Why do Girls Persist in Science?

A Qualitative Study of the Decision-Making Processes

of Pre-Adolescent and Adolescent Girls

Holly McDonnell James

Eleanor Drago-Severson
Philip Sadler
Candace Julyan

A Thesis Presented to the Faculty
of the Graduate School of Education of Harvard University
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Education

2002

Contents

Chapter One

Who Does Science?

"I had to use small wheels so it would go faster. [Using] gears helped too," Hannah, a seventh grader, explained to the audience of parents as she held up her racing car made with LEGO™ bricks [LEGOs]. It was the last afternoon of a five-day, physics-based, engineering camp in which Hannah and fourteen other elementary through high school girls participated during July of 2000. In turn, the girls proudly showed their parents what they had been building all week using LEGOs, motors, and a computer program.

Like Hannah, many of the girls made vehicles that moved either slowly or quickly by using a combination of wheels and gears of varying sizes. Some designed increasingly complex computer programs in order to have their vehicles respond to light or touch. Katie, for example, made a car that moved when it saw light and stopped when it saw darkness. Similarly, Beth made a mallard duck that "walked" when on land and "swam" when on water. She programmed her duck to tell the difference between land and water (a dark blue piece of paper) by using a light sensor that detected the brightness contrast between land and water. In another variation, Marie made a frog and programmed it to play music while it walked. Once the touch sensor that she built onto the front of the frog touched something, the frog stopped walking and played music.

All of the girls, based on my observations at the camp and individual interviews and group discussions with them, seemed to really enjoy their experiences at the camp. For five days they were actively engaged in building and programming and often did not want to interrupt their activities for lunch breaks. During interviews, many told me about what they learned at the camp and how much they enjoyed it. For example, Beth, a fifth grader, told me,

> I thought [the LEGO camp] was really fun and I learned a lot. And I didn't know how to use LEGOs that well and I didn't even know what programming was…or if you needed motors for a car or anything. I learned a lot. And I thought it was really fun.

Likewise, Sunny, a ninth grader, explained,

> I learned…very complicated programming…at the camp. I learned you [can] play a song, start this while this is going, and if this happens then start this while you stop that. And it was fun and interesting to think about a program that would work and trying new ones if they didn't.

For these girls, exploring physics and engineering concepts within the context of a summer camp was both fun and educational. In fact, all of the girls told me they would like to attend the camp again the following summer because they had enjoyed it so much.

Since it appeared that these girls truly enjoyed their experiences at the science camp, why is it that, in general, few girls pursue science and engineering careers? As I outline in the next section, few girls compared to boys decide to pursue science-related jobs, particularly those related to the physical sciences. The purpose of this study was to gain an understanding of why some girls choose

to persist or not in science and engineering careers and the classes leading up to them. In order to do so, I explored the decisions related to the choice of classes to take and the career considerations of a small group of late elementary through high school girls who were engaged in science, both while participating in a physics-based engineering summer camp and in classes during two school years. By focusing on how and why these girls, at their age, made sense of their decisions to continue or not with the sciences, I hoped to uncover ways of encouraging adolescent girls to continue learning about science and thereby broaden their higher education and career options.

In this chapter, I begin by discussing current statistics on women's participation in the sciences to illustrate that fewer women than men are deciding to pursue science and engineering careers. I discuss studies that further suggest that girls are deciding not to take science classes in high school, particularly physics (NSB, 2000), and that even in the middle school they express less interest in science careers than do boys (Benbow & Minor, 1986; Hill, Pettus, & Hedin, 1990; Jacobowitz, 1980; Smist, 1994).

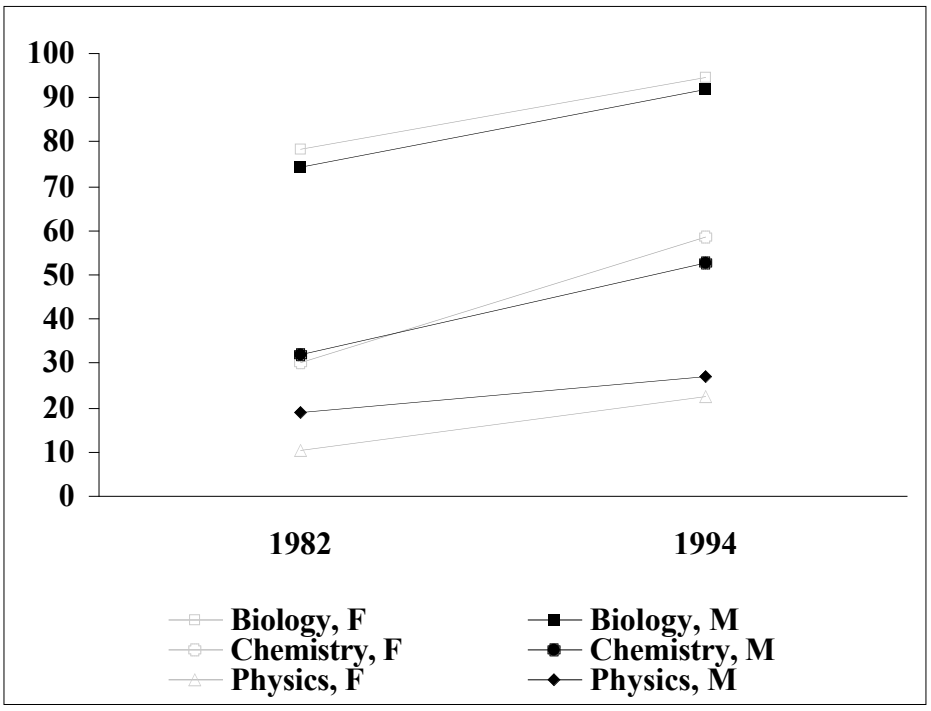
A theoretical model by Eccles and her colleagues (Eccles (Parsons), Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983; 1985) suggests that several factors, including interest and perceptions of ability, explain why students persist in some subjects but not others. I outline this model [Eccles' model] and explain how it and related studies informed this investigation. Finally, I present my research questions in the last section.

Current statistics on women's participation in the sciences

Current studies reveal that women account for 46% of the workforce, but only 23% of all employed scientists and engineers (National Science Board [NSB], 2000). They are represented least in the fields of physical science (22%) and engineering (9%) and although they are more represented in the life sciences, they only account for 36% of life scientists (NSB, 2000). While there is some evidence among recent college graduates (those graduating since 1990) that female participation in the sciences is slowly increasing, with recent female graduates making up 30% of all scientists and engineers, their participation within the physical science domains has not increased since 1993 (NSF, 2000).

Enrollment statistics reveal that high school is the time when students, in general, begin to make decisions about whether or not to pursue certain science classes. While 93% of all high school students took biology in 1994 (the most recent year in which data is published by the NSB), only 56% took chemistry and 25% physics (NSB, 2000). These differences in class participation by science domain are shown in Figure 1. Additionally, Figure 1 illustrates how participation in science courses across the domains has increased since 1982, but that a consistently higher percentage of girls than boys have taken biology classes since 1982 and a lower percentage of girls has taken physics classes. Yet, as Figure 1 also indicates, the difference between male and female participation in general physics classes has decreased from 1982 to 1994.

Figure 1: Percentage of high school graduates taking science courses, by gender: 1982 and 1994.



Adapted from Appendix Table 5-21, NSB 2000.

However, boys are significantly more represented than girls in Advanced Placement [AP]/honors physics courses, the classes believed to lead most directly to physical science-related careers (Oakes, 1990). Girls only made up 32% of the students in AP/honors physics classes in 1982 and 36% in 1994 (NSB, 2000). Thus, while girls are becoming more represented in AP/honors physics courses, boys still made up the majority of these classes, which may be more important for pursuing physical science careers in the future.

Outside of the classroom, middle and high school boys are reported to have more physical science experiences than girls (Catsambis, 1995; Greenfield, 1996;

1997; Jones, Howe, & Rua, 2000; Kahle & Lakes, 1983; Kahle, Matyas, & Cho, 1985). For example, boys reported reading more science articles, watching science television shows, and conducting extracurricular projects involving items such as batteries, electricity, and pulleys (Kahle & Lakes, 1983). When given a choice of science topics to pursue for class projects, boys more often chose physical science topics while girls chose biology (Jones, 1990). It is not surprising then that by middle and high school, boys have been found to express greater interest in physical science-related careers than did girls (Benbow & Minor, 1986; Hill, Pettus, & Hedin, 1990; Jacobowitz, 1980; Smist, 1994).

Jones et al. (2000) have noted that middle school appears to be the time at which gender differences in attitudes toward science begin to appear. They hypothesized that girls' lack of physical science experiences during this time could put them at a disadvantage later in school for learning physics concepts and for developing positive attitudes toward science.

While the above studies reveal gender differences in science participation beginning in the middle school years and progressing through high school and beyond, they do not explain why girls, more so than boys, become disengaged with the sciences. Nor do they explain, conversely, why some girls, such as those who attended the engineering summer camp in which I observed, *chose* to participate in science activities. My study was designed to address this gap. As I discuss below, it was theoretically informed by the following literature (i.e. Baker

& Leary, 1995; DeBacker & Nelson, 2000; Khoury & Voss, 1985) and model of academic choice (Eccles et al., 1983, 1985).

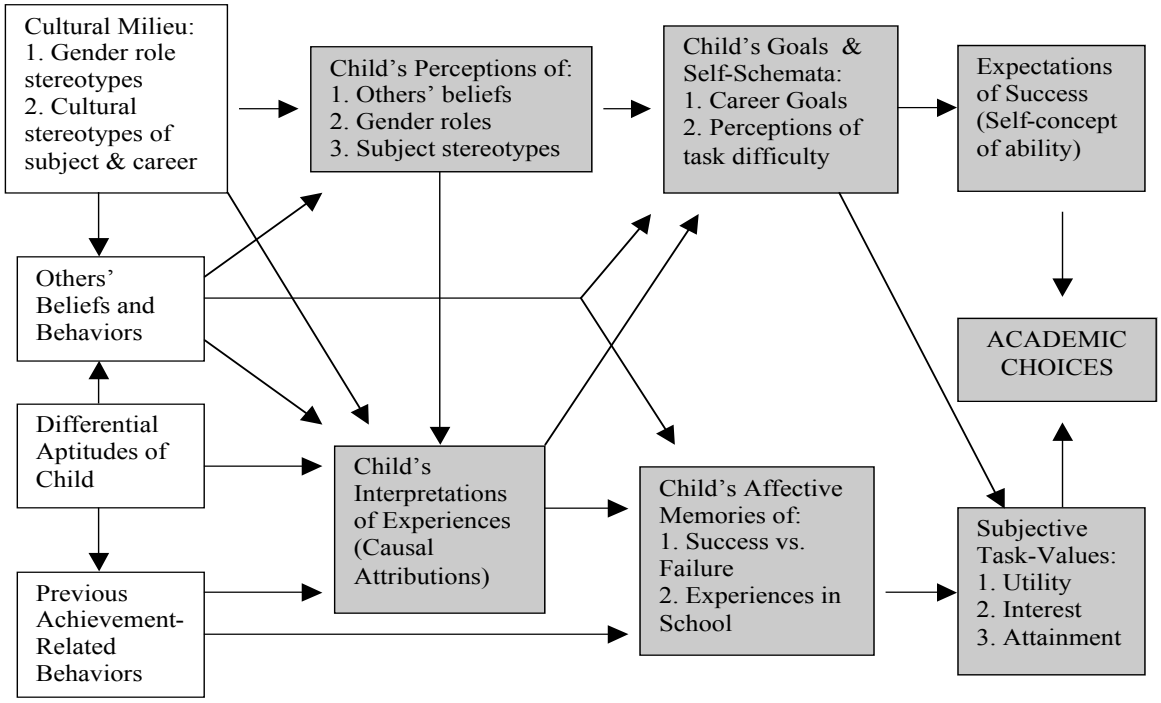
Related literature and an expectancy-value model

Eccles and her colleagues have developed a model, based on expectancy-value theory, which may help to explain why some students persist in science while others do not (Eccles et al., 1983; 1985). As of yet, though, their research has not explored students' decisions to pursue science. Instead, they have predominantly focused on explaining gender differences in students' decisions to pursue mathematics. Nevertheless, their model, coupled with findings from studies of science education conducted by other researchers, provided a framework that informed my investigation by identifying factors relevant to girls' educational and career choices.

Eccles' expectancy-value model proposes that a student's persistence in, choice of, and performance in classes can be predicted by their expectations for success (or perceptions of ability) and their perceptions of the value of each class (i.e. how interesting or useful they perceive the class to be). According to the model, students who expect to succeed and who believe that a class is useful and interesting will persist and succeed in that class. An adaptation (Wigfield & Eccles, 2000) of the most recent version of the model is presented in Figure 2.

Although I have presented the whole model to show its scope, my investigation explores only those variables that are shaded.

Figure 2: Eccles' Expectancy-Value Model (Wigfield & Eccles, 2000)



As shown in Figure 2, the model predicts that a student's perceptions of ability in a class and the values they attach to a class are influenced by their long and short-term goals and their estimates of the difficulty of the subject. These beliefs, in turn, are influenced by the student's interpretation of past experiences of success and failure (attributions), perceptions of others' expectations, such as parents and peers, and their perceptions of the gender stereotypes of the subject.

There was some evidence in the science research literature (i.e. Baker & Leary, 1995; DeBacker & Nelson, 2000; Khoury & Voss, 1985) to suggest that the

shaded variables, in particular, were relevant to girls' choices in regards to science. I present findings from this literature below to emphasize their predictions for girls' participation in science courses and careers. Because the purpose of much of this literature has been to explore factors that may explain gender differences in science participation, findings are often expressed as comparisons between boys and girls. Since these studies are primarily quantitative, they focus on gender differences in outcomes, yet they do not address *how* or *why* certain variables may influence course decisions. Nor do they examine differences and similarities *among* girls.

Perceptions of ability

Perceptions of science ability have been found to be positively associated with adolescents' intentions to take science courses (Marsh & Yeung, 1997a; Tippins, 1991), to pursue science careers (Hollinger, 1985; Jacobowitz, 1983), and to the amount of effort they report exerting in science class (DeBacker & Nelson, 1999). Middle and high school girls, in general, reported less confidence in their scientific abilities than did boys (Jacobowitz, 1983; Khoury & Voss, 1985; Matyas, 1984; Post-Kammer & Smith, 1985; Tippins, 1991) despite achieving at equal (Jacobowitz, 1983) or higher levels on science assessments (Khoury & Voss, 1985). Thus, previous research has suggested that girls are pursuing science

classes and careers in fewer numbers than boys because of a lower sense of science ability.

However, as shown in Figure 1, girls are taking biology classes in equal or greater numbers than boys. This would suggest that their perceptions of ability in biology are equal to or greater than that of boys. Indeed, it has been found that among fourth to sixth grade students, girls do have equal perceptions of ability in biology, but that boys have a greater sense of competence in physical science (Andre, Whigman, Hendrickson, & Chambers, 1999). These findings suggest that it is important to assess beliefs of ability in *specific* science domains. In fact, Marsh (Marsh, 1992; Marsh & Yeung, 1997b) has found that perceptions of ability are *domain-specific*.

Moreover, Marsh and Yeung (1997a) found that perceptions of ability contributed more to taking a course when perceptions of ability were lower in other school subjects. As such, they predicted that students would choose to take classes in which they believed they were more capable *relative* to other classes. Thus, in regards to science, students would choose to take biology rather than physics if they believed that they were more likely to succeed in biology. Based on these findings, girls who *are* pursuing science classes and careers would be expected to have a high sense of ability in science relative to their other subjects.

Perceptions of task difficulty

Eccles et al. (1983) predicted that if students perceived a task or subject to be difficult, over time they would begin to believe that they were less capable of succeeding in that subject. As such, according to their model, perceptions of task difficulty influence perceptions of ability.

Few studies have specifically assessed gender differences in perceptions of science difficulty. This could be because perceived ability and perceptions of task difficulty have proven to be empirically indistinguishable (DeBacker & Nelson, 1999). In general, though, there have been mixed findings in regards to gender differences. Andre et al. (1999) found no gender differences among fourth to sixth grade students' perceptions of the effort they expended in their science classes. In contrast, Jones et al. (2000) found that sixth grade girls believed science to be more difficult to understand than did boys.

Goals and self-identity

Along with perceptions of task difficulty, Eccles et al. (1983, 1985) predicted that expectations for success and task-values were influenced by a student's short- and long- term goals and self-identity. In particular, they stated that the more one felt the need to identify with gender-typed roles, the less they would value activities that they perceived to be inconsistent with those roles. For

example, the value of science should be low for a girl who perceives it to be a masculine activity and who wants to affirm her feminine identity.

While few science studies have specifically addressed issues of self-identity, some have explored whether girls' career goals appear to be gender-typed. For example, Baker and Leary (1995) found in their study that while the elementary through high school girls asserted that women can and should pursue science careers, most of them personally did not aspire to science-related jobs, particularly physical science ones. The girls that did desire science-related jobs most often spoke of wanting to help people or animals. Physical science jobs were rejected because the girls could not see how they would be helping others.

Similarly, Post-Kammer and Smith (1985) found that eighth and ninth grade girls reported that they would be equally willing to consider both traditionally female and male jobs, except for the specific jobs of drafter and engineer. The girls were less willing to consider these two traditionally male jobs and showed less interest in them than any of the other jobs. Unfortunately, their reasons were not explored. Possibly their career goals were influenced by perceptions of engineering, a physical-science related job, as being a male domain, as the findings below suggest.

Perceptions of science stereotypes

Assessments of whether students believe science to be a male domain have revealed mixed findings. In general, though, they suggest that boys hold more stereotyped views of science than do girls. For example, findings from Draw-A-Scientist tests, which ask students to draw a picture of how they envision a scientist, have most often revealed girls and boys of all school ages as having stereotypic images (Kahle & Meece, 1994). They depict scientists as men and they describe science as a male domain. Yet, others have found that although both boys and girls, elementary through high school, hold stereotyped views of science, boys often rate science as more of a male domain than do girls (Andre et al., 2000; De Backer & Nelson, 2000; Jones et al., 2000; Khoury & Voss, 1985). A few studies have even found that while middle and high school boys express male-stereotyped views of science, girls do not (Greenfield, 1996; 1997).

More pronounced stereotypes emerge for the physical sciences than for life sciences when beliefs are assessed by specific science domains. For example, neither girls nor boys in the ninth and tenth grades perceived biology to be a male domain (DeBacker & Nelson, 1999). However, boys were found to have more stereotyped views of physics and chemistry (DeBacker & Nelson, 2000). Similarly, Baker and Leary (1995) reported that girls did not associate masculine stereotypes with the life sciences, only with the physical sciences. Moreover, they found that eighth grade girls in their study held stronger stereotypic views of physics than did girls in the fifth or eleventh grades. Thus, these findings by

science domain suggest that students hold more stereotypic beliefs about the physical sciences than the life sciences and that for girls, at least, beliefs about physics may vary with age.

Despite the above findings of girls and boys holding stereotypic beliefs in regards to the physical sciences, few studies have explored whether or not their stereotypic beliefs influence course and career choices. In the one study that has addressed this, stereotypical beliefs were not found to influence the science enrollment plans of either male or female tenth grade students (Khoury & Voss, 1985). Thus, it is possible that even if girls hold stereotypic beliefs of physics as a male domain, their beliefs may not influence their course choices.

However, Eccles et al. (1983) distinguished between beliefs of school subjects versus careers. For example, they hypothesized that even if girls did not stereotype their math classes as masculine, their perceptions of math careers as masculine would lower their utility value of math and affect their career goals. As such, it is important to assess not only girls' perceptions of each science domain in regards to their classes but also their career goals.

Perceptions of parental/peer support

In general, it has long been shown that peer group attitudes are related to educational aspirations at the middle and high school level (Ide, Parkerson, Haertel, & Walberg, 1981). However, there is evidence that suggests that parents

have a stronger influence on adolescents' aspirations than peers and that their influence increases, relatively, from ninth to twelfth grade (Davies & Kandel, 1981).

In regards to science, Baker and Leary (1995) found that among their sample of elementary through high school girls, parents overall did not have an influence on the girls' interest in science or their career aspirations. An exception was that parents influenced the girls who were considering physical science careers, in particular. In general, the girls rejected laboratory-based and physical science careers, but the few that aspired to physical science careers said they did so because of a parent's influence. They indicated that positive experiences with their parents involving science influenced them to consider science as a career option. Khoury and Voss (1985) found that support from fathers, but not mothers, influenced tenth grade girls' science enrollment plans. Baker and Leary (1995) did not distinguish between support from mothers or fathers. These findings suggest that parental support, and maybe father support in particular, is important for girls to consider physical science careers.

Likewise, there is some evidence that peer support is important for pursuing a physical science career, but not as important for the life sciences. Jacobs, Finken, Griffen, and Wright (1998) found that peer support was positively related to high school girls' preference for physical science careers, but not life science careers.

Lastly, it is possible that peer support to pursue science varies by grade. The eighth grade girls in Baker and Leary's (1995) study indicated that they believed that their friends would not be supportive of a girls' career choice in science, whereas eleventh grade girls believed their friends would be supportive.

Task-values

Eccles et al. (1983) suggested that a class can have 1) intrinsic value, whereby one inherently enjoys the class, 2) utility value, which is determined by the importance of the task to future goals, and 3) attainment value, which is defined as the importance of doing well in a class. However, researchers who have explored the attainment value of certain tasks have been unable to empirically distinguish between attainment and utility values (DeBacker & Nelson, 1999; Eccles et al., 1983). Thus, interest and utility have been more commonly explored in the research literature.

In general, attitudes have been found to be subject-specific (Andre et al., 1995; Marsh and Yeung, 1996). Students' interest in science classes and careers seems to depend upon the science domain being assessed. In terms of class interest, high school boys have tended to show more of an interest in the physics curriculum while high school girls have shown more of an interest in biology (Benbow & Minor, 1986; Steinkamp & Maehr, 1984; Weinburgh & Englehard, 1994). Elementary and middle school students have not shown gender differences in their liking of science classes or of specific science domains (Andre et al., 1999;

Greenfield, 1997). Thus, interest in science classes and careers depends upon the science domain being assessed and the age of the students.

In terms of career interests, it is often reported that boys have a greater interest in science careers than do girls (Benbow & Minor, 1986; Hill et al., 1990). However, when the differences are assessed by subject-specific preferences, such as biology- versus physics-related careers, the only consistent difference found is girls' lesser interest in physics-related careers (Baker & Leary, 1995; Jacobowitz, 1980).

These findings suggest that girls' interest in biology rather than physics plays a role in their differential participation in science classes and careers. Yet, contrary to the predictions of Eccles' model that interest influences course choices, interest has only been found to be weakly associated with the science course choices of tenth grade girls and boys (Khoury & Voss, 1985). However, it was found to be a strong, subject-specific, predictor of career considerations (Jacobs et al., 1998; Post-Kammer & Smith, 1985). Thus, interest may not be as strongly associated with course choices as it is with career considerations.

It is also possible, however, that the weak association reported by Khoury and Voss (1985) is reflective of the relationship between general science interest and specific course choices. Jacobs et al. (1998) and Post-Kammer and Smith (1985) found that the relationship between interest and career considerations was subject-specific, such that an interest in biology predicted an interest in health professions but not physics-related careers. Similarly, an interest in physics was

predictive of an interest in physics-related careers but not health professions. If the relationship between interest and course choices were also found to be subject-specific, a weak association between general science interest and specific course choices, such as that found by Khoury and Voss' (1985), would be expected.

In contrast to gender differences in interest in science being found among high school students, gender differences in utility have only been found among middle school students. Specifically, a lower percentage of eighth grade girls than boys have reported thinking that science will be important for their future (Catsambis, 1995; Lee & Burkam, 1996), while no differences in utility beliefs were found among tenth grade students (Khoury & Voss, 1985). Moreover, utility beliefs have been found to be more associated with the science course choices of high school students than middle school students because high school students often reported that taking science is necessary as a prerequisite for college admission (Baker & Leary, 1995; Greenfield, 1996). In fact, believing that science is useful has been found to be the most important consideration in tenth grade girls' plans to enroll in science (Khoury & Voss, 1985). These findings suggested that utility might be an important factor for high school girls in deciding whether to take science, but not for middle school girls.

Based on these findings from studies of task-values, high school girls, in general, expressed greater beliefs of science usefulness than middle school girls, but mainly in regards to fulfilling college prerequisites. They also reported a greater interest in biology than physics by high school.

Overall, findings from science education research support the relevancy of the variables in Eccles' model for explaining girls' persistence in science. I summarize key findings below to show how my research questions built upon these previous studies.

Research questions

In addition to providing insight into variables that might be influential to girls' course and career decisions, the above findings from the science education literature highlight the need for research that 1) is subject-specific, 2) explores developmental differences, and 3) utilizes qualitative methods to address issues of how and why, from the students' perspective, these variables, among others, might work together to influence persistence and choice.

For example, findings from above studies revealed that students' interest and perceptions of ability in science classes and careers were dependent upon the science domain being assessed, with girls having reported lower perceptions of ability and interest in physics than biology (Andre et al., 1995; Baker & Leary, 1995; Benbow & Minor, 1986; Jacobowitz, 1980; Steinkamp & Maehr, 1984; Weinburgh & Englehard, 1994). Moreover, how students' perceptions of ability and task-values influenced their choices was suggested to depend upon how they perceived their abilities in relation to other school subjects (Marsh & Yeung, 1997a). Taken together, these findings emphasize that it is important to explore

how girls feel about *specific* science course and careers *compared* to their other classes. More often, research has only explored students' beliefs in one domain at a time. Because I asked the girls in my study about their beliefs in *all* of their classes I was able to explore their feelings about science relative to their other subjects.

Findings from the above studies also revealed developmental changes among variables within the domain of science for girls. For example, Greenfield (1997) reported that girls in elementary school liked science more than girls in middle or high school and that middle school girls reported lower perceptions of ability in science than did elementary or high school girls. Baker and Leary (1995) found that eighth grade girls in their study held stronger stereotypic views of physics than did girls in the fifth or eleventh grades. Science utility beliefs were also found to be more associated with the science course choices of high school students than middle school students (Baker & Leary, 1995; Greenfield, 1996). Findings such as these suggest that it is important to explore developmental differences that may influence how course choices are made across the school years. Because I included girls from elementary through high school in my study I was able to address developmental changes such as these.

Lastly, findings from the mainly quantitative studies conducted in the domain of science examined girls' feelings toward science, usually in comparison to boys, but few explored the relationship between those beliefs and academic decisions. They failed to explain *how* and *why* girls' beliefs might work together

to influence their course and career decisions. Exploring the girls' understanding of how their beliefs worked together was a focus of my study.

Specifically, my study was designed to investigate the following questions:

1. *How and why do the pre-adolescent and adolescent girls in my study make their decisions to persist, or not, in specific science careers and the courses leading up to them?*
    a. *How do these girls perceive that the variables in Eccles' model, among others, influence their decision-making process?*
    a. *In what ways, if any, are there differences and similarities in how these girls, when grouped by age, make their course decisions?*
1. *How might an understanding of how and why these girls make course and career decisions inform Eccles' model of academic choice?*

By using qualitative methods to address the above questions I explored a wider range of influences on girls' academic choices than previous quantitative studies that were limited to predetermined variables. As such, I was able to provide a fuller picture of how and why the girls in my study made their decisions to persist, or not, in specific classes and careers.

Lastly, by exploring whether and how the variables in Eccles model, among others, influenced the decisions made by the girls in my study, I assessed whether her model explained their decisions in regards to science. Thus, the findings revealed in this study extend our understanding of Eccles' model as it relates to science persistence.

After outlining my methodology in Chapter two, I discuss my findings in regards to Eccles model more fully in Chapter three. In that chapter I focus on the girls' multiple reasons for choosing which classes to take in an effort to illustrate how their beliefs worked *together* to influence persistence before proceeding to a more detailed analysis of each variable. In Chapter four I more fully discuss the girls' interest in their classes and how their interest influenced their class and career choices. In Chapter five I outline the classes they perceived to be useful to their future goals and in Chapter six I discuss their perceptions of ability. Lastly, I illustrate how my findings have implications for educational practices in Chapter seven.

Chapter Two
Methodology

In my introduction and review of the science education literature in Chapter 1, I argued that there are gaps in the science education research. Specifically, much of the previous literature has examined who drops out of the classes leading up to science and engineering careers, and when, by comparing the course enrollment patterns and career choices of girls to boys. Girls are portrayed as dropping out of science in greater numbers and sooner than boys. Their exodus begins in the middle school years, continuing through the high school years and beyond, and is greatest in the physical sciences. Because the research has primarily explored the differences between girls and boys, rather than examining differences and similarities *among* girls, little is known about why some girls choose to pursue science, particularly the physical sciences, rather than drop it.

Moreover, research examining factors believed to be influential to course and career choices, such as perceptions of ability and interest in a subject, has also focused on gender differences in outcomes. Thus, for example, girls are seen as being less interested in science than boys and less sure of their abilities. By making gender comparisons of quantitative outcomes more is known about how girls and boys differ in regards to various variables than about *how* or *why* these variables may influence their decisions to persist in the sciences. Little is known

from the *girls' perspective* how their beliefs and values influence their course and career decisions and why.

My research addressed these gaps in content and methodology by: 1) including girls who are pursuing science experiences, particularly physical science ones, 2) focusing on elementary through high school girls as they begin to consider their class and career choices, and 3) presenting girls' beliefs and values, in their own words, to explain how and why they make their course and career decisions. Specifically, my main research question addressed how and why the girls in my study made their decisions to persist, or not, in specific science careers and the courses leading up to them.

Because I wanted to learn about how and why girls make decisions about classes and careers, from their perspective, I chose to use semi-structured, in-depth, interviewing as my primary method of investigation. As Maxwell (1996) explains, qualitative methods are especially suited for "[u]nderstanding the *meaning*, for participants in the study, of the event, situations, and actions they are involved with and of the accounts that they give of their lives and experiences" (p.17). He also emphasizes the usefulness of qualitative methods when trying to understand "the *process* by which events and actions take place" (p.19), such as *how* girls make their class and career choices.

In regards to science education in particular, researchers have specifically called for studies using qualitative methods to elaborate upon quantitative findings (Krockover & Shepardson, 1995; Maehr & Meyer, 1997). Maehr and Meyer

(1997), for example, note that questionnaires have been the primary method of investigation in past science education studies, yet it is often unclear how students interpret such questions or what events they are recalling in their responses.

In this chapter, I outline how I selected my participants and I provide a brief summary of the major characteristics of each girl in the study. I describe how I collected and analyzed the data, including individual interviews, focus groups, and observations of the camp. Lastly, I discuss the limitations and validity concerns I faced with this study.

Curriculum and goals of the science camp

The girls that participated in this study were enrolled in a physics-based, engineering, summer camp offered by the College of Engineering at a university in the Boston area for a week during July of 2000. I chose to invite the female students at this camp to participate in my study because the camp satisfied my criteria of wanting middle and high school aged girls who were actively taking part in physical science experiences. The annual camp was unique in that it offered engineering-based experiences to middle and high school girls for five days, six hours a day. As such, participation in the camp provided girls with the rare opportunity to develop and explore an interest in the physical sciences through engineering.

The curriculum of the camp allowed for active explorations of physics and engineering concepts through building with LEGO® bricks. As the Director of the camp explained to me in an interview, LEGOs were chosen as the main manipulative because they are not intimidating to students. She elaborated that,

> …[K]ids aren't scared to pick up a LEGO and snap it to something else. And so we thought what a great way to get kids to design and build and test like an engineer does. Give them a simple problem, like how do you make a vehicle that will go the furthest, and then you design and build a test, you retest, you theorize, you discuss the difference between your design and someone else's.

Thus, while working on design projects, students explored science and physical principles. In addition to building with LEGOs, they were taught and encouraged by graduate school students in the engineering program at the university to design programs on the computer that allowed their LEGO projects to move and/or play music.

The goals of the camp, as explained to me by the Director, were 1) to develop students' competence in structural building and in understanding the physics of design, 2) to increase their confidence and perseverance in finding solutions, 3) to gain a better understanding of what engineering is, and most importantly to the Director, and 4) to have fun while learning.

Sample selection

Each year the camp is available on a first come, first serve basis to students entering grades five through ten for one of two sessions.[1] The first session is open only to girls while the second session is open to boys and girls. Seventeen girls were enrolled in the camp during the summer of 2000; fifteen girls attended the all-girls session and two attended the co-ed session. I asked all of these girls to participate in my study by sending them (and their parents) a written invitation before the start of camp (Appendix A). Thirteen chose to participate and signed written consent forms. Participation for each was voluntary and contingent upon a parent's approval. Twelve of these girls attended the all-girls session and one went to the coed week.

Due to logistical reasons, such as the distance some of the girls lived from Boston (including New Hampshire and Connecticut) and their busy after-school schedules, the remaining four girls that attended the camp chose not to participate in my study. For these same reasons, one of the thirteen girls who did sign up was unable to complete the study since I was only able to interview her once. Thus, twelve girls made up my final sample.

[1] However, if older students express an interest in attending, and there is space for them, they will be accepted. This happened during the summer of 2000, the year in which I invited campers to participate in my study. As a result, one girl entering the eleventh grade was accepted to the camp and chose to participate in my study.

Description of the girls

All of the girls are Caucasian, except for one, Amrita, whose parents are Indian. All attended the summer camp during July 2000 for the first time, except for three girls, Sophie, Courtney, and Sunny, who had also attended it the previous summer. Thus, as shown in Table 1, the main descriptive characteristics by which the twelve girls in the study varied included age and the type of school they attended. Each girl chose a pseudonym for reasons of confidentiality.

The girls attended a variety of different schools, except for the three fifth graders who all attended the same elementary school. While most of the girls attended their local, coeducational, public school, three girls attended independent, religiously affiliated schools, two of which were single-sex. There did not appear to be any consistency, however, in how the schools were structured by grade level. Thus, differences in camp participation by grade, such as the greater number of participants in the seventh grade than from any other grade, did not seem to be related to school structure.

Moreover, because only two girls, Rachel (an eleventh grader) and Berta (a fifth grader), heard about the camp either from a teacher or at their school[2], it did not seem that school factors accounted for the differences in grade participation. As I show in Table 1, most of the girls instead heard about the camp from their parents. Because this suggests that there was a high degree of parental support for

[2] Berta learned about the LEGO camp at a fair being held at her school to advertise summer programs.

pursuing science experiences among this group of girls, I discuss it in more detail in the section on limitations and validity concerns.

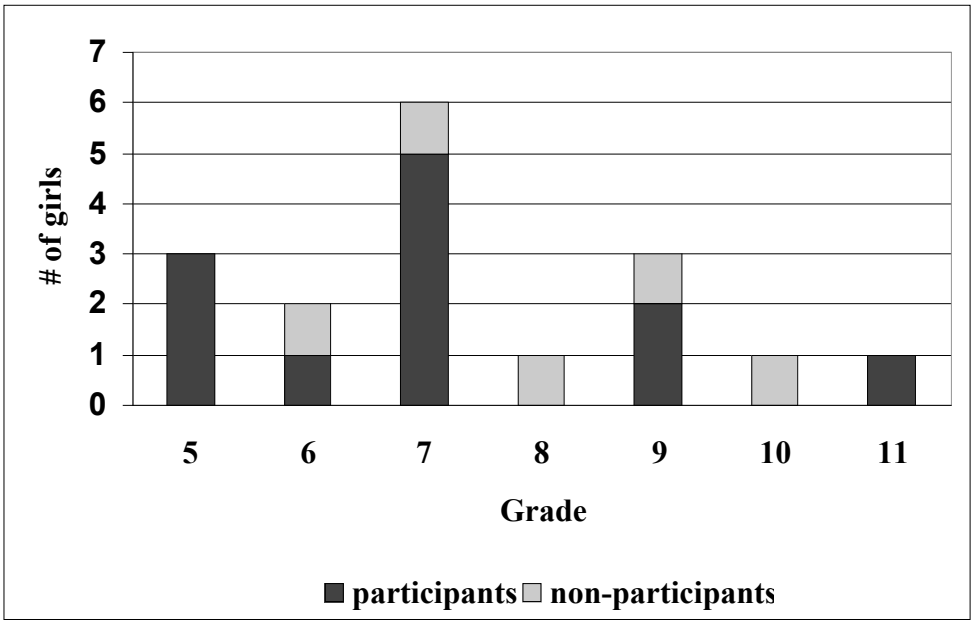
Table 1: Descriptive characteristics of study participants (by pseudonym).

Pseudonym	Grade	School Description	Heard about the camp from
Berta	5th	Public school, grades 3 - 5	School
Beth	5th	Public school, grades 3 - 5	Parent
Laura	5th	Public school, grades 3 - 5	Friend
Sophie	6th	Jewish school, grades 1 – 8 (4 – 8 single-sex)	Parent
Amrita	7th	Public school, grades 6 - 8	Parent
Courtney	7th	Quaker school, pre-school - 8	Parent
Katie	7th	Public school, grades K - 8	Friend
Hannah	7th	Public school, grades 7 - 12	Parent
Marie	7th	Public school, grades 6 - 8	Parent
Lisa	9th	Public school, grades 7 - 12	Parent
Sunny	9th	Public school, grades 9 - 12	Parent
Rachel	11th	Catholic school, grades 5 – 12, all girls	Teacher

Lastly, the girls varied in grade level from entering fifth grade to entering eleventh grade during the 2000-2001 school year. At least one girl from each of the grades represented at the camp chose to participate in my study, except for the eighth and tenth grades (Figure 3). As such, my sample satisfied my criteria of

wanting a range of girls, beginning in upper elementary and continuing through high school. Specifically, there were four girls in the upper elementary grades (grades 5-6), five in middle school (grade 7), and three in high school (grades 9 and 11).

Figure 3: Total number of female campers (N=17) compared to study participants (N=12), by grade level during the 2000-2001 school year.



Data collection

Data collection consisted of four main components: 1) two or three individual, qualitative interviews with each of the student participants conducted over the span of a year, in May 2000, July 2000, and March 2001, 2) three focus group in which each student participated once during the camp session in July 2000, 3) observations of the five days of camp in their entirety, and 4) individual,

qualitative interviews with the camp director (in May 2000) and one counselor (in July 2000).

The interviews

The three, individual, qualitative, student interviews were the main source of data. They were longitudinal in design in order to follow the decision-making process of each girl over time. As noted by Dornyei (2000), it is necessary and important to explore student motivation over time to assess how it fluctuates and develops. Thus, I conducted the first interviews in May of 2000, the second interviews in July of 2000 during and immediately after the end of camp, and the third interviews in March of 2001. Each was semi-structured and, on average, one hour in length. For each interview, participants met with me either at their home, at Harvard's Gutman Library, or at the camp for the July interviews, depending on their preference and logistics. All of the interviews were recorded on audiotape and transcribed by me.

As shown in Table 2, four of the twelve girls (Berta, Amrita, Katie, and Rachel) were only interviewed twice because they had not yet signed up for the camp when the first interviews were conducted in May. For these girls, I conducted a slightly longer interview in July that incorporated questions from both the first and second interview protocols.

Table 2: Schedule of individual interviews by participant.

		INTERVIEWS		
Participant	Grade in 2000-2001 School Year	May 2000	July 2000	March 2001
Berta	5th		X	X
Beth	5th	X	X	X
Laura	5th	X	X	X
Sophie	6th	X	X	X
Amrita	7th		X	X
Courtney	7th	X	X	X
Hannah	7th	X	X	X
Katie	7th		X	X
Marie	7th	X	X	X
Lisa	9th	X	X	X
Sunny	9th	X	X	X
Rachel	11th		X	X

There were few differences in the responses of the girls interviewed twice compared to those interviewed three times. The main difference was that the girls who I interviewed for the first time in July had difficulty at times describing what they had done in their classes the year before, often saying things such as, "I don't remember." As such, their descriptions of their classes tended to be less rich compared to those of the girls whom I talked with in May. However, while they may have related fewer details, many of them were still able to recall their affective responses to their classes and teachers of the year before (e.g. how much they liked their teachers or found their classes to be boring). Given that my primary purpose for the interviews was to explore their feelings towards their classes, as I describe more fully below, more than to learn about the specific

activities that they did, I believe that the data I collected in the two interviews was comparable to that from the three interviews.

The protocols for the three interviews were informed by the results of my previous pilot studies as well as by Seidman's (1998) model for in-depth interviewing. Each consisted of open-ended questions to encourage multiple ways of sharing (Appendix B). I did not necessarily ask the same questions for every girl nor were questions asked in the same order. Instead, the interviews were flexible and evolved from each girl's responses.

I had piloted my questions prior to this study with three groups of girls: 1) eighth grade girls enrolled in an engineering-based physics class at an independent, pre K-8 school in Cambridge, 2) twelfth grade girls in a calculus-based, advanced physics class at an independent, pre K-12 school in Cambridge, and 3) the female campers who attended the engineering camp the previous summer. These experiences taught me to broaden the way I worded my questions. For example, I learned that by first asking the girls to describe all their classes and then to tell me how they "felt" about each elicited more open and in-depth responses than asking them how they "liked" their science classes.

The purpose of the first interview was to explore the girls' current feelings about science within the context of their past feelings towards science and relative to other subjects. Thus, in addition to asking them how they felt about all of their classes, I asked them to specifically describe their past and current science

experiences, both in and out of school, and how they came to be participating in the science camp.

The focus of the second interview was the girls' experiences at the summer camp and their perceptions of its value. Furthermore, I asked them about their expectations for success and enjoyment of science during the upcoming school year and began to explore their career aspirations.

During the third interview I again asked the girls about their current feelings towards science, relative to their other subjects, and their intentions to study science or not in the future. By asking them similar questions to the first interview I was able to compare their responses from one school year to the next. This allowed me to explore whether their feelings toward science and their other classes, as well as their career aspirations, had changed and why.

For all of the interviews, in order to minimize the risk that the girls would respond to my questions in ways that they believed would please me, I emphasized to each girl before every interview that there were no right or wrong answers and that I wanted to learn about *her* opinion. Additionally, at the end of each interview, I asked each girl whether there were topics that we had not discussed which she felt were relevant to her course choices and career aspirations.

I believe that the girls felt comfortable answering my questions. During the member checks (Maxwell, 1996) at the conclusion of the last interviews each of the girls readily gave me feedback when I presented my views on their beliefs. They even corrected what I said. I do not believe that they would have done so if

they did not feel comfortable sharing their opinions with me. Moreover, several of the girls asked me about my study and my career plans which suggested to me that they felt at ease. I discuss this more in the limitation and validity section at the end of this chapter when I address reactivity.

Other sources of data

Other data was collected in order to provide a more thorough understanding of the information gathered through the individual interviews as well as to provide contextual information. Thus, the information gathered from 1) the focus groups, 2) my observations of the camp and individual interviews, 3) counselor interviews, and 4) member checks with each girl provided a means of triangulating the data. Maxwell (1996) describes triangulating data collection as "collecting information from a diverse range of individuals and settings, using a variety of methods" (p.75). He explains the purpose as 1) helping to reduce the risk that conclusions will be limited by using only one method and 2) allowing a better assessment of the validity and generality of the interpretations developed from the data (which I discuss more in the validity section at the end of this chapter). Below, I more fully discuss my reasons for including these additional sources of data and I provide examples of what I learned from each.

Focus groups

I conducted and recorded with audiotape three group discussions during the camp, once with each age group (grades 5-6, 7, 9-11) for approximately one hour. I grouped the girls by age in order to better address my research question concerning whether there are age differences in how these girls make their course decisions. The discussions were designed to spark debate on subjects that the participants may have found difficult to talk about in individual interviews due to a lack of knowledge or previous contemplation (Morgan, 1997), such as what they thought they would learn about in a physics, chemistry, or biology class. Additionally, I explored topics that were not the focus of the individual interviews, such as coed versus single-sex science instruction, in order to assess the girls' perceptions about their influence on their experiences at the camp.

For example, I asked the girls that were attending the all-girls session of the camp whether they would have also come to the coed session and why. In general, they expressed a preference for the all-girls session. However, they told me that it was not because they did not want to work with boys, but rather that they would not want to be the *only* girl. They feared that if they had signed up for the coed session they might have been the only girl at the camp and they worried that if so they would be lonely. I revisited this issue of needing a friend at the camp with each girl on an individual basis during subsequent interviews. I discuss the educational implications of their desire to attend the camp with a friend in the last chapter.

Participant observations and counselor interviews

I observed the girls during the entirety of the summer camp (the camp ran for 5 days, approximately 6 hours/day) and took written field notes. My interactions with the participants at the camp helped me to build a rapport with them and to understand the summer program. Thus, my observations provided a descriptive context of the girls' experiences with engineering and physics that I used to spark discussions in subsequent interviews. As a source of triangulation, they also served as a validity check for my interviews. For example, Courtney told me that she did not enjoy building with LEGOs during the first interview, but during the camp she spent five days building a chicken and showing it to counselors and campers. Because she showed it to so many people I believed that she was proud of her work. Moreover, she said that if she could she would return the following summer.

I also took observational notes and wrote analytic memos (Maxwell, 1996; Miles & Huberman, 1994) before, during, and after each interview with the girls in order to compare what was being said to how it was said. For example, I observed and noted what they were doing with their bodies while they talked, such as leaning forward and making eye contact with me. Actions such as these suggested to me that they were interested in what they were describing. When they paused during a response and avoided eye contact I interpreted it as meaning that they were having difficulty answering my questions. Often when I asked the elementary and middle school girls how they thought what they were learning in

their classes would be useful to them in the future, if at all, they would start and stop their responses several times before answering completely or saying they did not know. I describe more in Chapter six how I interpreted this to mean that they had not often thought about how their classes would be useful to them on a personal level.

My interview with the camp director also provided me with a descriptive context for the camp, including her goals for what the students would learn and her rationale for the curriculum and methods of instruction (Appendix C). Similarly, I invited two counselors, in writing, that I felt had interacted with the most girls based on my observations to be interviewed. Only one on the counselors chose to participate in my study. I interviewed her once immediately after the conclusion of camp for an hour (Appendix D). The purpose of the interview was primarily to compare her perceptions of the girls' experiences at the camp with mine and to explore any similarities and differences in our views.

Member checks

At the end of the last interview (which for eight of the girls was their third interview) I shared with each girl in a member check my interpretations and emerging theories about what was important to them in making their class and career decisions. Each girl was invited to respond to and elaborate upon my ideas to make sure that I was telling *her* story correctly. All of them agreed with my findings and several elaborated upon them, particularly the older girls, which

made me believe that they were comfortable with this process and capable of participating in my analysis. Their feedback provided another means of checking my interpretations as I discuss in the validity section at the end of this chapter.

Data analysis

Analyzing the data was an ongoing, cyclical process of examining the data, interpreting it, reexamining the data, and then reinterpreting it. Throughout the analysis phase I utilized both single-case and cross-case methods of analysis. At first I examined the data for each girl separately (i.e. single-case analyses) in order to try and understand her perceptions of the value of her classes and her ability to succeed in them, among other things. Then I utilized cross-case methods of analysis in order to make comparisons *across* the girls and to note any similarities and differences. I describe these various methods in detail below.

Single-case analyses

To begin, I transcribed all of the audiotape recordings of the individual interviews with the girls, including noting any nonverbal sounds (such as sighs or laughter) and pauses in speech. I then coded each interview for both etic and emic concepts (Strauss & Corbin, 1998). Etic concepts were generated from Eccles' model as well as from previous research in science education. For example, "interest" was a theoretical concept that I used to categorize the intrinsic value that

the girls associated with various classes. Emic concepts were ones that emerged inductively from the data, such as several of the girls' belief that their teachers' personalities influenced their liking of a class.

Codes were added and/or revised throughout the analysis period as themes began to emerge and be refined (see Appendix E). Previous observations and interviews were reread for codes that emerged in later interviews. Because I was interested in how the girls' perceptions changed or not over time, I took care to note when codes first emerged.

I crafted profiles (Seidman, 1998) from the codes, themes, and analytic questions that emerged from the three (or two) interviews of each girl in order to facilitate my understanding of how each girl's beliefs and feelings may have changed over time and how those beliefs influenced her course choices and career aspirations. These analyses helped me to answer the first part of my research question, namely what was important to each individual girl in her class and career choices. I was able to determine for each girl, for example, whether her interest, her beliefs of ability, the usefulness of her classes, or her perceptions of her parents or friends' beliefs influenced her decisions.

Cross-case analyses

After completing the above single-case analyses for each girl, I began cross-case analyses in order to address the second part of my research question

concerning whether there were differences and similarities in how the girls made their course decisions when grouped by age. To explore codes and themes that emerged across cases, I developed matrices for each category (Miles & Huberman, 1994; Strauss & Corbin, 1998). For example, I created a display of how each of the girls talked about the perceived value of their science classes. Additionally, I used graphs as a descriptive means of assessing to what extent themes were common or not across cases (i.e. how many girls believed that math was their most useful class).

Because I was interested in investigating the possibility of variations in beliefs by age, in addition to other variables, I then created matrices based on the three categories of grades to analyze themes across age. This allowed me to explore, for example, whether girls in middle school described their perceptions of ability differently than girls in high school.

In order to compare the *processes* of decision-making, I conducted cross-case analyses of the profiles. Because the profiles were designed to illuminate the broader connections between each girl's feelings and beliefs, they were crucial for assessing how the beliefs worked *together*, if at all, to influence persistence. Again, I looked for patterns by age to address such questions as whether middle school girls spoke about the role of interest in their decisions differently than high school girls.

Writing memos (Miles & Huberman, 1994, Strauss & Corbin, 1998) about each theme that emerged helped me explore relationships and then to develop a

grounded theory to explain how and why these girls made their academic choices. In Chapter three I compare the grounded theory to Eccles' model and discuss similarities and differences.

Limitations and validity concerns

In this section I address validity concerns of 1) researcher bias in regards to interpreting the data, 2) reactivity, and 3) the generalization of my findings to other samples and settings.

Interpretation of my data

In regards to validity concerns about the coding and interpretation of data, I incorporated three measures to minimize researcher bias (see Maxwell, 1996). First, my interviews with the counselors at the camp allowed me to discuss my observations of the girls at camp and to compare theories for their behavior. Similarly, I also shared my emerging theories throughout the data analysis phase with an advanced doctoral student at The Graduate School of Education at Harvard University who was trained in qualitative research methods and theories of achievement motivation and who read several of my transcripts and coded them. I then used these discussions and her coding and alternative interpretations as a basis for further questioning with the girls. For example, the doctoral student and I both saw evidence in some of the transcripts from the first interviews of the

influence of teachers' on the girls' class interest. In order to explore this possibility with all of the girls I included questions about their teachers in the second and third interviews such as, "would you want to take this class again next year if you had a different/same teacher?" I discuss their responses in regards to teacher influence on their interest in Chapter four.

Third, and most importantly, I conducted member checks with each girl, as described in the data collection section, to elicit their feedback on my interpretations. With all of these methods I not only tested my interpretations but I also incorporated alternative interpretations in my writing. For example, throughout the following pages I made clear when I was presenting beliefs as stated by the girls or sharing my own theory based on discrepant evidence (Maxwell, 1996).

Reactivity

Maxwell (1996) defines reactivity as "the influence of the researcher on the setting or individuals studied" (p.91). Throughout the following chapters I have attempted to illustrate when and how I may have influenced the participants in this study. More specifically, I believe that I affected their responses in that many of them, particularly the elementary and middle school girls, had not previously given much thought to how they would choose between classes. At the time of the study most of the younger girls did not have a choice in what they could take.

When I asked them to pretend that they had a choice, or to consider what they might want to take in future years, it was a novel idea for many of them. While all of the girls had thought about which classes they liked, and why, it was clear based on their responses in the first interview compared to the last interview that they had not previously considered other factors as having an influence on their class decisions or career aspirations.

For example, as I discuss in Chapter five, the girls had not seemed to consider which classes might be personally useful to them in the future and why until I asked them. In the first interview they often paused before answering my question about which classes they believed, if any, would be useful to them in the future. By the last interview they seemed to have given more thought to the question, or at least anticipated it, because they answered it more readily.

An example from Amrita shows how the girls seemed to consider multiple reasons for choosing their classes for the first time. In the first interview Amrita said that interest would be her main consideration, but by the member check during the third interview she decided that the usefulness of her classes, particularly as dictated by her parents, would be most important. While it is possible that her views changed from the first year to the next, I believe that it is more likely that my questioning caused her to consider the order of her criteria for choosing classes for the first time. It was not until the member check during the last interview that I explicitly asked her to put in order the factors that she believed would influence her class and career choices. At first she said that would choose a

class based on the order of "How valuable, how hard, how much I like it." But then when I asked her whether there were any other factors that she believed were important, she actively rearranged factors by order of importance while responding to me. She said,

> What my parents think. Definitely. That would probably come in somewhere between the second and third, how hard and how much I like it. Yeah, it would come before how much I like it. Actually that would come first…Yeah, actually first I would decide what they want and then valuable and how much they want, they would probably tell me how valuable it would be. And then how hard it was and my friends would be last.

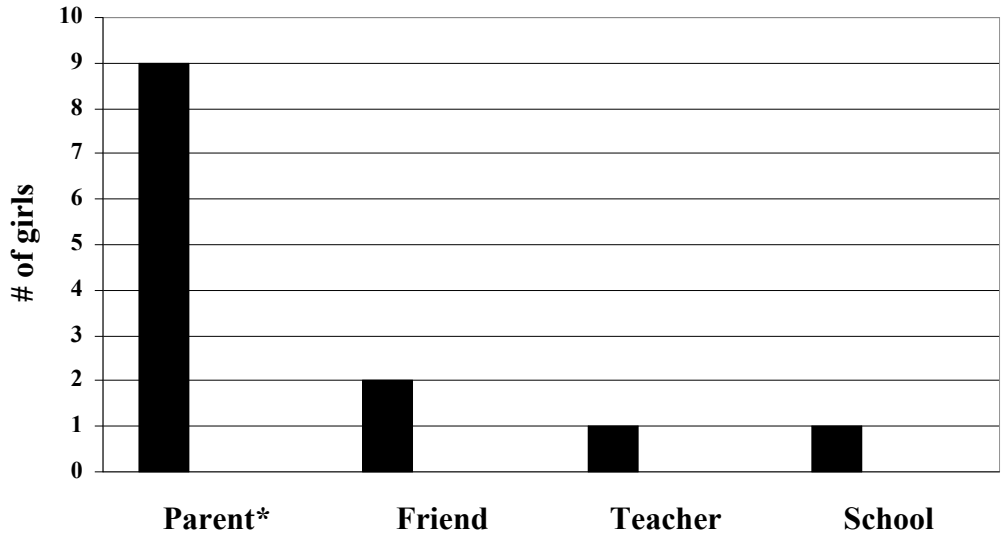
To me, Amrita was considering the influence of various factors on her class decisions for the first time while she actively rearranged their importance. As this example illustrates, it is likely that my questions had the effect on the girls of having them consider for the first time what reasons *they* would have for choosing to take classes in the future. Before each interview I purposely had told them that I was interested in *their* views and that there were no right or wrong answers to my questions.

Generalization of findings

Because I used a select sample the extent to which my findings can be generalized to other settings and samples is limited. My sample consisted of girls who had *chosen* to participate in the physics-based engineering camp. I intentionally chose this group of girls on the premise that their participation

indicated an interest in science. However, their participation also reflected a high degree of parental support for science. Parents were often the ones who heard about the camp, presented it as a choice for their daughters to attend, and paid the tuition. In Figure 4, I show the predominant influence of parents, particularly mothers, on girls' participation in the camp.

Figure 4: How the girls first heard about the camp



Note: Parent includes 7 mothers and 2 fathers.

For example, Courtney attributed her participation in the camp to her mother's influence. She said, "I usually don't realize that a lot of things I like are science and when my mom saw [the LEGO camp brochure] she thought it would be something that I like because it um sounded interesting." Courtney did not believe that on her own she would have decided to go to the LEGO camp because

she did not usually like things related to science. Her mother convinced her that she would like the camp and should attend it.

Similarly, Sunny's mother told her about the camp and said that she thought she would like it. Sunny explained, "Well [my mom] told me that you know there was a camp going on that it was LEGOs and she thought I would like it and if I wanted to go, I could." In contrast to Courtney, however, Sunny was interested in what she would be doing at the camp and thus volunteered to go.

In addition to supporting camp participation, many of the parents of the girls in this study were employed in science-related jobs, such as engineering and computer programming (see Table 3). Several of the girls said that they felt supported and encouraged to pursue science experiences because of their parents' involvement in science fields.

Three girls in particular, Sunny, Beth, and Amrita, all relayed instances in which their parents, all engineers, influenced their beliefs about science classes or careers to pursue. Sunny said that her parents would make her take four years of math and science in high school regardless of fewer school requirements. Beth believed that math and science were important classes to do well in because her dad was an engineer. When I asked her which classes, if any, she believed they would want her to do particularly well in she answered, "Well for my parents? Science and math [are important classes to do well in]….My dad would be really mad [if I brought home an average grade in science or math]….Because well my

dad he does science." And Amrita planned on becoming an engineer because her parents told her that she had to before pursuing any other career.

Table 3: Occupations of participants' parents

FATHERS	MOTHERS
Mechanical Engineer/Educator (2)	*Computer Programmer/Software Designer*
Mechanical Engineer	*Civil Engineer/Computer Scientist*
Electrical Engineer	*Mechanical Engineer/Educator*
Computer Programmer (2)	*Nurse*
Educator	Educator (2)
Owns business	Accountant (2)
Accountant	Office Assistant
Works at communications company	Works at a newspaper
Stay-at-home dad	Stay-at-home mom
Unknown	

Note: Science-related jobs are in italics

Therefore, although I discuss in more detail the influence of parents on the girls' attitudes and beliefs towards science throughout the following chapters, it is important to note here that many of the girls in this study experienced strong parental support for science. As such, their attitudes and beliefs towards science may not represent the general population of students. Caution should be exercised in making broad generalizations based on these findings.

Nevertheless, as I describe in the last chapter, the ways in which the girls of this study made sense of their class and career choices revealed ways in which educators, parents, and career counselors can help promote all girls' interest in the sciences. Additionally, the findings from this study served as a basis of

comparison to previous research and raised questions about science participation that can be used in further explorations with other samples. Throughout my writing I highlighted these connections. Finally, the grounded theory that I developed based on the girls' beliefs served to inform and extend Eccles' model of class choice, as I outlined in the next chapter.

Chapter Three

Multiple Reasons for Class Choices

All of the girls but Sophie, a sixth grader, explicitly or indirectly discussed more than one reason for their current and/or future class choices. As such, I feel that it is important in this chapter to present an overview of the girls' perceptions of how multiple factors worked *together* to influence their decisions before presenting a more in-depth discussion of the individual variables in Chapters four through six. Because I found age-related differences in the reasons the girls gave for the classes they chose to take I have organized this chapter by age groups, as I discuss more below. At the end of this chapter I highlight to what extent the girls' reasons are explained by Eccles et al.'s (1983) model for academic choice.

During each of the individual interviews with the girls I asked questions to explore what reasons they had for their class choices. For example, I asked the high school girls to explain why they chose the classes that they did for that year as well as their reasons for what they believed they would choose the following year. For the middle and elementary school girls who did not yet have a choice in their classes I amended the question so that they would consider hypothetical and/or future choices. For example, I asked them if they could have chosen their classes for the current school year, and also for the next school year, which ones would they have wanted to take or not and why (Appendix B).

In a member check at the end of the last interviews I presented each girl with my beliefs about how and why I thought she would choose her classes based on our past discussions. Then I asked them whether they agreed and whether they would make any changes or add anything. If they listed more than one reason I asked them to rank them from most to least influential and to explain their order.

I present a display of the reasons each girl listed as Table 4. The numbers in the table represent the order in which the girls perceived that the factor influenced their class decisions with "1" being the most influential. The "X"s in the table denote factors that I believed might influence the girls' choices, based on comments that they made throughout the three interviews, but that they themselves did not volunteer as an influence during their member checks. For example, Katie had said in an interview in July 2000 that she would not want to take math in the future because she believed that she would not do well in it. But when I asked her in March 2001 in a member check to discuss the factors that she believed would influence her choices she did not mention ability. Therefore in Table 4 I marked ability with a "X" for Katie.

I marked Rachel's choices with a "+" because although she discussed several reasons for choosing her classes she did not place them in a particular order. As I discuss in a later section, she believed that the factors that influenced her reasons varied depending on the type of class she was deciding to take. Because her criteria varied she was not able to place them in a static order.

Table 4: Factors that the girls believed influenced their class choices.

Participant	Grade	Interest	Ability	Utility	Parents	Peers	Teachers
Berta	5th	1	X				
Beth	5th	1	X		X		
Laura	5th	1			X		
Sophie	6th	1					
Courtney	7th	1	X				
Hannah	7th	1	X				
Amrita	7th	4	3	2	1	5	
Katie	7th	1	X	2	4	3	
Marie	7th	1	2	3			
Lisa	9th	1	2	3			4
Sunny	9th	1	4	2	3		5
Rachel	11th	+	+	+			+

Because I found age-related differences in the reasons that the girls gave for the classes they chose to take, I discuss their reasons below by age groups. Specifically, all of the elementary girls and two of the seventh graders, Courtney and Hannah, stated that interest would be their *only* reason for choosing classes. Except for Sophie, however, all of these girls made comments that suggested other factors might also play a role in their decision once they have a choice. I have shaded these girls in Table 4 to delineate them from the girls who explicitly

discussed multiple reasons. For example, the other seventh graders, Katie, Marie, and Amrita, discussed how well they would do in a class and how useful it would be in addition to interest. Amrita was a notable exception in how she ordered her reasons, however, so I present her choices in a separate section at the end of the chapter.

The high school girls, Lisa, Sunny, and Rachel, also considered multiple reasons for the classes they chose to take. In comparison to Katie, Marie, and Amrita, however, they were more specific in their reasons and their reasons varied by type of class, such as electives versus core courses. Additionally, unlike the middle school girls, they were more concerned with the teacher they would have.

Interest as the only stated reason by the younger girls

For Berta, Beth, and Laura, all fifth graders, Sophie, a sixth grader, and Courtney and Hannah, both seventh graders, liking a class or career was the *only* reason they gave when I asked them in each interview to explain which classes they hypothetically would want to take in the future. Similarly, disliking a class was the only reason that they gave for not wanting to take a class again. For example, Laura told me in March 2001 that if she could choose her classes for sixth grade she would want to take English, math, science, and writing. When I asked her to explain why she would choose those classes she answered, "Because writing I like to write, and science I like to build things, and there's writing in

that…And math I just like to do math and then reading I like to read." Laura believed that an interest in what she would be doing in her classes would be her reason for choosing to take them. I discuss in Chapter four what she and the other girls in the study specifically liked and disliked about their classes.

Similar to Laura, the other elementary girls and Courtney and Hannah believed that interest would be their only reason for choosing classes in the future. However, their responses to other questions suggested to me that their parents or how well they believed they would do might also play a role in their actual choices.

For example, Hannah, a seventh grader, only reported interest as an influence on her class choices during her member check in March 2001, yet earlier in that same interview she said that if she could choose not to take a class it would be math. When I asked her why she said, "Because um I don't like math at all. It's like hard and stuff…because there are so many rules. It's just really confusing." Thus although her reasons included not liking math, she also referred to believing that it was hard. To me, Hannah did not like math *because* she found it to be difficult and confusing. As such, I believe that her perceptions of ability affected her decision not to take it. As I discuss in Chapter six, math was the one class that several of the elementary and middle school girls believed that how well they would do would play a role in their decision to take it. I discuss the implications of this finding for Eccles' model at the end of this chapter.

Despite not listing them in their member checks, Laura and Beth, both fifth graders, implied that their parents would have a direct influence on the classes they chose to take in high school. Laura said that she planned on taking math, science, and English in high school because her parents told her "that when I get to pick my classes those have to be in my curriculum." Likewise, Beth believed that she would continue to take science and math in order to please her father. She explained, "Well because my dad is an engineer, as you know. And he'll really want me to. And I like [science and math] a lot, as I said." Thus, while Beth's own interest would be a reason for taking math and science in the future, she implied that pleasing her father would also be one.

Nevertheless, despite referring to the future influence of their parents or their ability to do well, the elementary school girls and Courtney and Hannah only recognized interest as a reason for their class choices when asked directly. They believed that interest would be their only reason for choosing classes in the future.

Middle school girls beginning to consider multiple reasons

Similar to the elementary school girls and Courtney and Hannah, Katie and Marie, both seventh graders, believed that interest would be their main reason for deciding to take a class. However, they discussed other factors as well, particularly their perceptions of the usefulness of their classes.

Katie, a seventh grader, said that she would choose to take math and English in the future because she considered them to be "basic" classes that she would use. She said, "I think I'd do all the basics [next year if I got to choose]. Like math and English are important to me. Stuff that I'm going to use." Likewise Marie said that she would choose to take "the four major classes" because "you can use those ones a lot when you get older." Thus, both Katie and Marie grouped several classes together in thinking about their future usefulness. To me, they were just beginning to think about the utility value of their classes because they were not considering how individual classes would be useful. In contrast, as I describe in the next section, the high school girls described the usefulness of their classes in specific ways.

Similar to Laura and Beth, Katie believed that her parents would influence which classes she decided to take in the future. In regards to math, she commented that her parents "would make me take it" in high school even if it were not required. She added that she thought they would want her to take English and science as well, but she was not as sure about those classes. However, of all the reasons she listed she believed that her parents' wishes would be the least important. While ranking her reasons, she said, "Um, liking would be first, useful would be second and friends would be third and parents would be fourth."

Consistent with how she ranked her reasons, Katie gave math as an example of a class she would choose to take even if her friends were not going to take it because she believed it to be useful. She said, "I don't think my friends

wouldn't be taking [math], but if they weren't, I think I still would because I think it's useful." Katie believed that she would consider the utility of math more than whether her friends were going to take it. However, because she had said that her parents would make her take math, I wondered whether they would really have more influence than either her friends or her beliefs of utility. As I discuss later in regards to Amrita, it is possible that Katie associated her own beliefs of utility with those of her parents.

Apart from Amrita, Katie was the only one who discussed the influence her friends might have on choosing her classes. Moreover, Katie and Amrita were two of only three girls (including Sunny, a ninth grader) who specifically listed their parents as influencing the classes they chose to take, although Beth and Laura, as I described, implied that they would take the classes that their parents suggested. Amrita, as I discuss later, believed her parents would have the most influence on her class decisions.

Thus, in general, the girls in this study perceived that others had little or no influence on their class choices. I believe that Amrita and Katie's inclusion of friends and parents was representative of their individual beliefs rather than age traits. However, as I argue below, the high school girls, as a group, believed that teachers could have a significant influence on their choices.

High school girls' consideration of multiple reasons

The high school girls (Sunny, Lisa, and Rachel) gave several reasons for choosing classes and, like the other girls, interest was a main consideration for them. However, in contrast to the others, their reasons were more specific and they varied depending upon the type of class they were choosing.

For example, Rachel, an eleventh grader, believed that interest would be a consideration in deciding between taking the honors or regular level of a required class. However, she chose her electives based on how well she believed she would do and their usefulness. She explained,

> Um, I think if it's a difference between like an honors course and a regular course the fact that if I like it then, yes, that plays a part in it. But if it's like a totally different elective and I don't need to take it the fact that I don't need to take this course but I'll probably do well in it and it'll look good on my college application, yeah I'm going to take it.

For Rachel, interest was her main concern if she was deciding between taking the honors or regular level of a required class. She later explained that she would need to like the subject in order to want to do the extra work required in honors classes.

As indicated in the above quote, for her elective classes Rachel considered how well she would do and whether they would be useful for her college application. She gave an example of choosing to take elective science and art classes in case she decided to apply to an engineering or art school. Additionally,

she chose to take an elective A.P. history class because she believed it would be useful for gaining admission to colleges. She said,

> I think the science classes will help me if I want to do engineering or stuff like that…and I'm taking a lot of art courses and hopefully that will help me get into a few things that I want to take and…I'm taking A.P. history so maybe, I don't think I'd want to major in history, but it might help [me to] get into college or stuff like that.

In contrast to Marie and Katie who grouped their classes together when thinking about their utility, Rachel considered the usefulness of individual classes. As such, to me utility played a more specific role in her decisions.

As I discuss in Chapter six, Lisa and Sunny, both ninth graders, also considered how well they would do and their perceptions of the class' usefulness when choosing electives. As such, the high school girls' reasons for choosing classes varied by the type of class.

The high school girls also considered the specific influence of teachers on their class decisions. For example, in March 2001 as a ninth grader Sunny said that had she been able to choose her classes that year she would have wanted to take history because she liked her teacher. She explained, "But I wouldn't have picked that [class] without knowing who I was going to have for a teacher. I would have picked it like now knowing that I had had that teacher because I really like the teacher." For Sunny, liking her teacher was her main reason for wanting to take history. She reiterated this belief in a member check when she said, "Sometimes [I choose a class] because I like the teacher that is teaching the class. Like if I know a certain teacher only teaches this class I'll take it if I like that

teacher." To me, Sunny believed that how much she liked her teachers would have a direct influence on at least some of the classes that she chose to take.

Rachel echoed Sunny's belief when she said that she decided which classes to take based in part on the teachers and how they ran the course. She explained, "I mean [the classes I choose] also has to do with sometimes who the teacher is or how the course is run. It's a small school so you hear a lot about how different classes are run and stuff." As I describe more fully in Chapter five, I believe that Rachel changed her career goals from wanting to be an engineer to a doctor after her tenth grade chemistry class because of her teachers. She felt that her chemistry teacher made her feel like she was not "worthy of taking her class" and "didn't really know anything," whereas her ninth grade biology teacher "was really good" and "really made you understand the stuff."

I believe that these examples reveal the high school girls' perceptions that they would choose to take a class or not *because* of their teachers. As such, they believed that teachers had a direct influence on their choices. I discuss the implications of this finding for Eccles' model in the last section of this chapter because her model does not indicate a direct relationship between teachers and choosing which classes to take.

Nor does Eccles' model account for the direct influence of parents on class choice that five of the girls in this study described. Similar to Katie, Beth, and Laura, Sunny reported that she believed she would have to take math and science

her senior year even though they were not required classes because her parents would make her. She said,

> Well they've [her parents] said that um, because of the way my high school credits work I only have to take, my senior year the only thing I'm required to take is English. They say that I'm taking four years of science and four years of math no matter what. I have no say in that. And yeah I will, you know, willingly but…I'd like it to be my decision to take them all four years instead of having them say, 'yes you are,' and me just go along with it. But, you know, they're my parents.

Sunny described having "no say" in taking math and science her senior year because her parents would make her.

Amrita also discussed the direct role she believed her parents would have in her class decisions. However, unlike the other girls, she believed her parents would influence which classes she chose to take more than any other factor, even her own interest.

Amrita as an exception

Although Amrita had initially told me in July 2000 that she believed how much she liked a class would be her main reason for choosing it, by March 2001 she believed that its usefulness would be more important. Thus, during the member check at the end of our interview in March 2001 I told her that to me utility seemed more important to her than interest in making her class decisions. I asked her whether she would agree and if there were other factors that she believed would be important. Amrita's response indicated that she equated her

beliefs about what would be useful with her parents' beliefs. She appeared to be thinking aloud when she said,

> What my parents think. Definitely….Actually that would come first. Because they're usually right, you see? Even though I try to be right they're always right. Yeah, actually first I would decide what they want and then valuable and how much they want, they would probably tell me how valuable it would be.

Amrita believed that her parents' beliefs about the value of her classes would dictate her own beliefs of utility and thus which ones she would choose to take. While utility was more important to Amrita than interest, her parents' beliefs *about* utility were really the most important to her class choices. The influence of her parents' beliefs on Amrita's decisions was even more apparent when she discussed career options. As I discuss in Chapter four, she was planning on becoming an engineer only because her parents believed that it would be a useful career for her. Her real desire was to earn a business degree and then start a company that would help people.

As I discussed in the previous chapter in regards to reactivity, because Amrita did not mention the influence of her parents on her class decisions until the second interview in March 2001 it seemed to me that my questions prompted her to consider, possibly for the first time, why she would choose her classes. This was evident to me during the member check when she actively rearranged her priorities while talking aloud.

As such, it is likely that the other girls in the study, particularly the younger girls, were also thinking about their reasons for their class choices for the first

time. While many of them did not mention the influence of their parents it is possible that their parents, or other factors, will have considerable influence *once they have a choice.* As Marsh and Yeung (1997a) suggested there may be differences between the classes that students say they are going to take and what they ultimately choose to take. It would be interesting to know which classes these girls would choose if their parents' choices differed from their own in the future. Further research is needed in order to follow up on their *actual* class choices and their reasons for choosing them.

Nevertheless, as I have indicated, at least five of the girls discussed ways in which their parents would directly influence their class choices. As I discuss next, this has implications for Eccles' model.

Comparison to Eccles' model

In this section I outline the ways in which the girls' reasons are explained or not by Eccles' (1983) model of academic choice (see Chapter one). I found consistencies with her model in 1) the influence of task-values on class choice, and 2) age-related differences in that relationship. However, in contrast to her model's predictions that perceptions of ability have less of an influence on class choice, I found that it varied based upon the type of class, subject, and age. Lastly, I found that adults had a direct influence on the classes these girls chose to take. I describe each of these issues in the following sections.

Age-related differences in the influence of task-values on choice

Consistent with Eccles et al.'s (1983) model that interest, a task-value, influences course choices, interest was the main reason given by all the girls except for Amrita for the classes they chose to take. More specifically, Eccles' research has shown that interest predicts the decisions of fifth through twelfth grade students to continue taking math and English (Eccles et al., 1983; 1984; Wigfield & Eccles, 1992). In this study, the girls believed that interest was a factor in choosing *all* their subjects. Thus these findings extend the scope of the model's ability to predict choice in all subjects for this group of girls.

Further, as Eccles et al. (1983) found for decisions regarding math, the high school girls in this study considered the utility value of their classes more than the middle school girls. While Katie and Marie, both seventh graders, spoke about the utility of their classes they did so only in general terms by grouping them all together as useful. In contrast, the high school girls were more specific about how their classes would be useful to them in the future. Moreover, they considered the usefulness of several of their classes, not just math. This suggests that Eccles' finding of age-related differences in the role of utility in choosing to take math extends to other subjects as well.

In general, seventh grade appeared to be the time in which the girls of this study began considering multiple reasons for course choices. It is possible that these age-related differences are developmental. For example, Wigfield and

Eccles (1992) found that children do not distinguish between interest and utility until the late elementary grades and suggested that there may be developmental differences in the ability to consider multiple reasons for choosing classes.

Influence of perceptions of ability on choice for certain types of classes

Eccles' model predicts that perceptions of ability have more of an influence on student's performance than on their decision to take classes. Specifically, her research found that fifth through twelfth grade students' perceptions of ability were not as influential to their decision to take math as either interest or utility (Eccles et al., 1983, 1985, Wigfield & Eccles, 1992). However, *depending on the type of class and the subject*, the girls in this study considered how well they would do when deciding which classes to choose. For example, Rachel, an eleventh grader, indicated that she would consider how well she would do when deciding to take an elective. Additionally, the younger girls believed they would consider how well they would do when choosing whether or not to take math in the future. As I discuss in the last chapter, this finding has specific implications for pursuing math and science classes that can often be electives in high school. As such, future empirical research should address the possibility that the influence of perceptions of ability on course choice varies by subject and/or type of class and that there may be age-related differences.

Influence of significant adults

Lastly, while Eccles' model predicts that significant adults, such as parents and teachers, have only an indirect influence on course choice, *the girls portrayed a more direct relationship*. The high school girls believed that whom they would have for a teacher could influence the classes they would choose to take, and five of the girls, representing all the age groups, believed that they would choose classes indicated by their parents. This finding has implications that I discuss in the last chapter for the direct role of parents and teachers in encouraging girls to pursue science classes.

Overall, the reasons the girls in this study discussed for choosing their classes were all ones identified by Eccles' model. As such, her model is useful for identifying ways in which to encourage girls to continue taking science classes. I make specific recommendations for this in Chapter seven. In the next three chapters I discuss the girls' reasons in more detail by defining their interest (Chapter four), their utility beliefs (Chapter five), and their perceptions of ability (Chapter six).

Chapter Four

Interest: "Science can be fun if you do it"

As I discussed in the previous chapter, interest in a class was the main reason why all of the girls, except for Amrita, would consider taking a class or not. It was more important to them that they liked a class than whether they believed it to be easy, hard, or useful. For example, Berta told me as a fifth grader that if she had a choice she would choose to take writing "because I really like to write." As a sixth grader Sophie said that she would choose to take science because "it's fun." And Marie, a seventh grader, said that she would choose French because "I really like French." As I discussed in the previous chapter, these findings are consistent with the predictions of Eccles' (1983) model that interest influences course choices.

As the above quotes reveal, however, the classes that the girls liked and disliked differed. In this chapter I detail their favorite and least favorite classes and illustrate that while the classes that they liked changed from year to year their reasons for choosing a class as their favorite stayed fairly consistent. In general, I found that the girls liked classes in which they did hands-on projects regardless of the subject matter. This was particularly true for the elementary and middle school girls. The high school girls were more concerned with which teachers they had than with the activities. In the last section I discuss how these reasons have

implications for continuing to take science classes and for pursuing science careers.

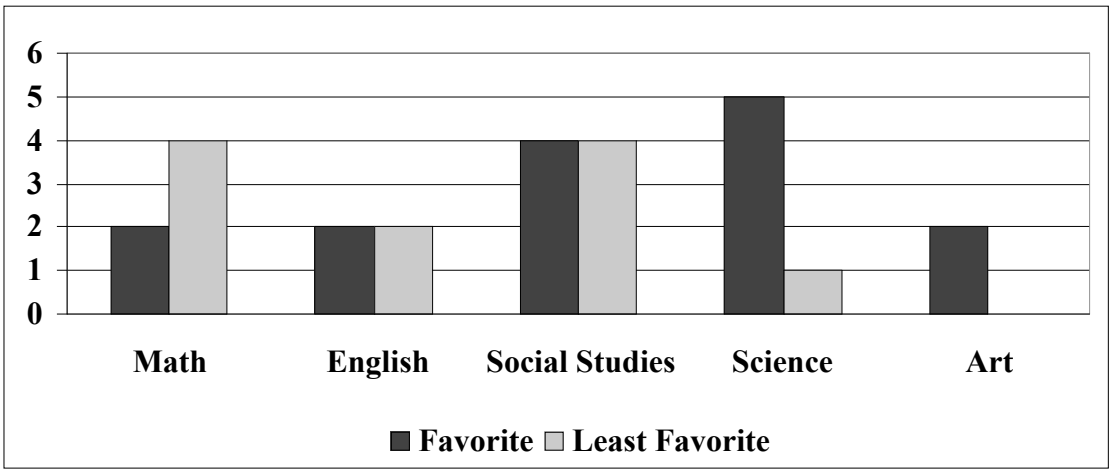
In terms of career choices, interest was the main reason for considering future careers for all of the girls but Amrita, a seventh grader. Specifically, being a doctor or a veterinarian, both biology-based careers, was popular with many of the girls, particularly the elementary school girls. Amrita was the only girl who was thinking of becoming an engineer, a physical science based career. As with course choices, Amrita's parents had more of an influence on her intended career choice than her own interest.

Classes that the girls liked and disliked

Although the girls chose a variety of classes as their favorite during the first year of the study, overall they chose science and social studies most often. Of the twelve girls in the study, five chose science as their favorite class and four chose social studies/history. Four girls chose two classes instead of one as a favorite. Amrita and Hannah, both seventh graders, and Lisa, a ninth grader, chose science and social studies while Courtney, a seventh grader, chose art and science. Sophie did not choose a favorite class, claiming instead that she did not like any of them because of her teacher. I discuss this more in the next section when I discuss the girls' reasons for their choices. Thus fifteen class choices are represented in Figure 5 that shows the girls' favorite and least favorite classes.

Interestingly, social studies was also chosen as a *least* favorite class by four of the twelve girls, Beth, Laura, Sophie, and Courtney. Four girls, Berta, Amrita, Katie, and Hannah, chose math as a least favorite class. Thus math and social studies tied for the least favorite class during the first year of the study. Eleven choices are shown for least favorite class in Figure 5 because although Courtney chose two classes, English and social studies, Marie and Sunny did not choose any (Marie said she liked them all and Sunny did not like any except for history). I discuss the girls' reasons for their least favorite classes in the next section.

Figure 5: Classes that the girls chose as their favorite and least favorite during the first year of the study, 1999-2000.



Although the girls' choices for the classes that they liked the most and least changed somewhat from the first to the second year of the study, the classes that they did *not* like remained more consistent than the classes that they did like. This is illustrated in Table 6 which shows the favorite and least favorite classes in years one and two for each participant. Choices that remained the same from years one to two are shaded.

Table 6: Favorite and least favorite class choices of each participant for years one and two of the study.

		Favorite Class		Least Favorite Class	
Participant	Grade Year 2	Year 1	Year 2	Year 1	Year 2
Berta	5th	Art	Art/Writing	Math	Math
Beth	5th	Science	Math	Soc.St.	Reading/Soc.St.
Laura	5th	Math	Writing	Soc.St.	Soc.St.
Sophie	6th	None	Science	Soc.St.	Soc.St.
Amrita	7th	Soc.St./Science	Math	Math	English/Soc.St.
Courtney	7th	Art/Science	Science	English/Soc.St.	Soc.St./Spanish
Katie	7th	English	Soc.St./English	Math	Science
Hannah	7th	Soc.St./Science	Science	Math	Math
Marie	7th	English	French	None	Geography
Lisa	9th	Soc.St./Science	Soc.St.	English	
Sunny	9th	Soc.St.	English	All but Soc.St.	
Rachel	11th	Art	Soc.St./Science	Science	

Specifically, six out of nine girls (Berta, Beth, Laura, Sophie, Courtney and Hannah) had the same least favorite class in years one and two of the study.[3] Social studies remained a least favorite class in the second year of the study for all four of the girls that chose it the first year. In comparison, only five out of twelve girls (Berta, Courtney, Katie, Hannah, and Lisa) had the same favorite class both years. Although science and social studies were still popular classes in the second

[3] Only nine girls chose a least favorite class because I did not ask the high school girls in the second year of the study to choose a class. As I discussed in chapter three, how useful they believed their classes to be seemed more important to them in *not* choosing to take a class than a lack of interest. As such, with the high school girls I mainly discussed the role of interest in choosing to take a class rather than not taking a class.

year (chosen by four and three girls out of twelve, respectively), the same girls did not necessarily choose them as their favorite classes.

The consistencies and changes in favorite and least favorite classes are explained by the girls' reasons for choosing the classes, as I describe in the next section. In general, although their favorite classes changed from year to year their reasons for liking a class remained the same. As such, their *reasons* for choosing the classes that they liked most and least were more informative than their actual choices in determining what made a class appealing or not to these girls.

Reasons for liking and disliking classes

In general, there were three reasons given by the girls for liking and disliking school classes: 1) the type of activities that they did, 2) the topics that they studied, and 3) their teachers. I describe each of these reasons in the following sections in the order in which the most number of girls referred to them. All of the girls mentioned activities in regards to liking their classes, eight believed that their teachers influenced their interest, and six attributed their interest to what they were learning (the topic).

As shown by these numbers, the girls often had more than one reason for liking a class or not. For example, Marie, a seventh grader, listed all three of the reasons in explaining why she liked all of her classes. She said,

> I really like [all my classes]…Well I like the teachers and I like what we're learning. And I think that the way that they set up what we're learning is interesting and I like that…they put us in little groups of four and we get to work together and we get to discuss what we're doing and we talk about how we're gonna do an experiment.

As she explained, she liked her teachers, the topics that they studied, and group discussions and experiments (the activities).

Marie was unique in that she liked all of her classes (at least in the first year of the study). It was more common for the girls to cite one or more of the above three reasons in regards to several but not all of their classes. Moreover, if their reason for liking a class was due to the activities or the teacher, their interest in that subject tended to vary from year to year. Their liking of a class was usually more stable if they attributed their interest to the subject matter.

As I discuss at the end of this section there were age-related differences in their reasons for liking a class. Overall, the elementary school girls liked their classes based primarily upon the activities that they did, whereas the high school and middle school girls also took into consideration their teachers and what they were learning. In regards to their interest in science, the elementary and middle school girls liked their science classes as long as they involved hands-on activities, regardless of the topics studied. The high school girls showed a preference for biology over physics.

Interest in hands-on activities

All of the girls mentioned liking classes that incorporated hands-on activities (active learning) and disliking classes in which they mainly listened to the teacher and took notes (passive learning). They often described classes with active learning as being "fun," and those with passive learning as "boring." These findings are consistent with a previous qualitative study that found that middle school students preferred doing hands-on activities and being active learners (Spector & Gibson, 1991).

For example, as a fifth grader, Beth said that science was her favorite class because she "loves experimenting." However she described her social studies class as "very boring" because "we just have to sit there and listen to the teacher talk." Berta, also a fifth grader, felt similarly about her science and social studies classes. In describing them she said, "In science it's kind of more fun because we do a lot of hands-on things. In social studies we just sit there and read." Like the other fifth graders, Laura also believed that her social studies class was "really boring" because "all we do there is sit there and read a book for like half an hour to an hour and a half." In contrast, she said that she had liked her third grade social studies class because they studied Native Americans by dressing in costumes, playing games, cooking food, and building a town.

Thus all three of the fifth grade girls believed that their social studies class was boring that year because it involved reading and listening to the teacher instead of doing hands-on activities. However, as evident by Laura's interest in

social studies in a previous year, they were not necessarily disinterested in *what* they were learning, just in *how* they were studying it.

Like Laura, many of the girls reported liking a class because of a special project that they did once during the year. As a seventh grader Katie said that she had liked her fifth grade social studies class because they reenacted being on the Mayflower. She explained,

> We did this thing and it was like we were on a ship. And it was from like the olden days when they came over on the Mayflower or whatever. And we had a certain amount of food and we would like hit people in wars and stuff. We did that at the end of the year and it was fun. And you got to read a card about what would happen each day. That's what I liked.

For Katie, reenacting an historical event was a hands-on activity that she enjoyed. Because of that one project she liked her social studies class that year.

Similarly, Courtney liked her sixth grade science class because it involved hands-on projects. She described a unit called "Technology of Paper" as being "fun" because they got to make paper. She explained that she enjoyed it because "I like doing activities. I don't like reading stuff and that kind of thing."

Amrita also described liking science because of a hands-on project. She explained that in her sixth grade science class everyone had to do a project at the beginning of the year for a science fair and she thought that was really fun. But after the science fair was over she believed that the class became boring because they just read out of books. She said,

> The beginning of the year was really fun when we did all the projects….And then we got into the end of the year…when we had to do exploring planet earth and like conserving the earth's natural resources and stuff like that, that was boring….The topics were fine. But yeah, learning out of a book, just like reading it [was boring].

Like Laura, Amrita seemed more bored by the lack of activities than disinterested in the topics she was learning. However, as I describe in the next section, she associated the activities with the teacher. Because the teachers chose the activities, Amrita held them responsible for making the class interesting or not.

In general, the girls' preference for active versus passive learning explained why science and social studies were often chosen as favorite classes and also why social studies was chosen as a least favorite class. The elementary and middle school girls in particular liked science and social studies when they involved hands-on activities but their interest was dependent upon the activities, not necessarily the topics as I discuss more in a later section. As such, the girls' interest was not sustained from one year to the next if the following year involved more passive learning. Conversely, a class that was previously considered to be boring could become more fun with active learning.

It is important to note, however, that the girls only liked the activities if they involved genuine inquiry so that they could explore concepts *on their own*. Sunny, for example, complained that the experiments they did for their science laboratories were "not fun" because they did not involve exploring on their own why things worked. Instead, she said that the laboratories were designed so that

they merely followed directions to replicate a procedure that they had already been shown. She explained,

> We do a lot of labs [in science class], but they're not fun labs. It's just to find out how things work the way they do. And it's really basic….I think it would be fun if we could um figure out on our own how and why it worked. Because then it makes us think. Instead of saying to us, 'Here is how it works. Go and do this lab to show you that it really does work that way.' More like um, 'Here this is the problem. This is what happens. There are a couple of components to it that you have to work with. Go figure out how and why it works.' That would be fun, I think.

For Sunny, science experiments were not interesting or challenging unless she was able to discover on her own how and why things worked. In fact, she said being able to explore things on her own was what made the LEGO camp enjoyable for her. She described building and programming her own designs as "neat to do something on your own" because it was "really really challenging." A qualitative study with fifth through eleventh grade girls focusing on what influences girls to choose science presented similar quotes from girls saying they wanted to "learn for themselves" and "figure things out" in their science classes (p.9, Baker & Leary, 1995).

Being able to explore how and why things worked on their own was an important factor in several of the girls' enjoyment of the LEGO camp. Like Sunny, Marie said that she enjoyed the camp because she liked experimenting with designs to find out what worked best and also being able to program them to do what she wanted. She said,

> I thought [the camp] was fun because we got to experiment with different things, like putting together cars and animals and stuff. And um I thought it was neat because if it didn't work then we could try and fix the design so that it would work better. And I also liked the programming because I thought that was interesting cause you can make the machine that you made do anything. So I thought that was neat.

Thus, Marie, a seventh grader, also liked independently experimenting with her building and designs and having a choice in what she decided to make and how to program it to move.

Rachel, Berta, and Laura expressed similar sentiments. Rachel, an eleventh grader, said that she liked programming because "you kind of get to, you know, have it do what you want it to do. That was fun to see it actually do it." Berta, a fifth grader, said that she liked the building because "you get to design what you want." Laura, also a fifth grader, described loving the camp because she liked "making something, like whatever I want, and then making it move." For them, having a choice in what they were building and programming was important to their enjoyment.

Hannah, a seventh grader, summed up what many of the girls expressed as a difference between the camp and their school classes when I asked them whether they believed there were any differences between the two. Like the other girls, she explained that she liked the camp because of the choices that they had. She said,

> I like the way…that they had us pick [what to build] because I'm used to just having some person say, 'I want you to build this.' Like that. So um I got to pick how I want to build it and stuff like that.

For Hannah, the freedom to choose on her own how and what she wanted to explore was not something that she was used to at school. I discuss the implications of this finding for teaching science at school in the last chapter.

Interest as dependent on teachers

Except for the three fifth grade students all of the girls mentioned liking a class or not because of a teacher. There were two ways in which the middle and high school girls viewed their teachers as influencing their class interest. First, some of the girls equated the type of activities they did with the teacher. These girls held the teacher responsible for their class activities and thus their class interest. Second, others such as Courtney, Katie, Hannah, and Marie, all seventh graders, believed that the teacher's personality made the class enjoyable or not. For these girls liking the teacher meant liking the class. In this section I give examples of both viewpoints of the teacher's influence on class interest.

Holding teachers responsible for activities

As I described in the previous section, in July 2000 Amrita said that she had liked her sixth grade science class because she liked doing a project for the science fair. However, she did not like it in fifth grade because she believed that her teacher made it boring by having them just read out of a book. She explained "the teacher can make the subject really boring." She elaborated,

> Last year [in 5th grade] science was like the worst class just because of the teacher. She just said like read the book and do it. So, I mean, science can be fun if you like do it.

For Amrita, science in particular could either be fun if it involved doing activities or boring if it did not. To her, the teacher was ultimately responsible for making it fun because she assigned the activities. As such, Amrita's interest in science class varied from year to year depending upon her teacher and the activities they chose.

In contrast to her science class, Amrita described her social studies class as "fun" because of the teacher. She explained that he had them do a lot of projects that made the class fun. She said, "Like the way that he taught [social studies], it wasn't like it was right out of the book. We did many projects related to like each subject….So in that way it was like really fun." Thus, for Amrita, the way the teacher chose to teach a class could influence whether she liked it or not.

Similar to Amrita, Lisa, a ninth grader, described how her interest in a subject changed from one year to the next because of the teachers. Lisa became interested in music in sixth grade because of her teacher, but then lost interest in it the following year because of a different teacher. She said, "I've never really been interested in music until like I had this really good teacher in sixth grade and I really got interested in music. But then the next year I had this really bad music teacher." She added that she "could have gotten that [music] for an elective [this year], but I decided not to." Lisa decided not to take music again because, according to her, her seventh grade music teacher was "really bad" and caused her to lose interest. Although Lisa did not elaborate upon what it meant to her that her

music teacher was "bad," several of the girls described personality attributes of their teachers that they viewed to have a negative impact on their interest in a class, as I describe below.

Teachers' personalities

Courtney, for example, told me in March 2001 that her seventh grade history class was one of her least favorite classes because her teacher was "really strict." She explained that her teacher was "not very sympathetic and she yells all the time. And everyone's kind of scared of her." For Courtney, having a teacher that she perceived as yelling a lot and being unsympathetic meant that she did not like the class.

Not surprisingly, many of the girls voiced a preference for teachers that they believed were nice to them and/or funny. For girls such as Katie and Hannah having a nice or funny teacher made the class more fun. For example, Hannah said in May 2000 that she liked her sixth grade social studies class because her teacher was funny. She told me, "I like social studies…because my teacher now is funny and she makes learning like fun, I guess….In class sometimes, she goes, 'okay my fine feathered friends' and stuff like that." For Hannah, having a teacher that used funny expressions made learning and the class more enjoyable for her.

Similarly, in July 2000 after her sixth grade year Katie said that if she could choose to take a class again she would take English because she had "a really nice teacher." She explained that, "He was really cool. And it was just fun because he

made the classes really fun and I liked learning the stuff." Katie was thus more willing to take a class in which she liked the teacher because she believed the class was more fun and interesting with a "nice" teacher.

Marie summed up the general feeling that a teacher could influence the degree to which the girls liked a class. When I asked her at the end of the sixth grade which classes she was looking forward to the next year she answered that she did not really know "Cause I don't know what teachers there are, so that might kind of change it a little. 'Cause the teachers might be nice or mean or something." Like many of the girls, Marie believed that a class would be better with a nice teacher than a mean teacher. She elaborated, "I like a class better if the teacher is nice and explains things more in detail and stuff. But if they're not really nice and they don't explain things as well then I don't really like the class as much because I don't really know what I'm doing." As the comparative language in her quotes revealed, for her the teacher's personality would only influence her interest in a class "a little." Having a nice teacher, one that explained things well, made the class "better," while having a not so nice teacher meant she did not like the class "as much."

Interest in a subject

Seven of the girls, Berta (5th grade), Sophie (6th grade), Hannah (7th grade), Marie (7th grade), Katie (7th grade), Lisa (9th grade), and Rachel (11th grade)

expressed an interest in a particular subject. These girls tended to describe liking or disliking the same classes from year to year (even if they did not choose them as their favorite or least favorite class) because of what they were learning, regardless of the teacher or activities that they did. Their reasons for their interest in a subject are explained in two ways: 1) liking the topics that they were studying, and 2) believing that they were capable.

Interest in topics

Sophie told me that she liked topics in science that had to do with animals because "I love animals." She added that she would take a class about animals even if the activities were really boring. Likewise, Lisa told me that she had always liked history: "I've always liked history. I don't really know why but it's just…always been interesting to me." Lisa's consistent interest in history suggested to me that she liked the subject regardless of her teacher or the activities that she did.

Similar to Sophie, Hannah voiced a preference for science saying simply, "Science I've always liked. I just enjoy science." Upon further questioning, however, Hannah's interest in science seemed to be dependent upon the topics she studied (or hoped to study) as well as on the activities they did in class. She explained that she had always liked her science classes and that in the future she would want to "study chemicals" or dissect things. She said, "I would want to study chemicals and stuff and do some experiments with them….Or like dissecting

things because I like doing that." To me, Hannah's interest in science was related to the topics she studied, such as things having to do with chemicals, but also to the activities. Moreover, when I asked her specifically whether she thought that she would like science no matter whom her teacher, she responded that she believed she would. As such her interest in science was unrelated to her teacher. In a later section I describe more specifically all of the girls' interest in science since it was a main focus of my study.

Interest dependent upon doing well

Katie, Berta, and Rachel's interest in a class was dependent upon what they were learning, but also closely related to their ability to understand the material and to do well. For example, Berta, a fifth grader, and Rachel, an eleventh grader, liked art partly because they always did very well in it. Berta explained that she wanted to take it again "because I'm very good at art and everybody knows that and I like it and I'm good at it." Because she juxtaposed expressions of interest with statements of ability, it seemed to me that her interest in art was partly due to believing that she was good at art and, moreover, that other people recognized her as being good at it.

Likewise, Rachel described consistently liking art and her interest seemed to be based in part on her own perceptions of ability as well as recognition by others. She explained,

> I've always liked art….Like I actually enjoy it and I learn stuff from it. Like last year I won an award from the Boston Globe….And that really kind of like you know like [told me], 'okay I might be good at this' or something like that. So it kept me kind of interested.

For Rachel, being publicly recognized for doing well in art added to her interest in the class. To me, Rachel and Berta's interest in art was partially dependent upon, or at least sustained by, their and others' belief that they were good at the subject.

In contrast, Katie, a seventh grader, discussed her *dislike* of math in terms of not doing well in it. She explained that she had never done well in math and that she would choose not to take it in the future if given a choice because she did not like it and was not good at it. She said, "I didn't like math. I wasn't good at it. I'm not good at math. I get like Bs and stuff. So I'm not very good at it. And I don't like it." Like Berta, because Katie alternated between describing a lack of interest and a lack of ability in math, I believed that they were closely related. As I described in Chapter three, I believe that Katie's dislike of math was due in part to her lack of ability to do well and vice versa.

Interest in science topics

Because I was particularly concerned with science for this study, I asked the girls specifically about their interest in regards to science topics. Often they could not remember topics that they had studied beyond the current year of science or they only remembered a large project such as participating in a science

fair. Of the topics that they did describe, there were none that they either liked or disliked as a group.

The elementary and middle school girls liked their science classes if they involved doing experiments, regardless of the topics that they studied. The topics that they were learning about were not as important to them as doing hands-on projects. In contrast, by high school the girls had formed opinions about which science topics or classes they liked and which they did not. Although Sunny claimed to not really enjoy any of the science topics that she had studied, both Rachel and Lisa said they liked biology because it involved learning about the human body and both had considered being doctors, as I discuss more later.

All of the girls believed that they knew more about biology than physics. This became apparent to me during the group discussions that I conducted in July 2000 at the summer camp. In order to assess what kinds of activities or concepts the girls associated with different areas of science, I asked them during the group discussions for their views about what they thought they would learn about in a biology, chemistry, and physics class. As shown in Table 7, which outlines the quoted statements about the three types of science by age groups, the girls were more specific about biology and chemistry than physics. Despite some confusion with my use of the terms "physics" and "biology" during the group discussions instead of "physical science" and "life science," which were more familiar to the girls, it was apparent based on their responses and how readily they answered that they believed they knew less about physics than biology.

Table 7: Descriptions of what the girls believed they would learn about in biology, chemistry, and physics classes, by age group.

	Biology	Chemistry	Physics
Elementary School Group	"About living things." "Dinosaurs" "Insects" "Things that are extinct." "Animals" "People" "Bio means the study of living things."	"You mix things together." "Learn how to bake." "Learn how to make medicine."	"Is that gym?" "Learn about physical things." "You learn what stuff is in something else. Like vitamin C is in milk." "There would be a ball and if it doesn't bounce really high it won't make it over the wall. That would be physics." "Gravity."
Middle School Group	"Life underwater." "Parts of animals." "Parts of your body." "Parts of the computer." "Study of life. That's what it means."	"Study elements." "Experiment with chemicals and make potions." "See how chemicals react."	"I have no idea." "I haven't taken it." "The only thing I know about physics is physical education."
High School Group	"Dissecting frogs." "Life." "Life science is what we call it. Although that has to do with plants too and biology isn't plants." "Ask me next year."	That's when you blow up the science lab. "Scientific equation." "Compounds and mixtures of things." "Medicine."	"What is it?" "That's the salad bowl on your head."[4]

[4] This refers to a statement made in an individual interview in which the girl said that her father gave a demonstration at dinner to explain physics. She explained that he "held a bowl of salad over my head and said, 'If I hold this bowl like 6 inches off of your head, how hard will it hit?' That would be physical science."

For example, all of the girls in each age group were able to identify biology as the study of living things and they listed several possible topics. Although less specific about chemistry, each group readily mentioned activities such as mixing things or chemicals, studying the elements, and making medicine. When I asked about physics, however, there was more uncertainty as can be seen by the several comments in Table 7 in which girls simply asked what it was or stated that they did not know. The girls whose parents were engineers, such as Beth and Sunny, gave more specific physics examples, such as gravity, a ball bouncing, and a salad bowl on the head.

It is possible that the girls' lack of knowledge of physics compared to biology may have been because as a group they had not done as many physical science-based activities at school. Although there did not seem to be any uniformity in the topics they had studied in their science classes, they rarely mentioned lessons involving physical science, such as a magnets and motors unit described by Laura. Moreover, based on the high school girls' responses, physics was not specifically studied until ninth grade at the earliest.

Sunny believed that her first science class that included physics concepts was in the second semester of the ninth grade. She explained that she was taking a class called physical science but that it included chemistry topics as well. She added that according to her parents, both engineers, it was not "real physics but kind of just everything all together." Rachel, the oldest girl in the study, had not taken physics by the time of our last meeting together in March of her junior year

although she planned to take it in the twelfth grade. As such, many of the girls may not have had the experience with physical science topics to know whether they liked them or not.

The girls may also not have been able to recognize activities that they had done as physics. Despite having attended the LEGO camp, when I asked them about science activities that they might have done outside of school many of the girls could not think of any. Yet when I asked specifically about using LEGOs, most said that they had been building with them during the school year. They did not recognize that building and designing involved physics even after attending the engineering summer camp.

Moreover, when I asked them each what they believed that they had learned at the summer camp, or what they thought the counselors had wanted them to learn, none of them mentioned specific science concepts. Instead, they said that they believed the counselors wanted them to "learn about building things," "basics of programming," "how to build a car," and "have fun." While having fun and learning about engineering by building were some of the goals that the director of the camp relayed to me in an interview, she also discussed wanting to develop students' understanding of the physics concepts involved in building and design.

However, while observing at the camp I rarely heard counselors discussing topics such as friction, torque, and gravity with the girls. One of the few times was on the second day of the camp when one of the ninth grade girls was unsuccessfully attempting to have the car she had built out of LEGOs drive up a

carpeted slope. A counselor approached her to help figure out why it was stopping partway up and spinning its wheels. He first asked her why she thought the car was stopping and then when she responded that she did not know he asked her, "Have you learned about friction at school?" When she answered that she was not sure, he gave her the example of ice-skating. He explained, "Well you know when you're ice-skating and you glide across the ice? That's because there's not a lot of friction." He then gave several other examples of walking across various surfaces.

This was one of the few lessons that I observed in which physical concepts, such as friction, were actually named. As such, it is likely that the girls did not associate the activities that they were doing with physics. In the last chapter I argue that this could be problematic in the future if they decide not to take physics because of its unfamiliarity.

Differences by age in reasons for liking classes

To summarize, the elementary school girls' interest in a class was based primarily on whether they liked the activities, whereas the middle and high school girls' interest was also dependent upon what they would be learning about and whom they would have for a teacher. Thus, the content of the class and who would be teaching it became more important with age.

It is possible that the younger girls did not talk about their teachers in regards to liking one class more than another because they tended to only have one

teacher for all (or most) of their classes. As such, differences in teacher personalities would not influence their class interest. Based on their findings with fifth, eighth and eleventh grade girls, Baker and Leary (1995) reported that teachers did not play a major role in girls' attitudes towards their classes until the eighth grade. However, although I found in this study that the fifth grade girls did not discuss their teachers in terms of class interest, the middle school girls, as sixth and seventh graders, held their teachers responsible for their class interest. Perhaps Baker and Leary (1995) would have found similar results had their sample included sixth and seventh grade girls.

Career Interests

The girls' career interests generally remained consistent from years one to two of the study with only four girls (Katie, Marie, Sunny, and Rachel) completely changing their minds, as I have shown in Table 8 (not shaded). This suggested to me that for the most part the girls were seriously considering careers at this age. For all of the girls except for Amrita, interest in what they would be doing was the main reason for the careers that they were considering.[5] This is consistent with previous studies that found interest to be a strong predictor of career considerations (Jacobs et al., 1998; Post-Kammer & Smith, 1985).

[5] For Amrita, her parents' desire for her to be an engineer was the main reason she gave for wanting to be an engineer. I discuss this more in a later section.

Table 8: Participants' career choices in years 1 and 2 of the study.

Participants by grade		Career Choice	
		Year 1	Year 2
Berta	5th	Paleontologist	Paleontologist
Beth	5th	Vet or Engineer	Vet
Laura	5th	Zoologist	Zoologist
Sophie	6th	Farmer	Farmer
Amrita	7th	Engineer/Business	Engineer/Business
Courtney	7th	Vet	Vet
Katie	7th	Music critic	Manager/Agent
Hannah	7th	Surgeon	Surgeon
Marie	7th	Vet	Contractor [Architect]
Lisa	9th	Archeologist	Archeologist
Sunny	9th	Fashion Designer	Lawyer
Rachel	11th	Engineer or Artist	Doctor

For example, Berta's interest in dinosaurs was the main reason she gave for wanting to be a paleontologist. She explained,

> I really want to be a paleontologist because I'm really interested in dinosaurs and I think it would be really fun to see a real dinosaur bone up close and get to touch it and study it and everything.

Likewise, both Beth and Courtney said that they wanted to be veterinarians because they liked animals. Beth said, "Because I love animals. That's why I want to be a veterinarian…I just love animals and I want to make them better with medicine and stuff." Courtney's reason sounded similar: "I want to help animals…I like animals and I want to help them." As both Courtney and Beth's quotes indicated, taking care of animals was a large part of their interest in

wanting to be veterinarians. Wanting to take care of animals or people in their jobs was a theme that emerged for six of the girls, as I describe more fully in the next section.

In regards to science, ten out of the twelve girls appeared to seriously consider science-related jobs by the end of the study. I have shaded the career in Table 8 if the girl believed it would involve using or needing to know science. Lisa, for example, described archeology as "sort of history and science put together." However, as I discuss in a later section, the girls were often unclear about what specifically they would need to know about science in order to do these jobs, particularly engineering.

Of the four girls that expressed an interest in engineering, three of them had parents that were engineers. As I discuss in the last section, it seemed to me that these three were more interested in other careers and they were considering engineering mainly to please their parents. In contrast, the girls that were considering careers related to biology, such as being a doctor or a veterinarian, were genuinely interested despite the fact that only Rachel, whose mother was a nurse, had a parent working in a medical field.

Interest in caring for and helping animals and people

Wanting to take care of and help animals or people emerged as a theme for six of the girls, Beth, Laura, Sophie, Amrita, Courtney, and Rachel. Consistent

with previous research (Baker & Leary, 1995; Jones, Howe, & Rua, 2000), these girls expressed an interest in biology-based science careers, such as doctors and veterinarians, because they wanted to help people and animals.

Hannah, a seventh grader, was an exception in that although she wanted to be a surgeon helping people was not a reason she gave for her interest. Instead, her interest was dissecting, which she described as "fun." Interestingly, Lisa, a ninth grader, had also described wanting to be a surgeon when she was in the sixth grade because she thought it was "really cool" when they "cut open a sheep's like heart and lungs and everything" in science class.

As mentioned, Courtney and Beth wanted to be veterinarians in order to help animals. Sophie and Laura told me that although they had also once wanted to be veterinarians they had decided not to because while they wanted to care for animals they did not want to see them hurt. Instead, Sophie decided to be a farmer and Laura a zoologist. As Sophie explained, "I always wanted to be a veterinarian, but now I've changed it. I want to be a farmer….Because I'm a person who doesn't like to see animals hurt very much." Likewise, Laura said,

> Well a vet takes care of animals and I wanted to be a vet, but now I don't. Because I wouldn't want them in cages and I wouldn't really want to see them die, even though I would save some, I wouldn't want to see them die.

Thus, Laura and Sophie's desire to help animals was the main reason for the careers that they were willing to consider as well as those that they had eliminated.

Amrita and Rachel wanted to help people. Amrita explained that after becoming an engineer (see footnote three), she wanted to start a business that would help people. Describing her company she said,

> It's gonna help. I haven't exactly decided what the company is going to do, but I decided that…everything that I do will be accessible and like make other people be able to use it, even people with disabilities and stuff. So like there'll be an elevator in every place and there'll be curbs on the sidewalk.

For Amrita, helping people by making things handicap accessible was important to her and a main reason for her interest in starting her own company.

As I discuss more in Chapter six, after the tenth grade Rachel decided to switch from thinking about being an engineer to being a doctor. In part, her decision was a result of believing that she was more capable in biology than in chemistry (which she associated with engineering). However, she also expressed a greater interest in biology and things pertaining to the human body than with engineering. In comparing the two she said, "I think I'm more interested about things pertaining to like the body. I think I might want to be a doctor." As her quote revealed, she was considering being a doctor because of her interest in biology. However, I believe her interest in being a doctor stemmed as well from wanting to help people on a personal level.

For Rachel, a main attraction of being a doctor was the ability to make people feel better. She explained, "I think a big part of [being a doctor] is…making people feel better about themselves and their situation…like being a doctor is hands-on and you actually treat the patients and you see their problems

and try to fix them." For Rachel, being able to interact personally with patients to help them was important to her. It was also the main difference she saw between being a doctor and an engineer. In comparing the two careers she said,

> With engineering it's more like you're dealing with not so much people that need the actual healing and I think um it would be easier for me to be more motivated if I see a person with a problem then, you know, oh let's fix this bridge or something like that.

Rachel did not feel that engineering would allow her to help people on a personal level the way being a doctor would.

Unlike the other girls, Rachel, the oldest girl in the sample, understood that her chosen career would involve having to know about and use science, particularly biology. The others were more vague about they would need to know about or do in order to pursue their chosen job. Ekert (2000) also found that while girls in general lacked knowledge about what they would need to do in order to pursue certain jobs, girls in the eleventh and twelfth grade knew more than younger girls.

Rachel also exhibited a more detailed knowledge of science-related jobs. Because I was particularly interested for this study in whether girls were interested or not in science-related jobs, I asked all of the girls which jobs they associated with science, as I discuss in the next section.

Knowledge of science-related careers

In order to assess the girls' understanding of their chosen job, I asked them each what they thought they may need to do or learn about and which classes they thought they would need to take. I was particularly curious about how the eight girls who desired science-related jobs, including the girls who wanted to study animals and Hannah and Rachel who were thinking of becoming doctors, believed their profession would use science.

Beth, for example, told me as a fifth grader that in order to become a veterinarian she would have to "work hard and go through college and training for vets or a doctor." When I asked her what classes she thought she might need to take in college or during training, she replied, "science and math maybe." To me, her responses indicated a general knowledge of needing further schooling in order to be a veterinarian but an uncertainty of the specifics of what she would need to know in regards to science.

Hannah, a seventh grader, was more specific than Beth in telling me what she believed she would need to do in order to become a surgeon. She told me that because of an experience at an afterschool program in which she dissected mice she knew how to take out a brain and a heart and that to be a surgeon she would need to learn how to replace them. She explained,

> I want to be a brain and heart surgeon because um we like killed and dissected…mice at my class. And um we took out the brain and the heart and we brought it in to school to show everybody. And so I know how to take them out. I'm not sure how to replace them yet.

When I asked her what else she might need to learn about in order to become a surgeon she replied that she would need to learn how to use a scalpel and that she might need to learn math. She said,

> I need to learn how to handle the tools cause like a scalpel is really sharp so I need to learn how to handle it. And um, well you need to learn math because math is a type of science and you never know, I don't know an example that you would need, but you'd probably need math.

Based on her association of math with science, I believed that Hannah considered being a surgeon a science-related job, but that she was unsure of how or what science she would need to know. Her understanding of what a surgeon needs to know was limited to practical concerns, such as how to use a scalpel. Similar to findings from previous studies with middle and high school girls (Baker & Leary, 1995; Wheeler, 2000), Hannah was unable to make a connection between science that she was learning at school and her career goals of wanting to be a doctor.

These limited responses about how some of the girls believed they would need science in their future jobs made me wonder what jobs the girls most associated with science. When I asked them to list jobs that they believed involved the use of science, all of them answered, "scientists." As Berta, a fifth grader, succinctly explained, "Well scientists obviously [use science] because they even have science in their names." Sunny, a ninth grader, elaborated that science-related jobs are "the researchers, the –ist people. The geologist, the oceanists and the, you know, the people that study stuff."

According to the girls, a scientist was mainly a person who worked in a laboratory. Katie, a seventh grader, defined scientists as "someone that likes, I don't know. It's like someone that like does a lot of research and works with science stuff….[They work] At a lab, a science lab." Similarly, Amrita, a seventh grader, said that when she thinks of scientists she thinks of a laboratory and chemicals. She said, "When I think of scientists I think of a lab. And I think of people who are playing with all those chemicals. Chemists, definitely." Berta, a fifth grader, also thought of people experimenting in laboratories, but believed that they could be found in the jungle as well: "[Scientists] experiment and they make new things to help you understand science….You might find a scientist working in a laboratory or out in the jungle trying to make an antidote out of a big leaf for people."

Consistent with previous research (Baker & Leary, 1995; Mason, Kahle, & Gardner, 1991; Wheeler, 2000), the girls in this study held a limited view of scientists as primarily people working in laboratories and doing research. In fact, Sunny, a ninth grader, made an interesting distinction between doctors and scientists. She did not believe that being a doctor or a veterinarian were really science-related jobs because they did not involve experimenting and making new discoveries. She explained,

> If you were like a person doctor or an animal doctor, if you were you know someone that went in and saw a patient, that's not really science. But if you were like a research doctor that was finding things out about the people, that would be science… in my mind. Like a physician, you've already learned all this stuff and it's just something that you know…I mean, yeah, I guess it kind of is an area of science but it's not something you think of right away because they're more people persons, you know?….It's not like they're finding out new stuff.

To Sunny, scientists were people that discovered new things through research and, unlike doctors, they did not interact with the people they were studying. It seemed to me that Sunny was distinguishing between research scientists versus applied scientists and that the categories were exclusive. According to her definition, someone such as Rachel who wanted to work personally with people would have to choose not to be a "scientist."

When I asked Rachel whether she saw any differences between a scientist working in a laboratory and doctors she replied that the actual hands-on help that she could provide for people as a doctor would have more immediate results than that of a research scientist. She said,

> [I]f you stay in a lab, in the long run you're probably helping people. But I think immediate results are more necessary now.…Like my idea of helping people is more on a level of like, not so much immediate results but just like helping the actual, physical person.

Thus, for Rachel, helping people was important, but so was the personal contact and seeing the results.

Knowledge of and stereotypes held of engineering

In general, the girls did not feel that they knew much about engineering despite attending the camp. Even Amrita who was planning on becoming an engineer admitted that she did not know what engineers did. When I asked her to tell me what she thought she might be doing as an engineer she replied, "I don't know what an engineer does, but I have to be one." Likewise, Courtney told me after attending the camp, "I don't really understand what an engineer is that much, but I never really wanted to be one." Thus, despite it being a stated goal of the camp, the girls did not feel like they learned much about the work of engineers.

In fact, when I asked each of the girls what they thought the counselors wanted them to learn about at the camp, only Katie said that she believed they wanted the campers to learn what an engineer does. However, she did not sound that sure to me. In response to my question she answered, "To learn to be engineers or whatever that [doing the activities] teaches you." Overall, the girls believed that the counselors simply wanted them to learn how to build things that would not fall apart and to program on the computer. For example, Amrita said she believed they wanted them to learn "just the basics of programming maybe. How do you get those remote control things to work." Similarly, Laura said they wanted them to learn "more about building things and making things move so they don't fall apart and break." Basically the girls believed that the purpose of the camp was to learn about the activities that they did, namely building and programming. They did not draw connections between the activities that they did

at the camp and their everyday lives or even to the work of engineers. As I discussed earlier in this chapter, this was probably because the counselors rarely emphasized the relevance of the activities to the girls' everyday lives and to the work of engineers. As such, a lack of understanding what engineers do could be one of the reasons why the girls were not interested in exploring engineering as a career option.

It is also possible that the girls were not considering a job as an engineer because of negative stereotypes they associated with it. During the group discussions I asked the girls (by age groups) whether they thought some careers were better suited for boys than girls and vice versa. I wanted to determine whether they held gender-specific stereotypes for certain jobs, such as engineering, which might prevent them from considering them. In general, each group did believe that there were certain careers better suited for boys, such as mechanics, engineers, and professional football players, but they were all adamant that girls were capable of and should be able to pursue any job that they wanted.

For example, when I asked the middle school girls specifically about engineering one of them said that it "Sounds like a boy type of thing," but they were all adamant that "that doesn't mean that boys are gonna be better at it." Additional careers that they believed were better suited for boys included professional sports and mechanics because they "like to get dirty." They listed these jobs, however, with the explicit caveat that "girls should be able to do anything."

The elementary school girls, like the middle school girls, stated that "girls are more intelligent than boys" and should be able to do whatever job they want. However, they too listed jobs that they believed were more suited for boys, including astronauts and train conductors. For example, one girl noted, "I've noticed that a lot of the astronauts are boys; only a couple are girls." And another said, "I've never seen a girl conductor on a train, but there probably are." When I asked them whether they believed or had ever been made to feel that engineering was more for boys than for girls they said that they had. However, they were unable to give specific examples other than one girl saying that when she builds at school the other girls say, "you're being so boyish."

The high school girls, more so than any other group, debated whether more boys than girls were engineers but mainly because one girl, whose mother is an engineer, vocally stated that they were equally represented. The other girls were not convinced. One suggested that it may only appear to be more boys than girls in engineering because boys have more "noticeable jobs." Another stated that she had actually visited engineering colleges and believed that there were definitely more boys than girls, saying, "I went to look at an engineering school, and it was like 75% male."

While the groups generally agreed on jobs that they believed were more suited for girls, including ballet dancers, gymnasts, cooks, fashion designers, beauticians, and babysitters, the elementary girls were the only ones who believed that more women than men were doctors and veterinarians. The middle and high

school girls believed that men and women were equally represented, although the high school girls believed that there were more female nurses. These findings are thus consistent with studies that have found that girls (grades five through twelve) do not associate masculine stereotypes with the life sciences but they do with the physical sciences (Baker & Leary, 1995; DeBacker & Nelson, 2000) and with engineering in particular (Janda, O'Grady, & Capps, 1978). In contrast to these studies, the elementary girls in this study believed that jobs associated with the life sciences, including doctors and veterinarians, were more feminine.

Baker and Leary (1995) found that eighth grade girls in their study held stronger stereotypic views of physics than did girls in the fifth or eleventh grades. However, I found that while the girls in this study were not informed about physics and believed that engineering was a male domain, only two girls, Rachel, an eleventh grader, and Courtney, a seventh grader, held strong *negative* beliefs about engineering. As such, negative beliefs did not vary by age in this study but rather by individuals.

Rachel, for example, was the high school girl who said that she had visited engineering schools and believed that they were mostly male. She told me in July 2000 that she was considering engineering because she found it interesting. But she was worried that she would not fit in at an engineering school because she perceived them to be mostly male and competitive, particularly as compared to the all-girl high school that she attended. Moreover, she explained that because her

friends did not see her as the type of person to go to an engineering school she was beginning to question whether she would fit in. She said,

> A lot of people are like, 'oh you're going to or you want to go to engineering schools? All dorks go there.' And a lot of my friends don't see me as that kind of person because I don't see myself as a person who would even really fit in there because I'm not really like that…it makes me think well maybe I don't, or maybe I shouldn't do that. Maybe I should be majoring in something like history or something like that. And then like I think well these people are competitive and they do all these things and I'm not like that so I shouldn't do that. Sometimes it kind of scares me and stuff like that.

It seemed to me that because Rachel believed that her friends held negative stereotypes of engineers, she was beginning to question whether she would be happy going to an engineering school. As she revealed in a later statement, she also believed that everyone at an engineering school would be too studious. She based this belief on her experience with her sister's boyfriend, whom she described as "someone who you would stereotypically think of as a person in engineering." She said,

> My sister had a boyfriend who was like an engineer and…I just didn't really get along with him. He was like someone who you would stereotypically think of as a person in engineering….And I was like, 'Oh gosh. I don't want to be like that.' I don't want to spend my free time you know studying up on, reading a physics book. I want to be like I don't know at a football game or something.

As I previously discussed, by our last interview in March 2001 Rachel had decided not to pursue a degree in engineering and was instead thinking of becoming a doctor. Her reasons for the switch was multi-faceted, including a growing interest in biology, a desire for a career that would allow her to help people on a personal

level, and a belief that she was more capable in biology. It was my belief however that Rachel's stereotyped views of engineering students as male, competitive, and too studious also played a role in her decision not to pursue engineering.

Yet Rachel was still planning on taking physics in the twelfth grade. Thus Rachel's stereotypical beliefs did not affect her course plans as much as her career plans. This is consistent with Khoury and Voss' (1985) finding that stereotypic beliefs did not influence the enrollment plans of high school students and with Eccles et al.'s (1983) hypothesis that even if girls did not perceive their classes to be masculine, perceptions of a career as masculine would affect their job choices.

Courtney, a seventh grader, also held negative stereotypes about engineering, which she equated to activities such as building with LEGOs like she did at the camp. She told me that although she tried to convince her friends to come with her to the camp they would not go to a camp called LEGO camp. She said,

> Well I've been trying to convince my friends to come, but they won't go to anything called LEGO camp….Well I didn't want to go to something called LEGO camp either….My friends and I don't exactly like LEGOs.

Courtney explained that while she actually liked the activities that they did at the camp, building with LEGOs was not considered "cool" by her friends. She concluded, "I guess it's not cool to go to a camp named LEGO camp." When I pressed her about why building with LEGOs was not cool among her peers, she

explained that the boys in her class played with LEGOs and they were too obsessed with them. She said,

> The boys in my class, they're like obsessed with Pokemon and LEGOs and they're like, 'Wow! I have this [LEGO kit]', you know? And so once in awhile they bring in LEGOs and they're like, 'look what I built.' And they're like, 'No, look what [I built].' Ugh.

To me, Courtney, and probably her friends as well, were repulsed by the degree to which the boys were involved with their LEGO building and they did not want anyone to think that they were similarly interested in them.

Overall, the girls knew more about and expressed more interest in science jobs such as doctors and veterinarians than jobs such as engineering. For two of the girls, Rachel and Courtney, negative stereotypes that they held about engineers may have played a role in their lack of interest in engineering. The other girls did not hold negative views about engineering, although they expressed the belief that it was more of a male career. To me, they did not feel deterred from being an engineer as much as they just were not interested. These findings are consistent with previous literature that found that middle and high school girls did not desire science-based jobs, particularly physical science ones, despite asserting that women should pursue them (Baker and Leary, 1995; Post-Kammer and Smith, 1985; Steinkamp & Maehr, 1984). As I discuss below, of the girls in this study, only Amrita, Laura, Beth, and Rachel had ever really considered being an engineer and I believe that their fathers were a main reason they had considered it.

Fathers' influence on interest in engineering careers

Although Laura, Beth, and Rachel had at one point considered being engineers, by the end of the study only Amrita was sure that she was going to become an engineer because her parents, both engineers, told her that she must. She explained that her father believed that a degree in engineering was a good basis for any career. She said,

> My dad says I can do whatever I want but first I have to become any type of engineer and then I can go do my M.B.A. and become a CEO of my company…He says [being an engineer] will help you do everything you need to do. Well it's weird because everybody in my family is an engineer, you know? My mom used to be a civil engineer before she became…a computer scientist. And then my grandfather is a civil engineer and like, so it's kind of like everyone in the family is an engineer.

Amrita believed that she would need to become an engineer because her father wished her to. She did not question that becoming an engineer would be useful to any future job despite telling me, as I have already noted, that she did not really know what engineers do. It seemed to me that she did not question being an engineer because everyone in her family was an engineer. However, although Amrita was willing to become an engineer it was not her interest. As I have described, she wanted to start her own company in order to help people. Thus, Amrita was the only girl in the study who was not pursuing a career, at least at first, because of personal interest. Instead, her parents, and particularly her father, had more influence on her choice.

Like Amrita, Laura and Beth also considered engineering at one point because their fathers were engineers. Laura, for example, said that she had thought about being an engineer when she was younger because she had seen her father, an electrical engineer, taking things apart at home. She explained,

> I thought about [being an engineer] once. Um, it was when I was little, I think, but I can't really remember when. Because it was when I saw my dad working once, like taking out this stuff and looking at it, like things for work. And so I asked him what he did and he said he was an electrical engineer. And so I thought about that, and I don't know. It never really appealed to me because, I don't know.

Although Laura said that being an electrical engineer, like her father, never really appealed to her, she told me that studying electricity was her favorite science subject. She even complained that the unit they had done in school did not cover as much material as she had wanted. She explained that at school "we didn't study enough about electricity because that's like my favorite subject in science. But like we only did about batteries and motors." She added that at home she built a motor using a kit that her father had given her for Christmas. She said, "Like at my house here I built a motor by myself. Because I have a kit of that." Laura did not feel that her interest in electricity was satisfied at school. Because she talked animatedly about building a kit at home, I believe that she really was interested in electricity but that she was perhaps not challenged enough at school and, as a result, was beginning to find science boring.

However, it is also possible that her real interest in electricity stemmed more from a desire to be in relationship with her father. She relayed to me that

when her father asked about her science class she would tell him, "all we did was work with batteries and stuff." He would then reply, "Well that's not very fun is it?" As such, it is possible that her dissatisfaction with the school unit was one that she expressed in order to agree with her father.

Additionally, Laura told me during our second interview in July 2000 that her father was not satisfied in his job because he was not working on the projects that he wanted. As a result, Laura concluded that she did not want to be an engineer because she too would probably not be able to work on the projects that she wanted. She explained,

> [My dad is] an electrical engineer and I did think about that because I like electricity, you know, and stuff like that but I didn't want to do that because, like my dad says he wanted to work on missiles but he only works on a small part of a cellular phone. It's not as fun as it would be if he works on missiles….[I don't want to be an electrical engineer] Because I wouldn't probably get what I wanted to be, what I wanted to work on.

To me, Laura was associating being an engineer with her father and because he was not satisfied at work, she had decided not to become an engineer, despite her interest in science and electricity. However, as I have already noted, Laura was more interested in becoming a zoologist so that she could work with animals.

Moreover, Laura was planning on taking math and science classes in high school because her parents believed that they were important subjects to learn. She explained to me in March 2001 that she knew her parents believed those subjects were important because they told her she would have to take them when she had a choice. She explained, "English, math, and science [are

important]….Because they've told me that when I get to pick my classes those have to be in the curriculum." Because of her parents' influence, Laura was planning to continue studying math and science.

Similar to Laura, I believe that Beth's interest in engineering was reflective of her desire to spend time with and share an interest with her father. During our first interview in May, 2000 at the end of her fourth grade year she told me that she had first thought about being an engineer because of her dad. She explained, "Probably in third grade [I first got interested in engineering] because I wasn't really interested in like my dad's work…until third grade when I noticed he was an engineer…[I became interested] mostly because my dad, my dad is an engineer." When I asked her what she liked to learn about in science class, she again referred to engineering and her father's influence. She said, "Um, probably engineering…Well my dad is an engineer, so. And I just love building things and creating things with LEGOs also." Because Beth responded to my question about her favorite science subject by saying that her father was an engineer and that she liked to build with LEGOs *also*, which implied that her father did too, it seemed to me that her interest in engineering was closely associated with wanting to share an interest with her father.

Unlike Laura, Beth said that she might still decide to be an engineer in the future although at the moment she wanted to be a veterinarian. When I asked her why she might want to be an engineer she answered, "Well because my dad is and um his work seems fun…[because] He just has a lot of friends there." Beth

believed that her father's job as an engineer was fun because he had a lot of friends. To me, having friends at work was more important to Beth's willingness to be an engineer than the work she would actually do. As such, relational aspects of her future work were more important than being involved with science.

It was my feeling that both Laura and Beth's interest in engineering arose in part as a way to share an activity with their fathers. To me, building with LEGOs or electrical kits at home provided them with a way to spend time with their fathers. Baker and Leary (1995) also found that the girls in their study who desired physical-science jobs did so because of experiences with a loved one.

However, Laura and Beth expressed a desire for a job that was "fun" and because Laura's father did not seem to have fun as an engineer, Laura decided that she would not either. In contrast, Beth said that she was still willing to consider engineering as a career because her father had fun at work. Ultimately, it seemed to me that having fun, perhaps in a relational context, was more important to both Laura and Beth for a future job than just sharing an interest with their fathers.

Summary

The girls in this study showed a preference for classes that involved hands-on activities. As such, they liked their science classes because they often involved experiments and large projects such as science fairs. As Amrita, a seventh grader, said, "Science can be fun if you do it."

By high school, however, the girls showed a preference for certain science topics. Consistent with previous studies (Benbow & Minor, 1986; Steinkamp & Maehr, 1984; Weinburgh & Englehard, 1994), they preferred biology rather than physics. Because the amount and kind of math and science instruction students have in elementary school has been found to shape their interests in those subjects later (Kelly, 1981; Meece, Parsons, Kaczala, Goff, & Futterman, 1982), it is possible that a lower exposure to physical science units in the earlier grades was a factor in the older girls' lack of interest. In general, all of the girls knew more about biology than physics and, based on their descriptions of class units, it seemed to me that they had done more biology-based units than physical science ones in their classes. By the end of the study, none of the girls had taken physics, although Rachel planned to in the twelfth grade.

In regards to future careers, seven out of the eight girls who expressed an interest in a science-related career were considering biology-based ones, such as doctors and veterinarians. Amrita was the only one who planned on pursuing a physical-science career but only because of her parents' influence. Rachel had considered being an engineer up until her junior year when she switched to wanting to be a doctor. Similar to the other girls who wanted to be doctors or veterinarians, Rachel wanted to care for and help people and she believed that being a doctor would allow her to do so on a more personal level.

However, Rachel was also not attracted to her image of engineering students as mostly male, too studious, and competitive. Apart from Courtney,

none of the other girls in the study expressed negative views about engineering but they all contended that it was a masculine subject. Yet they believed that women were either equally or more represented among doctors and nurses.

Therefore, to me the greatest obstacles to pursuing a physical science career for these girls in regards to interest is their masculine image of engineering and their lack of knowledge and experience with physics, as a subject, as well as a career field. In contrast, several believe that they will pursue a biology-based career because of their interest in the subject and their desire to help others.

Chapter Five

Utility: "Science is everywhere"

In this chapter I outline which classes the girls believed would be the most and least useful to them in the future and then I discuss their reasons for their choices. By asking them whether and how they perceived their classes to be useful, I assessed if utility was a consideration for them when they thought about which classes or careers to pursue in the future and how they defined the utility value of a class. As I discuss in the last section of this chapter, although all of the girls could articulate ways in which they perceived their classes to be important, only the high school girls and three middle school girls were influenced by the perceived utility value when making class or career choices. The younger girls did not use utility as a factor in their class and career considerations.

Math was chosen by the most girls as the subject that they believed would be most useful to them in the future. They considered social studies (or history) and foreign language classes to be least useful. I found little difference from the first to the second year of the study in either the classes that the girls chose as most and least useful or their reasons. Unless I specified otherwise, the results I discuss in this chapter are from the first year of the study.

The girls conceptualized their classes as useful in three ways: 1) for future work, 2) for everyday knowledge, and 3) for high school transcripts. There were

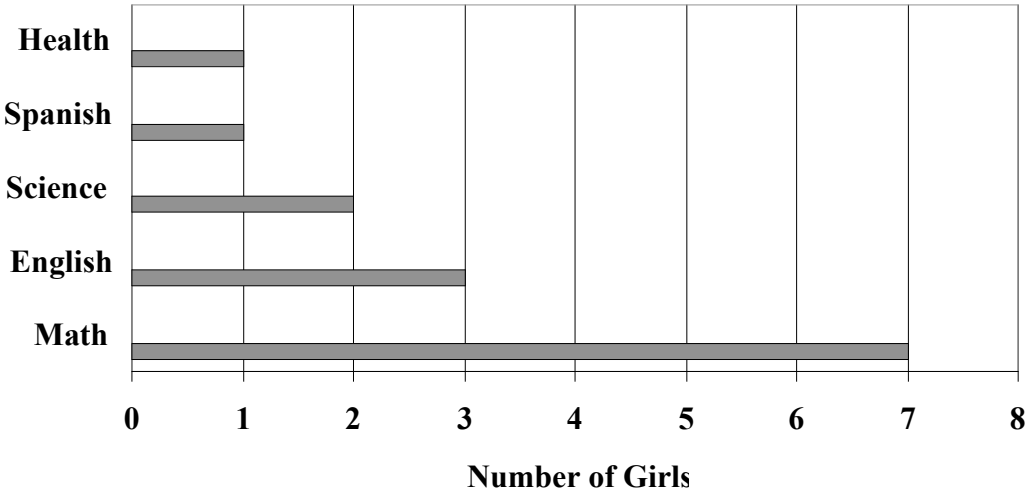
grade-related differences in how the girls thought their classes would be useful in that the older girls had more varied reasons for believing that a class would be useful in the future than did the younger girls. Moreover, the older girls conceptualized the usefulness of their classes in more personal terms.

Classes that the girls perceived to be the most and least useful

Math was chosen more than any other class as the subject that these girls believed would be most useful to them in the future. As shown in Figure 6, seven out of ten girls believed that what they learned in their math class would be the most useful to them in the future. Of these seven, three chose math as one of two classes that they thought would be the most useful to them, including Beth, Laura, and Katie. Four chose math as their only useful class, including Berta, Sophie, Courtney, and Marie. Three out of the ten girls believed that English was their most useful class (Laura, Amrita, and Katie), two chose science (Beth and Hannah), and one girl each chose Spanish (Hannah) and Health (Sunny). I discuss their reasons in the next section.

Lisa and Rachel, both in high school, are not represented in Figure 6 because they were unable to choose just one or two classes that they thought were most useful. Instead, they thought most of their classes were useful. I discuss this in more detail when I discuss differences across the age groups.

Figure 6: Classes that the participants perceived to be the most useful (N=10).



There was less variety in responses for least useful classes. As shown in Figure 7, foreign language classes and social studies were the two classes that were most often chosen as least useful (by four and five girls out of twelve, respectively). Hannah, a seventh grader, believed that her religion class would not be useful to her and both Beth, a fifth grader, and Rachel, an eleventh grader, believed that all of their classes would be useful.

Figure 7: Classes that the participants perceived to be least useful (N=12).

Except for Beth who believed that all of her classes were useful, the girls had no trouble choosing their least useful class. They each chose one class without hesitating in their response. In contrast, many of the girls, particularly the elementary and middle school girls, only chose a most useful class after a pause or after prompting by me. When asked to explain how they thought the class they chose would be useful to them in the future they often gave general rather than specific responses. This suggested to me that the elementary and middle school girls had not often thought about their classes in terms of *personal* usefulness. Rather, it seemed that they were repeating what they had been told.

For example, Laura, a fifth grader, gave a general reason for choosing both math and writing as her most useful classes. She said, "Well I know because I've heard this a million times, that you use math in everything you do and you use writing in basically everything you do so." Her reply suggested to me that she was repeating what she has been told, either by her teachers or her parents, without thinking about the concrete ways in which she personally would use math.

Although the high school girls also had difficulty choosing a useful class, it seemed to me that their difficulty was in choosing just *one* class and not because they did not know how their classes would be useful. As I describe more below, the high school girls had more varied reasons for finding a class useful, which could account for their delay in deciding which class would be most useful. Their multi-faceted assessment of the utility of their classes seemed to make it harder for

them to pick just one class as the most useful because they perceived uses for most, if not all, of their classes.

Ways in which the girls perceived their classes to be useful or not

Overall, the girls gave three reasons for believing their classes to be useful or not, including whether they were useful for: 1) future work, 2) high school transcripts, and 3) everyday knowledge. With all of the girls discussing usefulness in terms of future careers, this was the most popular or thought about reason for finding a class useful. In contrast, only the high school girls discussed class usefulness in terms of their transcripts and getting into colleges.

Useful for future careers

Math was most often described by the girls as being useful for future careers while social studies and foreign languages were least useful for future jobs. But even girls like Hannah who did not choose math, social studies, or a foreign language, described their choices in terms of future jobs.

For example, Katie, a seventh grader, believed that math would be the most useful class because both of her parents used it in their careers. She explained, "[Math] seems like a big part. Both my parents, my dad's an engineer and my mom's a…person that does taxes [accountant]….They both have a lot to do with math and numbers and stuff."

Berta, a fifth grader, also believed that math would be useful to her future job. She said,

> Even though I hate math it will probably be really involved in my life for jobs and things. I'll have to add up things and subtract things. And if I worked at a store and my machine broke I'd have to use a piece of paper and my mind or a calculator. So math might be really important.

In contrast, she believed that what she learned in social studies (her choice for least useful), and maybe reading, would not be useful to future jobs. She explained, "…if I'm going to work at a bank it doesn't really matter if I know the 50 states… social studies and maybe reading [won't be useful later in life]."

Hannah, a seventh grader, chose science as one of her most useful classes and she, too, explained her choice in terms of future careers. She said, "I'm going to be a surgeon so you need to know about science." Likewise, it was her reason for thinking her religion class would not be useful. She said, "Um, probably religion [will be least useful] because you don't really need it unless you're going to be a priest or a nun. Because it's not really going to help you if you're a surgeon or an accountant or something."

Thus while many of the girls, such as Hannah, Berta, and Katie, believed that their classes would be useful to future jobs, they did not often discuss how they would be useful to their *own* career goals. And even when they chose a class because of its perceived usefulness to their career, they were often unsure how *exactly* it would be useful. For example, Katie suggested that math would be important to a future career because her parents both use it in their jobs. Yet, she

said she wanted to be a music critic or a photographer. She did not explain how math would be useful to her in those careers. Likewise, although Berta gave an example of how she might use math while working in a store, she did not list working in a store among her career aspirations. Instead, she said she wanted to be a paleontologist. Thus, it seemed to me that while both girls believed that knowing about math would be useful in some jobs, they had not given much thought about how it may or may not be useful in their chosen careers.

Yet both girls told me that they had changed their career plans several times in recent years. It is possible that their general responses about how math might be useful in the future reflected their uncertainty of what they will be doing rather than an uncertainty of how math would be used in a specific career.

In contrast to Katie and Berta, Hannah, a seventh grader, chose science as her most useful class because she wanted to be a surgeon. But she seemed unclear about what kinds of science she would need to learn in order to become a surgeon. When I asked her what classes she thought she would need she replied, "Science or something like science. Biology, maybe. Math...I'm not sure what type [of science]." When I asked her what things she thought she would need to learn about she answered,

> I need to learn how to handle the tools 'cause like a scalpel is really sharp so I need to learn how to handle it. And um, well you need to learn math because math is a type of science and you never know, I don't know an example that you would need, but you'd probably need math.

Her responses indicated to me that although she was fairly certain that she would need to take science classes in order to become a surgeon, she was not really sure how they would be useful.

Similarly, Beth, a fifth grader, wanted to be a veterinarian and she believed that math and science would be important classes to take. When I asked her what specifically she thought she would need to do or study in order to be a veterinarian she replied that she would have to "work hard and go through college and training for vets or a doctor." She was not sure what exactly she would need to know about math or science.

Again, these general reasons for thinking a class would be useful to a future career, but not necessarily the career that they were considering, suggested to me that many of the girls, particularly the ones in elementary and middle school, had not given much thought to how their classes would be useful in their personal lives. This may have been because they were still exploring career possibilities and were not sure what information would be useful to them in the future. Yet, even for those that had given some thought to their specific career goals, many did not know how exactly the information they were learning about in their classes would be helpful. To me this mainly reflected the girls' lack of understanding and information about what different jobs entailed. Ekert (2000) also concluded that high-achieving middle and high school girls lacked information about what they would need to do for future jobs.

It is possible that their teachers did not emphasize real-life applications for the information that they were learning, leaving the girls to draw their own general conclusions. Two girls in particular, Beth and Amrita, suggested that the only use their teachers gave them for learning the class material was to do well on the MCATs.[6] When I asked Amrita in March 2001 as a seventh grader whether they ever discussed ways in class in which what they were learning would be useful in the future she indicated that they only talked about the MCATs. She said,

> Never. In class? Never. Everything that we do since the beginning of sixth grade has been for the MCATs. That's all we ever like, it's like the only reason why we should hear this is because we need to know for the MCATs. They cut out the science fair this year because they said that takes too much time in the curriculum and we don't have enough time preparing for the MCATs. We don't have this for the MCATs, we don't have that for the MCATs.

Amrita believed that her teachers emphasized learning for the MCATs at the expense of other things such as the science fair, which she enjoyed.

In May 2000, Beth also referred to the usefulness of her classes for the MCATs, which she had just finished taking as a fourth grader when I interviewed her. She described her math class, in particular, as having been useful for the test. She said, "Math probably [is a useful class]. Learning fractions. Because if I didn't learn them I wouldn't be able to do the MCATs….We just had the MCAT tests today….And that's why it was useful." When I asked her whether she believed what she learned would be useful in other ways in the future she seemed unsure in her response. She said, "I don't know how this would be useful, but I

[6] The MCATs are standardized assessment tests used in Massachusetts.

just think learning decimals will be useful because like I learned that 3.5 is 3 and a half and I didn't know that before." To me, Beth seemed unable to elaborate upon other ways in which what she learned in math may be useful in the future beyond the MCATs.

Useful for everyday knowledge

The girls most often spoke about their math, science, and English classes as being useful for everyday knowledge, regardless of their age. They gave specific examples of needing math, such as to pay bills and taxes and to buy groceries, and English, in order to know how to read and write. However, as with their references to future work, when they spoke about science being useful for everyday knowledge, they were often vague about how specifically they would use the information apart from science being "all around us," as Berta described it.

Berta, a fifth grader, was clear about how she thought she would need math in her everyday life. She said, "Um, you're going to need math your [entire] life because when you're older you're going to have to handle your taxes and stuff and your bills and going to the groceries and buying stuff." Yet to me her response about how she thought science would be useful was more general. She said,

> Science would probably be very important because it's something that's all around us and it's there forever until like the world ends. And so if I don't know anything about science I won't be able to answer my kids' questions like, 'where do babies come from?' That's a question that every parent doesn't know how to answer for awhile.

Although Berta believed that science was "all around us" she was unable to be more specific about what she would need to know for everyday life other than "where babies come from."

Lisa, a ninth grader, described science in almost the same terms as Berta when she said, "Science is everywhere." While looking out the window of the room where we were talking she elaborated on why she thought science was useful. She said,

> Even looking out this window you can see like the tree. That tree is like science [pause]. Like if you know about something [in science] you aren't gonna mix two chemicals together that are gonna explode in your face. Like if you know things in the periodic table, the elements and everything.

Like Berta, Lisa believed that knowing about science would be essential because it is everywhere, as shown by the trees, but she was unable to be specific about how she would use that knowledge.

However, Lisa was more specific in how she would use the information from her health class, both in her everyday life and as a doctor. She explained,

> We've learned a lot about um like how to take care of cuts and bruises and stuff. Like different diseases and stuff you could get…Plus, I don't know, I may still decide to be a doctor. And just everything about health is pretty much stuff that I could use in everyday life.

To me, Lisa's ability to be more specific about how she would use what she had learned in her health class, in contrast to her science class, was probably a reflection of the curriculum. Real-life, concrete, applications had obviously been

the focus of her health class, such as taking care of cuts and bruises. Yet her science teacher had probably not emphasized the everyday purpose of needing to know which chemicals could safely be mixed.

Similar to Lisa and Berta, Sunny, a ninth grader, described science and math as fundamental to everyday life. She explained,

> They are used so much in society today. I mean a hundred years ago you didn't have to know anything you just had to know how to milk a cow and plow a field.…But today it's like everything is so math and science oriented….It's like the world is getting smaller because of all this new technology and so you have to know things.

Like the others, Sunny described math and science as being essential to know because "everything is so math and science oriented." Yet she was unable to be more specific about what *she* would need to know in everyday life. In contrast, Sunny and the other high school girls were much more specific about needing classes for their high school transcripts.

Useful for high school transcript

The high school girls, including Rachel, Lisa, and Sunny, were the only ones to mention specifically needing classes for their high school transcript for admission to colleges or to take future college courses.

Rachel, an eleventh grader, mentioned that her science classes would be useful if she decided to go into engineering, her art courses would be useful if she

decided to go to art school, and her history class would help her to get into colleges. She explained,

> I think the science classes will help me if I want to do engineering or stuff like that.…And I'm taking a lot of art courses and hopefully that will help me get into a few things that I want to take and…I'm taking A.P. history so maybe, I don't think I'd want to major in history, but it might help [me to] get into college or stuff like that.

Rachel perceived that many of her classes would be useful to her future goals; she assessed the utility of her classes in terms of future career possibilities but also in terms of their usefulness for getting into the schools of her choice.

Likewise, Sunny, a ninth grader, said that she had chosen to take French as an elective because "you need it for college." In thinking about future classes to take, she said that she would "probably take some form of history just you know for the credits…[that I need for] college cause you know you have to take classes in college." As I summarize below, the high school girls had several reasons for believing their classes were useful, including that they would "look good on my college application," as Rachel told me.

Differences in utility beliefs by age groups

There were not any differences across the age groups in terms of the classes that the girls perceived to be most and least useful. All age groups, in general, believed that social studies or foreign languages would be least useful to them in the future while math would be the most useful. However, none of the elementary

school girls listed a foreign language as least useful because they were not taking one at the time of the study.

There were age-related differences, however, in the reasons that the girls gave for the usefulness of their classes. The high school girls had the most reasons for believing that their classes were useful. Like the elementary and middle school girls they often thought about utility in terms of future work and everyday life, but unlike the others they also considered whether their classes would be beneficial for college admission. Baker and Leary (1995) found similar grade-related differences in that eleventh grade girls considered college admission when choosing their classes but fifth and eighth grade girls did not.

Differences across the age groups in the ways that classes were perceived as being useful may be related to the greater amount of choice the high school girls have in choosing their classes compared to the middle and elementary school girls. Because the high school girls had more choice in the classes they took, they might have given more thought to why they would choose to take one versus another. The utility value of classes might be more relevant to students when they have a choice in classes. If so, the increased ability to choose one's classes might explain why utility beliefs seem to have more of an influence on the high school girls' class choices than on the younger girls' choices, as I describe next.

Utility beliefs as an influence on class choices

In making their class choices, the three high school girls were influenced by whether or not they believed that their classes would be useful to their future goals. As I discussed in Chapter three, none of the elementary school girls and only three of the middle school girls, Amrita, Katie, and Marie, mentioned usefulness as a reason for hypothetically choosing to take future classes.

Amrita, a seventh grader, was unique from the rest of the middle school girls in that she did consider utility, albeit in a limited way, when thinking about future classes to take. As I discussed in Chapter three, she was the only girl in the study who believed that the utility of her classes, as indicated by her parents, was more important than her interest when choosing her classes. In general, however, the high school girls had the most specific reasons for choosing their classes.

Katie and Marie, both seventh graders, said that if given a choice of classes to take in the eighth grade they would choose "all the basics." Katie explained that this meant that she would take classes like English and Math because they are "stuff that I'm going to use." Similarly, Marie said she would pick "the four major classes" because "you really need to know a lot about those four things because if you don't then you're not really educated very well." Both Katie and Marie grouped several classes together as being important rather than thinking about how specific classes might be useful. To me, this meant that while they

were thinking about their future class choices in terms of utility, they were thinking of general rather than concrete uses.

In contrast, Sunny, a ninth grader, said that she chose her elective classes because of their usefulness to her specific career goals. She said she chose to take art because she believed that it "would be helpful for me and my future." At that point in July 2000 she wanted to be a fashion designer. Thus, Sunny's reasons for choosing her elective classes were more specific than those of Katie and Marie.

Rachel, the oldest girl in the study as an eleventh grader, had the most specific reasons for choosing her classes based on utility. As I have described, Rachel said that she chose to take science and art classes in case she decided to apply to engineering or art school. Additionally, she chose to take A.P. level courses, such as history, because she believed they would be useful in gaining admission to colleges. To me, Rachel had a specific reason, based on utility, for all of the classes she was taking, not just her electives.

As for science classes, Rachel indicated that she was planning to take two science classes her senior year, physics and anatomy. Although utility was her main reason for wanting to take physics, interest also played a role in her decision to take anatomy. In regards to physics she said, "pretty much you need to take physics in order to get into college." But as I discussed in Chapter four, Rachel took biology in the eleventh grade and was planning to take anatomy in the twelfth grade because she was considering being a doctor. Although she believed that

anatomy in the twelfth grade would be a useful class to take, she was also planning to take it because she was interested in it.

In general, however, the utility value of classes played more of a role in the high school girls' class choices than it did for the middle school girls, which is consistent with Baker and Leary's (1995) findings. It is possible that utility becomes more of a reason for taking a class when there are choices. This would be supported by the fact that Rachel, the oldest girl in the group, and thus the one with the most choice of classes, considered the usefulness of *all* her classes while Sunny seemed mostly to consider the usefulness of her elective classes.

The younger girls might not have thought of class choice in terms of utility because they had no choice in the classes they took. In effect, someone had already decided for them which classes were useful. Courtney expressed this belief when she said, "Everyone always says you need math like the most. That's why we have math everyday and the other classes only…three days a week or four days a week." Courtney rationalized that math must be the most important class because she was required to take it the most often.

When I asked Courtney what she would choose next year for classes if she had a choice she was unable to conceptualize having a choice. She said,

> What classes would you be able to choose from? I've never had to choose.…I think I'd still take all my classes because I have to know them. If I didn't take them I'd probably fall behind in everything. I'd take all those classes and if I got to take a couple more I'd probably do [pause] what other classes are there?

Twice Courtney asked me what classes she would be able to choose from if she were allowed to choose her classes. As she said, she never had a choice before and she was not sure what she could choose. As such, it did not seem to me that she had ever thought about which classes she would need on a personal level; she was merely taking classes because they were required. To me this was evident when she said that she would continue to choose the classes that she was taking because otherwise she would "fall behind." It did not occur to her that she would not fall behind if she could choose never to take them again.

It is possible that the elementary and middle school girls, like Courtney, did not think of which classes to take in terms of personal usefulness because they could not conceptualize having a choice since they had not yet had any. As such, they may have had a harder time interpreting and answering my questions about class choice than did the older girls.

Summary

Math was the class that the girls believed would be most useful to them in the future because they were able to make connections with what they were learning to real-life applications. They all thought that they would be using math somehow in their future work or everyday lives, such as for paying bills and buying groceries. This is consistent with Eccles et al.'s (1983) review of the mathematics literature that found that students perceived mathematics to be useful.

In contrast, many of the girls, particularly the elementary and middle school girls had trouble conceptualizing how they personally would use what they were learning in their other classes. The high school girls perceived more ways in which their classes would be useful and considered those uses while making class decisions. However, their main concern was whether their classes would be useful for college admission.

In regards to science, several of the girls, such as Sunny, Lisa, and Berta, made references to it being everywhere and fundamental to everyday life. However, they were unable to be more specific about what science information they would need in the future. Even girls like Hannah and Beth who were planning to pursue a science-related career were unsure what kinds of science they would need to know for their jobs. However, in terms of taking science classes in the future, the girls in this study were convinced that they would need to know more science, even if they were unsure about what in particular.

I speculated that having teachers that did not stress real-life applications of what they were learning could have been a reason for the girls' inability to be more specific about what they believed would be useful in the future. I discuss the implications of this more in the last chapter by emphasizing that all of the girls will be users of math and science in the future, regardless of whether they pursue science careers. As such they will all need to be informed about math and science in an everyday sense.

Chapter Six

Ability: "She made us feel like we didn't really know anything"

Because perceptions of ability have been shown to be associated with adolescents' intentions to take science courses (Marsh & Yeung, 1997a; Tippins, 1991) and to pursue science careers (Hollinger, 1985; Jacobowitz, 1983), I explored this concept in several ways with all of the girls. I asked them which classes they believed they were doing well in or not and explored with them why.

As I discuss in this chapter, the most number of girls chose math, followed by science, as the class in which they believed they were doing poorly and found difficult. For them, not doing well in a class foremost meant earning low grades. Believing a class to be difficult meant they had trouble understanding the material or had to work hard in order to do well. I outline their beliefs about what it means to them to do well in the first part of this chapter and then I discuss the classes in which they believed they were and were not doing well and their reasons.

Overall, the girls believed that they could do well in their classes as long as they tried hard. Moreover, the effort they were willing to expend closely related to interest in that if they liked a class they were motivated to try hard to learn the material. Math was an exception in that it was the only class in which several of the girls believed that they would not do well even with effort. These findings support previous research that found that girls attributed doing well to effort

(Dweck, Goetz, & Strauss, 1980; Dweck & Repucci, 1973; Li and Adamson, 1995) but that they attributed failure in math to low ability (Eccles et al., 1983; Entwisle & Baker, 1983; Rhee, 1992; Stipek & Gralinski, 1991; Tapasak, 1990; and Wolleat, Pedro, Becker, & Fennema, 1980).

Unlike previous findings, however, the high school girls attributed doing well or not in their classes, specifically science and math, to their teachers and how they taught the material. While none of the girls explicitly attributed doing well in their classes to an innate ability, a few suggested that they or others had an ability to learn quickly and easily which facilitated their understanding.

In the last part of the chapter I reveal how according to the girls their beliefs of ability influenced their decisions about which classes to choose. Only the high school girls mentioned ability as a criterion for their career considerations. Lastly, I discuss the implications of these findings for pursuing science courses and careers.

What it means to the girls to do well in a class

When I asked the girls in May 2000 and again in March 2001 what it meant to them to do well in a class they gave a range of indicators they used to assess their performance, including grades, comparison to others in the class, amount of effort they had to expend to earn a high grade, understanding the material, and the difficulty of the work teachers assigned to them compared to others. While most

of the girls used more than one of these means of assessment, they all relied upon grades to some extent. Grades were usually the first criteria that they listed. As such, of all the indicators, to me grades were the most important to the girls in assessing their performance.

For example, Sunny told me in eighth grade that she relied first on her grades to tell her how she was doing in a class and then she assessed how much effort she put into her work. She explained,

> My grades mostly [tell me how well I'm doing] but if they're bad then I think well, you know, did I try my hardest? Could I just be you know stupid in that area and not get it. Um, and if I haven't tried my best then I just say well, you know, gotta work on that and do better next time.

According to Sunny, if she received a low grade she would assess how much effort she spent trying to do well. If she did not spend a lot of effort she would conclude that she could have done better. To me, this indicated that Sunny primarily used grades to gauge her class performance but that she used effort as a subsequent method of assessment. Moreover, because her questions to herself when she did poorly included asking whether she was "stupid," I suspected that she believed that ability played a role in her success or not. I discuss this possibility more in the ability section.

Berta, a fifth grader, also used several criteria to assess her performance in her art class but first listed grades. After grades, she assessed the difficulty of the work her teacher assigned her and then compared it to others. She explained that she knew she was doing well in art because, "I get good grades on it. I get like As

in art and my teacher…gives me hard work and then gives everybody else less hard work and some people really easy work." For Berta, earning high grades in art and being assigned more difficult work to do than the others in the class meant that she was doing well.

Amrita, a seventh grader, used grades and social comparison when assessing the class in which she did the best but she also judged how well she understood the concepts being taught. When I asked her which class she believed she was doing the best in she immediately responded, "Definitely math I do the best.…I always get a 100 on all the math tests." Later she added that she knew that she was good at math because she did "Better than other kids." Thus Amrita used grades by themselves, such as earning 100s, but also as a means of social comparison with the others in her class to determine that she was doing the best in her math class. As such, grades seemed to be most important to her as a means of assessment.

Yet Amrita also assessed how well she understood the material when judging how she was doing in the class. When I asked her in July 2000 how she expected to do in her seventh grade classes the following year she responded,

> I know I'll do well in math and English [next year]. I don't know about science. Science has never been my best subject…cause I can never understand like all the concepts of everything we learn, like pollution and everything. I can never understand everything.

Amrita believed that she was not doing as well in science because she did not fully understand all of the concepts. I did not ask her what her grades had been the

previous year but she indicated that she had done well in all of her classes. Thus, it is possible that Amrita believed that she was doing poorly in science despite earning high grades. Earlier studies have found that middle and high school girls believe that they do poorly in science despite doing well on science assessment tests (Jacobowitz, 1983; Khoury & Voss, 1985).

Similar to Amrita, Marie indicated that she used grades and how well she understood the material to determine that she was doing well in all of her classes. She told me in March 2001 when she was in the seventh grade that

> I think I'm doing well in all my classes. I don't think I'm not doing well in any of them because so far I've been getting really good grades and I understand everything really well so I don't think I'm doing badly in any of them.

For both Marie and Amrita how well they understood the material being taught was a consideration to them in determining how well they were doing in a class. Yet, for Marie, understanding the material was a validation of her good grades in general, while Amrita seemed to believe that she did not understand the science concepts despite good grades.

Overall, most of the girls first cited grades or test scores before they discussed other means of assessment. Two of the girls, Katie and Hannah, both seventh graders, used only grades to judge how well they were doing. As such, grades seemed to be a widely used and important indicator of success for the girls in this study.

Rachel was an exception. During her junior year she told me that she believed that it was more important to actually understand the material she was learning than to earn high grades. She explained,

> [To me, doing well] is not even so much the grades just like the fact that I feel like I'm learning something or I'm understanding something. I think that's the most important part. That I actually like understand it….Some courses I'll study two nights before the test and then just learn the information and go into the test and do well and then I'll forget it. And um like I don't really think that's like understanding the material so much.

Rachel believed that really understanding the material so that she would retain the information even after the test was more important than just doing well. However, I believe that grades were also important to her because she spoke of the futility of taking A.P. classes unless she was going to do well on the exam. She said, "If like students aren't doing well on the A.P. exam then it's really not worth taking the course." To me, Rachel was concerned about needing good grades in A.P. classes that would be important for college admission as well as future course credit. As I describe in the next section, it was common for the girls to express concern about the grades that would appear on their transcripts.

Concern about grades for college admission

Concerns about grades were commonly expressed, particularly by the high school girls, in regards to high school transcripts and getting into colleges. In this section I give examples from each of the three high school girls in this study that

revealed their concern for college admission. Additionally, I show how Hannah and Marie, both in the seventh grade, talked about needing good grades in order to get into college. However, in contrast to the high school girls who spoke very explicitly about classes that they would need to take or grades that they would need to earn in order to gain admission to a good college, the middle school girls expressed more general concerns.

At the end of her eighth grade year Sunny told me that she believed it would be important to earn good grades in ninth grade because that is when colleges start to look at high school transcripts. She explained that, "next year it will probably be very important [to do well] because you know colleges are looking at your grades in ninth grade and up." In the ninth grade she expressed a desire to do well in her English class so that she could later be in an advanced English class that would earn her credits for college. She said, "I'd like to do really well in English. Um, because you can get into a like Advanced Placement course which is good for like college credits senior year and stuff." For Sunny, it was important to do well so that she would have a strong high school transcript that would help her with college admissions and earn her college credits.

Similarly, Lisa said that she wanted to earn high grades in the ninth grade so that she would make the Honor Roll. She explained,

> I'm going to try really hard next year to get on the honor roll….That's my biggest goal for next year….Almost every semester for the last…two years I've brought home at least one D. I'd rather at least bring it up to a B or C at least.

She added, "I want to be able to do well in school so I'll be able to get into a good college and get a good job." For Lisa, earning high grades and making the honor roll would help her to get into a good school and subsequently a good job.

To me, these two examples, as well as Rachel's concern about doing well on A.P. exams, illustrated that concerns about grades in regards to colleges were prevalent among the high school girls of this study. As Rachel explained to me during her junior year, she and her classmates thought often about which colleges they were going to attend and they began to meet with their advisors to discuss the possibilities. She said,

> I mean right now there's the whole thing about where are you going to go to college and it's a big part of what we're doing at school now, meeting with our advisors and things and just talking about it with friends.

For Rachel, attending college was a primary concern by the eleventh grade. She perceived that earning good grades was an important element of preparing for college admission and, as I discuss in the implications section at the end of this chapter, her belief influenced her decisions about which classes to take. If there were some classes in which she perceived she would not do well, she would opt not to take them for fear of a low grade appearing on her transcript.

Two of the middle school girls, Hannah and Marie, also talked about wanting to earn high grades so that they could go to college. However, in comparison to Rachel, Sunny, and Lisa who spoke about particular classes or grades that they needed for college admission, Marie and Hannah spoke more

generally about wanting to do well. For example, Marie revealed that she believed that it was important to do well in school so that she could go to college and ultimately get a good job that would enable her to buy a house. She said,

> I think it's really important [to do well in school] because if you don't do well in school then you can't go to college for awhile and then you might not do well in college and then you might not get a good job and then you can't get a house.

To me, her goal of wanting to go to college in order to be able to buy a house seemed unusual. She had previously told me that her parents were looking for a new house, so I wondered if buying a house was really a goal expressed by her parents. As I discuss in the next section, perhaps going to college was originally a goal of her parents as well.

Hannah also reported wanting to do well so that she could go to college but she seemed to confuse college with medical school. She explained that it was very important to do well in school because "I'll need to do well to get into good colleges and stuff. I want to go to Tufts Medical School for college." For Hannah, going to medical school was the same as going to college. Because she did not realize that she would need to complete college before going to medical school, I believe that she did not have a clear idea of what going to college would achieve for her. Ekert (2000) reported similar findings of girls not having enough information about the schooling they would need to reach their goals.

As I point out in the next section, it seemed likely to me that parents were the ones who desired good grades for colleges and that their daughters, by striving

for those grades, were trying to please them. By high school, the parental message had been internalized so that wanting good grades for college had become their own goal.

Earning good grades to please their parents

Many of the girls reported that they believed that their parents valued high grades. They knew this, they said, from what their parents had told them and, for some of the girls, such as Beth and Berta, because they were rewarded for good grades on their report cards. They believed that high grades were important to their parents so that they could go to college.

For example, Beth said that she knew her parents wanted her sister and her to do well because when they brought home good grades on their report card their dad rewarded them. She explained, "When we get a good grade on our report card we usually get like a Beanie Baby or something. So that sort of shows that it's important to my dad." She added that she did not like bringing home low grades because her parents would get mad. To me, Beth's desire to earn high grades was in part to please her parents so that they would not be mad with her.

Like Beth, Berta believed that her parents wanted her and her sister to do well because they gave them rewards for good grades. She explained,

> If we get good grades in school we get a small treat for our good grades on our report card…maybe a comic series to come in the mail or something. Like we have a scooter in the garage for my sister.

She added that she believed her parents hoped that with good grades she would qualify for a scholarship to college. She told me, "They want me to do good and get scholarships. They're like, 'Oh yes, definitely get a scholarship that would be great.'" Berta knew that her parents wanted her to earn high grades because she was rewarded for them. She knew that they believed high grades were necessary for a scholarship because they told her so.

It seemed to me that Berta had internalized her parents' desire for her to earn a scholarship when she told me that she wanted to earn one so that she would not have to "work off" the cost of college later. She said, "I really want to try and get a scholarship…so I won't have to work off money." To me, it was no longer just her parents' goal, but Berta's goal as a fifth grader to earn a college scholarship.

Hannah and Marie, both seventh graders, told me that they believed that their parents wanted them to do well in school so that they could go to college. When I asked Hannah why she thought her parents wanted her to do well in school she responded, "Because they want me to go to good colleges." Likewise, when I asked Marie the same question she said, "They're really into getting good grades and um I think it's important to them that I go to college and that my sister goes to college because then we can get a good job and we can do stuff." Both Hannah and Marie believed that their parents wanted them to do well in order to go to college. Like Beth and Berta, it seemed to me that their desire to earn high grades was in part attributable to wanting to please their parents.

Similar to Beth, Lisa, a ninth grader, described her parents as getting mad at her for earning low grades. To her, this indicated that it was important to them that she did well. She said, "It's just really important to [my parents] that I do well. They're wicked mad every time I bring home the D." Additionally, Lisa described her mother as being mad at her that she was not accepted by the public high school that her mother wanted her to attend. She explained,

> I tried to get into Latin School but I didn't because it's really hard to get in in eighth and ninth grade. When we first got the response back my mother was sort of mad at me….I don't know why really. I think she expected me to get in maybe.

To me, Lisa was confused, and possibly hurt, that her mother would be mad at *her* for not getting into a school.

She later explained that she believed her mother wanted her to go to the Latin School because it was supposed to be a better school than the one she was attending. She added that if she had tested well enough for both public schools her mother would have made her go to the Latin School against her wishes. In fact, she believed that her parents really wanted her to go to a private school, but she was not willing. She said,

> Actually they both want me to go to private school which I refuse to do….I've always gone to public school. And I just feel like I would never be able to adjust there. And I'm really happy where I am right now.

To me, Lisa felt pressure from her parents, particularly her mother, to go to a high school that was judged to be better than the one that she was attending, presumably to increase her chances for getting into colleges.

However Lisa believed that the school she was attending would enable her to go to the college of her choice and, as she explained, that was her main concern. She said,

> [The principal] told us the first day of school that you can get into almost any college of your choice from this school and that's what I want….If I go to…wherever my mom wants me to go to, I have a feeling I probably won't be able to go to any college I want to.

While Lisa appeared to be resisting her parents' wishes, she and her parents shared the same goal of wanting Lisa to go to a good college.

To summarize, all of the girls in this study relied foremost on grades as an indicator of success. They believed that high grades were necessary for college admission and, by high school, earning those grades had become a primary focus for that reason. Before high school, it seems possible that their desire to do well in school was in part an effort to please their parents. All of the girls believed that their parents wanted them to do well in school and go to college.

Classes in which the girls believed they were and were not doing well

In general, all of the girls believed that they were doing well in most of their classes based on their own criteria of earning high grades. When I asked them to pick a class in which they thought they were doing the best, they often responded that they could not pick just one class because they believed there were several, if not all, in which they were doing well. Likewise, when I asked them

which classes they believed they would do well in the upcoming school year they usually responded that they would do well in most or all of their classes.

Beth, for example, told me that she thought she would do well in all of her upcoming fifth grade classes when I asked her in July 2000. She said, "I think I'll do pretty well actually [in my classes next year].…I don't want to brag…well usually I do well in all the things." Later the next school year when I asked her in March which class she believed she was doing the best in, she had a hard time choosing just one. She told me, "This year, social studies and math [I'm doing the best in]….I'm not sure…can I say like a lot because they're tied?" Despite not wanting to seem like she was bragging, Beth indicated that she was doing well in all of her classes.

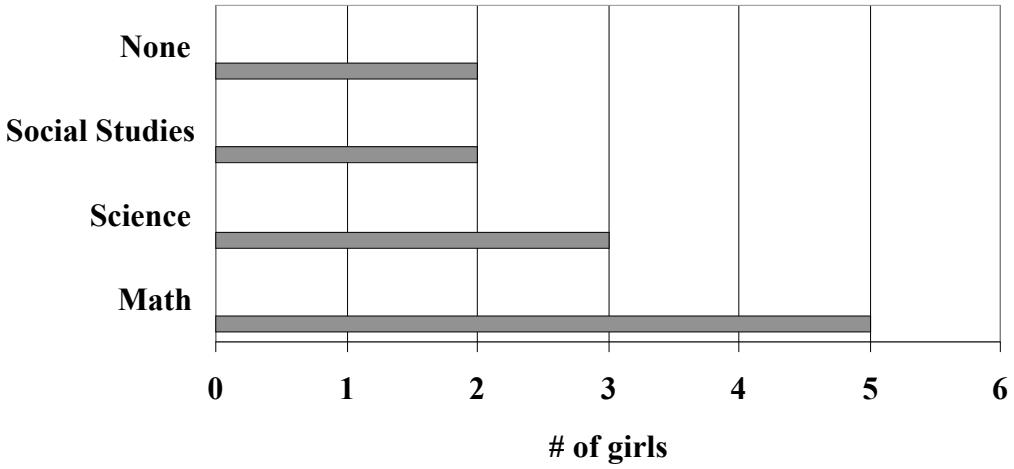
Despite Beth's comment that she did not want to brag, none of the girls seemed uncomfortable talking about how well they were doing in school. Most of them talked about doing well in their classes and reported earning high grades. Moreover, several spoke of participating in honors and advanced classes. This suggested to me that, in general, they were doing well academically.

Even when I asked them about the classes in which they believed they were *not* doing well, many of the girls replied that they were doing well in all of their classes. After amending the question to ask which class they were not doing as well in compared to their other classes, most of them would choose one or two classes. Laura and Marie were exceptions in that they consistently stated that they were doing well in all of their classes. Even when asked which class they found

most difficult, Marie contended that there were not any that she found hard. Laura listed her math class but only because she felt there was a lot of homework, not because she had trouble understanding the concepts. Likewise, Beth chose social studies as the class in which she was not doing as well because she was not interested in it, not because she found it difficult. I discuss these reasons in more detail in the following section.

All of the girls, except for Laura and Marie, eventually discussed at least one class in which they believed they were doing less well compared to their other classes. As shown in Figure 8, math was chosen most often (by 5 girls), followed by science (3 girls), and then social studies (2 girls).

Figure 8: Classes in which the participants believed they were not doing as well compared to their other classes



However, not doing well for many of the girls meant earning Bs rather than As. For example, Katie, a seventh grader, described getting Bs in math as doing poorly: "I'm not good at math. I get like Bs and stuff. So I'm not very good at it."

To her, earning Bs meant that she was not very good at math. Similarly, Amrita described herself as not doing well in science because she did not get perfect marks on her science final like she did in her other classes. She said, "In language arts, math, and social studies I got a 100 on those finals. And then science I got a 94 because it was kind of hard, the science final." To Amrita, not earning a perfect score on her science final meant that the test was hard.

To me, these comments revealed that these girls were used to earning high grades and, as a result, their criteria of doing well in a class was high. As such, their beliefs about which classes they believed they were doing poorly and why would not necessarily be the same as those of girls who were not doing well. As I describe below, the girls in this study often attributed not doing well in a class to a lack of interest or effort, rather than to a lack of ability as has been found in earlier studies (Dweck & Repucci, 1973; Dweck, Goetz, & Strauss, 1980). However, as in Katie's example above, math was an exception. Many of the girls attributed not doing well in math to finding it difficult to understand. I return to their beliefs about math when I discuss attributions made to ability and class difficulty.

Reasons for doing well or not

The girls attributed doing well or not in their classes to several things including: 1) effort, 2) interest, 3) the difficulty of the class, 4) the teacher, and 5) an innate ability. It was common for the girls to attribute doing well or not in a

class to more than one reason, particularly interest and effort. Table nine shows the reasons given by each girl in the study for doing well or not in their classes. All of the girls talked about effort, believing for the most part that they could do well in their classes as long as they tried hard. For them, interest was closely related to effort. They described how being interested in a class helped them to do well because it motivated them to try hard.

Table 9: Reasons given by each girl for doing well or not in their classes

		Attributions				
Participant	Grade	Effort	Interest	Difficulty	Ability	Teacher
Berta	5th	X	X	X	X	
Beth	5th	X	X		X	
Laura	5th	X	X			
Sophie	6th	X	X			X
Amrita	7th	X	X			X
Courtney	7th	X	X	X	X	
Hannah	7th	X	X	X		
Katie	7th	X	X	X		
Marie	7th	X	X			
Lisa	9th	X	X	X		X
Sunny	9th	X	X		X	X
Rachel	11th	X	X		X	X

Seven girls attributed not doing well in a class, particularly math and science, to its difficulty, while two girls attributed doing well in all of their classes to their ease. Thus class difficulty was mentioned by nine of the girls as a reason for doing well or not. For at least five of the girls, finding a class difficult or easy to learn meant that they had an innate ability, or lack of one, in that subject. Lastly, five girls, including all of the high school girls, perceived that their

teachers influenced how well they did in class by how willing they were to provide help or how difficult they made tests. In the following sections I provide examples of each of these five attributions as well as indicate which girls spoke of them. In the last section of this chapter I discuss the implications of the girls' beliefs for future class and career choices.

Effort

All of the girls primarily referred to effort when discussing why they were doing well or not in their classes. They believed that they could do well in their classes as long as they tried hard and, conversely, they needed to try harder and pay more attention in order to do better. As I discuss in this section and the class difficulty section, math was an exception for several of the girls in that they did not believe they would do well with effort.

Amrita, a seventh grader, attributed doing well in her math class to practicing problems at home. She explained to me during her interview in March 2001 that, "When I learn [math] for the first time it's not always the easiest. I have to do like 15 or 20 problems before I can actually get every single one right after that." She added later that she considers herself to be smart at math, which to her meant doing better than other students, because she pays more attention in her class. She explained, "[I would describe myself as smart in] Math…[meaning] Good at it…Better than other kids, I don't know…Because I pay more attention

than they do…You're not born with [a math ability]. You need to work towards it." For Amrita, doing well or not in her math class was due to her effort. She did not believe that she was born with an ability to do math.

Likewise Hannah, also a seventh grader, described herself as smart in science because she paid attention in class: "I consider myself to be smart in science a little….Because I always paid attention in science so like I knew it." When I asked her what she would need to do in order to do better in her classes she responded simply that she would need to "study more." To me, Hannah and Amrita's comments clearly revealed a belief in effort in order to do well in a subject. To both of them, working hard meant paying attention in class and studying more at home.

Laura and Sunny both referred to trying hard, particularly on their homework, as being necessary to do well in their classes. When I asked Laura as a fourth grader in May 2000 what she believed she would need to do in order to do well in her classes she responded, "I'd have to practice a lot and like really try a lot on the homework. Like not just rush through it." Thus Laura, too, seemed to believe that she could do well as long as she spent time at home learning the material.

Sunny told me as an eighth grader in May 2000 that the only reason she did not get all As and Bs in her classes was because she did not do her homework. She explained,

> You see the problem before was I wouldn't do my homework as much as I should. So that would bring my grade down. Cause I got like perfect test scores. I don't even have to really listen in class most of the time. It just like kind of goes in my brain. And so I passed, like aced all the tests, but not do my homework, which is 20% of your grade. So I'd be brought down to a B, B minus.

While Sunny admitted that not doing her homework played a role in how she did in her classes, she did not attribute doing well entirely to effort. As I describe more in the ability section, Sunny believed that she had an ability to learn things easily and quickly. She indicated this in the quote above when she said that she does not "have to really listen" because it just "kind of goes in my brain." To me, she believed that she did well in her classes because of an ability to learn the material easily *and* because of effort.

Courtney believed that she could do well in all of her classes as long as she tried hard *except for math*. In May 2000, when she was in the sixth grade, she described math as her most difficult class because unlike her other classes trying hard did not mean that she would do well in it. She explained,

> I guess math [is more difficult than my other subjects] because math is harder to…Like with the other subjects…if you try really hard in it, it makes a big difference. But in math…if you don't know what it means…no matter how hard you try it's still hard to figure out like what to do…like if you don't try at all…it's like almost the same thing as when you try hard.

Unlike Laura who believed that she could do well in *all* of her classes as long as she tried hard, Courtney believed that trying hard to do well would only work in some classes. She found math difficult to learn even with effort. As such, she did

not believe that effort alone was responsible for her performance in math. Instead, she referred to the difficulty of math as I describe more in that section.

Berta also believed that she did poorly in math even when she tried hard. She told me in July 2000 the summer before her fifth grade year that in order to do better in her math class she would have to pay more attention in class. She added however that she was not sure paying more attention would help. She said,

> [In order to do better in math] I think I'll have to pay attention more instead of dozing off and just try to really remember things. Otherwise just keep it my bad subject and move on….Well, maybe I'll get better at it if I do that stuff but I think that is really hard to do. Cause math is just like my weak spot.

Like Courtney, Berta's belief in effort seemed to be subject-specific in that she did not seem certain that paying more attention in math would help her to do better. Like Sunny, Berta seemed to suggest a belief in ability when she described math as her "weak spot." As I describe in the class difficulty section, math was an exception for several of the girls in believing that they could do well with effort.

Interest

In addition to effort, all of the girls attributed doing well or not in their classes to interest, particularly as it related to trying hard. For example, Beth attributed doing well in science and not doing well in social studies to interest. She said in July 2000 before her fifth grade year,

> I didn't really like social studies that much [in 4th grade]. And so I think that's why I didn't do well. I thought it was boring. But in science…I think I did well because I liked it and, well liking it helped because if you like it you try harder I think.

For Beth, liking a class helped her to try harder in it to do well. To me, effort, interest, and doing well were closely related for her.

Likewise, to me, effort and interest were related to doing well or not for Lisa, Rachel, and Hannah. Lisa told me in July 2000 before her ninth grade year that she believed she learned better when she found a class interesting because "you listen better. Or at least I do." Although Rachel described her eleventh grade biology class as difficult she admitted that she spent more time trying to learn it because she liked it. She said, "I think biology is definitely one of my harder courses but it's something I like more so I'm spending more time on it actually understanding it." Hannah echoed those beliefs when she described not doing well in her English class because of her lack of interest. She explained in March 2001 as a seventh grader that she was not doing well in English "Because like I'm not really interested in English. It's not something that I want to know so I don't really like pay attention too well in it." For Hannah, not being interested in her English class meant that she was not motivated to pay attention and, as a result, she did not believe that she did as well in it.

Therefore, Lisa, Rachel, and Hannah primarily attributed their performance in a class to effort, including paying attention and spending more time on learning the material. Lisa and Rachel believed that they spent more effort when they

found the class interesting or fun. Conversely, Hannah believed that she did not do as well when she found a class boring because she was not motivated to pay attention. Both effort and interest played a role in how well these three girls believed they did in their classes.

Class difficulty

While discussing reasons for not doing well, many of the girls referred to the difficulty of the class. Math however was the only class in which difficult concepts were blamed for doing poorly. As shown in Table 10, which compares the classes the girls believed that they were doing least well in to the ones that they found most difficult, five girls believed they were doing least well in math because they found it to be difficult.[7] Although Sunny and Rachel, both in high school, believed they were doing least well in science because of its difficulty, they attributed the difficulty more to how their teachers taught it than to finding the concepts hard to understand. I discuss this more in the teacher section.

The remaining girls either did not attribute doing poorly in a class to its difficulty, such as Sophie and Amrita, in which case their choice for most difficult class was different from that in which they were not doing well, or they did not believe any of their classes were difficult, such as Beth and Marie. For example, when I asked Marie why she believed that she was doing well in all of her classes

[7] Only five girls believed that they were doing least well in math *because* they found it to be difficult. Although Laura chose math as her most difficult class, she did not believe that she was doing poorly in it.

she responded simply, "I find…all [my classes] easy. I understand them all." She attributed doing well in her classes to their ease and her understanding.

Table 10: Classes in which the participants believed they were doing least well compared to most difficult

Participant	Grade	Class not doing well	Difficult class
Berta	5th	Math	Math
Beth	5th	Social studies	None
Laura	5th	None	Math
Sophie	6th	Social studies	English
Amrita	7th	Science	English
Courtney	7th	Math	Math
Katie	7th	Math	Math
Hannah	7th	Math	Math
Marie	7th	None	None
Lisa	9th	Math	Math
Sunny	9th	Science	Science
Rachel	11th	Science	Science

Of the girls that believed math and science to be difficult classes, only Laura believed that math was difficult because of the amount of work involved in the class. The rest believed that the concepts were hard to learn or difficult to understand. For example, as I described in the effort section, Courtney and Berta found math hard to understand even with effort. Berta referred to it as her "weak spot" and questioned whether she could do better even with effort, while Courtney

conceded that "no matter how hard" she tried in math she found it "hard to figure out like what to do."

Likewise, Katie described herself as consistently doing poorly in math and she attributed it to finding it hard to memorize concepts and to feeling nervous about tests. She said,

> I don't like memorizing stuff [in math class]. I can't, I just forget it all. Or I get nervous in tests and stuff. But I don't get nervous in English tests. It's just mostly math cause I'm not that good at it….I've been getting low marks all my life in math. Even when I was like in first grade and stuff I didn't get good marks.

For Katie, math was a difficult subject in which she had always done poorly, earning "Bs and stuff."

Hannah described math as harder than her other classes and attributed the difficulty to the increasingly complex concepts. She explained, "it's kind of like as you move up in the math world, it gets harder as it goes along. But with science and social studies it always stays at like the same level."

Courtney and Berta, in particular, seemed to believe that they had a hard time learning math *even when they tried hard.* Thus, I wondered whether they believed that one had to have an innate ability in math in order to do well. When I posed that question in July 2000 they answered that although they did not believe that some people were more naturally able to do well in math they believed that there were certain innate abilities that made learning easier. I discuss this below.

Ability

Although none of the girls explicitly attributed doing well or not in their classes to an innate ability, a few suggested that there were certain traits that enabled them or someone else in their class to do better in school. Specifically, Beth, Berta, Courtney, Sunny, and Rachel believed that they or others had an innate ability to learn quickly and easily with little or no effort.

Sunny, for example, replied when I asked her why she thought she did so well in her classes that she was just able to learn things quickly and easily. When I asked her whether she believed she was born with an ability to learn things quickly she decided that she probably was. She said, "I don't know [if I was born with the ability to pick things up quickly]. Maybe. Or you know, yeah, it probably was, because my parents certainly didn't teach me to learn quick." To me, her statement indicated that she believed she had an intrinsic ability to learn quickly that allowed her to do well in school.

Berta, Courtney, and Rachel also suggested that an ability to learn quickly and easily was innate. However, in contrast to Sunny, they did not believe that they were capable of learning quickly and easily. Instead, they described other students in their class as having that ability. For example, Rachel described one of the girls in her class as "a genius," capable of doing well without trying. She said,

> I know that one of my friends is like a genius and…she never does her homework….But you know she does get it done or she does it the period before and it's like perfect. And then she goes into class and she understands everything. Even if she hasn't done her homework she knows everything. She doesn't even have to read it to know….We read it and we still don't understand it.

Rachel believed that her friend was able to do well without doing homework whereas she could not. In fact, when I asked Rachel whether she believed that she could do well in all of her classes as long as she tried hard enough, she replied no. To me, this suggested that like Sunny, Rachel believed that there was an innate ability that allowed some people to do well in school without effort. Conversely, she believed that there may be a limit to how well she could do with effort alone.

In contrast to Rachel, Courtney and Berta believed that anyone could do well with effort, but that some people, particularly "smart" people, had an easier time learning things. Berta, for example, believed that learning came "natural" to the smart students in her math class, but she also believed that maybe they studied more or learned concepts sooner. She said,

> [The 'smart' kids in math know more because] maybe they study math. I don't. Some kids, I know there's this girl in my class, when she was in fourth grade she moved up to fifth grade for math class because she was really smart. She's really smart anyway though. And I think it just came natural to her because it's just really easy for her….Well, she, maybe she had an older sister like when she did her multiplication her older sister might have been doing division and she might have learned how to do division earlier.

Berta's example of the smart girl in her math class suggested to me that she believed in a combination of effort and ability such that smart students learned

more easily but that they also might have learned more outside of school by studying.

Similarly, Courtney believed that smart students understood more and were capable of solving problems quicker than other students. She attributed this to being born more observant and to thinking differently. She explained,

> Everyone can do well if they try, but [smart kids] just understand more about what [the teacher is] talking about…. All the questions that I always think about, they know the answers to….It's not just that they know about a lot, it's also that they um think a lot different than we do.…Not a lot different….Maybe they're just more observant or something….It's not like a gift to be really smart but there are some things that you can be born with that would help you with that. Like you could notice small details, um, be able to like, um, solve problems quicker.

For Courtney, being born more observant and able to solve problems quicker allowed smart students to understand things better than she did in school. However, as she made clear in the quote, she believed that everyone could do well if they tried.

Interestingly, Beth was the only one to suggest that ability may be subject-specific. She described herself as doing well in math and science and when I asked her whether she believed she was born smart in math and science she replied that she had to work hard in some classes, but was born smart in others. She explained, "Like in some subjects we were born [smart] and some we have to work really hard…. Math and science [you're born smart]. And the ones where you have to work really hard is social studies and reading." In comparison to the other girls who talked about ability, Beth believed that she was smart in some

subjects but not in others. However, when I asked her later to define what it meant to her to be smart, she answered, "Like doing well, sort of…trying hard." Her answer implied that for her being smart meant trying hard and doing well, not necessarily having an innate capability. So I am not sure whether Beth really believed she had an innate ability in math and science. It is possible that she interpreted my question in a way other than I intended.

Overall, the five girls that alluded to an innate trait that allowed them to do well in school seemed to believe their performance in school was attributable to a combination of ability and effort, rather than to just ability.

Teacher

As I discussed in Chapter four, many of the girls believed that their interest in a class was influenced by how the teacher taught the class. Similarly, for five of the girls, including Sophie, Amrita, Lisa, Sunny, and Rachel, their beliefs about how well they were doing in the class were related to the teacher.

For some, such as Amrita and Sophie, their teacher's influence on their performance was as basic as making tests too difficult. Amrita, for example, explained to me in July 2000 that she did not do as well in her sixth grade science class compared to her other classes because the science final was too hard. She blamed this on her teacher. She said, "In language arts, math, and social studies I got a 100 on those finals. And then science I got a 94 because it was kind of hard,

the science final. She always makes everything too hard." Amrita believed that she did not do as well in science because her teacher made the test too hard.

Likewise, Sophie explained that she got low grades on her fifth grade science tests because her teacher did not sufficiently review the material. She told me in May 2000,

> I'm not really good [in science]…because on a lot of tests I get low grades because I can hardly remember what I've learned because she doesn't review it very much with us. She just reviews the reading book, not notes and everything.

Sophie believed that she did not do well in science because her teacher did not review the necessary material for the tests.

In contrast to Sophie and Amrita, Lisa, Sunny and Rachel believed that their teachers played a larger role in how they did in their classes. Instead of just making tests too difficult to do well, they believed that their teachers were responsible for how much they learned. Sunny told me that, "the teacher really is the class. You know, they're the ones teaching it. So if they can't do a good job, then you really don't learn much." She believed that how much she learned in a class was dependent upon how well the teacher could teach it to her. She gave an example of how she believed that her eighth grade pre-algebra teacher left her with many unanswered questions. She explained,

> I don't like the way he teaches…he never explains anything really. He just shows it to us [and says] 'that's the way it is, that's the way the book says it, that's all you need to know.' But he won't answer our questions like why does it work that way? Why is a negative times a negative a positive?…. He says, 'Well that's the rule. That's just the way it is.' So I came home and I would ask my mom and she would just sit down at the kitchen table and…scribble for half an hour until she found the answer. And it's not even that hard.

Sunny believed that she was not learning as much as she could in her math class, such as why things work the way they do, because her math teacher was incapable or unwilling to explain to her what she believed were ultimately easy concepts. The fact that she was able to understand the concepts when her mother showed her proved to Sunny that the problem lay with her teacher, not with her ability to understand.

Nevertheless, Sunny believed that her math teacher's pattern of leaving things unexplained often left her feeling frustrated and questioning whether she could learn the material. She said of her math teachers, "Sometimes I just get so frustrated at the way that they're explaining things…that it's like, 'Ahh [said with frustration], I will never understand this!'" She related similar feelings about her science teacher when she said that "he expects us to be as smart as he is. And when we make mistakes he makes it seem like it's always our fault when it's sometimes not." Thus, although Sunny primarily attributed not understanding concepts in her math and science classes to her teachers' inability to teach it to her, she also allowed that their inadequacy influenced her own perceptions of ability.

Like Sunny, Rachel, an eleventh grader, held her teachers responsible for how much she learned in her classes, particularly science, and she believed that they influenced her perceptions of ability. She believed that she learned a lot in her ninth grade biology class because of her teacher: "I thought that I had a really good teacher [in 9th grade]. She like um, she really made you understand the stuff. So I think I understood bio more." In contrast, she felt that she did not learn as much in her tenth grade chemistry class because her teacher made her and the rest of the class feel like they were incapable of learning the material. Describing how her chemistry teacher made her feel, Rachel said, "she made us feel like we didn't really, were worthy of like taking her class and we didn't really know anything. We were just kind of like these high school kids who didn't really belong in this class." It was Rachel's belief that her biology teacher made her feel capable of learning biology, while her chemistry teacher made her feel incompetent. As I describe more in the next section, Rachel believed that these perceptions of ability influenced her decision about which science classes to take in the eleventh grade.

Interestingly, both Sunny and Rachel also admitted wanting to try harder to do well in a class if they liked their teacher. Rachel explained in a member check in March 2001 that having a teacher that she liked and that she felt was a good teacher encouraged her to try harder:

> Like I think when you have a teacher who you think is really teaching you the material and who is like very understanding to your needs and is really like a good teacher and you're not doing well in it then I personally feel like it's my fault and that I need to do better and try harder. Whereas if you don't like the teacher you're like, 'oh it's their fault.'

According to Rachel, if she did not do well in a class she blamed the teacher unless she felt that the teacher was doing a good job of teaching the material. Having a good teacher but not doing well thus encouraged her to try harder.

Likewise, Sunny said that when she was not doing well in a class in which she liked the teacher and felt they were doing a good job of teaching the material she felt bad. She explained,

> I can feel it when the teacher is disappointed in me, you know, and I feel bad about that and I don't want to let them down…the teacher looks at me and says, 'You're slipping, Sunny' and I just feel so bad, you know.

She repeated in March 2001 that liking her teacher made her want to do better in their class. She explained, "If I like the teacher I feel more of a need to do good, you know? To like, I don't know, help the teacher out kind of. I have more respect for a teacher that I like." Sunny believed that she tried harder in classes in which she liked the teacher because she did not want to disappoint them. This is consistent with prior research that found a link between liking a teacher and the amount and quality of effort students were willing to exert in their classes (Miller, Greene, Montalvo, Ravindran, & Nichols, 1996; Montalvo & Roedel, 1995).

Holding the teacher responsible for their class performance was the only attribution that was age related. Apart from Amrita and Sophie who believed that

their teachers made tests too difficult, only the high school girls believed that their teachers played a large role in their class performance. This may be because the high school girls had more experience with different teachers in each of their classes than the younger girls who often had only one homeroom teacher. As such, they may noticed more differences between teachers.

For example, Rachel described how the French classes for her grade were taught by two teachers and that she believed she did better than a friend of hers, who she believed was actually "a lot smarter," because her teacher was easier. She explained,

> Like French last year my teacher was easier, not so much easier, but she was like overall a nicer person and my other friend had a different French teacher but it was supposed to be the same course. And um you know she was like a lot smarter than me and she ended up doing a lot worse.

Rachel believed that having different teachers influenced how she and her friend did in what was presumably the same French class.

Relationship to class and career choices

All of the girls, except for Sophie and Laura, believed that how well they expected to do in a class would influence which classes they chose to take in the future. However, with only two exceptions, math was the only class of which the elementary and middle school girls spoke in terms of either choosing or not choosing to take depending on how well they believed that they would do in it.

The two exceptions were art and Spanish; Berta said that she would choose to take art because she did really well in it and Courtney said that she would not take Spanish because she was "not very good at it." As I discussed in Chapter four, whether they liked a subject or not was more important to the class decisions of the girls in these age groups.

In contrast to the elementary and middle school girls, the high school girls considered how well they would do for most of their class choices. For them, interest *and* perceptions of ability were important factors in their class decisions. Moreover, only the high school girls specifically mentioned their perceptions of ability when they considered future career options.

Doing well as a factor in the choices of the elementary and middle school girls

As I noted previously, math was the one class in which several of the girls believed that they were not doing well due to its difficulty. All of those girls, including Berta, Hannah, Katie and Lisa, said that if given a choice they would not take math again because they expected to do poorly in it. Berta, a fifth grader, said that she would not take math "Because I'm really bad at math and it's just not my thing." Similarly Hannah said that she would not choose to take math because "I don't like math at all. It's like hard and stuff…Because there are so many rules. It's just really confusing." Both Berta and Hannah hypothetically chose not to

take math the following year because they believed that it was hard and they would do poorly in it.

In contrast, Beth, Amrita, and Marie all said that they would take math in the future because they believed that they would do well in it. They also reported liking math, though, and gave interest as a reason for choosing to take it again. For example, Beth, a fifth grader, said that she would choose to take math again because she believed that she did better in math than her other subjects and because she had "fun figuring problems out." Likewise, Amrita, a seventh grader, believed that she did the best in math and that it would be her first choice of class to take it again because she found it to be "easy." In explaining why she would choose it first, Amrita said, "Math is easy. That's why I like it. It's fun actually…Definitely math I do the best in." Both Amrita and Beth believed that because they found math to be easy it was a fun class for them. To me, their interest in the class was based, in part, upon their ability to do well in it. Because they believed that they would continue to do well in it and because they enjoyed it (or enjoyed doing well), they would choose to take math again.

Amrita, in particular, was so certain that she would do well in math in the future that when I asked her if she would choose to take it even if she were told that it would be difficult, she replied that she believed that she *would* do well and thus she would still choose to take it. She said, "If you said English were hard I would just drop it. But math I don't know. I think I would be able to do it so." Amrita believed that she would be capable of doing well in math, even if it were

difficult, because she had always done well in it. English, however, was a class in which she had not done as well in the past and thus she would be more likely to not take it if she knew it was going to be difficult. For Amrita, how well she would do in a class would only be a consideration in her future choices if she had not done well in it in the past.

Expectations of doing well did not influence the class choices of Laura and Sophie, the remaining elementary and middle school girls. It is possible that they did not consider how well they would do in their classes when they were contemplating future choices because they assumed that they would do well. As I previously noted in this chapter, most of the girls believed that they were doing well in school and always had done well. Many perceived that they would continue to do so. As such, for classes in which they believed they had always done well, their perceptions of ability would not be a main consideration because they would assume that they would do well again.

Believing that they were capable of doing well in most of their classes could explain why math was the only class in which the elementary and middle school girls considered their expectations for success when deciding whether they would want to take it in future years. According to attribution theory (Weiner, 1985), they would expect to do well in their classes in which they attributed past successes to effort as long as they were willing to continue trying hard. Conversely, they would be less likely to pursue classes in which they believed they had not done well in the past due to class difficulty because they would not

expect the difficulty to change. In fact, as I described previously, many of these girls viewed math concepts as becoming progressively more complex. Moreover, as I showed in Table 10, math was the only class in which several of the girls believed they did poorly because of its difficulty. As such, these girls, according to attribution theory, would expect to continue to do poorly in math in particular.

Doing well as a factor in the class *and* career choices of the high school girls

In contrast to the elementary and middle school girls who only considered how well they would do in math when thinking about future choices, the high school girls judged how well they would do for most, if not all, of their class choices. As I have previously discussed, they believed that having good grades on their high school transcripts was very important for college admission. As such, they seemed less willing to take a class if they knew they would do poorly in it and, conversely, more willing to take a class if they believed they would do well.

Lisa, for example, explained that she would choose her classes based "On how well I did last year and what I was interested in most is what I would do." She added that she would probably choose not to take algebra II in ninth grade because she had not done well in Algebra I the year before. For Lisa, interest and perceptions of ability played a role in how she believed she would choose her classes. Like the elementary and middle school girls, because she had done poorly in math in the past, she said that she might choose not to take it again in the future.

Interest and perceptions of ability also played a role in Rachel's class decisions. She told me in March 2001 that the classes she chose to take in the eleventh grade were ones that she liked and expected to do well. She explained, "I think [the classes I choose] has a lot to do with…if I like a certain subject and if I know I'm going to do well in it because there's really no point in taking a class that I don't like or I don't do well in." She elaborated further by saying that in choosing whether to take an Honors or AP level class instead of the regular section she would assess whether she liked the class and believed that she would do well in it. However, in deciding whether to take an elective class, how well she believed she would do would be her main consideration. She explained,

> I think if it's a difference between like an honors course and a regular course the fact that if I like it then, yes, that plays a part in it. But if it's like a totally different elective and I don't need to take it the fact that I don't need to take this course but I'll probably do well in it and it'll look good on my college application, yeah I'm going to take it.

Rachel believed that if she did not need to take a class then she should consider whether she would do well in it and if it would look good on her college application. She gave the example of choosing to take AP history in the eleventh grade because she had done well in her elective tenth grade history class. In explaining her reasoning for choosing to take the AP class she said, "Well in tenth grade I took history which you don't have to and I did well in that so. I liked history and I thought I might as well take AP." For Rachel, how well she would do in her classes influenced her choice of which electives to take.

Similarly, how well she would do in a class influenced Sunny's choice of electives. She explained that she chose to take Technology Education, an elective class, in her ninth grade year because she believed that she would do well in it, which to her meant easily earning an A. She said, "I think I had heard that [it] was with LEGOs, and um, so I wanted to try it out just to see what it would be like. I figured I'd already know most of the stuff. An easy A." Because Sunny had had a lot of experience building with LEGOs, both at home and at the summer camp, she believed that she could easily do well in the elective class. As such, she chose to take it. Thus, like Rachel and Lisa, Sunny considered how well she would do in a class, particularly electives, before she chose to take it.

Additionally, both Rachel and Sunny considered how successful they would be when they contemplated future careers. They were the only ones in the study to discuss their perceptions of ability in relation to career choices without my prompting them to consider how successful they would be. Some of the younger girls admitted that they would probably do well in the profession they were considering after I asked them how successful they thought they would be, but they did not seem to eliminate choices based on ability. Instead they based their choice on interest, as I describe more in that chapter.

In contrast, Rachel and Sunny's career choices seemed to be based more on how successful they believed they would be. Sunny, for example, switched from wanting to be a fashion designer, as she told me in May 2000, to deciding to be a lawyer, as she explained in March 2001. The reason for the change, she said, was

because she had come to believe that she would fail at being a fashion designer and that she would be good at being a lawyer. She explained the change to me in March when she said,

> I was going to start out with my own [fashion designer] business. And there's so many fashion designer businesses starting it's really hard to like get off the ground. And I realized just how much work it would take just to get a little far in the business. And I just decided I didn't have it. That it would be basically a failure if I tried.

Sunny decided not to be a fashion designer because she did not believe that she would be successful. She believed, however, that she would be a competent lawyer. She said,

> I wouldn't be a star [lawyer] or anything but I'd get the job done. And I'm good at, I remember things, like you know if I'm in an argument I can bring up something that someone had said. And I'm good at twisting people's words to make them confused and you know that's what lawyers do.

Sunny also said that she wanted to be a lawyer because she liked to argue. As she said, "I like to argue. Why not get paid for it?" Thus, while interest played a role in her career decisions, her perceptions of how successful she would be played a larger role. She decided not to be a fashion designer, her first interest, because she did not believe that she would succeed.

Similar to Sunny, Rachel changed her career plans during the course of this study and, to me, the change was based, in part, on her perceptions of being able to succeed. Rachel explained in March 2001 that she wanted to be a doctor because she believed that she would be successful, which to her meant being able to earn

enough money to live well and support a family. She explained, "Now I'm sort of going towards [being a doctor] because I think that in a way it's something that I'll be able to succeed in and live substantially on that income and support a family."

Prior to wanting to be a doctor, Rachel had told me in July 2000 that she had considered being an engineer but that a bad experience in her tenth grade chemistry class had changed her mind. As I discussed earlier in this chapter, she believed that her chemistry teacher made her feel incapable of doing well in chemistry, while her biology teacher made her feel competent. Rachel explained that her experience in chemistry class changed her mind about being an engineer because it caused her to question her ability, whereas doing well in biology made her want to pursue a biology major and become a doctor. She said,

> I think before tenth grade I was in to the whole engineering thing and then I had chemistry and I hated that. It was a bad experience. And I think this year taking biology, I'm doing well in it, so I think [wanting to be a biology major] has a lot to do with the topic and just myself I think I've realized that I'm the only one who can say whether I like something or not and whether I can do it. And last year I had problems with thinking that I couldn't do it or that I wasn't going to learn it and it wasn't going to happen.

For Rachel, having a teacher that made learning chemistry difficult caused her to question her ability and ultimately to change her career goals to an area in which she believed she would be more successful, namely biology.

However, because I was not sure why Rachel associated chemistry with engineering I asked her whether she saw the two areas as related. She answered,

> Not necessarily related, but…also I'm not as interested in math as I thought I was. So that might have something to do with it. Chemistry was something that I regret taking so I think just the fact that it was science, and engineering has something to do with science, it was kind of like I don't want anything to do with it ever again.

While Rachel believed that engineering and chemistry were somewhat related because they are both sciences, she indicated that her career switch was partly due to her growing disinterest in math, which she also associated with engineering. She added later that she believed math was "harder for me now." Thus, it seemed to me that her decision not to pursue engineering was based primarily on her belief that she was more capable in biology than in either math or chemistry. As Marsh and Yeung (1997a) predicted, Rachel chose to pursue an area in which she felt more capable *relative* to other subjects. She believed that she would be more likely to succeed in a biology-related career. Moreover, she appeared to be more interested in biology, as I described in Chapter four.

In general, Rachel's experiences with her science and math classes and her subsequent career choices seemed predictive of what might happen to several of the girls in the study. As I discuss below, based on their perceptions of ability, it seemed probable to me that several of the girls would choose not to pursue physical science careers.

Summary

In explaining why she decided not to pursue a career in engineering, Rachel alluded to what she saw as a connection between math and engineering. For her, believing that math was becoming more difficult and less interesting helped to convince her that she would not be successful as an engineer. At the same time, she believed that she was doing well in biology and thus she became more interested in being a doctor.

Like Rachel, several of the girls in this study, including Berta, Courtney, Katie, Hannah, and Lisa believed that math was difficult and attributed not doing well in it to finding the concepts hard to understand. Despite believing that they were doing well in school in general and that they could continue to do well in most subjects as long as they tried hard, math was the one class in which these girls expected to do poorly in the future, even with effort.

Because math is a requirement for many physical science majors and careers, it seemed unlikely to me that the above six girls, in particular, would pursue physical science careers in the future. The obstacle to considering physical science careers at this point in their schooling would appear to be their belief that they are less capable in math compared to their other subjects, rather than believing that they are incapable in science. Only Sunny, Rachel, and Amrita described their science classes as difficult and they attributed the difficulty more to how their teachers taught the class than to finding the concepts hard to understand.

However, at least five of the other girls in the study (Beth, Laura, Sophie, Amrita, and Marie) believed that they were doing well in math. For the most part they attributed their success to trying hard and paying attention, although Beth believed that she was also doing well because of a natural ability. For them, attribution theory (Weiner, 1985) would predict that they would continue taking math as long as they perceived that they could do well with effort. To me it did not seem that perceptions of ability, either in math or science, would be an obstacle to these girls in pursuing physical science careers. For them, other factors, such as interest or utility, might play a deciding role in their future class and career decisions.

The most disturbing finding for me, as an educator, was that Sunny and Rachel believed that they were not doing well in their math and science classes because of how their teachers taught the class. They both believed that they were not learning as much as they should and they were left with feelings of inadequacy. Rachel, in particular, believed that her chemistry teacher played a significant role in making her feel incapable of doing well. While there was ultimately a combination of factors that influenced her decision to not pursue engineering as a career, her low perceptions of ability as influenced by her teacher was a pivotal one. Sunny and Rachel's descriptions of the practices used by their teachers provides insight for educators about what can be harmful to students' perceptions of ability, as I discuss in the next chapter.

Chapter Seven
Implications and Future Research

The purpose of this study was to explore the class decisions of twelve elementary through high school girls who participated in a physical science-based engineering camp in order to gain an understanding of why they might choose to persist or not in a science and engineering career and how they made sense of their decision-making processes over time. I purposely chose girls who were enrolled in an engineering camp on the premise that their participation indicated an interest in science. In fact, nine out of the twelve girls were considering science-related jobs by the last interviews of the study in March 2001. The majority of these girls (five out of nine) wanted biology-based careers, particularly those that involved taking care of and helping animals or people, such as veterinarians and doctors. Amrita, a seventh grader, was the only one considering engineering, a physical science based career.

The career preferences of the girls in this study were thus similar to the employment figures that I presented in Chapter one that show that women choose life science jobs in greater proportion than physical science ones (NSB, 2000). However, as a group, the girls in this study were more interested in pursuing science careers than would be expected in the general population given that women only account for 23% of scientists and engineers (NSB, 2000).

To me, parental support was a main factor in these girls' interest in science careers. As I showed in Table 3, many of the parents were employed in science-related jobs and they encouraged the girls' participation in the camp (Figure 4). Additionally, as I discuss below, several of the girls reported doing science activities at home, particularly with their fathers.

Therefore, using a sample of girls with a professed interest in science careers and strong parental support could be viewed as a limitation in terms of generalizing the findings from this study to other groups of girls. However, as I share in the following sections of this, the ways in which the girls of this study made sense of their class and career choices revealed several ways in which educators, parents, and career counselors can help promote *all* girls' interest in the sciences and particularly the physical sciences.

Educators' role in girls' science participation

Findings from this study suggest that in order to interest girls in science, educators need to capitalize on the exploratory nature of science by incorporating hands-on activities into the curriculum at all levels of schooling. As in other studies (AAUW, 1998; Baker & Leary, 1995; Kahle, 1996), the girls in this study showed a preference for classes that involved active learning. In particular, they liked science and social studies because they more often did experiments and large projects in those classes. As Amrita, a seventh grader, said, "science can be fun if

you do it." Because science is conducive to hands-on activities, it has the potential to be very appealing to girls of these ages.

It does not appear that activities need to be done every day or even every week in order to increase class enjoyment. Many of the girls in this study described liking a class because of doing one large project, often at the end of the year. Laura and Katie, for example, described projects in their social studies classes and Courtney and Amrita spoke favorably of science fairs and projects in which they participated.

However, teachers cannot just have students engage in activities for the sake of being active. The activities need to involve genuine inquiry, such as building a motor as Laura described doing at home, or designing and programming LEGO creations as the girls did at the LEGO camp (as described in the first chapter). In this study, the girls did not like activities in which they followed a list of instructions merely to replicate a previously conducted laboratory. They wanted to be able to have more choice and independence in their explorations. It was these aspects of the LEGO camp that they most appreciated. As a study commissioned by the AAUW (1998) concluded, girls "seek to be the developers of knowledge, rather than passive receivers of knowledge" (p. 50). Additionally, a review of the literature found that increasing student choice in learning, even a little, enhanced students' interest in their classes at all grade levels in elementary through high school (Stipek, 1996).

Moreover, it appears that in order to sustain long-term interest in a subject, doing activities is not enough. The elementary and middle school girls in particular liked science and social studies when they involved hands-on activities but their interest was dependent upon the activities, not necessarily the topics. They lost interest in a class they previously liked if the following year it did not involve active learning. In contrast, their interest in a class more likely remained consistent from year to year if they expressed an interest in the subject matter, rather than just the activities.

Believing that they were capable in a subject also helped to sustain their interest. As such, teachers need to assess that girls understand the material. It is important that they do so even when girls are earning high grades on tests and in the class. For the girls in this study, earning high grades did not necessarily mean that they believed they understood the material or that they were doing well because they had very high personal standards of success. As seen in other studies (Jacobowitz, 1983; Khoury & Voss, 1985; Matyas, 1984; Post-Kammer & Smith, 1985; Tippins, 1991), girls can score just as high or higher than boys in their science class, in particular, and still not feel like they understand the concepts. My findings suggest that it is particularly important for teachers to assess and gauge girls' understanding of and perceptions of ability in math, since that was the class in which several girls felt that they were not capable, despite earning high grades.

Teachers also need to be aware that the way in which they teach their classes can affect girls' perceptions of ability. Sunny, for example, described her

math teacher as not taking the time to explain why things worked the way that they did. As a result, she was left feeling that she did not fully understand the math concepts. Rachel described having "a test every week" and covering "a chapter in 4 days" in her chemistry class. They both complained that because of the fast pace of the class and the amount of information that they were required to learn each week they and their classmates were often left feeling that their teachers expected them to know more than they did. Rachel and Sunny's experiences suggest that in order to increase girls' perceptions of understanding the material in their math and science classes teachers need to cover less material in more depth and at a slower pace. In fact, recent studies and reports have concluded that science teachers should teach for greater understanding of fewer topics (Gallagher, 2000; Massachusetts Department of Education, 1999; National Research Council, 1996; Sadler & Tai, 2001).

In regards to particular science topics, while the elementary and middle school girls did not seem to be as concerned about *what* they learned as whether they did hands-on projects and experiments, their descriptions of class units suggested that they did more biology-based units than physical science ones. By high school the girls in this study reported less interest in physics and more interest in biology, which is consistent with previous studies (Benbow & Minor, 1986; Steinkamp & Maehr, 1984; Weinburgh & Englehard, 1994).

It is possible that the lower exposure to physical science units in the earlier grades was a factor in the older girls' lack of interest. As I discuss in the next

section, I found that most of the experiences that the girls had with physical science was from learning at home with parents, particularly those girls whose parents were engineers, such as Laura, Beth, and Sunny, or from participating in extracurricular activities, such as the LEGO camp. A first step for increasing interest in physical science, in particular, could be to include more units into the science curriculum at all school levels so that *all* students can benefit from the experience.

The Massachusetts Department of Education, for example, has incorporated physics and engineering standards into their curriculum framework for all grades pre-K through twelfth (Massachusetts Department of Education, 1999). The engineering standards were included for the first time in 1999 to focus on design and principles of engineering. Policy changes such as these at the state level portend greater exposure to the physical sciences and engineering for all students.

At the classroom level, teachers can make more explicit connections between the activities the students do and the science concepts they are learning. For example, as I pointed out in Chapter four, I rarely overheard the counselors at the LEGO camp helping the girls to associate the activities they were doing, such as driving a car up a mountain, with physical concepts, such as friction. Naming these concepts while the girls are actively exploring them in what they described as a "fun" environment may help their learning. As I discuss in the next section, there is much that parents can do on a personal level to promote their child's experiences with science.

Parents' role in girls' science participation

In general, I believe that the parents of the girls in this study had more of an influence on the extracurricular activities in which the girls participated than on their class choices, at least at this point in their schooling when most of the girls were not choosing their own classes. For example, as I noted, all of the girls had parental permission to participate in the LEGO camp and nine of the girls first heard about the camp from their parents (Figure 4). In particular, the girls spoke of their mothers as giving permission and informing them of their choices.

Interestingly, though, while mothers played a larger role in determining which extracurricular programs their daughters attended, fathers were more likely to encourage doing science activities at home. Four of the girls (Beth, Laura, Sophie, and Marie) said that they built with LEGOs or other science kits at home with their fathers but only one girl (Sunny) talked about building with her mother. Moreover, three girls (Beth, Sophie, and Courtney) said that either their mother was not interested in building or that she did not know enough to help them.

Courtney, for example, said that although she bought a LEGO kit and software after the camp in order to continue building and programming at home she did not use them much because when she encountered problems she had no one to help her. She explained that although her mother wanted to help she did not know enough. She said, "My mom's interested in it but like I know a lot more than she does. And she's always…trying to get me to show her so she doesn't

exactly know." As this quote makes clear, parents need to be trained to support their daughter's learning at home. For example, it would be helpful if the LEGO camp trained parents to use the software that enabled the LEGOs to move. Additionally, schools and teachers could offer "science nights" in which parents are invited to learn more about the concepts covered in their child's curriculum, possibly by doing experiments themselves.

Moreover, the extracurricular experiences that the girls in this study had were dependent on parents knowing about the activity and having interest in sending their daughters. Parents, as well as educators, need to be encouraged to send girls to extracurricular science activities. As the director of the LEGO camp reported to me, more parents called to ask about the LEGO camp for their sons than for their daughters. It was her perception that parents did not immediately think of sending their daughters to an engineering camp. As I describe below, sending their daughters *with a friend* is one way in which parents could encourage their daughters to attend science activities

Teachers and schools can play a role in informing parents about extracurricular science activities for their daughters. Berta heard about the camp at a summer activity fair hosted at her school. Rachel was encouraged to enroll in the camp by one of her high school teachers. These examples emphasize the importance of having information sent to schools and then having the schools and teachers send it to parents.

More directly, parents can also encourage their daughters to take physics as well as other science classes that are not required when they are offered in high school. Amrita's parents, for example, seemed to play a large role in her class choices. In fact, Amrita said that they would have more influence on her class choices than any other factor, including her personal interest. Likewise, Sunny, Laura, and Katie reported that their parents told them that they would have to take four years of high school math and science despite it not being a requirement at their school.

Lastly, attention needs to be paid to how girls are rewarded for bringing home high grades. Findings from this study suggest that having very high standards of success based on grades may be detrimental to pursuing science careers if girls opt not to take math classes for fear of not earning a grade of an A, as several of the girls suggested. Parents may inadvertently help to limit girls' career options in this way if they emphasize, and in some cases reward, high grades more than effort. In this study, girls spoke of wanting to earn high grades in order to please their parents from as early as the fourth grade. While emphasizing good grades in high school for college admission may seem prudent, it may be just as important for parents to encourage their daughters to try their best and to broaden their interests, particularly in elementary and middle school.

Peer support for extracurricular science activities

In general across grade levels, for these girls, peers were not as influential in their class decisions as either teachers or parents. It is possible that they were not concerned about taking classes with their friends at school because they felt that they knew everyone in their classes anyhow. Rachel, for example, said that because her school is small she sees her friends whether they are in her class or not so she no longer chooses classes in order to be with them. She explained,

> I think when I was younger I think maybe the fact that like my friends are taking it that had some play in [my class choices] but not anymore. I think not now because it really has no effect on me now. Just because our school is so small that I always see my friends so it's not like, 'oh if I take this course I'll never see them.'

For Rachel, an eleventh grader, having her friends in her class was not a priority because she felt that she was able to see them anyhow.

It may be that having friends in a class would be more important to the girls if they did not know other students. Four of the girls, Beth, Laura, Hannah, and Sunny, specifically chose to attend the LEGO camp or a similar robotics class with a friend. Additionally, Katie signed up for the LEGO camp with a friend that ultimately could not participate. For these girls having a friend accompany them was an important requirement for their participation. Moreover, all of the girls said that they enjoyed making friends at the camp and that it would be a main reason for them to return the following summer.

Peer support is possibly more important for classes or activities that the girls think are socially unacceptable. Although none of the girls in this study discussed a class at school in such a way, two girls expressed concerns about engineering. Courtney, a seventh grader, worried about participating in the LEGO camp for fear of how it would appear to her friends. Rachel, an eleventh grader, was hesitant about pursuing an engineering degree because she perceived engineering students to be mostly male and too studious. As I describe in the next section, there are ways in which parents, teachers, and career counselors can help to change these stereotyped images.

Career Counseling

The girls' interest in science careers was influenced by 1) wanting to help others, 2) a general lack of knowledge of science careers, particularly those related to the physical sciences, such as engineering, and 3) for two of the girls, negative stereotypes. These findings suggest that science classes, schools, and programs such as the LEGO camp, should make explicit connections between what the girls are learning and real-life applications. Doing so will help to increase their awareness of engineering and other physical science-based careers, as well as the courses leading up to them.

Wheeler (2000) suggested brainstorming with girls the many types of jobs that use science, along with ways that science is used in everyday life, in order to

broaden their perceptions of what science is and who does it. As I found in this study, the girls had a very limited notion of scientists working in laboratories and often could not make connections between the sciences that they were learning in school with their career goals. These findings were consistent with Baker and Leary's (1995) study with elementary through high school girls. In their study, the girls expressed a desire to have real-life connections made in their science classes because they believed that it was lacking in their current classes.

More specific suggestions include having the counselors at the LEGO camp, all of whom were students in a science field, share with the campers their own career goals, the courses they are taking and plan to take in order to achieve those goals, and the work they expect to do in that field. Likewise, parents could discuss with their daughters what they do at work. Many of the girls in this study did not know what engineers did despite having parents who were employed in the field. Teachers and schools could host "career nights" in which scientists, and particularly female scientists, are invited to school to share what they do.

In the classroom, students could be encouraged to research and create biographies of female scientists of various areas of science. For younger students, teachers could create guessing games with clues describing different types of science careers. Students could use these clues to learn about and name various jobs. Science organizations such as the Society for Women Engineers provide information on the Internet that would be useful for these types of research projects (i.e. Society for Women Engineers, 2000).

Because the girls in this study were interested in being doctors or veterinarians, teachers and/or career counselors could bring careers that incorporate engineering *and* biology to their attention. The camp director, for example, stated that while she initially wanted to be a doctor in high school she became interested in biomedical engineering in order to learn more about what she described as "the motion and fluid mechanics of the blood flow and oxygen through your body."

It is my hope that with the educational changes that I have discussed in this chapter girls will begin to have greater and deeper experiences with science and a more informed knowledge of science-related jobs that will inspire them to explore the many possibilities in those fields. Having had a daughter during the course of this project I hope, on a personal level, that she will grow up believing that she can pursue any career she desires, including being an engineer or physicist.

Future research

As I discussed in Chapter three, it would be interesting to follow the girls from this study as they proceed through their schooling to see whether the class and career choices they believed they would make in the future are actually the ones they do make. As I noted, it seemed to me that the younger girls, in particular, were just beginning to consider what would influence their class choices.

All of the elementary girls, and two of the seventh graders, believed that their interest in a class would be their only reason for choosing to take it. In contrast, the remaining seventh graders were beginning to consider the usefulness of their classes, although not as specifically as the high school girls. The high school girls considered multiple reasons for choosing classes, including the teacher who would be teaching it and how useful they believed they would be for getting into college. Thus, for the girls in this study, seventh grade appeared to mark a crucial shift in their thinking towards considering multiple reasons.

Future research should continue to explore the sense that these girls make of their class choices over time with in-depth, qualitative interviews. Doing so would allow for a fuller developmental analysis of when, how, and why girls begin to consider varied reasons for choosing their classes.

Specifically, I would be curious to explore the role that parents play in girls' class decisions at various ages and degrees of class choice. Towards that end, it would be informative to talk with the parents themselves and ask about the goals they have for their daughters and how they view their role in achieving those goals. To me, it seemed that many of the parents of the girls in this study were actively advocating for their daughters to have a greater understanding of science, particularly as seen by the crucial role most of them played in their daughter's attendance at the LEGO camp. For those parents with sons as well as daughters it would be interesting to explore whether they had different goals for their children based on gender.

Additionally, it would be interesting to interview the boys at future sessions of the LEGO camp in order to determine how the boys, across grade levels, make sense of similar questions. For example, I wonder whether parental and peer support would be just as necessary for their participation in the camp as it was for the girls.

In sum, for the girls in this study, their interest in actively exploring science at all levels of schooling and their belief that science is essential to their lives (even if they are not sure how) proved to be important reasons for taking science classes and contemplating future science careers. Encouraging and sustaining their interest and beliefs of utility should thus be a main focus for educators and parents concerned with increasing female participation in the sciences.

Appendix A: Informed Consent Forms

Dear Parents/Guardians,

I am a doctoral student at the Harvard University Graduate School of Education. For my thesis project I am conducting a study to explore girls' interests in science, particularly physics and engineering. My purpose is to learn more about the reasons girls give for their interest in science activities, classes, and possibly careers. I would like to include female campers at the Tufts University's LEGO® camp in my study.

For part of my study, I will be collaborating with Tufts University by participating and observing at the LEGO camp this summer. During the camp, I plan to conduct discussion groups with 5-6 girls at a time during their lunch hour. The discussions will take place during lunch so that the girls will not miss any camp activities. If a girl chooses not to participate in a discussion group, she will eat lunch with the counselors and the other campers as she will on the other days.

Additionally, I would like to interview each girl, individually, at three times during the year. Each interview would last approximately 45-60 minutes. Topics that I would like to pursue in these interviews include students' interest in science, their perceptions of their ability in science, and their plans to take more science in the future.

The first round of interviews will ideally be completed in May. The second round of interviews will take place shortly after camp ends in July, while the last set of interviews will be in the spring of the following school year (2001). If at any time, however, the girls wish to end their voluntary participation in the study, they may do so.

I realize that participation in the interviews will be a large time commitment for parents and campers. I will make every effort to schedule them at a mutually agreed upon time and location. One possible meeting place would be at Tufts so that the girls could see where they will be attending camp this summer.

I would like your permission to use my written observations of the camp, the group discussions, and interviews in my study. I will not be videotaping or tape recording my daily observations of the camp, but I will tape record the discussion groups and interviews. However, the names of the girls will not be used on the tapes (or the transcripts) of the group discussions and individual interviews. I will protect the identity of each girl, as well as that of the camp, by using pseudonyms. While I will quote directly from interviews, I will use only the assigned pseudonyms in all papers, presentations, and/or in discussions with my colleagues. Five years from the completion of my project, all the data will be destroyed.

At the completion of my project, I will send a summary of my findings to each girl, her parents, and the camp director. Again, identities will be concealed in this summary. I hope that it will serve to start discussions among us all about how we as educators and educational researchers can best encourage young girls to remain engaged in the sciences.

Parents, I would appreciate your permission to have your daughter participate in this project. Please note that her participation in my study, however, is not a required part of camp. She does not have to participate if she does not want to. Her choice will not affect her participation in the camp in any way.

Please let me know whether you would be willing to have your daughter participate in my study by signing and returning the attached consent form with the requested camp forms. It would also be very helpful to me if you could fill out your preferences for interview days and times in May on the attached calendar. I would appreciate if you could return the form even if your daughter will not be participating so that I will know.

If you have any questions, please feel free to contact me. Because I am temporarily living abroad until next year, I can best be reached by email at: holly_mcdonnell@gse.harvard.edu. If you would prefer to speak with me, you can leave a message for me at (781) 259-9572 and I will then contact you. If you are unable to reach me, you can also contact [the Director of the summer camp].

Thank you,

Holly McDonnell James
[address and phone number]
holly_mcdonnell@gse.harvard.edu

Dear Camper,

I am a student at Harvard University. I am studying why some girls are more interested in science than others. I am writing to all the girls who will be at the Tufts LEGO camp because I want to hear what your interests and feelings are about science. I will be at the camp talking with a few girls a day during lunch. I hope that you will choose to join in one of these group talks, but you don't need to if you don't want to. It is your choice. If you don't want to, you can eat lunch with the girls who aren't in that day's group (just as you will on the other camp days).

In order to really learn about your interests and feelings, I want to also talk with each girl by herself for an hour at three different times over the next year. During the first talk, this May, I will ask you about things that you have done in science classes at school to find out what kinds of things you like or don't like. After the camp is over in July, I will meet with you again to find out what you liked doing or not at the camp. The last time that I meet with you will be the next year in May! I will want to know about the science things that you have done that year in school and also about what sorts of jobs you are thinking of doing when you are older and why.

There are no right or wrong answers to any of my questions, and there aren't any answers that I am hoping to hear. I am interested in hearing what *you* think. To help me remember everything that you tell me, I will use a tape recorder each time that I talk with you. Nobody but me will ever listen to the tapes and I will not tell people what you have told me. You can tell people what we have talked about if you want.

At the end of my study I will write about everything that I have learned in a report for my teachers at Harvard. In the report, I will talk about what I have learned from you and the other girls, but I will not tell your names. I might use your exact words to help explain things, but I will not use your real name. You can choose a name that you want me to use for you instead!

Your thoughts and ideas will really help me learn more about what girls like or not in science and about what schools can do to help girls become more interested. If you would be willing to join a group discussion at camp during one lunch period and talk with me three times during the year, please check the box and sign the consent form on the next page after talking with your parents.

I have sent a letter to your parents telling them all of this and how to reach me. If you want to talk to me about any of this, they can help you contact me. I look forward to seeing you soon!

Thank you,

Camper's Consent

Please check **one** choice:

_____ I am willing to be in Holly James' research project. I understand that my real name will not be used in her final report and that I can end my participation in this project at any time.

_____ I do *not* wish to be in the research project.

Signed,

_____ _____
name of camper date

Parent's Consent

I am willing to have my daughter participate in Holly James' research project. I understand that her identity will be concealed in all papers, presentations, and discussions and that her participation is voluntary. She may end her participation at any time.

Signed,

_____ _____
name of parent/guardian date

Please include the following information so that I may contact you to arrange interviews:

Phone #: _____

Email: _____

Address: _____

Appendix B: Interview guides for the girls in my study

INTERVIEW GUIDE #1

Before each interview, I: 1) introduced my study and its purpose for learning more about girls' academic choices, 2) emphasized to each participant that there are no wrong or right answers, that I am interested in her opinion, 3) reminded her that she did not have to answer any question that she did not want to and that her answers are confidential, and 4) asked for her permission to tape record and assured her that while I will discuss what I learned in my final report, her identity will be protected. Finally, I asked her whether she had any questions before beginning the interview and let her know that she could ask questions at any time.

***Reasons for camp participation**:*

1. How did you hear about the Lego summer camp?
2. Why did you want to attend this camp? (Why did you think your parents asked you if you wanted to go?)
3. What are you hoping to do/learn/build at the camp?
4. How do you feel about learning science this summer with only girls? Would you have gone to the co-ed session? Why or why not?
5. How might what you do at the camp compare to your past science classes at school?

Feelings about science (and other classes):

6. Describe a typical day at school. What classes are you taking?
7. How do you feel about each of your classes?
8. If you could choose one of your classes from this year to not take, which would it be and why?
9. Which one would you definitely take again? Why?
10. Would your choices have been the same last year? Why or why not?
11. How do you feel about your science class compared to your other classes?
12. Describe some of the science activities that you've done in school so far this year (and past years).
13. How did you feel about each of those activities?
14. In what ways, if any, might the science that you have learned in past years be useful to your future?
15. What, if anything, that you have learned about in your classes will be useful to you in the future?

Ability and attributions in science:

16. Which of the previously mentioned science activities do you feel good at/not good at? Why?
17. How do you know when you are good at something? What is your personal criteria for success?
18. How important to you is it to do well in science (and in your other classes)? Why?
19. What do you think you would need to do in order to do well in science (and your other classes)?

20. Tell me about the person in your class who you think is doing the best in science. Why do you think they are successful?
21. How well do you think you are doing in each of your classes?
22. How do you feel your performance in science compares to your other classes? Why? How about in previous years?

Extracurricular Activities and Interests:

23. What do you do after school and on the weekends when you have free time? What are you doing this summer?
24. What experiences (if any) with science have you had outside of school?
25. In thinking about your reasons for wanting to participate in the camp this summer, are there any that we haven't discussed today?

INTERVIEW GUIDE #2

Perceptions of Camp:

1. What was going to the camp like for you? Tell me how you felt about it.
2. Describe the projects that you worked on. How did you feel about them?
3. How did the building compare to the programming for you?
4. If you could start camp over again, would you change anything that you've done?
5. Which projects, if any, would you want to do again? Not do again? Why?
6. Are you satisfied with your buildings/designs/programs? Why or why not?
7. How did your experiences at camp compare to your past science experiences at school?
8. What was working with girls like for you?
9. How might the things you have done/learned at camp be used in real-life? Do you think that you, personally, will have a use for the things you have learned or done?

Future expectations:

10. How much do you think you will build with LEGOs (and/or design projects) after camp is over? Why?
11. What kind of things might you design/build? Why?
12. If you could, would you participate in the camp again next summer (or a similar type camp?) Why or why not?
13. Do you think your friends from home or school would want to attend this camp? Why or why not?

14. Describe to me what you think science class will be like this fall. How do you feel about it?
15. How do you expect to do in it? Why?
16. How important is it to you to do well in next year's science class? Why?

17. What other classes will you be taking next year? Describe them. How were they chosen?
18. If you were allowed to choose classes for next year, what would be important to you in your decision? How would you pick which classes to take?
19. How do you feel about the classes you will be taking? Which ones are you most looking forward to? Why?
20. How do you think you will do in each class? Why?
21. Which ones do you want to do the best in? Why?
22. Which, if any, do you think it's most important to do the best in? Why?

23. How important do you think it is to your parents that you do well in school? How do you know that? (How do they communicate their expectations to you?)
24. Which classes, if any, do they think are more important for you to do well in? Why do you think that they think that?
25. Which of your classes next year do you think will be most useful to you in the future? Why?

Career aspirations:

26. What kind of job do you want when you're older? Why?
27. Describe the things that somebody in your chosen profession(s) does.
28. What do you think you will need to do in order to become a (chosen profession)?
29. What do your parents do for work? Have you ever thought about doing the same profession as them? Why?
30. In thinking about future careers, what would make you change your mind about what you want to be?
31. Describe what an engineer does.
32. Would you consider a career in engineering? Why or why not?
33. What do you think you would need to do in order to become an engineer?
34. Have you ever done engineering type projects at school? Describe them.
35. In thinking about your reasons for wanting to be a (chosen profession), are there any reasons that we haven't discussed today?

INTERVIEW GUIDE #3

Feelings about science (and other classes):

1. Describe your classes this year. Which one would you take again, not take again? Why?
2. Which class is your favorite? Which is your least favorite? Why?
3. How do you feel about science compared to your other classes?
4. Describe some of the science activities that you've done in school this past year. How did you feel about them? Why?
5. What experiences (if any) have you had outside of school this year with science? If any, how did you get involved in them?
6. How much time have you spent this past year building or designing with LEGOs or other materials? Describe these activities.

Perceptions of ability:

7. Some kids are better in one subject than in another. Which class do you think you are best in? Why?
8. Which class do you think you are worst in? Why?
9. Tell me about the person in your class whom you think is doing best in (above class). Why do you think they are successful?
10. How do you feel your performance in science compares to your other classes? Why?
11. How good would you be at learning something new in science? In Math? Why?
12. Are there any classes in particular that you want to be good at? Why?
13. Are there any classes in particular that you think your parents want you to be good at? Why?
14. How does your performance in your classes compare to that of your friends? Why? How does that make you feel?

Future plans:

15. If you were allowed to choose your classes for next year, what would you want to take? Why? (What would be important to you in making your decision)?
16. How do you think your friends/parents would feel about your class choices? Why?
17. Some things that you learn in school help you do things better outside of class. Which ones do you find most useful? How? Least useful?
18. Compared to your other classes, how useful is what you learn in science? Why?
19. What kind of job do you want when you're older? Why? Do you think you would be good at it? Why or why not?
20. How do you think your friends/parents would feel about your career choice? Why?
21. Can you tell me what some careers in science might be? Would you consider a career in science? Why or why not?
22. In thinking about future careers, what would make you change your mind about what you want to be?
23. If you could, would you participate in the Lego camp again this summer (or a similar type camp)? Why or why not? Do you think your friends would want to?
24. Why do you think your parents wanted you to participate in the camp last summer?
25. What do you think the counselors wanted you to learn or get out of the camp?
26. In thinking about your reasons for next year's class choices, or for wanting to be a (chosen profession), are there any that we haven't discussed today?

Appendix C: Interview guide for camp director

Personal Background:

1. How did you come to engineering? (interests, schooling, etc.)
2. Describe your job at the university.

Camp:

3. Describe how the camp came to exist (e.g. its history)
    a. Why this age group?
    b. Why this topic/curriculum?
4. Describe the goals of the camp. Are the current goals the same as when you first envisioned them?
5. Are the goals for the boys the same as for the girls? How so?
6. What methods do you employ at the camp to reach those goals?
7. In what ways, if any, do the methods differ for girls versus boys?
8. In what ways, if any, do you believe that the goals were met last year?
9. In what ways, if any, do you see the girls' participation in camp benefiting them in the future?
10. How do you see the camp fitting into the girls' overall science education?
11. Why do you include a show-and-tell for parents at the end of camp? What do you see as the role of parents in the girls' participation?

Science Persistence:

12. What is your personal theory, based on your own experiences, of why fewer girls than boys persist in S&E? Which factors do you believe most influence persistence for girls?
13. What obstacles do you foresee for the girls participating in your camp to continue with S&E?

Appendix D: Interview guide for camp counselor

***Background information**:*

1. Tell me about yourself: are you a student at the university, age, major, career plans?
2. When did you first get interested in science? To what or to whom do you attribute your initial interest?

Perceptions of role as counselor:

3. How did you hear about the summer Lego camp? How was the camp described to you?
4. What do you see as your job at the camp?
5. Why did you want to be a counselor?
6. What experience did you have working with kids prior to the camp?
7. What experience/knowledge did you have of the curriculum prior to camp?
8. What training, if any, did you receive before the camp? How did the counselors, as a group, prepare for camp? What things did you have to do?

Perceptions of camp goals:

9. Describe the goals of the camp in your own words. What did you want the campers to get out of this experience?
10. In what ways, if any, did the methods used to reach those goals differ for girls and boys?
11. In what ways do you think these goals were reached for the girls, if at all?
12. Do you think that anything they learned/did at camp will be useful to their future? If so, in what ways?

Perceptions of girls' participation and interest:

13. Describe the girls' involvement with the projects based on your observations.
14. In general, how would you describe their comfort/feelings of ability when working with Legos/computers/physics concepts?
15. How would you describe their interest, if any, in the various projects?
16. Do you believe that they will continue to build with Legos after camp? Why or why not?

Appendix E: Analytic codes

Extracurricular Activities:	
Parental Involvement	P
Sibling Involvement	S
Friends' Involvement	F
Feeling of being unique	Unique
Social aspects: making friends, knowing people	SOC
Time commitment	Time
Attributions:	
Teacher	Att-T
Parental help / involvement	Att-P
Help from classmates	Att-C
Interest	Att-I
Effort	E
Ability	A
Pace of class	Pace
Perceptions of Ability:	
Can do work without help / independently	Ind
Past grades	PG
Grades (current)	G
Taking advanced classes / "working ahead of grade"	Ad
Teacher Assessment	TA
Understanding of what doing	U
Comparison to others	C-O
Personal Goals	Gls
Pleasing Others	Pl-O
Parental Goals	P-Gls
Consequences of not meeting P-Gls	+/- Cons
Utility:	
Useful in everyday things	ED
Getting into schools	Sch
Future classes	FC
Future work or career	FW
Future tests	FT
"Good education"	GE
Concern with making money or the cost of things	Mon

Interest in Careers:

Wanting to take care of or help something	Care
Challenge (or lack of it)	CH
Finding things "icky"	Icky
Animals	An
Time commitment involved	Time
Lifestyle	LS
Influenced by media / T.V.	TV
Having a back-up plan / "something to fall back on"	BU

Interest in Classes:

Valuing an activity because learned	L
Dependent on teacher	T
Dependent on what learning / Topics	Top
Challenge / Complex material to master	CH
Active Learning	AL
"Fun"	fun
Having a choice in activities / independence	choice
Passive Learning	PL
"Boring"	B
Working with others / Groupwork	Grp
Being helped or helping others	help
Sharing what learned with others / teaching them	Sh
"Real – life situations" / lessons relate to current events	Cur
Frustrating	F
Competition	Comp
Public Recognition	PR
Gender Issues	GI
Age Issues	AI

References

American Institutes for Research (1998). *Gender gaps: Where schools still fail our children.* Washington, DC: AAUW.

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching*, *36(6)*, 719-747.

Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*, 3-27.

Benbow, C., & Minor, L. (1986). Mathematically talented males and females and achievement in the high school sciences. *American Educational Research Journal*, *23(3)*, 425-436.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching*, *32*, 243-257.

Davies, M., & Kandel, D.B. (1981). Parental and peer influences on adolescents' educational plans: Some further evidence. *American Journal of Sociology*, *87(2)*, 363-387.

DeBacker, T.K., & Nelson, M.R. (1999). Variations on an expectancy-value model of motivation in science. *Contemporary Educational Psychology*, *24*, 71-94.

DeBacker, T.K., & Nelson, M.R. (2000). Motivation to learn science: Differences related to gender, class type, and ability. *The Journal of Educational Research*, *93(4)*, 245-254.

Dornyei, Z. (2000). Motivation in action: towards a process-oriented conceptualisation of student motivation. *The British Journal of Educational Psychology, 70 (4)*, 519-538.

Dweck, C., Goetz, T., & Strauss, N. (1980). Sex differences in learned helplessness: IV. An experimental and naturalistic study of failure generalization and its mediators. *Journal of Personality and Social Psychology*, *38*, 441-452.

Dweck, C., & Repucci, N. (1973). Learned helplessness and reinforcement responsibility in children. *Journal of Personality and Social Psychology*, *25*, 109-116.

Eccles, J., Adler, T., Futterman, R., Goff, S., Kaczala, C., Meece, J., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. Spence (Ed.), *Achievement and Achievement Motives* (pp75-146). San Francisco: W.H. Freeman.

Eccles (Parsons), J., Adler, T., Futterman, R., Goff, S., Kaczala, C., Meece, J., & Midgley, C. (1985). Self-perceptions, task perceptions, socializing influences, and the decision to enroll in mathematics. In S. Chipman, L. Brush, &

D. Wilson (Eds.). *Women in Mathematics: Balancing the Equation*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Ekert, J. (2000). Ordinary success: minority adolescent girls managing the demands of their achievement. Unpublished doctoral dissertation, Harvard University.

Entwisle, D., & Baker, D. (1983). Gender and young children's expectations for performance in arithmetic. *Developmental Psychology, 19*, 200-209.

Gallagher, J.T. (2000). Teaching for understanding and application of science knowledge. *School Science and Mathematics*, *100(6)*, 310-318.

Greenfield, T. (1996). Gender, ethnicity, science achievement, and attitudes. *Journal of Research in Science Teaching*, *33(8),* 259-275.

Greenfield, T. (1997). Gender- and grade-level differences in science interest and participation. *Science Education*, *81(3)*, 259-275.

Hill, O., Pettus, W. & Hedin, B. (1990). Three studies of factors affecting the attitudes of blacks and females toward the pursuit of science and science-related careers. *Journal of Research in Science Teaching*, *27(4),* 289-314.

Hollinger, C. (1985). Self-perceptions of ability of mathematically talented female adolescents. *Psychology of Women Quarterly*, *9(3),* 323-336.

Ide, J.K., Parkerson, J., Haertel, G.D., & Walberg, H.J. (1981). Peer group influence on educational outcomes: A quantitative synthesis. *Journal of Educational Psychology*, *73*, 472-484.

Jacobowitz, T. (1980). Factors associated with science career preferences of black junior high school students. Eric Document 212 851.

Jacobowitz, T. (1983). Relationship of sex, achievement, and science self-concept to the science career preferences of black students. *Journal of Research in Science Teaching, 20(7)*, 621-628.

Jacobs, J., Finken, L., Griffen, N., & Wright, J. (1998). The career plans of science-talented rural adolescent girls. *American Educational Research Journal*, *35(4)*, 681-704.

Janda, L.H., O'Grady, K.E., & Capps, C.F. (1978). Fear of success in males and females in sex-linked occupations. *Sex Roles*, *4*, 43-50.

Jones, M.G. (1990). Gender differences in science competitions. *Science Education*, *75*, 159-167.

Jones, M.G., Howe, A., & Rua, M.J. (2000). Gender differences in students' experiences, interests, and attitudes towards science and scientists. *Science Education*, *84(2),* 180-192.

Kahle, J.B. & Lakes, M.K. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching*, *20(2)*, 131-140.

Kahle, J.B., Matyas, M.L., & Cho, H. (1985). An assessment of the impact of science experiences on the career choices of male and female biology students. *Journal of Research in Science Teaching*, *22(5),* 385-394.

Kahle, J.B., & Meece, J. (1994). Research on gender issues in the classroom. In D. Gabel (Ed.). *Handbook of Research on Science Teaching and Learning* (pp 542-557). New York: MacMillan.

Khoury, G., & Voss, B. (1985). Factors influencing high school students' science enrollment patterns: Academic abilities, parental influences, and attitudes toward science. Paper presented at the National Convention of the National Association for Research in Science Teaching. French Lick Spring, IN.

Krockover, G., & Shepardson, D. (1995). The missing links in gender equity research. *Journal of Research in Science Teaching*, 32(3), 223-224.

Lee, V., & Burkam, D. (1996). Gender differences in middle grade science achievement: Subject-domain, ability level, and course emphasis. *Science Education*, *80*, 613-650.

Li, A., & Adamson, G. (1995). Motivational patterns related to gifted students' learning of mathematics, science and english: An examination of gender differences. *Journal for the Education of the Gifted, 18(3),* 284-297.

Maehr, M. & Meyer, H. (1997). Understanding motivation and schooling: where we've been, where we are, and where we need to go. *Educational Psychology Review, 9(4),* 371-409.

Marsh, H. (1992). Content specificity of relations between academic achievement and academic self-concept. *Journal of Educational Psychology*, *84(1),* 35-42.

Marsh, H., & Yeung, A. (1996). The distinctiveness of affects in specific school subjects: An application of confirmatory factor analysis with the national educational longitudinal study of 1988. *American Educational Research Journal*, 33(3), 665-689.

Marsh, H., & Yeung, A. (1997a). Coursework selection: relations to academic self-concept and achievement. *American Educational Research Journal*, *34(4),* 691-720.

Marsh, H., & Yeung, A. (1997b). Causal effects of academic self-concept on academic achievement: Structural equation models of longitudinal data. *Journal of Education Psychology*, *89(1),* 41-54.

Mason, C.L., Kahle, J.B., & Gardner, A. (1991). Draw-a-scientist test: Further implications. *School Science and Mathematics*, *91(5),* 193-198.

Massachusetts Department of Education (1999). Science and technology/engineering curriculum framework: Public comment draft. http:www.doe.mass.edu/frameworks/scitech99/toc.html.

Matyas, M. (1984). Science career interests, attitudes, abilities, and anxiety among secondary school students; the effects of gender, race/ethnicity, and school type/location. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. New Orleans, LA.

Maxwell, J. (1996). *Qualitative Research Design*. Thousand Oaks, CA: Sage Publications.

Miles, M. B., & Huberman, A.M. (1994). *Qualitative Data Analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Miller, R., Greene, B., Montalvo, G., Ravindran, B., & Nichols, J. (1996). Engagement in academic work: The role of learning goals, future consequences, pleasing others, and perceived ability. *Contemporary Educational Psychology*, *21*, 388-422.

Montalvo, G., & Roedel, T. (1995). Pleasing the teacher: A qualitative look. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Morgan, D.L. (1997). *Focus Groups as Qualitative Research*. Thousand Oaks, CA: Sage Publications.

National Research Council (1996). *National science education standards.* Washington DC: National Academy Press.

National Science Board (2000). *Science and Engineering Indicators – 2000* (NSB-00-1). Arlington, VA: National Science Foundation.

National Science Foundation (2000). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000* (NSF 00-327). Arlington, VA.

Oakes, J. (1990). *Lost Talent: The Underparticipation of Women, Minorities, and Disabled Persons in Science.* ED 318 640.

Post-Kammer, P., & Smith, P. (1985). Sex differences in career self-efficacy, consideration and interests of eighth and ninth graders. *Journal of Counseling Psychology*, *32(4)*, 551-559.

Rhee, E. (1992). Sex differences in attributions for math and science performance: A literature review. Unpublished qualifying paper, Harvard University.

Sadler, P., & Tai, R. (2001). Success in introductory college physics: The role of high school preparation. *Science Education*, *85(2),* 111-136.

Seidman, I. (1998). *Interviewing as Qualitative Research*. New York: Teacher College Press.

Smist, J. (1994). Gender differences in attitude toward science. Paper presented at the Annual Meeting of the American Educational Research Association. New Orleans, LA.

Society of Women Engineers (2000). What are you doing for the rest of your life? Is engineering for you? http://www.swe.org/SWE/StudentServices/CareerGuidance/brochure1.html

Spector, B. & Gibson, C. (1991). A qualitative study of middle school students' perceptions of factors facilitating the learning of science: Grounded theory and existing theory. *Journal of Research in Science Teaching*, *28 (6),* 467-484.

Steinkamp, M., & Maehr, M. (1983). Affect, ability, and science achievement: A quantitative synthesis of correlational research. *Review of Educational Research*, *53*, 369-396.

Stipek, D. (1996). Motivation and Instruction. In D.C. Berliner and R.C. Calfee (Eds.), *The Handbook of Educational Psychology* (pp85-113). New York:MacMillan.

Stipek, D., & Gralinski, J. (1991). Gender differences in children's achievement-related beliefs and emotional responses to success and failure in mathematics. *Journal of Educational Psychology, 83*, 361-371.

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (2nd Ed.). Thousand Oaks, Sage Publications.

Tapasak, R. (1990). Differences in expectancy-attribution patterns of cognitive components in male and female math performance. *Contemporary Educational Psychology, 15*, 284-298.

Tippins, D. (1991). The relationship of science self-efficacy and gender to ninth grade students' intentions to enroll in elective science courses. Paper Presented at the Annual Meeting of the American Educational Research Association. Chicago, IL.

Weinburgh, M, & Englehard, G. (1994). Gender, prior academic performance and beliefs as predictors of attitudes toward biology laboratory experiences. *School Science and Mathematics*, *94(3),* 118-123.

Wheeler, K. (2000). Sparking connections: An exploration of adolescent girls' relationships with science. Unpublished doctoral dissertation, Harvard University.

Wigfield, A., & Eccles, J. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, *12*, 265-310.

Wigfield, A., & Eccles, J. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68-81.

Wolleat, P., Pedro, J., Becker, A., & Fennema, E. (1980). Sex differences in high-school students' causal attributions of performance in mathematics. *Journal of Research in Mathematics Education, 11*, 356-366.

Vita

Holly M. James

1987-1991	Princeton University Princeton, NJ	Bachelor of Arts June 1991
1991-1993	Children's Ski Instructor Aspen Skiing Company Snowmass, CO	
1993-1994	Shady Hill School/ Lesley College Cambridge, MA	Master of Education June 1994
1994-1996	First Grade Teacher Maria Hastings Elementary School Lexington, MA	
1996-1997	Consultant Tufts University Department of Engineering Medford, MA	
1997-present	Doctoral Candidate Harvard University Graduate School of Education Cambridge, MA	Master of Education June 1998
1998-1999	Teaching Fellow Harvard University Graduate School of Education	