common theme in their notion of inquiry is its role in promoting student thinking. All the teachers in the study aimed to enhance students' independent thinking through inquiry activities.

The variation in the teachers' inquiry teaching seems to be related to the way they coped with school constraints. In particular, as reported in other research studies, these teachers expressed curriculum constraints on utilizing inquiry teaching. They felt constrained by the amount of content to be covered in the limited time. Efficient content coverage does not necessarily invite student thinking that requires more time on less topics. In reconciliation with the curriculum constraint, the teachers in the study adopted various strategies that ranged from utilizing a limited number of authentic scientific inquiries within teacher-driven questions to broadening the definition of inquiry in compliance with efficient content coverage. Whether these different versions of inquiry are effective for the teachers' goals for science teaching, and in particular for developing students' thinking skills, requires further research.

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Informal Science Education for Girls: Careers in Science and Effective Program Elements

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Abstract

Addressing the need for continued support of after-school and summer science enrichment programs for urban girls and at-risk youth, this paper describes the educational and career paths of a sample of young women who participated in the Women in Natural Sciences (WINS) program during high school. This study also attempts to determine how the program affected the participants' educational and career choices after graduation in order to provide insight into the role informal science education programs play in increasing the participation of women and minorities in science, math, engineering, and technology-related fields. Findings revealed that almost all of the young women enrolled in a college program after completing high school. Careers in medical or health-related fields, followed by careers in science, emerged as the highest-ranking career paths. The majority of the sample perceived having staff to talk to, the job skills learned, and having the museum as a safe place to go as having influenced their educational and career decisions. (This paper is a summary of Fadigan & Hammrich, 2004)

Introduction

Women have a long history of under-representation in science careers that persists to this day. Over the past several decades, educators have designed and implemented numerous activities and programs to encourage the participation of girls in science and to narrow the gender gap.

Evaluations of these programs often reveal an increase in girls' positive attitudes toward, and interest in, science, an increase in content knowledge, and an increase in their knowledge of career opportunities in science immediately following, or a few months after, participation. Unfortunately, it is difficult to assess if the positive effects of science education programs for girls are long lasting. Conducting follow-up evaluations with participants of such programs is not a common practice, often due to financial and time constraints. Thus, it is difficult to determine whether or not girls who participate in science enrichment programs eventually pursue careers in science after high school.

The intent of this paper is to summarize the findings of the study by Fadigan and Hammrich (2004), which tracked a group of young women 3 to 8 years after they completed a science program for girls. The study describes the educational and career pathways of a sample of young women from urban, low-income, single-parent families who participated in a single-sex, informal, science education, enrichment program while in high school. This study also attempts to determine which program elements affected the participants' educational and career choices, to provide insight into the role informal science education programs play in increasing the participation of women in science-related fields.

Background

Females are at risk of not being equally represented in both school science and the workforce. From infancy through adulthood, females and males are treated quite differently (Sadker & Sadker, 1994). Science textbooks and curricula often fail to equally represent females in graphics and text. Science content, when traditionally presented in schools, and especially in the physical sciences, does not have as great a relevancy to real-life experiences for girls as it does for boys. For instance, concepts are frequently presented using male-oriented examples such as guns, sports, and automobiles. Compared to boys, girls often have fewer opportunities to use tools and equipment and participate in out-of-school-time science experiences.

Although students spend a great deal of time learning in the classroom during regular school hours, a large amount of learning also occurs during non-school hours. Learning can take place in a variety of environments including schools, homes, museums, and community centers, to name just a few. Participation in extracurricular activities may help students to improve academically, learn the values of teamwork, competition, and responsibility, and enhance their self-concept (American Association of University Women Educational Foundation [AAUW], 1999; Eccles & Barber, 1999; Nettles, Mucherah, & Jones, 2000; Shmurak, 1998; U.S. Department of Education, 2000).

When out-of-school-time science activities are voluntary and intentionally designed not to be a part of a school's curriculum, they are referred to as informal science education. Informal science education programs conducted by museums and science centers frequently provide opportunities for mentoring, improving science and job skills, and counteracting negative science stereotypes. Science programs designed specifically for girls increase their understanding and perceived value of science (AAUW, 1998), as well as offer opportunities to develop skills they might have otherwise missed out on, such as utilizing science equipment or acquiring job skills (Eccleston, 1999; Pierce & Kite, 1999), and increase feelings of self-concept and empowerment (Baker, 2002).

Program of Study

The Women in Natural Sciences Program (WINS) is a yearlong natural science enrichment program offered for academically talented females. To be eligible, girls must be entering the ninth or tenth grade, be enrolled in public school, maintain a C or better average in all major subjects,

live in households where one or both parents are absent, and demonstrate financial need (i.e., be eligible for reduced-price school lunch). Since 1982, the WINS program has been offered free of charge to all participants, and includes materials, admission fees, field trip transportation, bus tokens for travel to and from the museum, and family memberships to the science museum. Approximately 30 young women are selected each year. The ultimate goal of the WINS program is to provide participants with the information, encouragement, and confidence they need to consider pursuing careers in the natural sciences, to make informed decisions, and to shape their own futures.

Over the course of 1 year, students attend classes at the local natural science museum, meet scientists, play science-related games, take field trips to local parks, laboratories, zoos, aquariums, and seashores, and spend 4 nights at an environmental education center. The thematic units presented to the girls include people and the environment, terrestrial ecology, taxonomy, and aquatic ecology.

After completing the yearlong program, approximately 15 to 20 of the WINS students remain involved in the program through participation in a second year program extension known as WINS II. WINS II includes opportunities for paid laboratory or museum positions, travel, and involvement in other established informal science education programs. Other WINS II girls sometimes acquire volunteer or paid positions in other programs and departments within the museum. Acceptance into the second year of the program is based on first year performance, as well as available funding.

After hosting a 15-year reunion for former participants, the WINS staff realized that many of them were attending universities and pursuing science-related careers. This event sparked the idea of a more formal tracking of the girls' educational and career plans.

Utilizing program records, surveys, and interviews, the researchers conducted a case study to compare the WINS participants' educational and career goals before and after completing the program, and to determine if elements of the WINS program influenced their decision-making. Between 1992 and 1997, 152 young women attended the program for at least 1 year. The majority of the participants described their race or ethnicity as African American or Black (83%). Historical records providing high school completion and college entrance were available for 117 of the original 152 participants. Seventy-eight former participants completed and returned a survey that confirmed this information and provided additional details about educational and career trajectories. Of the 78 women who returned a completed survey, a sub-sample comprising 12 survey respondents was asked to participate in an interview.

Plans Before the Program

As part of the original application form, participants answered the question: "What are your current education and career plans once you graduate from high school?" The majority of participants (92%) indicated a desire to enroll in a college or university. Medicine and health-related career choices were most popular career plans (42%), followed by choices falling into the science, technology, engineering, and math (STEM) category (25%). Law and education were the third and fourth most popular desired careers, respectively.

Even though a high number of students desired science-related careers, their choices were not always specific. Many girls listed general careers such as scientist or doctor. This may hint that, in early adolescence, girls are uncertain of their career plans or may be lacking adequate career

information (AAUW, 1999). If girls knew more about science careers before high school, a crucial drop-off point for many, they may have a better chance of staying in the science pipeline.

It is also important to note that the top four career choice categories, medicine and health, STEM, law, and education, can be identified as careers that enable the individual to help others. This finding is consistent with the work of Baker and Leary (1995) and Shmurak (1998), who found that girls in each of their studies selected science-related careers based upon a desire to help people, animals, plants, and the earth.

Progress After the Program

Information regarding educational paths was available for a total of 117 of the 152 original participants. Not only did all 117 participants in this case study graduate from high school, but 93% of these women also enrolled in some type of college program after high school. Originally, 67% of the careers listed by the 117 participants on their application forms were science-related (including medicine and health). Historical records and surveys provide data regarding the careers that 100 of these 117 participants pursued, and show that 45 % of the 100 actually pursued a career in a science-related field.

Careers in medical or health-related fields (pre-med/biology and nursing) rank highest with 25 students (25%) employed in, or pursuing a career in, this area. Careers in science (biology, computer science, and chemistry) fields rank second with 20 students (20%) working or studying in these areas. None of the women in this study are pursuing physics or math. The under-representation of these women in the physical sciences is similar to that reported by the National Science Foundation (2000). It is also worthwhile to note that 2 of the participants who selected careers in education are concentrating on science education.

Thirteen participants are pursuing graduate studies: 6 in a science-related discipline and 2 in secondary science education. The other graduate-level participants are studying in the fields of business, elementary education, law, psychology, and rehabilitative counseling.

Effective Program Elements

One particular question on the WINS survey directly addresses the participants' perceptions of which program elements affected their educational and career paths. The question lists different program components to which participants could respond. The results of this survey question, together with the data from the 12 interviews used to further explore participants' perceptions of each program component they identified as influential, provide insight into the ways in which the women perceive the WINS program as having affected their lives.

Three to 8 years after their involvement in the WINS program, the majority of participants perceived the **science classes and content** they learned in WINS as having an influence on their education and career decisions. Interviews revealed that the structure of the WINS classes--the hands-on nature of activities, the frequent opportunity for discussion and debate, the guest speakers, and the number of different scientific fields and topics covered--were important to these participants. During the interviews, the young women indicated that the science information they acquired in the WINS program later aided them with high school or college science courses. Seana felt she had an advantage in her schoolwork "because when I took biology and everything I understood what was going on." Fatimah shared similar thoughts, exclaiming: "It was good that I went to WINS because I actually learned it before I got to high school." Research tells us that informal science education programs for girls (and boys) can affect students' attitudes toward

science, their achievement in science (Lee-Pearce, Plowman, & Touchstone, 1998), and their perceptions of scientists, but the literature has not yet indicated these programs directly affect students' education and career decision-making.

All the interviewees, as well as the majority of survey respondents, indicated that **going on field trips** influenced their educational or career decisions. These women remembered the trips as fun, educational opportunities to escape the fast pace of life in the city. Maureen recalled her experience, noting: "I hadn't really been out of the city, as far as going out to the middle of nowhere and just experiencing nature and the beauty of nature."

Over the years, WINS II participants have travelled to many parts of the world. Many WINS II students participated in other science enrichment programs, attended youth summits, and shadowed teens from other science institutions. The majority of respondents indicated an **opportunity to travel or attend other science programs in the second year of the program** influenced their educational or career decisions. The interviewees discussed how travel provided focus and direction for participants.

Almost half of the young women indicated that **career information** learned while in the program and **meeting scientists** at the museum influenced their education or careers decisions. The interviewees spoke of careers they learned about or scientists they met while in WINS, claiming that outside of the WINS program they did not have many opportunities to meet scientists. Bobbi summed this up by saying: "Well, beside your science teacher, who do you know that you can actually meet that knows that much about science?"

In the WINS program, students met girls from all parts of the city with whom they shared many commonalities, one of which being their enjoyment of learning science. Forty-three of the 78 survey respondents (55%) indicated that **the friends they made** in WINS influenced their educational or career decisions. For interviewees, it was important to have friends with whom they shared similar interests in science. Arlene stated: "It was nice to find somebody that shared some of the same interests as me so I didn't feel like the outcast in school." She added: "Since I had all these high interests in science, it's nice to find people that were just as determined as I was to make their goals and their dreams come true." Maureen articulated her perception of the importance of the friends she made in WINS by saying:

> They have similar interests, so when I start talking about something science-related they don't look it me like I'm speaking another language. They understand. A lot of them came from similar socio-economic backgrounds that I did, similar parts of the city that I did where the crime rate tends to be up, violence tends to be a big factor there, single-parent homes. To be able to have people that understand you in that way and to connect with you in that way tends to be very helpful, tends to kind of provide a safety net for you to lean back on. To have somebody there encouraging you when you kind of get discouraged by what you see around you.

WINS staff encouraged participants to pursue post-secondary education by planning activities to assist in preparing students for selecting, visiting, applying to, financing, and succeeding in college. Thirty-eight of the 78 respondents (49%) indicated the **college information** they learned in WINS influenced their educational or career decisions. Three of the participants mentioned the lack of resources available at their high schools. They mentioned the heavy workload of the few counselors prevented any intense or personalized attention to their needs.

Teamwork, leadership, responsibility, cooperation, punctuality, and communication are skills stressed during the first year of the program. Forty-seven of the 78 survey respondents (60%) indicated the **job skills** they learned in WINS influenced their educational or career decisions. During the interviews, the young women most frequently spoke about the development of their communication skills, especially the ability to speak in front of groups of peers or adults. Being part of the WINS program also instilled a positive work ethic and sense of pride in participants.

Reinforcing the need for more out-of-school time programming for high school-aged teens, the majority of survey respondents (53%) indicated that **having the museum as a safe place to go** influenced their education or career decisions. Considering participants' low-income and single-parent family status, their perception of the WINS program as providing a secure, stable environment is worth further attention. The interviewees described the museum as a fun place where you always could learn something new, hang out with friends, or just take time out to sit and think. Interviewees perceived the museum as providing an opportunity to escape their sometimes dangerous neighborhoods or family or emotional problems. Maureen said: "It was definitely really helpful in helping me to put myself in an ambitious mind set, to know that there's a lot more for me out there then just dodging bullets." Similarly, Arlene commented: "I don't have to worry about a drive-by [shooting]. That's always good."

Fifty of the 78 survey respondents (64%) indicated that **having staff available to talk to** influenced their educational or career decisions. The interviewees described the WINS staff as approachable role models who took time out to answer their questions, offer advice, and help out with homework. They said they felt as though they were treated as individuals and as young adults, rather than children. Fatimah described the staff as:

> more like friends instead of just mentors or adults that are there telling you what to do. They were sitting there right beside you, and even if they already knew the things you were learning, they were still interested in it, and they were like learning new things as they went along, working with us. So it was like, they weren't really adults. They were just older kids.

Some participants described the staff as being like an extended family to them. Sereeta commented: "If we were having a problem we all knew that we could go and talk to somebody about it. So, it made it a little bit, it was more of like a kind of a friendly, family-like atmosphere." Bobbi also described the program as being "like a new family to me." The women often felt that they could easily relate to the staff, especially when it came to their interest in science. Salina exclaimed: "I never really met anyone who was a science nerd like I wanted to be and it was really cool having someone that was knowledgeable." Several of the women also talked about the lasting effects of their relationships with staff members. They acknowledged they are still able to rely on the staff for advice. Bobbi considered the relationships to be "lifelong."

Implications for Science Educators

The WINS program provided participants with an assortment of positive experiences. In the eyes of the participants, WINS offered mentoring relationships with adult staff, a safe and stable place to call their own, job skills, and socialization experiences with like-minded peers. The participants' positive perceptions of the program elements raise the question of what type of role informal science education programs for girls can serve in narrowing the gap for women and minorities in SMET-related fields.

In the area of career education, especially within the science-related fields, it appears that students need to be exposed to the variety of different potential careers long before they reach high school. Students need opportunities to explore their options and learn more about the training requirements and the day-to-day responsibilities associated with science-related careers. For instance, students need to discover the rigorous requirements for a career as a doctor early on in their education so that they may take the necessary course work in high school.

In addition, careers in the physical sciences, more so than careers in life sciences, continue to be dominated by men. Based on WINS participants' interests in careers in which they are able to help people, perhaps women do not perceive physical science careers as having that characteristic. Career educators and science teachers can present these fields to girls in a new light, and allow them to see the dual possibility of both studying physical science and helping others.

Conclusion

Although the trajectory of not every member of the sample has led to a career in science, these women, each in her own individual way, have achieved success and overcome barriers associated with the risk factors of gender, race, and low socioeconomic status. In early adolescence, the majority of the sample displayed a high-level interest in science-related fields, valuing human interaction and opportunities to help others. In adulthood, over half the sample in this study maintained their aspirations for science-related careers. Their interest in occupations stressing human interaction and opportunities to offer assistance to others persisted as well.

Informal science education programs can play an immense role in the lives of young women and low-income students. When the duration of intervention is long enough to allow participants to form relationships with staff, feel they are in a safe, stable environment, and acquire skills for adulthood, participants benefit by gaining the confidence and support needed to succeed in science careers. Efforts to provide youth with a safe and supportive environment are crucial. This does not mean merely providing youth with a physical space. Youth needed to be treated with respect and made to feel they belong. Additional studies, including action research by teachers, of science education programs for girls are much needed in order to narrow in on the most effective strategies for keeping girls interested in science throughout their lives.

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Readers' Forum

Recreating Cuthbert's Experiment

In my role as a reviewer for this journal, I was privileged to read Anthony Cuthbert's paper (see p. 72) about English children's models for hearing, smelling, and seeing, and just as I was about to teach a very similar topic to my own Year 7 class of 25 13-year-old Australians of mainly Anglo-Celtic or World War II European immigrant background. I decided to use his test to discover what models my students were using, and to then design teaching and learning to help them reconstruct their understanding of how stimuli are received by receptors.

Using diagrams similar to those used by Cuthbert, I instructed the students to find a way to display how they believed we hear things, smell things, and see things by writing notes, and/or drawing, on the diagrams. Unlike Cuthbert, I did not encourage them to use arrows to complete the diagrams. I kept the results, also not telling the students that this test was to be repeated at the completion of the unit.

Interestingly, my students held the same range of models as Cuthbert's students, despite being on the other side of the globe. While the majority of the class was using either one or two models to explain the three related phenomena, only 20% of my students using one model only were using the preferred western science model.

Following this initial test, I explained how western science explains the three phenomena and wrote the explanations, as three separate hypotheses, on the whiteboard. I then invited the students to create experiments to test one of the hypotheses. For homework, they investigated aspects of their chosen hypothesis and planned experiments. The experiments included an eye dissection, touch test, reaction time test, and use of a cathode ray oscilloscope and flutes, lasers or torches, mirrors and dust, smelly objects (flowers, perfumes, cheeses, and detergents), flasks with stoppers, and blindfolds.

We spent four lessons (320 minutes over 2 weeks) investigating hearing, smelling, seeing, tasting, touching, and the nervous system, and each student then wrote a report. The students were able to display a sound understanding of scientific methodologies as they implemented controls and tried to control sources of error. The experiments proved much more difficult to plan and carry out than we had originally envisaged, though, and, in many cases, the experiment performed did not really test the hypothesis chosen. However, the students were able to discuss this in their reports.