Giant Planets Front-end Evaluation

Mothers and Daughters: Attitudes and Interests

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EXECUTIVE SUMMARY AND DISCUSSION

A 1998 report published by the American Association of University Women (AAUW) jolted many into the realization that, while no legal barriers prevented females from excelling in science, significant cultural and mental barriers exist (AIR, 1998). In the ensuing years, many studies explored the impact schools and families have on females' attitudes toward science, though few have considered the museum's role. A recent article in *ASTC Dimensions* discussed the impact mothers' actions at science museums may have on their daughters (Taylor, 2005). Attempting to expand upon this notion, this study tested the hypothesis that mothers' actions at science museums reflect pervasive attitudes that influence daughters' thinking beyond how to interact with science exhibits.

GIRLS' AND MOTHERS' ATTITUDES TOWARD SCIENCE

Overwhelmingly, mothers and girls in this study responded positively to science—saying they liked it, were good at it, and thought it was fun. Their interviews strongly suggest that they believe science can be creative and interesting, that they are not scared by science, and that science helps solve real-life problems. This positive attitude, however, stands in sharp contrast to their interest in pursuing a career in science—over one-half of girls did not want to be scientists, and almost one-third were not sure. While it is likely that some girls' responses reflected their uncertainty about pursuing any career, let alone a career in science, other studies in school settings support this finding. Though girls and women see science as a viable and positive option for females, they pursue degrees and careers in science less frequently than do males (Farenga & Joyce, 1999).

The effectiveness of existing initiatives to engage females in science may explain respondents' extremely positive attitudes toward science in this study, in that girls and their mothers may be familiar enough with the message that women can and perhaps *should* be interested in science. While it is likely that women and girls do have positive attitudes toward science, it is also likely that the responses in this study reflect an urge—on the part of the women and girls participating—to give the "right" answer, known as courtesy bias. The presence of a courtesy bias is supported by the fact that although over three-quarters of girls agreed with attitudinal statements such as "I like science," few said that science was their favorite academic subject and/or they were interested in pursuing a career in science. Based on previous studies, women generally demonstrate a higher courtesy bias than men; likewise, older women are more prone to courtesy bias than younger women (RK&A, 2005). The courtesy bias trend is important to consider given the extremely positive attitudes representative of participants in this study.

On the whole, mothers' and daughters' attitudes toward science were similar and positive. Mothers' attitudes were, on average, more favorable than their daughters; likewise, mothers' impressions of their daughters' attitudes were similar to, but generally more positive, than the girls' attitudes. These findings reflect the courtesy bias trend as it relates to age. It is interesting that mothers overestimated how good their daughters think they are at science, how interested they are in becoming scientists, and how much they like science. Possibly, this overestimation of daughters' attitudes is a result of the mothers' pride in their daughters' achievements;

however, courtesy bias may also be a factor. The general similarity between mothers' and girls' attitudes may reflect two forces—mothers imposing their more favorable attitude upon their daughters, and a positive cultural attitude toward science that has been adopted across generations.

However, in attempting to build a statistical model that would predict a girls' overall attitude toward science, two variables investigated in this study revealed predictive power: 1) mothers' impressions of daughters' attitudes toward science; and, 2) to what extent girls like science classes. Thus, a girl's positive attitude toward science is not because of her mother's attitudes or actions regarding science, but rather her mother's beliefs *about* her daughter's attitude toward science. **Whether a mother likes science does not predict her daughter's science attitude; instead, whether a mother *believes* her daughter likes science is predictive of her daughter's science attitude.** In addition, how much a girl likes science as an academic subject is predictive of her overall science attitude.

IMPORTANCE OF SCIENCE AND ASTRONOMY

According to girls' responses, science and astronomy are important for similar reasons, most significantly because of society's need to know and learn more. More specific responses stress the importance of learning more about sustaining and improving human life, reflecting an attitude among respondents that science is strongly tied to daily life. Responses included the importance of medical and technological advances, as well as the possibility of finding another planet that could eventually sustain human life. A smaller, though still significant, number of girls also said that astronomy was important to pursue because it allows scientists to discover and understand the unknown. While girls may recognize the importance of investigating the unknown, they are much more concerned with the ways astronomy and science can directly impact their own lives. Girls' responses show that they recognize the importance of science and astronomy in general, yet often fail to appreciate its importance to them personally.

While the semantic difference may be subtle, there is a difference between girls' recognizing the *importance* of and showing *interest* in studying science and astronomy. As other studies have shown, most adolescents understand the importance of science and astronomy, yet are not interested in pursuing further studies in those fields (Anderson, et al., 2005; Jenkins & Nelson, 2005). If young people, regardless of gender, are going to be motivated to lead science-rich lives, they must realize how science affects them personally. For many people, their interest in astronomy extends only as far as it relates directly to them. As this study shows, participants' interest in astronomy hinges on a personal connection. Their interest in the giant planets focused on whether the planets had water to support life, whether people could go there, and/or whether humans could live there. Other studies corroborated findings that reflect girls' tendencies to link science to their own lives, and focusing on this connection has been shown to reduce the gender gap in science education (Curran, 1992).

RESOURCES GIRLS USE TO OBTAIN SCIENCE INFORMATION

Most girls said that they think about science outside school, in the routine of their daily lives and/or when thinking about or experiencing nature. Much of the evidence shows girls are likely to think of science when it is associated with a familiar idea, rather than out of inherent curiosity. The main resources girls use to learn about science are school, the Internet, and/or books—all resources that are easily linked to formal education. This study shows that the majority of girls tend to think about science when they have to—for school—or when it relates to their everyday lives.

Although girls report thinking about science outside school, one-half of our respondents reported they had not participated in any extracurricular science activities within the last year. Extracurricular programs have proven to be an effective method of introducing girls to science and building their self-confidence with the subject (Lee, 1998).

MUSEUM VISITATION AND GIRLS' ATTITUDES TOWARD SCIENCE EXHIBITS

Interviewees said overwhelmingly that they enjoy visiting science museums, and almost every girl easily came up with two favorite exhibits to talk about, most of them related to science. Good science exhibits clearly affect girls, especially when they are given the opportunity to see or do something firsthand—such as touching, experiencing something directly, or participating in a story. One experience several girls mentioned was seeing an actual science lab, whether there were scientists working in it or not. Seeing a real work environment allowed them to imagine where they might work if they were to pursue science, and it piqued their interest as well as spurred their memory. Girls enjoyed exhibits focused on direct participation, with several mentioning specifically that participating in a storyline (being assigned a role and following the fate of that individual) strongly increased their interest and held their attention. Girls also enjoyed exhibits that showed them something new and unknown, or presented something familiar in an unusual way.

GIRLS' KNOWLEDGE OF THE GIANT PLANETS

In general, girls were aware of the giant planets and had learned something about them at school, but they did not know a great deal about them. As one girl expressed it, after describing one or two basic thoughts that came to mind when she thought of the giant planets, "You never really learn much more about them than what you learn in school." Almost all girls knew basic facts about the planets—shapes, distances, names, or major characteristics like Jupiter's red spot or Saturn's rings—and a smaller number used information they had learned to hypothesize about the planets. As seen with girls' responses regarding the importance of science and astronomy, much of the specific information girls had retained or were curious to learn about was connected to the planet's relation to Earth and its ability to sustain life.

In one section of the interview, the interviewer read girls seven statements and asked them to respond whether each made them curious to learn more or not curious to learn more. The

intention of this portion of the interview was to see whether there was a tipping point—a certain point at which girls had heard enough statements to become interested, or certain statements that girls consistently found more interesting than others. The evaluators read the statements in three different orders to make sure that patterns seen would reflect the statements and not the order. Girls responded overwhelmingly that they were quite curious about all the statements, but there did not seem to be a clear tipping point. It is likely that a courtesy bias was also at work in this section of the interview, as many girls replied "curious" to every single statement, and a trend is apparent among those who responded primarily "curious." The "not curious" responses they gave almost all occur at the third, fourth, or fifth statement, suggesting that they may have offered one or two "not curious" responses for good measure upon realizing they were being *too* curious.

RECOMMENDATIONS

The results of this study indicate that girls' attitudes toward science are extremely positive. They like science, enjoy going to science museums, and favorably remember science exhibits they have seen. Despite all this, they do not wish to pursue careers in science. This study did not find evidence that mothers' attitudes toward science cause girls' hesitancy to enter science fields. However, both girls and mothers made it clear that science was important to them because it could impact their lives on a personal level, though few girls reported participating in or having an interest in participating in meaningful science experiences outside school. **Thus, strong outreach to promote girls' participation in extracurricular science activities created around topics linked to everyday life may be a major element in promoting girls' interest in leading science-rich lives.**

One of the few areas where girls reported having meaningful science experiences outside school was in museums. **Exhibits that tie science to girls' everyday life will be highly successful in building their interest. Such exhibits should include aspects that allow direct participation, perhaps even in a storyline.** Girls may be attracted to assuming the role of a female scientist in an exhibit, conducting an experiment throughout the exhibition, and walking into a lab environment. **A theme to focus on may be the juxtaposition of the completely unfamiliar aspects of the giant planets (which girls find exciting) and those that they know are similar to Earth (which they more easily assimilate).** This theme also lends itself to a discussion of the topic that girls find most pressing: will we one day be able to live on any of the giant planets, and what are the conditions that will allow that?

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INTRODUCTION

This report presents the findings from an evaluation conducted by Randi Korn & Associates, Inc. (RK&A), for the Space Science Institute (SSI) in preparation for an upcoming exhibition tentatively titled *Giant Planets*. The exhibition will focus on interpreting and presenting planetary astronomy, with a focus on the giant planets.

GOALS AND OBJECTIVES

This study's goal is to provide the exhibition development team with information about one segment of *Giant Planets*' target audience—namely, females—and their understanding and perception of concepts associated with the proposed exhibition's content. Specifically, the research objectives are to identify:

- Girls' interest in space exploration and discovery—the giant planets, in particular;
- Girls' awareness and knowledge of the giant planets;
- Girls' attitudes toward science and science research;
- Girls' opinion of the impact of science and science research on their lives and on the lives of others;
- Girls' barriers to participating in extracurricular science activities;
- Mothers' attitudes toward science and science research;
- Mothers' estimations of girls' attitudes toward science;
- Mothers' perception of their role in forming girls' attitudes toward science;
- Where girls obtain science information;
- Findings from past research studies that have examined girls' relationship to science, science research, and planetary science; and
- Findings from past research studies that have examined mother-daughter dynamics and their impact on science attitudes.

METHODOLOGY

To investigate visitors' understandings and opinions, RK&A employed three data collection strategies: face-to-face questionnaire interviews, self-response questionnaires, and open-ended interviews. Questionnaire and in-depth interview respondents at all locations were selected using a random sample selection procedure. In most cases, data collectors intercepted respondents as they entered the museum. A few respondents were intercepted as they exited the museum. In either case, interviewers intercepted the first eligible visitor and asked her to participate in the study. When an interview ended, the data collector returned to the initial interception area to wait for the next eligible visitor. This random sample selection method ensures that a representative sample of visitors participates in the study. A description of each method follows.

Questionnaire Interviews

RK&A used a standardized questionnaire because it is the most efficient method to gather information from a large number of people. Moreover, the resulting data can be analyzed using a variety of statistical procedures. RK&A consulted with SSI staff to develop a two-page standardized questionnaire with a variety of question formats, including Likert scale ratings (see Appendix A). Using a systematic random sampling method, trained data collectors intercepted female visitors 8-18 years old who were accompanied by their mother or a female guardian, and asked them to participate. Those who agreed were interviewed.

A total of 223 girls were interviewed in various Museum locations on the National Mall in Washington, D.C. The majority of the data were collected at the National Museum of American History. Data were collected in August 2005.

Self-response Questionnaires

The interviewed girl's mother or female guardian filled out a self-response questionnaire while the data collector interviewed the girl. RK&A consulted with SSI staff to develop a two-page standardized questionnaire, asking many of the same questions that appeared on the girls' questionnaire (see Appendix B).

RK&A used a standardized questionnaire because it is the most efficient method to gather information from a large number of people, and the resulting data can be analyzed using a variety of statistical procedures. A total of 223 women responded to questionnaires.

In-depth Interviews

For this study, RK&A also crafted a series of open-ended questions aimed at eliciting more detailed information about girls' attitudes, knowledge, and interest in planetary astronomy. For this phase of data collection, data collectors used the interview guide to encourage and motivate respondents to share any feelings, opinions, or other thoughtful responses. The interview guide also questioned girls about a potential big idea and titles provided by SSI.

A total of 34 visitors were interviewed at the National Museum of American History and the Hirshhorn Museum in Washington, D.C. The interviewers used an interview guide (see Appendix C), to probe visitors about their responses. Girls who rated science either as one of their two most favorite classes or one of their two least favorite classes in the questionnaire were asked to participate in the in-depth interview. All interviews were tape recorded and transcribed to facilitate analysis.

DATA ANALYSIS AND REPORTING METHOD

The quantitative questionnaire data were analyzed using SPSS/PC+, a statistical package for personal computers. Frequency distributions were calculated for all categorical variables (such as age group). To examine the relationship between two categorical variables (such as reasons for visiting by age group), cross-tabulation tables were computed to show the joint frequency

distribution of the variables, and the chi-square statistic (χ^2) was used to test the significance of the relationship. Summary statistics, including the mean (average) and standard deviation (spread of scores: "±" in tables), were calculated for the rating scales and other variables measured at the interval level. To compare the means of two-related groups (such as mothers and daughters), a paired T-test was performed. To compare the means of more than two groups (such as elementary, middle, and high school students), an analysis of variance (ANOVA) was performed.[1]

Stepwise multiple regression analysis was used to examine the relationship between a dependent variable (such as girls' attitude toward science) and a set of independent variables (such as grade level, mothers' attitude toward science, and frequency of museum visitation), to identify which independent variables, if any, comprise a model that successfully predicts the dependent variable. For instance, stepwise multiple regression analysis was used to determine which factors affect girls' attitudes toward science.

A standard level of significance of less than 0.05 was used to preclude relationships bearing little or no practical significance. When the level of significance is set to $p \leq 0.05$, any relationship that exists at a probability (p-value) less than or equal to 0.05 is "significant." When a relationship has a p-value of 0.05, there is a 95 percent probability that the relationship exists; that is, in 95 out of 100 cases, there would be a relationship between two variables such as age group and reason for visiting. Conversely, there is a 5 percent probability that the relationship would not exist; in other words, in 5 out of 100 cases, a relationship would appear by chance.

Verbatim responses to open-ended questionnaire items and interview questions were analyzed qualitatively. In other words, they were reviewed, and, as patterns were detected, categories were developed and similar responses were grouped together. Responses were tallied, and in most cases the percentages and frequencies are reported in tables.

[1] For instance, an ANOVA was used to compare the average attitudes toward science by grade level. If the F-statistic resulting from an ANOVA was significant, a post-hoc Scheff multiple comparison test was used to determine which group mean(s) differed from which other group mean(s). For example, if the F-statistic indicated that the age groups had different mean ratings of an experience, the Scheff test was used to pinpoint which event groups differed.

I. PRINCIPAL FINDINGS: GIRLS' QUESTIONNAIRE INTERVIEWS

RK&A collected 223 questionnaire interviews from girls. Data collectors approached an additional 117 visitors who declined to participate. Therefore, the overall refusal rate was 53 percent. While this refusal rate is higher than most studies conducted in museums, it is consistent with other studies conducted at the Smithsonian Institution and on the National Mall.

DEMOGRAPHIC CHARACTERISTICS

This section presents findings about respondents' gender and age, museum visitation behavior, and participation in extra-curricular science activities.

Gender and Age

All respondents were female. The majority of participating girls (40 percent) were scheduled to enter sixth, seventh, or eighth grade in the upcoming academic year. Respondents' grade levels[2] ranged between second grade and the first year of college (see Table 1 below).

Table 1
Grade level Girls Entered in Fall 2005
(*n* = 223)

Grade Level	%
Elementary (grades 2-5)	33.7
Middle (grades 6-8)	39.9
Secondary (grades 9-12)	25.1
College	<1

Museum Visitation

Respondents had visited an average of four museums in the past 12 months, with the number of reported visits ranging from zero to 20 museums. The type of museum they said they visited varied widely—over one-quarter (26 percent) reported they had visited a history museum and almost one-fifth (19 percent) had visited a science museum (see Table 2, next page).

[2] Since the study was conducted during the summer, grade levels reflect the grade respondents were about to begin.

Table 2
Types of Museums Visited in the Last Year
(*n* = 223)

Museum Type	%
History	26.1
Science	18.8
Art	13.6
Natural History	9.4
Space	7.3
Other	16.9

Nearly one-half of respondents (48 percent) said their parents were typically the ones who decide which museums to visit, while almost one-quarter (23 percent) said they typically decide themselves. Less than one-fifth of respondents (14 percent) said their school decides which museums to visit (see Table 3 below).

Table 3
Who Typically Decides Which Museums to Visit
(*n* = 223)

Decisionmaker	%
Parent	47.8
Me	22.9
School	14.0
Friend	1.3
All/Group	7.6
Other	6.3

Extracurricular Science Activity Participation

One-half of respondents reported that they did not participate in any extracurricular science activities within the last year. One-tenth (10 percent) said they participated in extracurricular science activities at camp, and almost one-tenth (9 percent) said they participated in science-activities at a museum (see Table 4 below).

Table 4
Respondents' Extracurricular Science Activities
(*n* = 223)

Participation	%
None	49.8
At camp	9.6

In museums	9.2
Other	31.4

GIRLS' ATTITUDES TOWARD SCIENCE

For this study, exhibition developers were particularly interested in girls' attitudes toward science. Therefore, data collectors asked respondents what interested them, what they were curious about, and what barriers to learning science they encountered.

Attitudes Toward Academic Subjects

Data collectors asked girls to rank seven academic subjects from least favorite to most favorite. Over one-quarter of respondents (27.5 percent) rated art as their favorite class at school, followed by nearly two-fifths (19.3 percent) who rated math or social studies as their favorite class (see Table 5 below). The favorite class varies by grade level, with art being selected most often by elementary and middle school girls and social studies being selected most often by high school girls. However, the percentage of girls who selected science as their favorite class remains constant across grade level at approximately 15 percent.

Table 5
Favorite Academic Subject by Grade Level*

Favorite Academic Subject	**Elementary % (*n* = 74)**	**Middle % (*n* = 87)**	**High % (*n* = 57)**	**Total % (*n* = 218)**
Art	35.1	29.9	14.0	27.5
Math	27.0	12.6	19.3	19.3
Social Studies	13.5	21.8	22.8	19.3
Science	**12.2**	**16.1**	**15.8**	**14.7**
English	2.7	8.0	21.1	9.6
Music	9.5	11.5	7.0	9.6

*X^2 = 24.58; df = 10; p=.006

How Girls Feel About Science

The questionnaire contained 18 science-related statements, and respondents were asked to rate the degree to which they agreed or disagreed with each statement using a scale from 1 ("disagree") to 5 ("agree"). For purposes of analysis and presenting the data, the items were recoded such that regardless of wording, a score of 5 represents the most favorable response and 1 represents the least favorable response. For example, if a respondent strongly agreed with the item, "science scares me," her response was scored as 1, or least favorable. A respondent who strongly disagreed with the statement, "science scares me," received a 5, or the most favorable response.

Respondents most strongly agreed with the statement "science can be creative," followed by "science can be fun" (means of 4.77 and 4.60, respectively). Girls strongly disagreed with the statements "I hope to never see science again" and "science scares me" (means of 4.58 and 4.40) (see Table 6, below).

Table 6
Mean Ranking of Girls' Attitudes Toward Science
(*n* = 216)

Statement	Mean Ranking Least favorable response (1) / Most favorable response (5)
Science can be creative.	4.77
Science can be fun.	4.60
I hope never to see science again.*	4.58
Science scares me.*	4.40
Science helps solve real life problems.	4.36
I enjoy visiting science museums.	4.33
I like science.	4.28
Scientists do their work alone.*	4.12
Science doesn't relate to daily life.*	4.12
I want to learn more about planets.	3.99
I use science in my daily life,	3.97
Science bores me.*	3.97
I am good at science.	3.85
Science never changes.*	3.77
I know a lot about planets and the solar system.	3.64
I can think like a scientist.	3.40
Science is about the stuff I learned in school.*	2.77
I want to be a scientist.	2.20

* Negative statements included in this table and throughout the study were recoded to assist in analysis and to avoid readers having to translate double negative findings. Therefore, higher mean rankings indicate more favorable responses; lower mean rankings indicate less favorable responses.

Girls' Attitudes and Age

Girls' grade levels were broken up into three age categories, elementary, middle, and high school students. A one-way ANOVA was used to test for statistically significant differences among school grade and attitudes toward science. If the ANOVA was significant, a post-hoc Scheffé test was used to determine which grade levels differed from other grade levels.

As respondents' grade levels advanced from elementary school to middle school, they responded less favorably to the statements, "I enjoy visiting science museums," and "I want to be a scientist." A similar relationship occurred between elementary and middle school girls when comparing how they responded to the statements, "Science doesn't relate to daily life," and "I want to learn more about planets."

When comparing attitudes toward science between elementary and high school girls, girls' responses indicate that older girls are more likely to recognize that science is a part of daily life. However, high school girls are less likely to express interest in learning more about planets and also report knowing less about planets and the solar system.

Finally, comparison analysis indicates that middle and high school respondents differed significantly when responding to the statements, "I want to learn about planets," and "I know a lot about planets and the solar system." In both cases, middle school girls responded more favorably than their counterparts, indicating, possibly, a more positive attitude toward planets (see Table 7, next page).

Table 7
Mean Ranking of Girls' Attitudes Toward Science by Grade Level (*n* = 221)

Rating Scale Most favorable (5)/ Least favorable (1)	**Elementary School** (*n* = 74) Mean	±	**Middle School** (*n* = 89) Mean	±	**High School** (*n* = 58) Mean	±	**Total** (*n* = 221) Mean	±
I enjoy science museums. [1]	4.5	(0.78)	4.2	(0.88)	4.3	(.089)	4.3	(.086)
I want to be a scientist. [1]	2.5	(1.30)	2.0	(1.11)	2.2	(1.30)	2.2	(1.24)
Science doesn't relate to daily life. [1, 2]	3.7	(1.27)	4.2	(1.10)	4.5	(0.94)	4.1	(1.17)
I want to learn more about planets. [1, 2, 3]	4.4	(1.06)	4.0	(1.08)	3.5	(1.26)	4.0	(1.17)
I know a lot about planets and the solar system. [2, 3]	3.9	(1.30)	3.8	(1.12)	3.2	(1.48)	3.6	(1.31)

[1] Elementary and middle school groups differ at the 0.05 level.
[2] Elementary and high school groups differ at the 0.05 level.
[3] Middle and high school groups differ at the 0.05 level.

II. PRINCIPAL FINDINGS: MOTHERS' SELF-ADMINISTERED SURVEYS

In this section, mothers' visit data and attitudes toward science are presented. Because the surveys were self-administered, the occurrence of non-responses is greater in this section than in others. A total of 223 questionnaire interviews were obtained from mothers. An additional 117 visitors were asked to participate but declined, for an overall refusal rate of 53 percent.

DEMOGRAPHIC CHARACTERISTICS

Museum Visitation

Respondent mothers reported visiting—with their daughters—an average of four museums in the past 12 months, with the number of reported visits ranging from zero to 20 museums.

Respondents reported visiting a range of museums over the past year. About one-fifth (21 percent) reported visiting a history museum, while a nearly equal percentage (19 percent) said they visited a science museum. One-tenth of respondents (10 percent) reported visiting an art museum. Other museums mothers said they visited were natural history and space museums. A small number of respondents (3 percent) reported visiting Smithsonian museums only, and did not clarify what type of museum they visited (see Table 8 below).

Table 8
Types of Museums Visited in the Last Year (Mother)
(*n* = 223)

Museum Type	%
History	21.2
Science	18.9
Art	10.4
Natural history	6.8
Space	6.6
Other	32.9

Just over one-quarter of respondents (26 percent) said the whole family typically decides which museums to visit together. Almost one-quarter (23 percent) said the parents typically decide for the family, while an even smaller number of mothers (17 percent) said that they typically decide which museum to visit (see Table 9, next page).

Table 9
Who Typically Decides Which Museums to Visit (Mother)
(*n* = 223)

Decision Maker	%
Whole family	26.0
Parents	22.8
Mom	16.8
Children	11.0
Other	23.4

MOTHERS' ATTITUDES TOWARD SCIENCE

Along with studying girls' attitudes toward science, exhibition developers were also interested in mothers' attitudes toward science and mothers' impressions of their daughters' attitudes toward science. Therefore, data collectors asked mothers both about themselves and about their daughters: what interests each, what they are curious about, and what barriers to learning science they encounter.

How Mothers Feel About Science

Each questionnaire contained 17 science-related statements, and mothers were asked to indicate the extent to which they agreed or disagreed with each statement. Their responses were coded in the same way as the girls' responses—a low rating (1) reflects the least favorable response and a high rating (5) reflects the most favorable response.

Like their daughters, mothers rated the statement "science can be creative" most favorably (i.e., they agreed with the statement). However, the second most favorably received statement was "science helps solve real life problems." Mothers' responses toward negative statements, such as "I hope never to see science again," and "science doesn't relate to daily life," were rated favorably (i.e., they disagreed with the statement). Another pattern mothers shared with their daughters was their reaction to, "I want to be a scientist," which again ranked lowest of all statements (see Table 10, next page).

Table 10
Mean Ranking of Mothers' Attitudes Toward Science
(*n* = 160)

Statements	Least favorable response (1) / Most favorable response (5) mean
Science can be creative.	4.90
Science helps solve real life problems.	4.83
I hope never to see science again.*	4.81
Science doesn't relate to daily life.*	4.77
Science can be fun.	4.66
I like science.	4.56
I use science in my daily life.	4.51
Science never changes.*	4.50
I enjoy visiting science museums.	4.47
Science bores me.*	4.27
Science scares me.*	4.14
I want to learn more about planets.	3.91
I am good at science.	3.77
I know a lot about planets and the solar system.	3.46
I can think like a scientist.	3.34
Science is about the stuff I learned in school.*	3.34
I want to be a scientist.	2.07

* Negative statements included in this table and throughout the study were recoded to assist in analysis and to avoid readers having to translate double negative findings. Therefore, higher mean rankings indicate more favorable responses; lower mean rankings indicate less favorable responses.

Mothers' Perceptions of Daughters' Attitudes

In addition to the 17 statements about attitudes toward science, the self-administered surveys also included 11 statements that required mothers to report their impressions of their daughters' attitudes toward science. Mothers' responses are ranked according to how they perceived their daughters' attitudes toward science: A low rating (1) indicates the least favorable response and a high rating (5) indicates the most favorable response.

When asked about their impressions of their daughters' attitudes, mothers replied most favorably to or agreed with the statement, "my daughter is good at science." The statements "my daughter enjoys visiting science museums" and "my daughter likes science," also received high ratings, indicating mothers' favorable impressions of their daughters' attitudes toward science. "My daughter wants to be a scientist" ranks lowest of the science-related statements, (i.e., mothers disagreed with the statement "my daughter wants to be a scientist,") similar to earlier findings regarding girls' attitudes toward pursuing a career in science (see Table 11, next page).

Table 11
Mean Ranking of Mothers' Perceptions of Girls' Attitudes Toward Science
(*n* = 183)

Statements	Least favorable response (1) / Most favorable response (5) mean
My daughter is good at science.	4.47
My daughter enjoys visiting science museums.	4.36
My daughter likes science.	4.31
My daughter thinks science can be creative.	4.31
My daughter thinks science can be fun.	4.30
Science scares my daughter*	4.30
My daughter uses science in her daily life.	4.25
Science bores my daughter.*	3.87
My daughter wants to learn more about planets.	3.80
My daughter knows a lot about planets and the solar system.	3.76
My daughter wants to be a scientist.	2.66

* Negative statements included in this table and throughout the study were recoded to assist in analysis and to avoid readers having to translate double negative findings. Therefore, higher mean rankings indicate more favorable responses; lower mean rankings indicate less favorable responses.

Mothers' Perceptions of Influences on Daughters' Attitudes

In response to the question, "In your opinion, what are some influences that shape your daughter's attitude toward science," mothers wrote in a wide variety of responses, none of which represent a majority of responses. Less than one-fifth of respondents (17 percent) said they think school is one of the influences shaping their daughters' attitudes toward science, and an even smaller amount (13 percent) said that teachers are. Good experiences with science and an inherent interest or talent in science received the lowest percentage of responses (2 percent each), indicating that mothers felt these factors had little influence on their daughters' attitudes toward science (see Table 12, next page).

Table 12
Mothers' Perceptions of Influences on Daughters' Attitudes
(*n* = 183)

Influence	%
School	17.1
Teachers	12.8
Parents	9.3
Television	5.8
Family/home	5.4
Friends	5.0
Hands-on	4.1
Media	3.5
Mom	3.2
Fun	3.0
Museums	2.4
Good experience with science	2.2
Inherent talent/interest	2.2

IV. PRINCIPAL FINDINGS: COMPARISONS

Mothers' and Girls' Attitudes Toward Science

Using a scale from 1 (least favorable response) to 5 (most favorable response), mothers' and girls' responses to attitudinal items were compared using a paired-samples T-test. See Table 13 for a ranking of the means of items where the difference in mothers and daughters' responses was statistically significant. Of the ten items where mothers' and girls' responses differed, mothers consistently provided more favorable responses than the girls with one exception. Girls disagreed with the statement "science scares me" more strongly than their mothers (see Table 13 below).

Table 13
Comparison of Mothers' and Girls'
Mean Rating of Attitudinal Statements*

Statements	Least favorable response (1) / Most favorable response (5) Girls' mean rating	Mothers' mean rating
Science scares me.	***4.40***	***4.14***
Science never changes.	3.77	4.50
Science is about the stuff I learned in school.	2.77	3.34
Science helps solve real-life problems.	4.36	4.83
Science doesn't relate to daily life.	4.12	4.77
Science can be creative.	4.77	4.90
Science bores me.	3.97	4.27
I use science in my daily life.	3.97	4.51
I like science.	4.28	4.56
I hope never to see science again.	4.58	4.81

*All items in this table differ at the 0.05 level of significance.

Mothers' Perceptions of and Girls' Attitudes Toward Science

Using the same scale from 1 (least favorable response) to 5 (most favorable response), mothers responded to items designed to elicit their perceptions of their daughters' attitudes toward science. Items were compared using a paired-samples T-test. Table 14 lists in rank order the five items in which mothers' perceptions of their daughters' attitudes and the girls' responses differed significantly. Girls perceive science as more fun and/or creative than their mothers think that they do (see Table 14). Mothers' responses indicated that they think the girls have a higher aptitude for science (mean = 4.47) than the girls' self-reported aptitudes (mean = 3.85). Likewise, mothers' responses indicated that they believe their daughters are more likely to want to become scientists (mean = 2.66) than the girls' responses indicate (mean = 2.20). Mothers also reported a more favorable score with regard to how often their daughters use science in daily life, (i.e., mothers more strongly agree with the statement "My daughter uses science in her daily life" than their daughters).

Table 14
Comparison of Mean Ratings of Mothers' Perceptions of Daughters' Attitudes Toward Science and Girls' Attitudes Toward Science

	Least favorable response (1) / Most favorable response (5)	
Statements*	**Girls' mean rating**	**Mothers' mean rating**
My daughter thinks / Science can be fun.	***4.60***	***4.30***
My daughter thinks / Science can be creative.	***4.77***	***4.31***
My daughter is / I am good at science.	3.85	4.47
My daughter wants / I want to be a scientist.	2.20	2.66
My daughter uses / I use science in my daily life.	3.97	4.25

*All items presented in this table differ at the 0.05 level of significance.

Overall Science Attitudes

Using the same scale from 1 (least positive) to 5 (most positive), an overall compound attitudinal score was generated for girls, mothers, and mothers' perception of their daughters; a mean compound attitudinal score was calculated for each group. Mothers rated their daughters' overall attitude toward science fairly high (overall mean = 4.04; see Table 15), yet slightly lower than their own attitudes toward science (overall mean = 4.14; see Table 15). **Interestingly, mothers rated their daughters' attitudes toward science significantly higher (overall mean = 4.04; see Table 15) than girls rated their own attitudes (overall mean = 3.92; see Table 15).**

Table 15
Mean Ratings of Compound Attitudinal Scores by Group

	Least positive attitudinal score (1) / Most positive attitudinal score (5)	
Groups	**Compound Attitudinal Mean**	**±**
Mothers' self-reported attitudes	4.14	0.65
Mothers' perception of daughters' attitudes	4.04	0.78
Girls' self-reported attitudes	3.92	0.69

t = 48.9 *d f* = 159; *p* = .000

Predicting Girls' Attitudes Toward Science

In constructing a model that predicts girls' attitudes toward science, two variables emerged with predictive power: first, girls' self-reporting science as a favorite academic subject; and, second, mothers' perception of their daughters' attitude toward science (see Table 16).

Table 16
Stepwise Multiple Regression Model
for Predicting Girls' Attitudes Toward Science

Rating Scale	Significant Predictor Variables in the Model	Model F	df	Sig.	R^2
Most favorable response (5)/	- Academic science ranking	22.781	2	.000	.263
Least favorable response (1)	- Mothers' reporting of daughters' attitudes				

IV. PRINCIPAL FINDINGS: GIRLS' IN-DEPTH INTERVIEWS

Of the 223 girls from whom questionnaire interviews were obtained, 34 were asked to participate in an in-depth interview (see Appendix C for the interview guide). Respondents for the in-depth interviews were selected based on their responses to the class ranking question on the questionnaire. Girls who selected science as one of their two most favorite classes were asked to participate in the in-depth interview, as were girls who selected science as one of their two least favorite classes. Interviewees ranged in age from nine years to 17 years.

In this section, girls' knowledge about planetary astronomy and thoughts about science and science exhibits are presented.

Aspects of Museum Exhibits Interesting to Girls

Girls were asked to describe two of the most interesting museum exhibits they remembered visiting. Given the science-centric content of the questionnaire, most interviewees assumed they were supposed to talk about science exhibits only, and as such, almost three-quarters of the interviewees described some kind of science exhibit. Those who did not initially mention a science exhibit were prompted to do so in their second description.

The girls described exhibits that addressed a wide range of topics. Several girls specifically mentioned an exhibit that included a laboratory where scientists work—some of them with scientists actually working in them (see the first and second quotations below). A few girls said they enjoyed exhibitions that included something real or authentic (see the third quotation). Likewise, a few girls said that hands-on exhibits were their favorite (see the fourth quotation).

> The paleontology area. The dinosaur skeletons. . . . There was a fossil lab that I enjoyed looking at—even though it was empty.
>
> So you actually got to see what scientists got to do when they're out working.
>
> And the most interesting exhibit I've ever seen was an exhibit on Egyptian mummies because I'm into Latin and mythology and for me that was very interesting. They even had . . . an actual mummy. So it was interesting.
>
> Well close to the area where I live, there's this place call Science City and there was this thing where we could ride a bicycle, it was a unicycle, across this rope that was hanging. And it looked like it was gonna be impossible, but when you got up and did it, it was so easy and it was crazy. I don't know how it works. I think I was in 5th grade at that time or something.

When asked what they liked about their favorite exhibits, interviewees' responses were much less varied. The majority of interviewees said that they enjoyed seeing or doing something firsthand (see the first quotation below). Many girls responded that they liked the exhibit they mentioned because it was interactive in some way—they could touch it, experience something firsthand, or participate in a story (see the second quotation). Many interviewees said they

enjoyed exhibits that showed either something different or something familiar presented in a new way (see the third and fourth quotations). A smaller number of interviewees responded that the exhibit was just plain fun, allowed them to see something old, or somehow tied to their own life and experience.

> It's kind of boring when they teach it to you [at school]. But then when you go to a museum and you can actually see it, it just makes it more interesting.

> Because you really got involved [at the Spy Museum]. You had to get a cover, you had to memorize your cover, you had to really get into it, and that was really cool, 'cause it just kept you involved the entire time.

> The African clothes—because I wanted to see how they lived their life different from us.

> It was just that it was so, it sort of made me look at things in a new way. It was really creative and sort of different than other things that you're used to seeing in like art museums and that.

Resources Used to Learn about Science

Most girls said they think about science outside of school. Many said they think about science in the routine of their daily lives and/or when thinking about or in nature. Interviewees were asked what resources they had used to learn about science in the past year. If they did not think of something on their own, the interviewers offered suggestions including museums, television, newspaper, school, the Internet, family, friends, and books. A majority of interviewees said they used school, the Internet, and/or books to learn about science.

Importance of Science and Astronomy

Girls were asked to explain why they thought science was important. Most interviewees said that science was important in order to learn and know more about the world. Some girls expressed the need to understand science as an abstract ideal—to better understand humans' place in the world—while a few said it was important to learn and know about something specific, such as the past, the earth, or technology (see the quotations below).

> Well, it's good to know about science because then you figure out how things can happen in the world. And it's hard to understand what happens in the world if you don't know a lot about it—science.

> I think [science is] important because it helps us learn about our world. There are many things we're totally ignorant about our world. We're not gonna know how to preserve it, with things like the greenhouse effect, we're not gonna know how to stop it. We're just gonna have no idea what to do.

Many interviewees also said that science was important because it helps improve the quality of life. Most girls said that people experience the benefits of science through medicine (see the first

quotation below). Several said that science, through the lens of technology, improves lives (see the second quotation). Some girls also said science was important, "because almost everything has to do with science." A few interviewees said science was useful because it helps solve problems.

> There are lots of diseases out there that still need to be cured and a lot of things that we [need to learn about]. Somehow it's gonna affect me and someone's gotta do it.

> Well it's really important to learn about how our universe works and, I mean we couldn't have as much technology that we have now if we didn't know so much about science. And so I think we're improving our ways of life every single day because of science, so I think that's why science is so important.

Interviewees were asked to describe the importance of astronomy. Similar to interviewees' rationales about the importance of science, a majority responded that astronomy was important to know and learn about. Specifically interviewees said astronomy was important to study because people need to better understand the Earth (see the first quotation below). Many girls also said that astronomy's importance stems from society's need to see and understand the unknown (see the second quotation). Several said that astronomy was important to determine whether there is life on other planets, figure out how to travel to distant worlds, and discover whether people could live there (see the third quotation). A few interviewees said that they did not know why astronomy was important.

> Well especially knowing about, like, meteors and stuff. If a meteor's gonna crash into Earth, knowing about it would be a good thing. But I think [astronomy] helps us to learn about how Earth works. If you know about how all the other planets work and how Earth is really a phenomena because your galaxy has to be just perfect, your planet has to be in the perfect space from the Sun to have people living and stuff life that. I think just knowing about a galaxy is important to know about how Earth works.

> My sister's going to be an aerospace engineer, so she's always bringing that subject up. I just think there's more out there than what, you know, we can see right now. I just think there's so much that we could learn from just going out and [exploring].

> I think that's important just because we don't know if we're the only life form and we need to know that there are other life forms out there. Because we might need to be living there in the future.

When asked why astronomers study planets and the solar system, interviewees' responses paralleled their rationales for the importance of astronomy. They overwhelmingly responded that astronomers study planets and the solar system to learn and know more. Many said astronomers were likely motivated to investigate space because people may someday live in space (see the first quotation below). Several interviewees said that astronomers were also interested in learning more about space from a cosmological perspective (see the second quotation). A few girls attributed more personal motivations for studying astronomy, such as the excitement of discovery (see the third quotation).

> Because one day they believe that somehow the Earth is not gonna survive and then we have to somehow get off.
>
> Because we already know everything there is to know about Earth and everything, and if we went to another place and we could find something similar or that would just could probably tell us more about ourselves or you could find something different which just shows more about how the Universe is created.
>
> Well, I've always kind of been interested in astronomy more than any other science just because I think it's amazing how things, 'ginormous' like revolve around the Sun. I think it's just amazing with all the stars and how everything just works. And so if I ever study astronomy, I know I would be intrigued by it. So I don't know why astronomers study it, but that's why I would study it.

Giant Planet Content Knowledge Level

Interviewees were shown images of Neptune and Uranus and asked what similarities and differences they observed, what the images made them wonder or think about, and what they were curious to find out about the two planets.

Almost all girls mentioned the size and color of the planets. Many also mentioned the circular or spherical shape of the planets (see the first quotation below). Many interviewees said that there were white "things" on Neptune and not on Uranus. Most called them spots, while some said they were clouds—referring explicitly to atmosphere, temperature, or texture. A few interviewees provided explanations for similarities and differences, hypothesizing about the axis and direction of spin of the planet, or its orbit (see the second quotation).

> They're both blue and Neptune looks from the picture bigger, not sure if that's right. This one definitely has more clouds. . . . They are both round.
>
> They're different colors. It looks like there's like a little bit of land on Neptune. And Uranus looks kind of cold

Interviewee responses to what the images made the girls wonder about or were curious about varied. Some wondered whether there was water and/or life on either of the planets (see the first quotation below). Some said they wondered if either planet could support human life (see the second quotation). A few girls said that they were more interested in the planets closer to the Earth—specifically Mars—than in Uranus and Neptune. Interviewees also raised questions about the difference in color, the exact size of the planets, the nature of the moons, what the white stuff on Neptune was, and how the planets differ from Earth.

> Well since there's clouds, there's got to be water on Neptune so if there really is water [then what does that mean?].

[I wonder] if people can live on that [planet] or go on that planet, to stay on [it] a number of years.

Interviewers also asked interviewees what they wonder and/or are curious to learn about—regarding all four giant planets: Jupiter, Saturn, Neptune, and Uranus. Most interviewees' responses paralleled the Uranus-Neptune image comparison conversation. They were curious about the presence of water and life, as well as the possibility of sustaining human life on the planets and what it is like on the planet. In addition, several wanted to find out more about the names of the planets and how they got them. Several interviewees said they were interested in the size of the planets, as it is beyond their range of experience. Several girls said they had questions about Jupiter's red spot, Saturn's rings, and the solar system in general.

Curiosity Regarding Giant Planet Facts

Interviewers read seven factual statements about the giant planets to the interviewees and asked them to indicate whether they were "curious" or "not curious" about the statement (the statements are included in Appendix C). The statements were read to the girls in different orders to eliminate order-based bias. Their responses were recorded by the interviewer.

In general, most interviewees said that they were curious about the statements. Almost all interviewees were intrigued by the statement, "There is no solid surface on any of the giant planets in our solar system that you could stand on." Most interviewees said that "Life on Earth may have depended on the giant planets, especially Jupiter," and "The Great Red Spot on Jupiter is a storm system so big that Earth would easily fit inside" piqued their curiosity.

A clear majority of interviewees said that they would be interested to know more about the following statements: "Giant planets are like miniature solar systems, with many moons, active magnetic fields and ring systems that change over time;" "Saturn's rings are not old (geologically). Even if the dinosaurs had telescopes, they would not have seen any rings;" and "All four giant planets in our solar system have ring systems." Fewer interviewees were curious about the statement, "With no continents or other solid surface to slow them down, the winds on the giant planets rage at hundreds of miles per hour."

Big Idea and Title Testing

Interviewees almost unanimously reported being interested in an exhibit about the giant planets, though again there is a high probability of courtesy bias. The two titles that received the highest number of positive responses were "Colossal Worlds" and "Exploring the Outer Solar System." Some interviewees said they selected "Colossal Worlds" because it sounded dramatic and exciting, and it did not directly reference planets (see the first quotation below). Others said that they were attracted to "Exploring the Outer Solar System," because it was straightforward (see the second quotation). However, these two titles were also the most negatively received of the title options. Several interviewees were not familiar with the word colossal (see the third quotation), while others said that "Exploring the Outer Solar System" reminded them of school or sounded like the title to an academic (i.e., boring) book.

> [I like Colossal Worlds] because it doesn't make them seem so dead for one thing, calling them worlds instead of planets. Calling them worlds kind of brings them to life. And colossal makes them sound cooler than just calling them giant.
>
> This one [Exploring the Outer Solar System] tells you what it's going to be about.
>
> I don't know what colossal means, so to me that's more of an adult thing. Kids might not know what it means, colossal, I don't even know what it means.

A majority of interviewees responded negatively to the title "Living with Giants," explaining that they were confused and uncertain of what to expect (see the quotation below).

> That one [Living with Giants] is just too vague. I have no idea what I would see when I walked into it. Is it about people? I don't get that it's supposed to be about planets.

Interviewees' reactions to "Giant Planets" and "Giant Worlds" were not as strong as the other title choices. Few interviewees said that either was their favorite or least favorite. However, both "Giant Planets" and "Giant Worlds" provided interviewees with clear expectations for the exhibition (see the first quotation below), while still capturing a sense of intrigue (see the second quotation).

> [Giant Planets] sounds exciting and it sounds like science. I know what it's gonna be about.
>
> [Giant Worlds] sounds interesting to me, it sounds like a mystery . . .

APPENDICES:

Removed for Proprietary Reasons