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Characteristics of Academically Talented Women Who Achieve at High Levels on the Scholastic Achievement Test–Mathematics

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An increasing volume of research has focused on the gender gap between males and females in science, technology, engineering, and mathematics (STEM) areas (Newcombe, 2007; Xie & Shauman, 2003). Although progress has been made during the past few decades, women still achieve fewer doctoral degrees in math, and even fewer women pursue certain fields in math and science, such as physics and engineering (Halpern, Aronson, Reimer, Simpkins, Star, & Wentzel, 2007). Although this gap has decreased over the years (National Center for Education summary

Over the last few decades, researchers have studied the issue of gender differences in math achievement, especially among highly able females. The Scholastic Achievement Test (SAT), the most widely used instrument in the screening of college applicants, continues to show large and consistent differences among high-ability males and females, with profound implications for the educational opportunities and life choices of females. This research study, using qualitative research methods, examined the psychosocial, home, and school characteristics of female seniors in high school who achieved above the 95th percentile on the quantitative section of the SAT. The findings suggest that educators and parents can promote the strengths of mathematically talented females resulting in a number of positive psychosocial factors such as: a view of math as positive and useful, a style that encourages the attribution of success to talent, and confidence and persistence in tasks. In addition, educators who model a passion for mathematics, provide challenging learning activities, and occasionally enable their female students to work cooperatively may encourage these students' talents. Parents who maintain high expectations for mathematics achievement, who are willing to donate their own time to work with their children on mathematics, and who seem excited and interested in the domain themselves may help their children to achieve at higher levels.

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Statistics, 2005), the overall trend of women scoring well below men on the mathematics section of the Scholastic Achievement Test–Mathematics still persists (SAT-M; College Board, 2006). Because higher scores on the quantitative portion of the SAT (SAT-M) can predict success in math and science careers (Lubinski, Benbow, Webb, & Bleske-Rechek, 2006), a study of gifted females who are successful on the SAT-M may provide information about the characteristics enabling their success in mathematics and related STEM fields.

This qualitative, comparative case study examined the academic experiences (such as teacher interactions, curricula, and test-taking strategies) and home experiences (including parental teaching and expectations) of 23 young women who were both identified as gifted and achieved above the 95th percentile on the quantitative section of the SAT. The mean score for young women on the 2007 SAT-M was 499, and the scores of the majority of the young women in this sample were over 700 out of a possible 800 points. A decision to choose students who scored at the top 5% on the quantitative section of the SAT was made because that percentage is similar to the cut-off scores on the aptitude or achievement tests used to identify students for gifted programs in many states. By focusing on participants' experiences, researchers were able to identify data-based common factors that appeared to have contributed to the women's success.

Background of the Study

The Continuing Gap in the SAT-M

The dynamic between male and female achievement in STEM fields shifts depending upon one's view or perspective. Some reports in the popular media have claimed that the achievement gap between men and women, as measured by performance scores on the SAT-M, has narrowed considerably (Vanderkam, 2005). Indeed, some trends in the data are positive, as 57% of the students who took the 2006 SAT-M and indicated that they

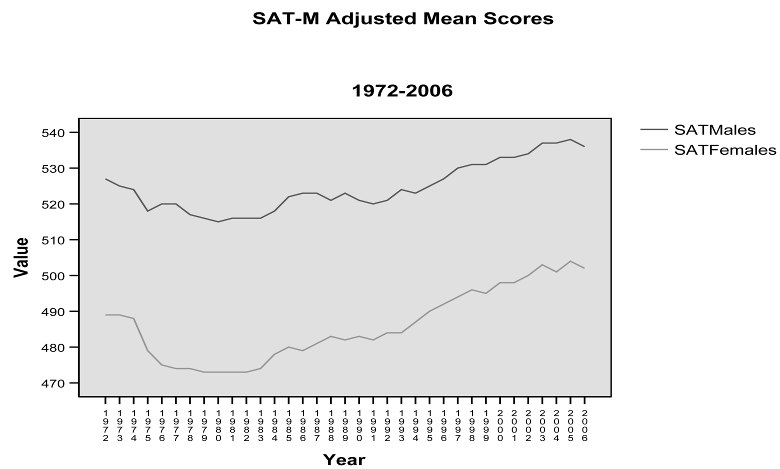

Figure 1. **SAT-M adjusted mean scores, 1972–2006.**

were in the top 10th of their class were female, and the highest overall GPA (A+) was achieved by more females than males (61% to 39%; College Board, 2006). However, women continue to score lower than men of comparable academic performance on the SAT-M, as evidenced by recent data summarized in Figure 1 (College Board, 2006). Although the SAT was renormed in 1996, and mean scores were adjusted during that process, a pattern continues of women scoring consistently lower than men. In 2009, for example, male scores (M = 534, SD = 118) and female scores (M = 499, SD = 112) differed (College Board, 2009). The effect size was approximately .3 standard deviation units, which is a small but nonnegligible difference (Cohen, 1988).

Upon further analysis, the situation for the highest achieving females in math, although improving, is also worse than for their high-achieving male counterparts. In 2007, only 36.5% of students scoring at or above 700 on the SAT-M were female, compared to the 63.5% who were male (College Board, 2007).

High test scores contribute to talented students' admission to prestigious colleges and their subsequent ability to garner scholarship dollars at 85% of private colleges and nearly 90% of public institutions. However, this testing gap has affected women's admission into the most competitive colleges and universities focusing on science, technology, engineering, and math for several decades (Callahan, 1979; Reis, 1998; Sadker & Sadker, 1994) as well as into top careers in these areas.

The Continuing Gap in STEM Careers

In many career fields, women appear to be approaching parity with men in terms of representation and achievement, but gaps remain in some STEM fields. Women currently achieve at rates equal to, or exceeding, men in other areas. For example, Halpern et al. (2007) reported that in 2005 women earned 58% of all bachelor's degrees in the U.S. and 59% of all master's degrees. In some fields, women are well-represented or even overrepresented. For example, in 2005 they earned 62% of biology degrees and 51% of chemistry degrees (Halpern et al., 2007; National Science Foundation, 2006a). However, in other STEM areas, women earned fewer science undergraduate degrees than men in the U.S. In 2004, women earned 46% of the undergraduate degrees in math, 25% of computer science degrees, 22% of physics degrees, and 21% of engineering undergraduate degrees (Halpern et al., 2007; National Science Foundation, 2006b).

In many domains, women achieve at advanced academic levels that are comparable to men. For example, women earned 45% of all doctoral degrees in 2004 (Halpern et al., 2007; National Science Foundation, 2006a). However, paralleling the trend at the undergraduate level, the achievement gap between men and women is wider in certain STEM areas at advanced degree levels. For example, in 2004 women earned less than 33% of all doctoral degrees in chemistry, computer science, math, physics, and engineering (Halpern et al., 2007; National Science Foundation, 2006b). Women are underrepresented at faculty levels as well. In 2003, women represented only 38.3% of faculty at all U.S. colleges and universities (Forrest Cataldi, Fahimi, & Bradburn, 2005), and in STEM faculty, there is more of a gap. In the faculty of social sciences, women represent 35.7%, in natural sciences, 22.9%, and in engineering, only 9.5% (Forrest Cataldi et al., 2005).

These gaps occur despite the fact that young women currently take more high school credits in math and science than young men (Halpern et al., 2007; National Science Foundation, 2006b). This lack of representation by women in certain STEM fields also extends to the workforce; women currently represent half of the total workforce, yet only 26% of the science and engineering workforce (Halpern et al., 2007; National Science Foundation, 2006c).

Reasons for Gender Discrepancies

A number of studies have explored the reasons for these gender discrepancies, generally focusing on either cognitive or psychosocial explanations. Other research has focused on purely biological factors, such as differences in spatial abilities (Gallagher & Johnson, 1992; Kimura, 2007; Lubinski & Benbow, 1992). Some studies have suggested that certain cognitive abilities, such as the ability to make rapid decisions (Gallagher & Johnson, 1992) and take risks on standardized tests (Becker, 1990), offer advantages for test taking.

Other researchers have explored the cause of the gender deficit in certain STEM fields by examining psychosocial variables such as influence of parents (particularly mothers; Bleeker & Jacobs, 2004; Jacobs & Eccles, 1993); a belief in the malleability of ability and intelligence (Dweck, 2007); differences in interests and preferences (Chipman, Krantz, & Silver, 1992; Lubinski & Benbow, 1992, 2001; Toutkoushian & Bellas, 2005); differences in self-perception (Eccles, 1994); epistemological beliefs (Belenky, Clinchy, Goldberger, & Tarule, 1986; Enman & Lupart, 2000; Gilligan, 1982); gender bias and discrimination (Heilman & Wallen, 2004; Norton, Vandello, & Darling, 2004); and differences in life experiences, often focusing on the demands placed upon women for raising a family (Arnold, 1992; Feist, 2006; Subotnik, Stone, & Steiner, 2001).

It is important that we understand issues that continue to negatively affect women's achievement in underrepresented

STEM fields; when considering the nuances of the topic at hand, it is helpful to have a model with which to frame these issues. In one such framework, the autonomous learning behavior model, Fennema and Peterson (1986) proposed that students who believe learning is possible for them and who perceive math as useful to them personally may develop confidence in the subject and subsequently may achieve academically. Studies have further suggested that confidence in math abilities is positively correlated with math achievement and course selection (Drysdale & Milne, 2004; Leder & Fennema, 1990; Seligman, 1991). Unfortunately, younger women may begin to express less confidence in their ability to learn mathematics than men—a gap that begins in 6th grade and widens until 12th grade (Drysdale & Milne, 2004; Herbert & Stipek, 2005). In past decades, decreased levels of confidence were found to contribute to declining math achievement in young women (Arnold, 1992; Fennema & Koehler, 1982), suggesting that a lack of confidence may precede a lack of success.

Beliefs about learning. Students who believe that learning is possible for them regardless of achievement on one particular task may work harder to achieve (Dweck, 2007). Thus, students' attribution style, or the method in which they attribute success and/or failure, may play an important role in talented females' lack of achievement in STEM-related areas. While capable men attribute success to ability, some research has suggested that capable women tend to attribute their successes to effort and luck, especially if these talented women view intellectual ability as fixed (Dweck, 1999, 2007; Gavin, 1996). Other research has suggested that gifted girls may attribute failure to not working hard enough rather than to a lack of talent, particularly in the science and mathematics domains (Assouline, Colangelo, Ihrig, & Forstadt, 2006). This may result in young women becoming more likely to abandon challenging academic tasks (Assouline et al., 2006; Dweck, 2007; Halpern et al., 2007)

Usefulness of math. Sex role congruency is an important influence on females' valuation of mathematics (Meyer & Koehler, 1990). If young women regard math primarily as a male domain, they may not choose to pursue advanced courses or careers in the area because they feel threatened (Steele, James, & Barnett, 2002). In addition, perceptions of math as a male domain and as unrelated to their lives are often linked to lower confidence levels in this population (Gjertsen, 1999; Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Tocci & Engelhard, 1991). As early as middle school, more young men than young women rate mathematics as useful and integral for future success (Tocci & Engelhard, 1991). As a result, these young women may opt out of higher levels of mathematics classes (Gavin, 1997; Gjertsen, 1999).

A student's beliefs about her abilities, her confidence in those abilities, and her view of mathematics as useful to her personally may be vital to promoting young women's talents in STEM fields (Drysdale & Milne, 2004; Leder & Fennema, 1990; Seligman, 1991). Understanding the home and school factors that are often associated with developing these affects in talented female students may help researchers and educators implement best practices that contribute to promoting STEM talents in capable young women (Halpern et al., 2007; Reis, 1998).

School factors. Gender differences involving school factors may also affect achievement in mathematics (Gavin, 1997; Reis, 1998). Teachers may still interact more often with males, either positively or negatively, as they question males more frequently and give male students more opportunity to respond to high-level cognitive questions than females (Jones & Dindia, 2004). Teachers interact with males to help them learn, but they tend to give more direct help and even complete tasks for females (Jones & Dindia, 2004). Mirroring students' issues with self-efficacy, teachers may attribute males' success to ability and females' success to effort (Fennema, 1990). On the other hand, teachers who challenge young women to defend their answers, show a passion for their subject, and use a variety of gender-sensitive strategies may have more success with both young women and young men in their classrooms (Gavin, 1996; Klein, 1985; McDaniel, 1994). Indeed, these teachers may prove to be mentors, influencing the eventual selection of STEM majors and careers in talented women (Tillberg & Cohoon, 2005).

Home factors. Family encouragement is a key component in the home environment for high-achieving children. Research has suggested that both talented boys' and girls' interactions with parents influence their choice of major in a STEM field (Bleeker & Jacobs, 2004; Jacobs & Eccles, 1993), although boys may interact more with their fathers than their mothers (Tillberg & Cohoon, 2005). Mothers' predictions of their children's success in a math-oriented career during the seventh grade have been positively related to their daughters' pursuits of STEM careers (Bleeker & Jacobs, 2004). Other research, however, suggests that some parents may communicate more specific career goals to males than to females (Renzulli & Reis, 1994), may tend to rate math as more difficult for daughters than for sons, may believe that young women have to work harder than boys in order to do well in math courses, and may believe that daughters are not as mathematically talented as sons (Herbert & Stipek, 2005; Parsons, Meece, Adler, & Kaczala, 1982).

The current study focused on the experiences of 23 females who had been identified as gifted and talented with high achievement in mathematics in an attempt to investigate the following questions:

1. What affective characteristics (such as confidence, perceptions of math usefulness, and causal attributions) do these gifted females believe helped them to achieve at such high levels on the quantitative section of the SAT test?
2. What contextual characteristics do these gifted females attribute to their high achievement on the quantitative section of the SAT test?

Methods and Procedures

Selection of Participants

A purposeful sampling method was used to select the 23 female high school students who had been both identified as academically talented, using state and local criteria, and also scored above the 95th percentile on the quantitative section of the SAT test. These students hailed from five different high schools, all located in rural and suburban areas in the northeastern region of the United States. Several of the group achieved at the top 1% on the quantitative section (SAT-M). Researchers worked closely with guidance departments of the participating high schools, four public and one private, to assure that each of the participants met the above-mentioned criteria and could be established as a critical case (Erlandson, Harris, Skipper, & Allen, 1993). Student and parent permission for participation in the study was sought. Students were contacted for interviews, which were conducted January through April, 1997, at school or other locations familiar to the student. Selected teachers whom participants identified as important or meaningful in their mathematical development were also interviewed.

Data Collection and Analysis

Qualitative, comparative case study methodology (Yin, 2002) was used in this study. Participants were interviewed using semi-structured interview techniques, which are most valuable when the fieldwork requires an insider perspective (Fetterman, 1989). Each interview lasted 2 to 3 hours and included open-ended questions in four areas. The complete student interview protocol is presented in Table 1. Next, an interpretative analysis technique (Gall, Borg, & Gall, 1989) was used to identify general themes that united the individual case studies. This methodology was used to create meaning from diverse data in order to gain an understanding of the factors that led to high math achievement for these academically talented young women but not to infer generalizability.

In addition to participant interviews, a document review was conducted of participants' permanent files, including their report cards, teacher comments, and standardized tests (IQ scores were included if testing had been completed as part of gifted/talented program identification procedures). Supplemental data were also collected through observations in classes, field notes, tape recordings and transcriptions, and the inclusion of a focus group of the participants at the end of the study. The data collection phase

Table 1

Interview Protocol—Question Categories

Question category	Example
School/Math Related Questions	Tell me about what it is like to be a student in this school.
	Tell me about what it is like to be a girl in this school.
	Tell me about the math instruction in this school. Do you enjoy going to math class in this school?
	Tell me about how teachers in this school respond to girls in math classes.
	If you are having trouble with a math problem, is the teacher willing to give you help? If so, how quickly?
	Have you ever tutored anyone in math?
	Do family members ever help you in math? If so, who does and under what circumstances?
	Tell me about any teachers in this school that may have been special to you. If so, why?
	Have you ever had a female teacher? If so, please describe the experience.
	Tell me about whether math will be useful to you in your future life or career. If so, how?
	Tell me about your performance on the math section of the SAT test.
	What do you remember about taking that portion of the test?
	Did you answer all of the questions? Did you feel you had enough time for all of the math questions?
	Tell me about how you proceed when solving a math problem.
	Do you translate problems from words into graphic representations or formulas?
	Tell me about how you attempt to solve unfamiliar math problems.
	If you do not know the answer to a problem, do you guess?
	Tell me about any specific test-taking strategy with taking the SAT-M such as guessing with partial information or omitting questions that you did not have enough information on.
Future Plans	Tell me about your plans after graduation.
	What college do you want to attend/job do you wish to have?
	If you go to college, what are your plans after that?
	Pretend that it is 10 years into the future; tell me about your life.

Question category	Example
Learning Behaviors	Tell me about your best subjects.
	Tell me about your weakest subjects.
	If you could describe your perfect class, what would it be like?
	Tell me about how you study for tests.
	Do you think that you have a good memory?
	Do you try to answer most of the questions on tests?
	Tell me about what you do when you do not know the answer to a question on a test.
	Tell me about what you do when you are having trouble understanding something.
	Do you like to investigate things?
	Tell me about your homework schedule.
	Tell me about your favorite kinds of assignments. Least favorite?
	Do you prefer to work alone or in cooperative groups?
	Tell me about what kinds of assignments or projects you get the best grades on? Lowest?
	Tell me about yourself in the classroom.
	Tell me about what kinds of classes you find most interesting.
	Tell me about what kinds of classes are most uninteresting.
	Tell me about the kinds of teachers who are exciting to you.
	Tell me about the kinds of teachers who are not exciting to you.
	Tell me about how teachers would describe you as a student.
	Tell me about whether you could be a better student. If so, how?
Personal Questions	Tell me about your early schooling.
	Did you enjoy math in elementary school?
	Did you ever receive awards in elementary school?
	Can you think of three words that describe you?
	Tell me about some things you are good at.
	What are some things that you like to do?
	How do you think other people would describe you?
	How do you think your (mother, father, sister, brother, girlfriends, boyfriend, teachers, enemies) would describe you?
	Who in your family are you most like?
	Who in your family are you most unlike?
	Can you think of a question I should have asked you but didn't?

lasted 6 months, including the time spent conducting follow-up telephone interviews that were used as needed to clarify elements of the interview during coding and analysis.

All interviews took place from January through April, 1997 at high schools in the northeast. Data from the interviews were transcribed and a case study summary was developed for each participant. Follow-up interviews were scheduled to clarify any questions and then case study summaries were sent to participants for member check verification. This member check provided participants with the opportunity to review the interview transcriptions to ensure accurate description of the program. Further clarification was sought about participants' questions that emerged at that time, and subsequent coding was carried out to include these ideas.

As suggested by Strauss and Corbin (1998), three levels of coding techniques—open coding, axial coding, and selective coding—were applied to the data. Researchers independently coded and then conferred with each other to confirm the decisions made about initial coding and emerging categories and theory. Next, they combined these open codes into broader categories using axial coding, which enabled the researcher to specify relationships among the many categories that had emerged. Finally, researchers systematically and purposefully identified the core category using selective coding. The core categories were verified using an interpretative analysis technique (Gall et al., 1989) to identify general themes that united the multiple individual case studies. At the conclusion of the interviews, a letter was sent to participants describing the overarching themes that emerged from the interview data. Participants were invited to respond and provide input as to the accuracy of the findings. Discrepancies were noted and follow-up interviews were conducted as required.

Findings

Five common themes were found in the data: (a) participants possessed certain aptitudes including quantitative skills and leadership ability; (b) they were highly involved with their schools and communities; (c) they were raised in homes that valued education (and mathematics specifically); (d) they possessed certain social-emotional traits that enabled them to thrive in and out of classes; and (e) they were fortunate to have attended a secondary school where they were taught well (see Tables 2 and 3 for a summary of the demographics). The majority of the participants (65% or 15 women) had high aptitude (IQ) scores between 130 and 145. All had opportunities for and had taken advanced coursework in the STEM areas in high school. A discrepancy existed between the SAT verbal and math scores of this group, as 78% (or 18 women) scored between 700 and 799 on the SAT-M, while only 22% (or 5 women) scored between 700 and 799 on the SAT-V.

These young women reported being involved with their schools and communities, participating in a diverse set of activities including local symphonies, yearbook, National Honor Society, Young Ambassadors, Academic Bowl, and more. Almost half (47% or 11 women) assumed leadership roles in these groups, such as president or editor. Over half (61% or 14 women) participated in a sport such as track, softball, tennis, or soccer, and a large majority (83% or 19 women) participated in a music-related activity such as band, private lessons with an instrument, or choir.

Demographic information also suggests that participants' parents were a diverse group in terms of education and career paths. Approximately half (50%) of the women's mothers had attained either a master's or a doctoral degree, while the remaining half (50%) of mothers had graduated from high school or college. Similarly, 44% (or 10) of participants' fathers had advanced degrees, while 56% (or 13) did not. Over half of these young women (61% or 14 women) had parents who worked in STEM fields, but these parents had followed diverse career paths. Five mothers were homemakers, while 6 others were teachers, and 7 others were involved in private enterprises such as photography, insurance, or the cultivation of a botanical greenhouse. Two worked in a government agency. Most of the fathers (21 or 90%) worked in private enterprise, although one was in the military, and another was a musicologist.

Table 2

Demographic Characteristics of Study Participants

Participant	IQ	SAT-M	SAT-V	Mother's occupation	Mother's education	Father's occupation	Father's education	High-level coursework	College attended	Parental teaching in math	Parental stereotypical beliefs
1	144	730	720	Volunteer	BS	Investment advisor	JD-Temple	AP Biology AP Calculus Physics	Princeton	No	Supportive of her goals
2	135	790	680	Real estate agent	BA	Internal consultant	BA	AP Biology AP Calculus	Harvard	In the past; older sister helps now	
3		690	720	Mail carrier	BA	Funeral director	AA	AP Biology AP Calculus	Coast Guard Academy	In the past	Supportive; helped her set goals
4		680			MA–Math	Musicologist			Barnard	Mother is a mathematician and she has helped her	High expectations
5	131	710	690	PE teacher	BA–Education	Military officer	BA, MA-Engineering	AP Calculus AP Chemistry AP Physics	Bowdoin	In the past	Supportive of her goals
6	136	800	620	Secretary	BA MA	Manager, mechanical engineering	MA	AP Calculus Honors Organic Chemistry: Independent Study AP Physics	University of Virginia	Father, if needed	Taught that girls do math
7	138	730	660	Teacher	BA MA	Administrator, pharmaceutical company	Ph.D.	AP Calculus Physics	Trinity	Yes, but mostly mother	She is encouraged in all ways
8	135	700	590	Greenhouse manager	High school	Computer specialist	BS	AP Music AP Physics	Marywood	Help from both	Highly encouraged by father; she gets her math from her dad
9	122	720	560	Housewife	High school	Computer specialist	BS	AP Calculus AP Physics	Wheaton	Help from dad	Highly encouraged by both, especially by father
10		710	760	Housewife	Ph.D.	Scientist	Ph.D.-Physics from Cal Tech	AP Calculus AP Physics	Columbia	No	Highly encouraged by mother
11		720	670	Director of photography at a local museum	BA	Contractor, innkeeper, boatyard manager	MA	AP Advanced Art AP Calculus AP Physics	Dartmouth	In the past by father	Highly encouraged by dad; when she was a little kid, he'd try to teach her algebra

Participant	IQ	SAT-M	SAT-V	Mother's occupation	Mother's education	Father's occupation	Father's education	High-level coursework	College attended	Parental teaching in math	Parental stereotypical beliefs
12	138	750	770	Clinical psychologist	Ph.D.	Mathematician	Ph.D.	AP Calculus AP Physics	Catholic University	Her dad helped her quite a bit	High expectations; her mother sees her as an underachiever
13	138	760	630	Volunteer, housewife	BA-Math	Corporation, CEO	MS, MBA	AP Calculus AP Physics Honors Organic Chemistry: Independent Study	Duke	Mom (math major), Dad, and sister	Parents encouraged her to do well
14	124	710	590	Teacher	MA-Math	Radiological control manager	BA	AP Calculus AP Physics Astronomy Drawing Painting	University of Connecticut	Mother (math major) in the past	High expectations
15	132	710	690	Physical therapist	MA	Plumber	High school	AP Chemistry AP Physics AP English AP Latin	Northeastern	No, but Mom is good in math	
16	133	730	600	Assistant librarian	Two years of college	Finance director	BA	Physics AP Music	Assumption	Father was a math teacher	
17	123	670	620	Teacher, special education	MA	Electrical trainer	High school	AP Calculus AP Chemistry AP Physics	University of Connecticut	Father helps her with math	High expectations
18	146	730	620	Teacher, math	MA	Contractor	BA	AP Calculus AP Physics	University of Delaware	Her mom, in the past	High expectations
19	141	700	680	Math tutor	BA-Math	Senior systems analyst	BS-Computer science	AP Calculus	University of Richmond	Mom	High expectations; Mom inspired confidence
20	148	760	720	Underwriting assistant	AA	Large account manager	BA	AP Calculus Honors Chemistry	Carnegie Mellon	Mom	
21	137	670	550	Nursery school teacher	MA	Clergyman	ThM, MA	AP Calculus Honors Chemistry	Lafayette		High expectations from father
22	139	720	660	Assistant sales manager	MA	Folder operator	High school	Advanced Biology (at college) AP Calculus		No	
23	142	690	710	Doctor	Ph.D., MD	Chemist	Ph.D.	AP Calculus Honors Physics	Stanford University	Mom and brother	Very high expectations

Table 3

Summary of Demographic Characteristics of Study Participants

Demographic characteristics	Percentage of participants
Cognitive characteristics	
IQ: 115–129	17.5%
IQ: 130–145	65.0%
IQ: Unknown	17.5%
Academic experiences	
High-level STEM courses (AP or IB)	100%
SAT-V Score Ranges	
Unknown	4%
500–599	18%
600–699	52%
700–799	26%
SAT-M Score Ranges	
670–699	22%
700–799	78%
Parents' education, highest level	
Mother–High school or associate's	18%
Mother–Bachelor's	32%
Mother–Master's or Ph.D.	50%
Father–High school or associate's	17%
Father–Bachelor's	39%
Father–Master's or Ph.D.	44%
Parents' occupations	
Mother or father working in STEM-related field	61%
Mother or father working in non-STEM field	39%
Parental teaching in math	
Yes	82%
No	18%
Involvement	
Athletics	61%
Music	83%
Colleges attended post study–selectivity*	
Most selective	53%
More selective	33%
Selective	14%
STEM major considered	56%
STEM major not considered	44%

Note. *Based on U.S. News and World Report Rankings of Selectivity (U.S. News and World Report, 2008).

All of the participants had been accepted to and planned to attend college. Participants' college plans were diverse, as 53% (or 12) the participants eventually attended colleges such as Harvard, Princeton, and Columbia, which were rated as *most selective* by the U.S. News and World Report Rankings of Selectivity (U.S. News and World Report, 2008). It is interesting to note that more than half (56% or 13) of the students were considering majoring in a STEM-related field. The majority (82% or 19) of participants reported that their parents taught them math and related STEM subjects at home before and while they were in school.

Research Question One

Research question one concerned the affective characteristics (such as confidence, perceptions of math usefulness, and causal attributions) that these gifted females believed helped them achieve at such high levels. Common affective characteristics that emerged from participants included a specific style of attribution, a view of math as useful, and confidence that led to task-persistence.

Attribution style. Consistent with the idea that successful individuals often attribute their success to ability (Dweck, 2007; Kloosterman, 1990; Renzulli & Reis, 1994; Wolleat, Pedro, Becker, & Fennema, 1980), more than half (57% or 13) of the participants attributed their math success to ability. These women were clearly aware of their abilities in math, as Participant 11 explained, "I pick math and physics up faster than kids who are actually paying attention" (personal interview, March 6, 1997). Participant 10 indicated, "I've got the 'thinking genes'" (personal interview, March 3, 1997). Another two participants attributed their success to both ability and effort. Seven attributed their success to effort, echoing the sentiments of Participant 22, who stated, "I'm not absolutely brilliant, but I work hard to make up for it" (personal interview, May 21, 1997). Eighty percent (18) of those participants with scores over 750 on the SAT-M attributed their success solely to ability. Compared to those students who did not attribute success to ability, those students who did believe that ability played a significant role in success had an average SAT-M score that was 7 points higher (719 vs. 712) and an average SAT-V score that was 69 points higher (687 vs. 618).

Usefulness of math. A view of math as useful to daily life has been shown to accompany success in mathematically talented women (Gavin, 1997; Gjertsen, 1999). We hypothesized that the majority of participants would view math as personally useful to them and found that all of the participants in this study believed that math was useful in life; they either related its utility to careers they want to pursue in the future or described it as useful to everyone in general:

> Math is useful to everyone. . . . For some people it's more important than others. If you go into engineering or architecture you deal a lot more with it. I'm hoping to go into therapy, but it still requires some math. Everything requires math in it. (Participant 8, personal interview, March 17, 1997)

It is particularly interesting to find that the majority (70% or 16) of the women interviewed had at least one parent who had majored in math, science, or engineering, or was using math in some type of applied fashion in their current work.

Confidence and persistence. Confidence is related to mathematics achievement (Drysdale & Milne, 2004; Leder & Fennema, 1990; Seligman, 1991). More than half (56% or 13) of participants in this study indicated that they were very confident about their academic abilities. Participant 15 described how her confidence allowed her to do better and how she knew she would be able to do well in math: "I'm as smart as the boys. Confidence allows me to do better" (personal interview, March 11, 1997).

These women persevered in the face of difficulty, and 60% (or 14 women) were definitive about their persistence when confronted with a challenge. Participant 14 stated, "You have to stick with it. It says a lot about you" (personal interview, March 13, 1997). Participant 9 described how she used to go "home and teach myself. I struggle for a couple of hours" (personal interview, March 10, 1997). Participant 3 summarized her thoughts about persistence: "If I want to learn something, I'll learn it no matter what" (personal interview, March 6, 1997).

Research Question Two

Research question two addressed the contextual characteristics to which these gifted females attributed their high achievement. Of particular note were school factors, such as challenging curricula and capable teachers.

School factors. A large majority (95%) of participants identified a number of school-related factors that accompanied their success in mathematics, including a positive view of their educational experience, challenging curricula, the importance of high-quality teachers, a chance to practice test-taking strategies focusing on speed, and a classroom environment that offered social learning experiences.

Participants' view of educational experiences. The participants were overwhelmingly positive about their overall school environment and the opportunities afforded them for learning; almost all (95% or 22 women) reported that they viewed their schools positively and many described their schools as nurturing, supportive, helpful, and challenging. Participant 3 stated, "This school has given me a lot of opportunities" (personal interview, March 6, 1997), and Participant 7 said that in her school, "They want the students to excel" (personal interview, March 7, 1997).

Challenging curricula. The majority of these academically talented young women had taken higher level courses such as Advanced Placement Calculus and Physics. Participants had mixed, but generally positive, responses as to the quality of their mathematics instruction. Fifty percent of respondents believed that their mathematics classes had been "demanding" or "good." Thirty-eight percent felt it had been "fair" or that it "depended on the teacher." Ten percent believed that they had "never been challenged" or that instruction had been "poor." However, the participants universally reported the belief that taking higher level courses beyond algebra and geometry helped them to be powerful mathematical thinkers and enabled them to do well on the SAT-M.

The importance of high-quality teachers. The women in the study were definitive about their perception that there was no difference in the way their mathematics teachers treated males or females. Ninety-five percent of participants described teachers as treating men and women absolutely equally, stating that they were "very equal" and "pretty much the same." Participant 1 demurred, stating her teacher "would sometimes laugh at questions from girls" (personal interview, February 5, 1997).

A teacher's personality and teaching style mattered to these young women. Fifty-three percent of participants said that a good teacher had enthusiasm and enjoyed the topic. In one high school group of participants, for example, one teacher elicited especially high praise from all of her students. Participant 3, who had Mrs. D. for math, stated, "Mrs. D. made math very cool because she loves it so much. She continues until everyone gets it, so it's really good" (personal interview, March 6, 1997). In addition to excitement, another 29% (7 women) felt that compassion and interest in the students was a key characteristic of good teachers. Participant 4 described Mrs. D. as being "like my mother . . . she makes everyone understand . . . I just love her" (personal interview, March 6, 1997). Clearly, participants admired teachers who expressed their enthusiasm for the topic. They reported that they also worked harder for teachers whom they saw as caring and nurturing.

Test-taking strategies and speed. Specific test-taking strategies were employed on the SAT-M by all participants, and some of these strategies were specifically taught in the classroom. Participants described teachers giving them extensive instruction on test-taking tips, such as where the more difficult questions were located and how to understand the items for which they could definitely obtain credit so they would not inadvertently omit those questions. Participant 7 explained that their teachers taught "a little trick here and there and I've found that they work" (personal interview, March 7, 1997). Participants developed strategies that focused on making educated guesses on problems that were difficult. After they guessed, some of the women marked difficult problems to enable a later review, if time permitted. For example, Participant 5 described how, "If I'm doing problems I get nervous if I spend too much time on a problem . . . either I take my best guess and I'll put it down on the paper or put a little dot next to the number and go back to it" (personal interview, March 5, 1997).

Guessing was a key strategy employed by most of the participants, but several emphasized that because the SAT penalizes for wrong answers, they decide to guess only if they are able to narrow the selections down to two. Participants focused on reviewing easier questions before tackling harder ones. Participant 17 outlined her strategy:

> If there are numbers 24 and 25, you know they are the hardest ones . . . so I'll say let's go back and check everything else and go back to the one[s] early on I omitted because those are easier and I'm guaranteed to probably get a right answer on those before I tackle the harder ones. (personal interview, March 11, 1997)

Perhaps partially due to advantages gained through test-taking strategies, all but one of the women interviewed indicated that they had absolutely no problem finishing the SAT-M. Several described finishing "easily" or "with plenty of time to spare," indicating that the test was a "snap." Participant 20 told how she "rolled through the test like a machine" (personal interview, May 21, 1997). Some of the women described the process as a game and Participant 11 saw speed as part of the enjoyment of taking the test, describing how she "loves to race on math problems" (personal interview, March 6, 1997).

Social learning. The majority of these young women showed a preference for group work and the multiple perspectives and understanding that may result. Participant 7 described:

> I like being in groups; it's helpful. I think when you talk about problems and concepts you understand them better and sometimes you understand the pieces that someone doesn't understand and they understand the piece that you don't understand. That's probably effective. (personal interview, March 7, 1997)

However, 25% (6) of participants enjoyed working alone and either enjoyed their independent learning or regarded themselves as competitive loners.

Home factors. Although these young women came from a wide range of environments, common factors were identified in their homes, such as high expectations from parents and caregivers, as well as parental teaching in math. Intellectual and academic achievements were valued highly in their homes. The perceptions of the women related to parental encouragement and home life focused on the value of education and strong work ethics. Eighty-four percent (or 18 participants) had parents who had completed an undergraduate degree or beyond, and of these, 56% (or 13 women) had parents who had completed a master's degree. Parents' vocations varied widely, from corporate executive positions to laborer. In the majority of homes, however, parents stressed academic achievement, success, and doing one's best. These parents modeled the work ethic they required of their children and their children identified them as hard workers who believed that work should come before play. Participants' parents communicated high expectations in achievement to their daughters, as 18 of the 23 participants believed that their parents had high or very high scholastic expectations of them or that they supported them in their learning.

Parental teaching in math. The participants in this study acknowledged that their parents taught them math in three ways: by encouraging their intellectual curiosity, through direct instruction, and by conveying positive attitudes about females and math. Participants' parents also encouraged their children's curiosity at an early age. As young children, participants were asked to evaluate, compare, contrast, analyze, and judge events and objects by their parents, who would patiently answer their questions and encourage their play. Parents directly instructed their daughters in math: 80% of the participants (18 women) indicated that one or both parents had taught or helped them to understand math. Participant 11 reminisced about her father: "When I was a little kid, he'd try to teach me algebra" (personal interview, March 6, 1997). Participant 13 explained that "I've been successful in math because my parents helped me a lot" (personal interview, March 17, 1997). Parents conveyed positive attitudes about young women and math to their daughters, as suggested by Participant 6, who was taught "that girls can do math" (personal interview, March 15, 1997). Participant 1 used the words "supportive of my goals" when describing how parents helped her to achieve in math (personal interview, February 5, 1997).

Discussion

These 23 talented women shared a number of background characteristics that may have contributed to their success in math at school and on the SAT-M. These characteristics, summarized in Table 4, may be categorized into three types of factors: psychosocial, school, and home. Psychosocial factors included a particular style of attribution of success and failure, a view of math as useful, confidence in abilities, and persistence in difficult tasks. School factors included a positive view of educational experiences, challenging curricula, enthusiastic teachers, and a preference for social learning through group work. Home factors included high parental expectations and parental teaching in math.

Psychosocial Factors

Several psychosocial factors accompanied the SAT-M success of these women, including their attribution style, their view of math, their confidence and perceptiveness, and some specific home and school factors.

Although research from previous decades has suggested that many women may attribute their success to luck or hard work rather than talent (Kloosterman, 1990; Reis, Callahan, & Goldsmith, 1994; Wolleat et al., 1980), more than half of the young women in this study attributed their success in math to their abilities. The young women in this study developed a perception of their own talents that may have enabled them to persist in the face of adversity. Perhaps attributing success to ability

Table 4

Common Characteristics Among Participants and Supporting Strategies to Promote Achievement on the SAT-M

	Common characteristic	Support strategies
Psychosocial		
Attribution style	Majority of participants attributed success in math to ability rather than luck or effort.	Provide specific, prescriptive feedback.
View of math	All participants viewed math as personally useful to them.	Discuss applications of real-world mathematics learning.
Confidence and persistence	Majority of participants were very confident about their academic abilities, and persevered in the face of difficulty.	Encourage young women in their pursuits of math, and teach that academic abilities are expandable by exposing them to new cognitive neuroscience research.
School		
Curricula	All participants had taken higher level (AP or IB) courses; participants were mixed as to quality of the courses. All participants felt the courses had helped them on the SAT-M.	Encourage young women to take the most challenging courses possible for their ability levels.
Teachers	Majority of participants valued teachers who were enthusiastic and enjoyed the topic. Majority of participants believed men and women were treated equally by teachers.	Get to know and nurture talented female students. Let your interest about the topic show.
Test-taking strategies	All participants employed test-taking strategies, often for speed. These were frequently taught in the classroom.	Develop test-taking strategies in the classroom, particularly those that emphasize improvement at timed tests.
Learning style	Majority of participants showed a preference for group work, although there were students who preferred to work alone.	Vary content delivery strategies in the classroom, including both group and individual methods of learning, and allow some student choice in the matter.
Home		
High expectations	Majority of participants' parents had a college degree, and stressed academic achievement.	Expect young women to live up to their abilities. Expect and help them to attend college.
Parental teaching	Majority of participants acknowledged parental teaching in math through encouragement, direct instruction, and by conveying positive attitudes about math.	Provide enriching toys and experiences in the home. Spend time together on math puzzles, games, and instruction.

is becoming more acceptable to talented women. However, this finding differs with recent research (Assouline et al., 2006) that suggests that talented young women may attribute success to hard work. A follow-up study could help to determine whether talented young women with high potential and lower achievement would attribute failures in mathematics to lack of effort or lack of talent.

Teachers and parents may help to develop an attribution style that enables talented young people to believe in their talents. Recently, the Institute of Education Sciences (IES; Halpern et al., 2007) summarized a body of research on topics related to the development of young women' talents in math and science, and presented a set of recommendations for parents and teachers. Evidence suggests that when teachers provide specific praise and feedback related to effort or task-specific abilities, students are more likely to attribute success to talent and hard work and less likely to attribute failure to a lack of talent or luck (Mueller & Dweck, 1998). Statements such as, "I can tell you worked hard on that project because of the detail in the geometric design" are specific and reinforce a student's belief that she can accomplish much when applying herself. Statements such as, "You did a good job at developing your formulae" reinforce the idea that the student is capable at a specific task. Statements such as, "You're so smart!" are general, and so the student may come to believe that when she is not successful, she is not smart anymore.

Confirming earlier research (Eccles et al., 1985; Gavin, 1997; Gjertsen, 1999; Kelly, 1986; Leder, 1988; Pedro, Wolleat, Fennema, & Becker, 1981; Tocci & Engelhard 1991), all of these talented young women understood that math was useful in life; this view was fostered in both home and school environments. Making learning meaningful and useful to these young women appeared to have an impact on mathematics achievement.

Students often see learning as relevant to them when they see real-world applications (Renzulli & Reis, 1994). Teachers and parents may wish to enable young women to make real-world connections and to help them value and respect the domain by emphasizing that mathematics is a vibrant, useful subject. Parents in math-related careers may discuss with their daughters how math ties in with their own and other careers and use opportunities to call attention to math applications outside the classroom. Teachers may work to incorporate real-world problem-solving applications into their curriculum.

Previous research (Armstrong & Price, 1982; Benbow, 1988; Drysdale & Milne, 2004; Lantz & Smith, 1981; Leder & Fennema, 1990; Reyes, 1984; Seligman, 1991) suggested that confidence is related to mathematics achievement. We found that that more than half of the women in the study expressed confidence in their academic abilities. This confidence, coupled with their attribution, may also have enabled them to persist in the face of difficulty.

One way that teachers may promote confidence levels in students may be to teach them that academic abilities are developmental. Research suggests that students who believe that academic abilities are fixed may be at risk for a decline in achievement when the content becomes increasingly difficult, but students who believe that academic abilities may be improved continue to work to achieve (Dweck, 2007). Exposing students to new research about cognitive neuroscience and the idea that intelligence may be developed may be one way to encourage young women to persist (Halpern et al., 2007).

School Factors

Although previous research suggested that teachers may treat their male and female students differently at the expense of females (Fennema, 1990; Jones & Dindia, 2004), young women in this study largely viewed their school and their teachers positively and believed no such differences existed. Instead, more than half of the participants believed that a teacher's personality, style, and passion for the topic affected how well students of both genders learned in class. Confirming previous research (Gavin, 1996; Klein, 1985; McDaniel, 1994; Tillberg & Cohoon, 2005), this study suggested that teachers who nurture and challenge their students may positively affect student achievement. Teachers who challenge young women to defend their answers and who have a clear passion for mathematics also seem to produce results. Participants in this study also reported that they did well with teachers who showed an interest in their lives outside of the classroom.

Successful teachers also offer students opportunities to become involved with individual learning activities that motivate and challenge them and with group investigative activities that enable learners to share ideas and become creative producers (Callahan, 2001). The majority of young women in the study preferred to learn and work in groups, expressing an appreciation for the multiple perspectives of group members, while a minority preferred to work alone. Teachers may consider varying the content delivery strategies in the classroom, alternating between group and individual work, and allowing students some degree of choice in the matter.

Math curricula mattered as well, as many women in this study believed that their math instruction and content had been rigorous and this preparation had helped them to be successful on the SAT-M. Consistent with the research of Pallas and Alexander (1983), encouraging capable young women from an early age to take the most rigorous mathematics academic program available to them prepared these young women for higher achievement levels (Reis, 1998). Teachers and guidance counselors, in particular, may consider encouraging more young women to take the most challenging courses of which they are capable.

All of the participants were taught practical test-taking strategies on the SAT, such as logical guessing to eliminate incorrect problems. In support of Gallagher and Johnson's (1992) findings, many of the participants were given timed tests in the classroom and taught to focus on working quickly and efficiently. Teachers who use these classroom strategies, and particularly provide practice on timed test-taking strategies, may help female students do better on the SAT.

Home Factors

Confirming earlier research (Armstrong & Price, 1982; Dickens & Cornell, 1993; Eccles & Jacobs, 1986; Frome &

Eccles, 1998; Herbert & Stipek, 2005), parents and the home environment played key roles in nurturing the mathematical talents in these young women.

Many of the participants understood the value of education and working hard to attain academic goals because many of their parents had done so and had passed these values, along with a work ethic that encouraged them to focus on the achievement of academic goals, down to their daughters. From an early age, parents may convey the idea that their daughters will attend college thereby setting forth the expectation that their daughters will achieve academically.

A large majority of the participants in the study indicated that they had received math instruction from one or more parents. Parents provided access to math games and books, and they exerted a positive influence over their daughters' achievement in math by teaching them math skills directly. Parents introduced both academic knowledge of the domain and the implicit understanding that math is an important subject, important enough to warrant the parents' time and attention.

Implications

This study has several implications for practice and research. The findings suggest that educators and parents can promote the strengths of mathematically talented females resulting in a number of positive psychosocial factors such as: a view of math as positive and useful, a style that encourages the attribution of success to talent, and confidence and persistence in tasks. In addition, educators who model a passion for mathematics, who provide challenging learning activities, and who occasionally enable their female students to work cooperatively may encourage these students' talents. Parents who maintain high expectations for mathematics achievement, who are willing to donate their own time to work with their children on mathematics, and who seem excited and interested in the domain themselves may help their children to achieve at higher levels.

The findings also suggest that additional research is needed to address other questions related to generalizability and attribution. Because these young women were from rural and suburban schools, an interesting follow-up study might explore the experiences of their successful urban counterparts. Another aspect to consider might be the reactions of talented young women when they experience an initial or persistent struggle or even failure in mathematics. Because the very highest achievers in the study attributed success almost solely to talent, are there other factors (such as achievement level) that influence attribution? By investigating the nuances of attribution, researchers may better understand the unique combination of factors involved in the establishment of an attributional style that may promote confidence and persistence, leading to success and higher levels of achievement.

Although women have made substantial advancements in many academic fields, gaps remain in levels of educational attainment in mathematics between talented men and women. Part of this is almost certainly due to females' continued lower performance on the SAT-M. The current study suggests some strategies that worked for these successful students—strategies based on promoting strengths rather than correcting weaknesses.

Limitations and Trustworthiness

Limitations exist in the comparative case study design used in this research. By limiting the site to one region of the United States, there is an effect on the external validity of the results. The nature of self-report data is a limitation, but the addition of other data sources, document review, and thick descriptive case studies help to address this concern. In addition, the findings emerging from the multiple cases in this study are not causal in nature and may not be easily generalized. A final limitation of the study is that the vast majority of parents of students in the study were biological parents, so some of the findings related to the environment may also be due to biological similarities rather than environmental opportunities (Scarr, 1996).

The limitations of qualitative research also focus on how accurately the study reflects the reality of the participants in the natural setting, the ways in which the biases of the researchers affect the study, and how the researchers addressed these biases in the study. Researchers must address these and other concerns when designing, conducting, and analyzing data for research. Lincoln and Guba (1985) propose four alternative constructs that address the soundness and the "trustworthiness" of a study: credibility, transferability, dependability, and confirmability. Trustworthiness was established through the use of the following strategies: triangulation of the data through multiple sources including interviews; observations; surveys and material data; member checking where the informant reviewed data interpretations for accurate representations of the informant's reality; and another researcher's examination of all phases of the research. Detailed case study data establish a framework for the study (Merriam, 1988). Trustworthiness was also ensured through the detailed description of the focus of the study, sample selection, triangulation of data collection, and data collection. Analyses were reported in detail to provide an accurate portrait of the methods used.

Conclusion

Women are still underrepresented in a number of upper level mathematics courses and in mathematically oriented careers. Females' scores on the SAT-M remain lower than their male counterparts. Although previous studies have attempted to determine reasons for these gaps, this study focused on identifying factors that accompanied the success of 23 women who were both academically gifted and achieved at the highest levels of the SAT-M.

Some psychosocial factors contributed to participants' success, and these included an attribution style that enabled them to clearly acknowledge their talents in math and attribute success to those talents, a view of math as useful in their lives, confidence about their abilities, and persistence in the face of difficulties. School and home factors influenced participants as well, as they had taken a rigorous set of math courses and had been exposed to test-taking strategies that included timed tests to improve speed. They had been influenced by teachers who were interested in their subjects and had been encouraged both at home and school to view math as a useful pursuit. Parents had created an environment in the home that encouraged academic pursuits and especially mathematical achievement.

Instead of focusing on deficits in both the educational and home communities of these young women, teachers and parents focused on promoting characteristics that enabled them to achieve mathematically. Young women's interests in and views of math as important were influenced both in their homes and schools through nurturing, enriching environments. Young women were taught to view abilities as expandable or improvable and were encouraged to develop an attribution style that promotes talent development (Reis, 1998). Challenging curriculum accompanied by test-taking strategies increased their math achievement. This research supports the influential role that teachers and parents can play as they help to support a generation of more confident, focused, mathematically talented women.

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