seek to understand how to provide role models in a manner that successfully prepares the girls to reach the same point as the boys (e.g., demonstrating that women are just as able as men in handling science equipment and encouraging them to do the same in their laboratory experiences). These first two perspectives, which are grounded in the belief that girls are not able to enter the science professions, were not suitable to guide our research as we approached it with the understanding that girls are successfully participating in science courses but choosing not pursue careers in the sciences.

The third perspective is *inclusive*. If we approached our inquiry from this perspective, we would assume that the curriculum and pedagogical practices aimed at fostering girls' interest in scientific careers do not reflect the girls' experiences, interests, or needs (e.g., science curriculums that only reflect the male-dominated approaches to viewing the world (Harding, 1991) and seek to provide role models in a manner more inclusive of such (e.g., including additional curriculums that reflect the unique approaches to viewing the world that some women scientists have used). The fourth category is *critical*. If we approached our inquiry from this perspective, we would assume that the current culture of science provides the dominant culture with position and privilege and seek to achieve social justice by disrupting that position and privilege through education. Providing women role models that, in some manner, disrupt the practices of the dominating masculine structures of science would fit this perspective.

As we approached our inquiry seeking to align our efforts designed to increase the number of girls choosing scientific careers with contemporary efforts aimed at addressing the overemphasis in science and science education on one way of viewing the world (e.g., Atwater, Crockett, & Kilpatrick, 1997; Calabrese Barton, 1998; Harding, 1991; Mayberry, 1998), it was a combination of the inclusive and critical perspectives that guided our inquiry. The inclusive perspective guided our study in that we sought to foster girls' interest in scientific careers by seeking to include their experiences, interests, and needs in our curricular strategies. The critical perspective guided our study in that the aim of our work was not just to increase the presence of the female sex in the sciences, but support the efforts to broaden the way science views the world by increasing the presence of the female voice. In referring to voice, we are referring to more than just words. We are referring to the girls' point of view or understanding of reality (Belenky et al., 1986). This perspective had a direct influence on our work in that some of the women role models that were involved with these girls were from a nontraditional fellowship program that involved establishing relationships with schools and serving as role models (see the section "Context"). These women were selected based on their success within the sciences and interest

with working teachers and schools. Their very involvement within this graduate experience that values working with teachers and students as well as scientific research disrupted the dominating structure of science. In addition, this perspective had a direct influence on our methodological approach in that we sought a methodological approach that would reflect the value of the girls' voices for science and science education.

Method

Our methodological approach sought the girls' own production of meaning to develop understandings that improve overall equity—that is, we approached the methodological design from a feminist perspective (Lather, 1986, 2001; Reinharz, 1992). This methodological approach was utilized to explore the cognitive process eighth-grade girls use in identifying a person as a science role model and to compare the girls' process to those of female science role models to determine what promotes effective relationships with science role models.

Context

The National Science Foundation's Graduate Fellows in K-12 Education Program (GK-12) was designed to make future science, technology, engineering, and mathematics (STEM) leaders (graduate students pursuing advanced degrees in STEM fields who were not intending careers in K-12 education) aware of the issues challenging K-12 education. The program involved in this study was a partnership between a research intensive university and a large local school district. In this program, full-time graduate student fellows worked in the schools for approximately 10 hours each week throughout the school year. The graduate fellows worked with classroom teachers to address the specific needs of their school (e.g., grade-level science standards and process skills). Included within the eight goals of this partnership program were (1) graduate fellows will improve their knowledge of effective pedagogical techniques, ability to communicate with nonscientists, and ability to work as part of a team; (2) third-through eighth-grade students will develop a broader range of images of mathematicians and scientists; and (3) classroom teachers will increase their use of university resources (including scientists). In light of this specific subset of goals for this project, teacher/scientist teams worked together to develop, implement, evaluate, and adjust programs aimed at improving the image of science and scientists held by students in the third through eighth grade. These projects included a unit of study initiated in the second trimester of the school year. In addition to working with graduate fellows involved in the overall project, activities included bringing diverse scientists from the local community to the classroom, researching famous scientists, and viewing videos of diverse scientists at work. As a result, the students participating in the program were presented with many different scientists (e.g., community members, project fellows) for different lengths of time (e.g., one visit, weekly visits).

Participants

Girls. The primary participants were selected from those that responded to a call for girl participants involved in the outreach program described above. This call was put forward by a teacher recruited to conduct the interviews (see section Facilitating Voice). All those that responded to the call were given student and parent permission forms at an initial information meeting. To assure a more heterogeneous perspective in the focus-group interviews, a purposeful sample of girls from each of the three most prevalent racial groups represented at this school was selected. Of these participants, four were Caucasian, five were

African-American, and four were Hispanic. These primary participants attended the same urban public school in the midwest. They all had one of two eighth-grade science teachers that were involved in the outreach program described earlier. Due to their science teachers' involvement in that program, all primary participants had at least one class per week in which a women scientist visited, completed a research project on diverse scientists, and were exposed to a number of visiting scientists involving a minimum of a one-class-period visit from underrepresented populations. The specific scientists with which these girls interacted varied with their sections of the course and the various activities in which they took part within those sections. These scientists did include some of the women participants described below. However, other diverse female scientists were brought into the schools as part of the program (e.g., those on part-time fellowships and those brought in as part of the unit aimed at expanding the stereotypical view of science/scientists) and their presence is also noted in the discussion of the girls that follow.

Women Scientists. In addition to better understanding how eighth-grade girls identify science role models, the study had as a goal investigating what promotes effective relationships between girls and gender-matched role models. This required us to also seek the perception of female role models. A total of eight women graduate student scientists participated in this study. In light of the longitudinal approach of this study, participants were selected from those that held full-time fellowships with the science outreach program described earlier. Each of the women worked in one or more K-8 classrooms in one or more middle school for approximately 10 hours a week throughout the entire period of this study. They also cooperatively planned units of study focused on expanding the image of science/scientists for the project schools. The average age of the scientist participants was 30 years. Seven of the participants were Caucasian and one was Asian-American. This ethnic breakdown represented the population of female scientists involved in the program as all eight female scientists involved in the program at the time of the interviews agreed to participate. It should be noted that this group was selected due to fact that they were serving as science role models for middle-level students and actively seeking to serve as role models for adolescent girls. These women held full-time fellowships and were serving across 10 middle schools, including the middle school from which the girls participating in this study were enrolled.

Data Collection

Feminist researchers find interviewing appealing for reasons that go beyond those noted by social scientists that defend qualitative methods against positivist criticism. For one thing, interviewing offers researchers access to people's ideas, thoughts, and memories in their own words rather than in the words of the researcher. This attribute is particularly important for the study of women because this way of learning from women is an antidote to centuries of ignoring women's ideas altogether (Reinharz, 1992, p. 19).

In light of the type of information we wanted to explore, perceptions of persons and relationships, and the population being studied, girls and women, open-to-semistructured focus-group interviews were the main source of data collection for this study. Focus-group interviews were selected because they are (1) socially oriented and a more comfortable arena for talking about perceptions as well as conducive to reflection on the ideas of others (Reinharz, 1992); (2) ". . . a safe environment where they can share ideas, beliefs, and attitudes in the company of people from the same socioeconomic, ethnic, and gender backgrounds" (Madriz, 2000, p. 835); and (3) inclusive in that they limit the "powerful voice of the researcher" (Wilkinson, 1999, p. 66).

Focus Groups With the Girls. The 13 girls who agreed to participate in the study were divided into three groups of four to five participants. Three longitudinal focus-group interviews were conducted with each group of girls over a period of 6 months (for a total of nine focus-group interviews). The first two focus-group interviews with each group used a semi-structured interview technique, employing a protocol of open-ended questions to better understand the participants' views, ideas, and thoughts of science role models. The second interview protocol was developed to build on the results identified in the first interviews. In the third focus-group interviews, we used a follow-up interview technique, asking specific questions to clarify and validate our findings from the previous interviews.

Sample topics of interest used in the first interview included whether the girls had role models, what they think of science role models, and what they think of the scientists they had met. Sample questions included the following: (1) In what ways can a scientist be a role model? (2) What makes a person your role model? (3) What do you want and not want to see in a science role model? and (4) This project you are participating in brings in science role models for students, such as yourselves. What suggestions do you have for those of us trying to match you up with a science role model?

Focus Group With the Women Scientists. The data for the women scientists were also collected through focus-group discussions at four points over a 6-month period (for a total of four focus-group interviews with women scientists). All interviews took place at the university the women attended and lasted 50–60 minutes. A woman scientist conducted the interviews. The audiotapes were collected and transcribed in full by a professional data transcriptionist.

The first interview explored the women's belief about what it meant to them to be a role model. The findings from this interview prompted us to expand our focus to not only explore the meaning but also the experience, of being a role model from the perspective of these women. Sample open-ended questions included the following: (1) What does being a role model mean to you? (2) What do you perceive as the positive and negatives of being a role model? (3) Based on your observations and experiences, what do you have to offer school children? and (4) Describe a particularly notable experience you have had so far in being a role model.

Facilitating Voice. In addition to selecting focus-group interviews as the form of data collection, the researchers took additional steps to eliminate barriers to understanding the perceptions of the participants. To assure that the voice of the adolescent girls was not just that of the majority population of the school (i.e., "girls" does not just mean Caucasian girls) (see hooks, 1981), steps were taken to include the voices of the diverse groups in this discussion of girls. First, equal representation was sought from the three most prevalent racial groups represented in the school. Second, because of the potential power-influence of ethnicity in a heterogeneous group, the girls were then divided into three discussion groups according to ethnicity (Caucasian, African-American, and Hispanic). Nine longitudinal focus-group interviews (three with each group) were conducted over a 6-month period as a means to explore in depth the ideas of science role models held by our primary participants.

To assure that the voices of the participants did not simply reflect what they believed the interviewers wanted to hear, we took steps to eliminate the power-influence of the interviewers (Reinharz, 1992). Based on our knowledge of the participants and the research topic, it was decided that the interviewers would be both strangers and friends (Reinharz, 1992). The interviewers that were recruited and trained were strangers to the program activities and research study in which the girls were taking part, yet familiar to the

participants (to foster a comfortable atmosphere for discussion). Both of the interviewers were women, each of whom would be considered a "friendly stranger" by the participants. The researchers contacted the teachers from the school site that were involved in the project and asked for recommendations for a teacher not associated with the program with whom the girls in this study would feel comfortable. From the recommendations received, a female teacher was recruited, hired, and trained to conduct all nine interviews with the girls. A female graduate student that was known by the women graduate students and was already trained to complete focus-group interviews was recruited to conduct all four interviews with the women. Although it was determined that the study would be better served by having interviewers that were both strangers and friends, we remained active in the interview process. As described in the data analysis section, we completed a progressive analysis of the data, analyzing the data as it was collected and using the themes that emerged to develop subsequent interview questions then meeting with the interviewers to discuss the interview protocol.

Data Analysis

Our primary purpose was to explore the cognitive process eighth-grade girls use in identifying a person as a science role model. Our secondary purpose was to compare the girls' process to the one used by women scientists seeking to serve as possible science role models. In light of these purposes, we first analyzed the data from the girls and used the themes that emerged from this data set to analyze the data from the women. Then, we compared the perceptions that emerged from the two data sets.

We analyzed the qualitative database using traditional qualitative procedures for coding and developing themes (Creswell, 2005; Miles & Huberman, 1994). The audiotapes were collected and transcribed in full by a professional data transcriptionist. Once all the transcripts were transcribed and reviewed by the research team, we made four case files, African-American girls, Hispanic girls, Caucasian girls, and scientists. We proceeded to code the interviews starting with the interviews of the girls (the primary participants) and then the interviews of the women scientists (the secondary participants). The data from the primary participants were coded using an *in vivo* coding technique to represent, as closely as possible, participants' own words. This open-coding process included segmenting the text into meaningful units and assigning code labels to each segment (e.g., current role models, characteristics of a role model, characteristics of scientists, aspects of scientists' work, physical characteristics for a science role model, personality characteristics for a science role model, desired activities with a science role model). The codes were refined throughout the coding process as new ideas emerged and as similar codes were grouped together into broader themes (e.g., the codes physical characteristics for a science role model, personality characteristics for a science role model, desired activities with a science role model were grouped into the theme of science role model characteristics). Each theme was discussed and clarified until a final set of three major themes emerged that best represented the voices of the participating girls: role model definition, science role model definition, and science role model characteristics. We then applied the themes to the data from the secondary participants, women scientists, using the same coding techniques.

Validation of the Findings

Validation of this study followed the guidelines for feminist research established by Lather (1986). These guidelines include triangulation, construct validity, face validity, and catalytic validity. Triangulation of sources was accomplished through the use of mul-

tiple focus-group interviews over the course of 6 months. The validity in this area was strengthened further by the inclusion of both girls and women scientists as multiple data sources. Construct validity was strengthened by our fluid analysis of the data and by adjusting subsequent interview protocols in light of emerging findings. Face validity was strengthened by involving the participants in a manner that gave them a voice in the process. All participants were fully aware of the purpose of the study and were provided with an open forum in which they could express their understandings in regard to that purpose. In addition, member checks were completed with the girls and women scientists. Finally, our research had a reality-altering impact (catalytic validity). As is explained over the course of this paper, our research process informs persons seeking to increase the range of participation by diverse populations in science and gave the girls/scientists involved in the study a greater self-understanding of their needs in regard to having or being a science role model.

Findings

How Eighth-Grade Girls Identify Science Role Models

The data from the 13 eighth-grade girls were analyzed first. Three overarching themes emerged across the three groups that described the girls' cognitive process in identifying a role model. These themes are (1) role model definition, (2) science role model definition, and (3) role model characteristics. We describe these themes in the following sections, using quotes as supporting evidence. All 13 girls are introduced in the first theme. All names (girls and scientists) are pseudonyms to protect confidentiality.

Role Model Definition. The girls defined the general term role model in a similar fashion. According to these girls, a role model is someone with whom they feel a deep connection. This becomes apparent in the descriptors used by the girls to describe a role model. For example, they noted that a role model is "someone you depend on," "there for you," "[someone that] helps us if we are in trouble," and "[someone with whom we] get along so well." To further support this deep connection, examples given by the girls of people that could be role models included mainly family members. All of the 13 girls shared that their role models are their family members (mostly their mothers followed by either grandmothers or fathers or siblings). The quotes below show the role models of each of the 13 girl participants:

Sherise: I'd say mostly my mom and my grandma. My mom . . . whatever we do she supports us. And my grandma, like she'll let anybody into her home . . . who are really needing it.

Trinique: My mom. She supports us . . . she helps us if we get into some trouble.

Dashay: My mom, my aunt and my sister . . . my mom help me with my math or if something goes wrong . . . if we get into trouble she talks about why we got in trouble . . . my aunt takes care of her kids and us really well . . . my sister, if I get into a fight she stops it.

Kina: My parents and my older sister. My parents, if I make a mistake they help me do it over. My older sister because she sticks up for me.

Reginna: Both of my grandmas.

Gabriella: My parents, because they are always right, you know. Like if we do something and then they tell you not to do it.

Rosa: My mom, because she gives good advice on what to do and what not to do.

Maria: My parents. I look up to my parents.

Adriana: My mom. I just like the things my mom does.

Sarah: My sisters.
Mary: My mom. She helps me on my homework.
Juli: My dad. He teaches me right from wrong.
Kristie: My grandma. We get along so well.

Science Role Model Definition. Despite questions aimed at exploring the girls' process in identifying science role models, the initial discussions of role models that emerged in the first session did not include any references to science or scientists. The girls were guided to discuss this omission using follow-up questions during that session. The resulting discussions revealed what is considered a stereotypical image of a scientist and the obvious disconnection between that image and their definition of a role model as described above. This disconnect was explored in subsequent interviews. Over the course of this study, their discussions began to show an evolving idea of a science role model and this theme describes that progression.

The girls originally described a scientist as a smart person, geeky looking, wearing a white laboratory coat and big glasses, and working in a laboratory. Most of them (10 of 13) also described the scientist as a male. The collection of quotes below illustrated a stereotypical view of the physical characteristics of a scientist held by the girls:

Sherise: A person with a big white lab coat, with maybe some big hair or some messed up looking hair or, it doesn't even have to be that but, like glasses or something.
Trinique: Want me to tell you for real? I'm thinking about like a white guy or something.
Mary: ...they'd be muscular so they can work with heavy stuff.
Sarah: I think a scientist would have a big head because they would have to have all that knowledge.
Kristie: I've never seen a scientist that had a child.
Gabriella: . . . scientists are mostly guys. I don't really see a lot of girls doing it.
Rosa: A guy.

The girls also initially described negative personality characteristics of scientists: "They're mean," "they are up there," "they're too smart," "they do some bad stuff," "they steal projects," and "[Scientists are] evil."

The findings revealed the interaction of this definition of scientist and their perception of a role model. The main reason the girls' originally could not picture a scientist as a role model was (1) role models are persons with whom they have a deep personal connection and (2) scientists are "geeky looking" people that are too mean or too smart to be connected to them.

In the second set of focus-group interviews, about 3 months after the first interview, students were asked to do an activity as part of the interview—to visualize a scientist and to describe what they saw. Only one girl reported seeing a male (Albert Einstein), whereas the rest reported seeing a woman scientist. They described characteristics of their visualized scientist as kind, smart, responsible, funny, and cool to talk to. Some of them also described someone that was "a bit like [Yvonne]," a Black scientist that they interacted with as part of the science outreach program curriculum unit but was not one of the secondary participants in this study. As the conversation continued, participants began to challenge their earlier comments that scientists could not be role models. For example, when one girl said anyone can be your role model, scientist or not, others agreed with her. Similar statements were made in all three groups.

When asked about their thoughts of scientists at the time of the third interview, most girls stated something to the effect of: scientists are normal people, but know science.

They could be men or women of any ethnicity. In that third and final interview, 6 months after the first interview, the findings revealed a distinct change toward the idea a scientist being their role model. When asked again whether a scientist could be a role model for them, most of the participants ultimately answered yes. After several minor debates, participants agreed that a women scientist could be a science role model for them. The following discussion provided a good example of why they considered one of the scientists they interacted with as part of the program to be a science role model:

Kristie: Yep. [Shari], I can see her as my science role model, Cause she's nice.
Mary: Yep. When we have a question she makes it specific. You can understand what she's explaining.
Juli: And she's into today's fashion. I love her shoes, her shoes are so cool.
Mary: You feel like you know her. Like she talks to us.
Kristie: She knows your name.
Mary: Yeah she acts like one of our friends.
Juli: Yeah like if you tell her to come here she won't just come over, you know answer the question and just leave. She'll sit and talk to us for a little bit.

Science Role Model Characteristics. What is an ideal science role model for these middle school girls? A cumulative analysis of all the transcripts across the period of the study revealed that an ideal science role model is someone who has a good personality, expertise in science, and is able to make personal connections. Findings also revealed different perceptions about the importance of gender-matched or race-matched role models.

According to the girls, a science role model must have a combination of good personality and expertise in their profession. To them, a good personality means having certain characteristics such as kindness, intelligence, helpfulness, willingness to work with kids, and have a sense of humor. Because they are science role models, they also must have expertise in science. For our participants, they would not consider someone as a science role model if he/she were super-intelligent but not very nice and they would hardly consider somebody who was really nice but did not really know science very well as their science role model.

The girls conveyed that it is important for them to have a personal connection with their science role models. They believed such a connection would motivate them in terms of learning and would make them feel more confident. These girls described such connections through interactions (e.g., the scientists would know their names and smile at them) and conversations (e.g., not just answer the question and leave, but rather talk to them). This is further supported by the fact that the girls did not mention the scientists from videos or books that were included in the diversity units. The following statements provide a picture of the importance of connecting to their science role models through discussions of those connections that were present or lacking.

Kristie: [Having a science role model] is cool, I don't know, to make you feel connected to somebody.
Sarah: . . . if we're late, if we're tired or something, she'll [the science role model] ask us if we're okay, if we don't feel good or something.
Juli: . . . like if you tell her to come here, she won't just come over, you know answer the question and just leave. She'll sit and talk to us for a little bit.
Adrianna: Yeah [she is a science role model]. Like if you have problems she could be easy to talk to . . . other than math . . . music.
Trinique: She's more down you know. She's tight.
Kina: [She is a science role model] because she hears us . . . it's just like she's there for us.
Sherise: Who? [Beth, a Caucasian scientist that visited their science class at the beginning of

the year]. She's not [a science role model], I don't really relate to her, I don't know, I mean I could ask her a question or something but . . .

Maria: She [Beth] is not [a science role model]. Maybe if I got to know her better.

Regina: [They weren't science role models because] I want someone I could be close to like a friend. That can come to you and feel comfortable talking to you.

Mary: I don't think [Beth] is a science role model. Cause I like barely know her.

Rosa: . . . like a person on TV, they may be smart, they may act like they're caring, you would not be able to have them as a role model because you don't, you don't know them.

The three groups of primary participant differed on the issue of race in relation to science role models during their discussions. The Caucasian and Hispanic girls reached a consensus that race-matched role models were not important. When asked if they wanted to have science role models from the same ethnic groups as themselves, girls within these groups typically answered, "Race doesn't matter at all. They [science role model] would be White, Asian, Black, Latino or whatever." However, some indicated the need for some diverse role models. They stated that "they shouldn't be all Caucasian," and "it should be mixed up instead of just one race." In contrast, our data revealed that the majority of African-American girls expressed a strong opinion that science role models should be persons of color.

Kina: They need more black people up in this school cause there ain't nothing but white people in this school.

Regina: They need a black scientist.

Sherise: To me they [race-match role models] help you more. They understand you more . . . Like my whole school year at elementary I had mentors and they were mostly black and I get along with Yvonne (African-American Scientist).

Trinique: It doesn't matter if they're just black but maybe some Latinos.

The primary participants within the different groups differed on the issue of gender in relation to science role models. There were girls within all three groups that explicitly stated that gender "does matter" or that they had a preference for one gender over the other when referring to science role models. The girls noted: "I don't feel comfortable around guy teachers," "I don't want a guy one either," or "I can get along better with guys ...they know kids, girl scientists are always saying you have to be good," "My whole life I see nothing but girls." Others noted that gender mattered for the boys. In discussing how they would feel if only women scientists were invited into the schools, some participants noted that they believed that boys should have male role models, which implicitly indicated that they did believe that the gender of the role model mattered for the boys. They worried that if only women scientists were role models, "then the males in our classroom will be uncomfortable," "if there's only girls all the time they have only girl scientists, the boys in our class might feel uncomfortable," and "they [boys] would probably drop out." Other girls verbalized that gender did not matter in a role model as expressed in "It doesn't bug me if there's guys or girls" and "It doesn't matter what gender they are just as long as they're funny, nice and smart."

Promoting Effective Relationships With Science Role Models

The codes and themes that emerged from the analysis of the girls' data were used to guide the analysis of the data from the women participants to compare what the scientists were trying to provide in this program to what the girls were seeking. These themes were (1) role model definition, (2) science role model definition, and (3) role model character-

istics. However, unlike the girls, the women's discussions of role models immediately included references to science and scientists. Thus, the first two themes that emerged from the girls' data set were not distinguishable from each other within the women scientists' data set and were ultimately combined into the theme science role model definition. The findings from the women's data set were then compared to and integrated with the girls' findings to understand what promotes an effective relationship with science role models.

Science Role Model Definition. Like the girls, the women scientists' definition of a science role model evolved during participation in the program and three interviews; however, this evolution was different than that of the girls. In the beginning, the women scientists' definition of a role model included being a person who has made it in their scientific field and enjoys what they do. A role model was an individual with personal qualities that attract students to them, as well as qualities that evoke students to pursue science. A role model was someone that has the ability to evoke actions in their students such as "[being] encouraging, an example of what they could strive for, inspire to work harder, set goals, develop good study habits, and to model good characteristics." In addition, all participants expressed the idea of being "a good example for students" as an important part of their role as a science role model.

Another common aspect of being a role model our women participants shared was "promoting science to kids." Most of them expressed their passion for sharing their love and enthusiasm for science and mathematics with students. By "doing the hands-on-science" and "showing how much a person can love math and science," students will "learn to appreciate the beauty, and see some of the applications" of science-related subjects. The scientists indicated that they wanted to be "the inspiration" for mathematics and science, so the "students would develop confidence in their ability" to do mathematics and science later in their lives. Some focused on bringing "neat equipment" or "designing interesting experiments" or "being the instrument" themselves. One participant stated, "I am concentrating on bringing something new or doing something interesting each time I go."

In the first round of interviews with the scientists, their perception of a science role model was a person that served as an example to strive for, had good study habits, and modeled good characteristics. Comparing this to the findings of the girls' data set, we see that the girls initially believed that scientists could not be role model for them because they were above other people ("too good," "too smart"). Likewise, the scientists' perception of a role model also included someone that has a love and enthusiasm for science. Comparing this to the findings of the girl's data set, we see that the girls initially believed that scientists could not be role models for them because they could not care for them personally. This uncovers a conflict between the scientists' and girls' perceptions of a science role model.

By the third focus-group interview with the women, their definition of a science role model had changed. The statements made by the scientists show us that in the beginning, their idea of a role model was more rigid and more specific to science. With time, they realized the importance of widening the scope of their role beyond focusing on science and also recognized the importance of their personal relationships with the students. Remarks made by the scientists that exemplify this shift include the following statements:

> My thoughts on being a role model have changed because at the beginning I thought that we were just going to be science role models like we're scientists, we're mathematicians or whatever. But these kids are so interested in your life and you as a person outside of science that you're a role model for almost every aspect of their lives. Like they want to know when I'm getting married and what my favorite color is and that stuff.

Another commented that "[her work with students] just made me realize . . . my role in the school is not just to be a scientist . . . " And another remarked,

> I started out thinking I had to be serious. I am like that around college students, the college students that I teach . . . [but] it's interesting to see that I'm sort of the safe person to go to and I guess I never would have thought that as far as being a role model, like oh I have to be scientific but yet I can, you know, I can help them out with their personal needs too.

Through time, the scientists came to realize that, to be a role model, a relationship that involves a personal connection needs to develop between them and the students. Statements expressing this realization include the following:

> The students are aware of what's going on in my family, I guess that shifted my role model aspect a little bit, now I'm human . . . they've all been sharing stories of when various people in their family have been sick and what goes on.

and

> I have the ask-a-scientist a question box in my lead, main teacher's classroom and half the questions they put in at first were not about science, they were about me! It's the curiosity about my life and that seems to have indicated to me that they view that as a role model type of thing too.

Role Model Characteristics. The women scientists also discussed the characteristics they came to consider as important for role models. This understanding was then compared to the findings from the girls. Some of the common characteristics include having knowledge, being "encouraging," "very diligent and understanding," and "easy to talk to." Some women scientist participants added, "When I think 'role model' I think I need to be respectable and probably cool" and "I think around younger kids its okay to be cool, that way they want to copy what you are doing." It seems that the scientists understand that "being cool" with younger individuals is an important way to connect with them. Besides being cool, other role model characteristics that ultimately overlapped with what the girls reported are "you have to be good" and "someone who's fun." An important characteristic recognized by the women scientists was being "encouraging" and "treating other people well."

One characteristic that did not overlap was that of gender. Whereas, the girls disagreed on the importance that gender had in regard to role models, the women expressed an idea that gender-matched role models were very important. They stated, "We are there interacting with them. Showing them that women do science and help them to be excited about science." "We, as women and scientists, can show another path for students, especially girls, which they can follow in life." This idea was also expressed by the girls.

Research Summary

The girls described a role model as someone with whom they had a deep personal connection. They found such connections with people such as their mothers, fathers, and siblings. The characteristics the girls expressed as being most important for role models reflected the need for such connections. In the beginning, the girls expressed that a scientist could not be a role model because they held stereotypical views that scientists are strange looking people that do things such as "steal projects"—people with whom they would not want to have a deep personal connection. Over time, the girls' view of scientists changed.

By the final focus-group interview, the girls came to believe that a woman scientist could be a role model for them. The catalyst for this change in perception appeared to be the relationships girls formed with the scientists brought into their classrooms as part of the program. The girls differed on the importance of the gender or race of a science role model.

While the girls were expressing the idea that their role model is someone with whom they had a deep personal connection, the scientists were seeking to provide the girls with role models that were good examples and would promote science. These women found that although they were trying to be perfect scientists and actively promote science, the girls they interacted with were interested in their personal lives, such as whether they were getting married and their favorite colors. As the women interacted more with the adolescent girls, they recognized the need to establish a personal connection with girls and become more "human." This reflects a change in the scientists' understanding of a role model over time. The scientists expressed the importance of a role model being from the same gender group, but did not express an understanding of the need for race-matched role models.

Discussion and Implications

Applying our developing understandings to Bandura's social cognitive theory, we came to understand that this theory does not account for a personal caring relationship within the observation process. According to this theory, the girls would have observed the behavior of other women, coded what they observed, and subsequently performed select behaviors they found desirable. However, the girls in our study sought a personal connection of intimacy and care. To them, a role model was someone who cared about them and shared common interest/experiences. It was only after they made connections with scientists that they started to see scientists as possible role models. This suggests that those that are not only present and observable in children's lives (Bandura, 1986), *but also in a caring relationship* with the girls, can serve as role models. Since our study only focused on females, the findings from this study cannot suggest whether social cognitive theory is gender specific or whether a personal connection is a needed component to the overall theory.

Our findings do support that, in general, sex-stereotypical images of careers serve as a limiting factor in the career aspirations of women (Greene et al., 1982; Gottfredson, 1981; Hackett et al., 1989; Osipow, 1983; Savenye, 1990). They also support that, specifically, the sex-stereotypical image of science serves as a limiting factor in the science career aspirations of girls (Packard & Wong, 1999). However, the findings raise questions as to why these stereotypical images are a limiting factor. Packard and Wong's (1999) findings are consistent with Bandura's social cognitive theory. They concluded that the negative impact was a result of a clash between the girls' image of a scientist and the girls' desired image of their future self (e.g., the girls do not want to grow up to be a mean, geeky-looking scientist with no personal life). Our findings suggest that perhaps there are additional negative impacts. In addition to the clash between desired images, our conclusions suggest that the impact may also be a result of the fact that the stereotypical image of a scientist causes the girls to believe that a scientist is someone with whom they could not/would not have a relationship. It is the image of a scientist that only cares about science and not people and is too good to care about them that prevents them from having a relationship with a scientist. Following this line of reasoning, the presence of caring teachers and lack of caring scientists in their lives would explain why more girls pursue teaching. When considering what it means to provide girls' with science role models, this distinction is important for two reasons. First, posters, pictures in a science text, videos, or one-time classroom visits could portray an image that a girl would find appealing; con-

versely, these could not provide a caring relationship. Second, the girls in this study initially believed that a scientist could not be a role model for them because they thought scientists were too good and too perfect. If the image used to attract girls to science is too perfect, this may have the opposite impact from what was intended. This distinction may also explain why differences in the importance of having role models of the same gender or race emerged in this study whereas the literature emphasizes the importance of these matches. Approaching this work from a perspective that emphasizes image, one would assume that it is easier for a girl to find her desired future self within an image of a woman. Similarly, a girl would find her desired future self within an image of a racially matched woman. However, approaching this work from a perspective that emphasizes relationship, the ability for a girl to form a caring relationship with a man, woman, or persons of similar and different racial backgrounds is influenced by many factors (e.g., relationship with father, previous relationships). Such a perspective could explain why some girls follow in their fathers' footsteps and become scientists or describe a male academic advisor as a role model.

As described above, our findings both supported and expanded the initial literature used to develop the study. In addition, these findings lead to an expansion of our initial framework. Specifically, the extent to which the findings focused on relationship led us to return to the literature. In the first of our series of discussions with the girls and women scientists, we heard two distinct forms of procedural knowledge. Procedural knowledge is the procedures used to develop knowledge and understanding (Belenky et al., 1986). The two forms of procedural knowledge are categorized as *separate* and *connected* knowing (Belenky et al., 1986): terms initially developed from the work of Gilligan (1982) and Lyons (1988). The eighth-grade girls spoke from a connected mode of procedural knowledge. The connected knower understands others, objects, and subjects through intimacy and care (Belenky et al., 1986). Studies show that females tend to define themselves using this category. For example, Lyons (1988) found that 63% of the women they study defined themselves from a predominantly connected mode of self-definition in contrast to 79% of the men that defined themselves from a predominantly separate mode of self-definition.

In regard to the general definition of role model, the girls initially identified those with whom they had a relationship: mothers, fathers, and teachers. For these girls, an understanding of what they want to be like as an adult comes from such relationships. When specifically asked whether a scientist could be a role model, they said no and described a person distant from themselves with distance preventing identification of the person as a role model. Even after they were exposed to more women scientists, their discussions still revealed a disconnect with the professional field. It was only after they came to have a relationship with scientists, ones in which they talked about families and fashion in addition to science and professions (i.e., a personal relationship), that they came to understand that a woman scientist could be not only a role model, but a role model for them.

Whereas the girl' discussions of role models came from a connected mode of thinking throughout the study, the discussions of the women scientists suggested a separate mode of thinking in the beginning. The separate knower understands others, objects, and subjects through impersonal procedures (e.g., the fact that women can be scientists) (Belenky et al., 1986). Belenky et al. showed that most of the adult women they interviewed that leaned toward separate knowing were attending or had recently graduated from a traditional liberal arts college. The women in our study were not only students in a college of arts and sciences but were working and studying in the scientific fields: ones built on objectivity and procedure. In terms of role models, the women scientists initially spoke of their need to be the perfect woman scientist to attract girls to the field. Ironically, this

perfect image (which was perceived by the girls as one of superiority) could have driven the connected knowers further from the profession if maintained. The women scientists came to understand that girls want to know them on a personal level, which surprised them, but they seemed able to adjust to this perspective over time. The findings from this study did not reveal whether the women changed to a connected procedural knowing; but they did reveal that the women came to understand the connected way of knowing from which girls spoke and some of them were able to make the connection.

Conclusion

As previously discussed and supported in this paper, research has shown that students are more likely to enter a profession when they are able to identify a role model in that profession. Thus, one common strategy for encouraging more girls to enter science professions is to provide them with science role models. However, knowledge of the cognitive process girls use in identifying a person as a role model was absent from contemporary understandings. It was our belief that such knowledge could not be derived from the use of statistical measures that provide students with a predetermined list of characteristics from which to choose. Such an approach would focus on a role model as a product created from distinguishable characteristics from our experiences, needs, and understandings and not on the process that emerges within girls' experiences, needs, and understandings. Thus, we sought to explore this cognitive process for adolescent girls as they became immersed in a program that was presenting them with many different scientists for varying lengths of time. Feminist research methods revealed the cognitive processes of adolescent girls and women by allowing them to speak for themselves. Our efforts to facilitate voice within experience and over time were rewarded with an understanding of a process that involved a personal connection of intimacy and care. This feminist study made a reality-altering impact as it gave the girls and scientists a greater self-understanding of their needs in regard to having or being a science role model as demonstrated by the fact that *these girls' voices changed some scientists' understanding and subsequent approaches to serving as a role model.* Some of the scientists allowed for a more caring relationship with adolescent girls that ultimately resulted in statements from the girls such as, "Yep, I can see her as my science role model ..."

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