Gender, Math, and Science: The Role of Parents

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STEM preparation (or lack thereof)

- A proper foundation in science, technology, engineering, and math (STEM) is critical for
  - The future career success of individual youth
  - The global competitiveness of the nation

- In U.S. only 35% of high school students take pre-calculus and 39% take physics (NSF, 2012)
The Role of Parents

- They are an untapped resource; most research focuses on schools
- Part I. Correlational evidence
- Part II. Experimental evidence
Proposed Sources of the Gender Gap in STEM

• Women’s purported lack of math ability
  ▫ Meta-analyses say there is not a gap in performance (Hyde et al., 2008; Else-Quest et al., 2010)
  ▫ Gaps remain in math self-concept

• Gender differences in interests (Su, Rounds, & Armstrong)
  ▫ Women and people
  ▫ Men and things

• Discrimination against women in science (Moss-Racusin)
The Gender Gap in STEM

- In the U.S.
  - 53% of PhD’s in Biology go to women
  - 39% in Chemistry
  - 19% in Physics; 23% in Engineering
- In Australia
  - 50% of PhD’s in Biology
  - 11% in Chemistry
  - 5% in Physical Sciences
- Must stop talking about the gender gap in science or STEM – it depends on the science - need to disaggregate the sciences
Part I. Correlational Research

• What factors predict STEM career intentions at the end of high school
  ▫ For girls?
  ▫ For boys?
Theoretical Framework

- Eccles’ Expectancy-Value Theory
- To take on a challenging task (e.g., choosing to take Physics in high school)
  - Must expect that one can succeed (expectancy)
    - Domain-specific self-concept, e.g., math self-concept
  - Must value the task
    - Intrinsic value: interest, enjoyment of task
    - Utility value: usefulness
The Questions

• What variables from the expectancy-value model predict adolescents’ preferences for STEM careers at the end of 11th (Australia) or 12th (U.S.) grade?
• Do these predictions differ for girls and boys?
• Mathematics as the “critical filter”: do math expectancies and values predict STEM careers?
• Do parent variables predict?
The Longitudinal Design: Australia (Watt)

9th Grade

Mother’s Perception of Child’s Math Ability
Math Interest
Math Self-Concept
Math Importance

11th Grade

Preferred Career O*NET scored for Math
Biology
Chemistry
Physics
Measures: Australia

STEM career variables, 11th grade

- “What career are you mainly considering for the future?”
- O*NET is an online database that quantifies the knowledge required from various fields for a particular occupation, 0-100
- Example: Biostatistician
  - Math = 95
  - Biology = 49
  - Chemistry = 12
  - Physics = 10
The Results: Australia

Standardized structural paths for boys/girls
The Results: Australia

- Many gender similarities
  - Math performance \((d = -0.03)\)
  - Mothers’ perception of adolescent’s math ability predicts math self-concept for both boys and girls
- For girls, not boys
  - Math self-concept predicts Math career, Physics career, Chemistry career
The Longitudinal Design: U.S. (Hyde)

7th Grade

Mother’s Perception of Child’s Math Ability

9th Grade

Math Standardized Test Score (Grade 10)
Math Interest
Math Self-Concept
Math Importance (UV)

12th Grade

O*NET scored for Math
Biology
Chemistry
Physics
The Results: U.S.

Standardized structural paths for boys/girls
The Results: U.S.

- Mother’s perception of the adolescent’s math ability (7th grade) predicts adolescent’s self-concept (9th grade)
- Adolescent’s standardized math test score is correlated with math self-concept
- Math test scores predict career physics for girls but not boys
Gender and STEM Career Aspirations: The Role of Parents

- Mother’s perception of the adolescent’s math ability predicts the adolescent’s math self-concept

  ▫ Consistent with other studies and the Parent Socialization Model (Eccles, Jacobs, & Harold, 1990)
  ▫ Is it a causal influence?
  ▫ Or is there a third variable – adolescent’s math performance (grades or standardized tests) – that accounts for both?
A small detour: The role of culture

- “Indulging our gendered selves”
- Gender segregation in engineering is high in wealthy, postindustrial nations
  - E.g., U.S., Finland, Switzerland
- Much less gender segregation in marginal, developing economies
  - E.g., Romania, Macedonia, Indonesia
- In wealthy nations, we have the luxury of following our interests
- In developing economies, goal is to find a stable, well-paying job – then women go to engineering
Part II.

- We turn to an experimental manipulation of parents’ STEM utility value beliefs (with Judith Harackiewicz)
Can we promote STEM course-taking for high school students?

- Designed an intervention based on social psychological principles to promote
  - perceived utility value of STEM classes
  - STEM class-taking
Parents: An Untapped Resource to Increase STEM Enthusiasm

- Numerous interventions in the schools – we need new strategies

- Can we convince parents of the utility value of math and science for their teen?

- Can we convince parents to talk to their teens about STEM course-taking, and will this influence their teens’ course-taking behavior?
The Sample

- The Wisconsin Study of Families and Work (Hyde, [www.wsfw.us](http://www.wsfw.us))
- Recruited pregnant women and their husbands or partners in 1990-91
- Continued to follow the families, 16ᵗʰ wave of data collection completed after the teens graduated from high school
- 181 teens were in 108 different high schools, majority in State of Wisconsin
The Intervention

- Randomly assigned 81 families to receive our utility value intervention (brochures and website); 100 families did not (control group)

- Brochures mailed to parents in Fall of 10th grade
- Different brochure mailed in January of 11th grade (booster)
- In 11th grade, parents given access to a password-protected website
- Intervention targeted exclusively at parents
Brochures in 10th and 11th grade

http://choicesahead.wceruw.org/
Gave parents skills in talking with their teens

Thanks to Wisconsin Center for Education Research
It’s a Process
The important thing is to connect with your teen and to gently steer the conversation in the direction of connecting schoolwork to everyday life or future plans. Asking just one question, even if there is no response, sets the stage for future conversations. Even if your teen doesn’t respond, you may have started them thinking about school in a different way. That’s a great start!

Be Persistent
Your teen might not enjoy these kinds of conversations, and they may resist your efforts to talk with them. This is normal. If your teen is slow to warm up to these discussions, remember to be patient. Try to avoid becoming upset or frustrated with them. Simply drop the conversation and wait for another opportunity to try again. By raising these issues in a gentle, non-confrontational way, you may plant some seeds of discovery. Over time, you may be able to help your teen discover what is exciting and interesting about their schoolwork.

Connect with your teen and gently steer the conversation in the direction of connecting schoolwork to life.

Be Ready
Your teen may not see all of the connections between schoolwork and life that you do, and this is where you can help. If they respond “This course has no relevance to my life,” or “I don’t see any point in learning this,” you can be ready with some good examples. You know your teen better than anyone—try coming up with several examples that might be particularly interesting to your son or daughter.

Be An Example
You could start by thinking about how you use math and/or science in your current job or daily life. You may find that you use math and science more than you realized! You can talk to your teen about the connections you’ve made in your own work. You could also go through page 12, on “Making Your Own Connections,” together with your teen.

You Can Do It!
As a parent, you have more power to influence your teen’s attitudes than you think. Most of the time, teens will respond to a conversation from an adult if the adult is willing to listen to them and respond to their concerns and questions. You can help your teen see the relevance of school for his or her future. Just remember to: Question, Listen, Connect!
You may not realize it, but you benefit from the application of chemistry every day. Our drinking water is cleaner and better tasting thanks to the chemical compounds used to filter our water. Many of the foods we eat have undergone extensive lab testing in order to find the best tasting combination of ingredients. You might also be surprised to know how often we use principles of chemistry in our jobs. Pharmacists, doctors, and environmental engineers all use chemistry in their jobs, and so do construction workers, chefs, nutritionists, gardeners, and farmers!

Occupations: pharmacists, doctors, nurses, environmental engineers, farmers, gardeners, landscapers, pool technicians, chefs, construction workers.

Daily life: medicines, swimming pools, drinking water, cooking, housecleaning.

**Occupations**

**Medicine**
- Doctors, nurses, and pharmacists need to understand chemistry so that they can prescribe the right drugs to their patients, and avoid harmful drug reactions that come from mixing different drugs together.

**Health and wellness**
- Nutritionists, dieticians, and other public health providers help us understand what kinds of foods we need to eat regularly in order to be healthy. Biochemists and food engineers study how best to combine chemical compounds in order to make our food healthier. A good example is the cereal most of us eat for breakfast. Most are fortified with several types of vitamins and minerals.
Second Brochure

- Updated for 11th grade and the choices ahead
- Emphasized utility in everyday life and the future
- Expanded guidance for parents
Helping Your Teen Find Value in Math and Science

The Research
Do you ever wonder what you can do to help your teen succeed in school and in life? Based on our motivation research at the University of Wisconsin, there's a simple thing that parents can do: Encourage their teens to discover the connections between school and life. Teenagers do not always appreciate the importance or value of their schoolwork, and they don't always see the relevance of their schoolwork to everyday life or to their futures. But our research shows that when they do perceive value, they become more interested in their schoolwork and work harder.

Connect To Your Teen
In this brochure, we're offering a variety of suggestions about possible connections between school and life that might work for your teen. These are just examples — you will have the best sense for what will appeal to your teen, and what connections will be most powerful. It may be easier to help your teen make connections for some school subjects than others, and every student is different. Some teens may respond to connections with everyday life, whereas others will respond to connections with future plans.

Help Your Teen Discover the Connections
The important thing is to help your teen make some of these connections for him or herself. Instead of telling your teen how relevant math and science are to everyday life and the future, it will be more effective if you help them discover the connections that are most meaningful to them. Helping your teen discover their own connections allows them to build on their own interests, and gets them more engaged in learning.

Scientific research shows that when students make their own connections between school and their lives they are even more successful in school.

Instead of telling your teen how relevant math and science is to their life and future, help them discover the connections that are most meaningful to them.
Math and Science in Daily Life

You can help your teen discover the importance of math and science by pointing out how knowledge in these areas impacts his or her daily life, and how it will be relevant to your teen's adult life. Math and science courses can help us understand the technology we use every day. For example:

**Cell Phones**

- **Physics** helps us understand why our phone calls are dropped in certain locations, such as in a valley or inside an elevator (because it is difficult for radio waves to travel through metal), and **math** helps us decide on the best rate plan, and which extra features we can afford.

- **Chemistry** helps us understand how electricity and water can interact to damage the phone, and why the LCD (Liquid Crystal Display) screen won't work right if it gets too hot or cold (the liquid crystals that make up the picture are susceptible to temperature changes).

**Driving**

- **Physics** helps explain why sports cars can go around corners at high speeds (because of their lower and wider stance) but SUVs flip over, and an understanding of **biology** helps engineers design crash-proof seats that keep us safe without damaging our internal organs.

- **Chemistry and physics** help us understand how hybrid cars can charge their fuel cells and provide better mileage than gasoline-burning engines, and **math** helps us understand the cost-benefit trade-off of buying a hybrid car (more expensive to buy but less expensive to run).
The Choices Ahead

Here are some examples of how math and science may be important to your teen's future, whether they are thinking about entering the workforce and starting a career, or continuing their education at a technical school, community college, or four-year college or university.

Careers

Taking math and science courses in high school helps teens begin the career planning process by helping them discover which topics are more or less interesting to them, and by giving them a solid foundation of basic job skills. For example:

- **Veterinarians** need math skills to calculate proper dosages of medication, and an understanding of biochemistry to avoid potentially harmful drug interactions, as do doctors, nurses, and pharmacists.

- **Welders** use physics and chemistry principles to understand how different metals react to heat, as do mechanics who need to know how the moving parts of a vehicle are affected by friction.

- **Farmers** need to understand principles of biology and chemistry to maximize crop yield, maintain the proper acidity of the soil, and use fertilizers correctly, as do landscapers, gardeners, and marine biologists.

- **Medical imaging technicians** use powerful imaging equipment — X-rays, computed tomography (CT) scans, magnetic resonance imaging (MRI) — to look inside the body without surgery, and need to be familiar with the physics concepts of x-rays and magnetic resonance to determine bone damage, diagnose disease, and develop treatment for various illnesses.

- When writing contracts for company mergers, **corporate lawyers** use math skills (e.g., algebra formulas, proportions) to determine what percentage of the profits each group will receive.
The Website

- Accessible only to families in experimental group
- Website contained:
  - Interviews with current University of Wisconsin students in different fields, discussing the STEM courses they took in high school and how useful they were
  - Clickable links for websites about STEM topics, career planning, college planning
  - Emailing option for parents to send links to teen
Making Connections: Helping Your Teen with the Choices Ahead

Dear Parents,

Your teen will be making important decisions over the next year and a half, and we're developing this website to help teens and their families with the choices ahead. Because we live in an age of global technology, this website emphasizes the importance of math and science courses. Even if students aren't planning to go into scientific fields, math and science courses are critically important for a wide range of careers, college preparation, and basic life skills. Students need a good background in math and science to keep their options open in today's workplace, and parents can play a critical role in helping their teens make the best choices for their futures.
Our website provides a collection of web resources to supplement our brochure that you should have received in January, 2009. You can also access a link to our brochure on this site.

Whether your teen is just beginning to think about the college application process or is interested in a specific field or career, these websites offer a lot of information that will be helpful for learning more about particular fields of study (biology, chemistry, physics, and math). Your teen can also learn more about specific careers (e.g., veterinarian, landscape architect, athletic trainer, engineer, nurse, statistician, and many more) and the preparation they require. The websites will also be useful for helping to plan programs of study in high school and college, and you will find information about college planning and the application process.

We have also assembled some general science websites to provide interesting examples of science and math in everyday life.

Finally, we provide a collection of brief interviews with students at UW-Madison who talk about their current studies and high school preparation.

We hope you will take the time to explore the resources assembled here, and that you will share this information with your teen. Your teen might also like to visit the site; We included a user ID and password for your teen in the original mailing of the brochure. If you have lost that information, you can call or email Corinne Boldt (800-443-6441 or cdboldt@wisc.edu) to receive a user ID and password for your teen.

We have organized the websites into five categories:

- **Pre-College Planning**
- **Science and Math Fields** (Biology, Chemistry, Physics, Math)
- **Careers** (Career Exploration Websites, Biology and Chemistry, Healthcare, Physics and Engineering, Math and Architecture)
- **Science in Everyday Life**
- **What UW Students are Saying**

Download our brochure: Making Connections: Helping Your Teen with the Choices Ahead
The Choices Ahead

Dear Students,

You will be making important decisions over the next year, and we're developing this website to help teens and their families with the choices ahead. Because we live in an age of global technology, this website emphasizes the importance of math and science courses. Even if you aren't planning to go into scientific fields, math and science courses are critically important for a wide range of careers, college preparation, and basic life skills. Students need a good background in math and science to keep their options open in today's workplace.

Our website provides a collection of web resources that may be helpful as you think about your future.
What UW-Madison Students are Saying

We interviewed several students at UW-Madison about their major and program of studies here, and asked them how their math and science classes in high school prepared them for life at UW. Here are some brief excerpts from their interviews.

"Math and science helped me with prerequisites to apply to the business school like calculus. High school math and science classes also gave me the basic understanding of concepts that are still referred to throughout the many classes I have taken at Grainger-from finance to marketing."

Ashley
Senior, Marketing major in the Business school

"I am glad that I took math and science courses in high school because it gave me a solid base / platform of knowledge / information for the field. I still utilize the material learned back then in advanced pre-veterinary classes today."

Caroline
Senior, Zoology/Pre-vet major

"I came to UW hoping to major in anthropology. After taking some anthropology classes, it was clearly not the right choice. However, my high school calculus and advanced science background gave me plenty of other options. I decided to major in chemistry after my first semester. Without my prior knowledge of math and science, I would have been either really unhappy or really behind."

Steven
Sophomore, Chemistry major
Biology

**Biologists** study living organisms: how they grow, reproduce, and interact among themselves and with their environment. Specialization in a particular aspect of biology is common (for example, neuroscience, which includes study of the brain, sensory perception, and nerve cell signaling). Regardless of the area of specialization, in modern biology full understanding of a process requires integrating studies at many levels of organization: populations, individual organisms, organ systems, cells, and molecules. This webpage provides an overview of the field, information about degree options and preparation required, a career path forecast, and profiles of professionals in the field. [www.careercornerstone.org/biology/biology.htm](http://www.careercornerstone.org/biology/biology.htm)

**Bioengineering**, or **Biomedical Engineering**, advances knowledge in engineering, biology, and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. Biomedical Engineering combines engineering expertise with medical needs for the enhancement of health care: engineering knowledge and skills are developed and applied to define and solve problems in biology and medicine. This webpage provides an overview of the field, information about degree options and preparation required, a career path forecast, and profiles of professionals in the field. [www.careercornerstone.org/bioeng/bioeng.htm](http://www.careercornerstone.org/bioeng/bioeng.htm)

Some photos by UW-Madison University Communications.
Science and Math in Everyday Life

A basic knowledge of science can help us understand many of the things that we use or that affect us in our daily lives: the weather and our environment, technology (computers, iPods, cell phones), medicine (X-rays, ultrasound, MRI scanners), transportation (airplanes, hybrid vehicles, bullet trains), and our food and water quality. For example, pole vaulters and drummers aren't research physicists, but they make use of physical concepts such as elasticity, momentum, conservation of energy, vibration, reverberation, and reflection to hone their skills. A basic knowledge of math can help us do many things that are important in our daily lives, such as budgeting, shopping, and keeping track of sports scores, and advanced math skills can help us manage our finances (exponential growth, compound interest). These intriguing websites provide more information on all of these topics and more:

**Exploratorium:** This is a great site from The Museum of Science, Art and Human Perception in San Francisco, with a diverse collection of articles, videos and interactive demonstrations on topics such as climate change, the human mind, the science of cooking, evolution, polar science, and many more. Very engaging!

[www.exploratorium.edu](http://www.exploratorium.edu)

**Encyclopedia Smithsonian: Science and Technology:** This is a wonderful site from the
Manipulation Check

- Did the intervention affect parents’ behavior?
  - In 86% families, parents *reported* sharing these resources with their teen
  - In 82% families, at least one parent *logged into* website
  - In 75% families, teen *confirmed* exposure to the brochures and/or website
Did it work?

We had hoped for

- Increases in parents’ perceptions of utility value of math and science
- Increases in students’ perceptions of utility value of math and science

But...
Overall, beyond our expectations!

- The intervention increased students’ math & science course taking in 11th and 12th grades by nearly a semester!
Significant main effects: parents’ education level, $\beta = .17$, and the intervention effect, $\beta = .16$, both $p = .03$

Harackiewicz, Rozek, Hulleman, & Hyde (2012), *Psychological Science*
Interaction Effect

- Intervention x Gender x Past STEM Performance (expectancy of success?)

Gender and Effects on Course-taking (11/12\textsuperscript{th} Grade)

Y axis is number of semesters of math & science taken in 11\textsuperscript{th} and 12\textsuperscript{th} grades

GPA is average grade in 9\textsuperscript{th} grade math & science classes
Effects on Youth Perception of Parent Support for Taking STEM Classes

Parent STEM Support (11th grade)

<table>
<thead>
<tr>
<th></th>
<th>Low GPA</th>
<th>High GPA</th>
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<tbody>
<tr>
<td>Girls Control Group</td>
<td>12</td>
<td>13</td>
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<tr>
<td>Girls Intervention Group</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Boys Control Group</td>
<td>11</td>
<td>12.5</td>
</tr>
<tr>
<td>Boys Intervention Group</td>
<td>10</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Next Steps

Can we scale this intervention up to an entire school district?

Reaching parents is difficult: how do you get them to open or read mail, go online for a website?

How can we design an intervention that will work equally well for parents of sons and daughters?

address not only utility value, but also expectancy of success
Some provocative thoughts

• We know a lot from correlational and longitudinal studies
• We’re ready for interventions!
  ▫ Evidence-based and theory-based
  ▫ Carefully evaluated, with control group and random assignment
Overall, the Role of Parents Demonstrated in

- I. Correlational, longitudinal studies
  - Australia
  - U.S.
- II. An experimental study targeted at parents
Thank you!

Janet S. Hyde
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www.wsfw.us
Dear Parents,

We're sharing this brochure with your family to help with the important decisions your teen will be making over the next year and a half. Because we live in an age of global technology, this brochure emphasizes the importance of math and science courses. Even if students aren't planning to go into scientific fields, math and science courses are critically important for a wide range of careers, college preparation, and basic life skills. Students need a good background in math and science to keep their options open in today's workplace, and parents can play a critical role in helping their teens make the best choices for their futures.

Our 30 years of research on motivation reveals that parents can help their teens appreciate the value of math and science courses. One simple strategy is to help teens discover the connections between their schoolwork and things they really care about, like understanding how their cell phone works, preparing for college or technical school, or planning careers. We encourage you to read through this brochure and talk with your teen about these connections as he or she chooses courses for next year and begins to think about life after graduation.

We are also developing a Web site with additional resources for parents and teens. This Web site, choicesahead.wceruw.org, is password protected for WSWF families. You have received a user ID and password from WSWF, and will need both to access the Web site, which should be available by January 15, 2009.

We wish you all the best as you continue to help your teen succeed in school and beyond.

Sincerely,

University of Wisconsin-Madison Student Motivation Research Team
Wisconsin Study of Families and Work
Judith Harackiewicz, Professor of Psychology
Janet Hyde, Professor of Psychology
Chris Hulleman, Research Fellow, Vanderbilt University
Parents’ education

INTERVENTION

Mothers’ Perceived Utility Value, 11th grade

STEM Course Taking, 11th & 12th grade

Students’ Perceived Utility Value at Graduation

Conversations with Parents 12th grade

+.25

+.17

+.18

+.17

+.23
Effects on Teen UV

![Graph showing Teen STEM UV (11th grade) for low GPA and high GPA girls and boys, comparing control and intervention groups.](image-url)
SCALES AND ITEMS (11\textsuperscript{th} grade)

Parent STEM Support:
My parents think math and science are important for my life.
My parents have encouraged me to take math and science courses.

Teen STEM Motivation:
I want to have a job that involves math or science some day.
I think math and science will be useful in my daily life.
Math and science are important for my future.
It is important to understand math or science to get a good job.

Mother STEM UV:
In general, how useful will [biology] be for your teen in the future?
(done for each topic: math, biology, chemistry, and physics)
Gender and Effects on Course-taking (12th grade)

The parent intervention may be most helpful with low-education families

- “I have been very concerned about [name] and how he would move forward. I didn’t go to a regular college, just took one year of night school. It was too hard trying to work full time and raise 2 kids while attending school. This website gives me hope for my kids.” (mother)