Why Aren't More Women in Science?

Top Researchers Debate the Evidence

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WHERE ARE ALL THE WOMEN? GENDER DIFFERENCES IN PARTICIPATION IN PHYSICAL SCIENCE AND ENGINEERING

JACQUELYNNE S. ECCLES

The president of Harvard University, Lawrence Summers, gave a speech in 2005 that set off a firestorm of discussion about the relatively low numbers of women researchers in the fields of science, engineering, and math. I found this debate particularly interesting because I have been studying exactly this issue for the past 35 years. I began my research career in the late 1970s with a grant from the then National Institute of Education specifically focused on the relatively low numbers of women at the most advanced levels of mathematics-related professions. A great deal of research was done on this topic at that time, and considerable funds were put into designing and testing a wide variety of intervention programs to increase female participation in mathematics-related careers, such as engineering and physical science. Great progress was made, moving the average enrollment of women in bachelor's degree programs in engineering from a little more than 3% to approximately 18% by the 1990s. It is interesting, both then and now, that women have always been well represented in mathematics itself, which turns out to be one of the least sex-typed undergraduate college majors. Furthermore, for at least the past 10 years, women have been very well represented in both undergraduate- and master's-level programs in the biological and medical sciences, as well as in MD programs. Nevertheless, women continue to be underrepresented in programs in physical science and engineering and on the university and college faculties in all of the natural sciences, engineering, and mathematics. Why?

GENERAL EXPECTANCY VALUE MODEL

As noted earlier, my colleagues and I have studied the psychological and social factors influencing course enrollment decisions, college major selection, career aspirations, and career choices for the past 35 years. I began this work with a particular interest in the psychological and social factors that might underlie the gender differences in educational and vocational choices, particularly in the fields of mathematics, physical science, and engineering. Frustrated with the many disconnected theories emerging to explain such gender differences, my colleagues and I developed a comprehensive theoretical model of achievement-related choices (Eccles Parsons et al., 1983; see Figure 15.1 for most recent version). Drawing on work associated with decision making, achievement theory, and attribution theory, we hypothesized that the kinds of educational and vocational decisions that might underlie gender differences in participation in physical science and engineering would be most directly influenced by individuals' expectations for success and the importance or value individuals attach to the various options they see as available. We then hypothesized how these quite domain-specific self- and task-related beliefs might be influenced by cultural norms, experiences, aptitudes, and more general personal beliefs (see Eccles, 1994; Eccles Parsons et al., 1983; Eccles, Wigfield, & Schiefele, 1998). We have used this model as a guide to our program of research ever since.

For example, consider decisions related to selecting a college major. According to our model, people should be most likely to choose a major that they think they can master and that has high task value for them. Expectations for success (domain-specific beliefs about one's personal efficacy to master the task), in turn, depend on both the confidence that individuals have in their various intellectual abilities and the individuals' estimations of the difficulty of the various options they are considering. We also predicted that these self- and task-related beliefs were shaped over time by both experiences with the related school subjects and activities and individuals' subjective interpretation of these experiences (e.g., does the person think that her or his prior successes reflect high ability or lots of hard work? And if the latter, will it take even more work to continue to be successful?). As I discuss in more detail later, gender role socialization and commonly held stereotypes

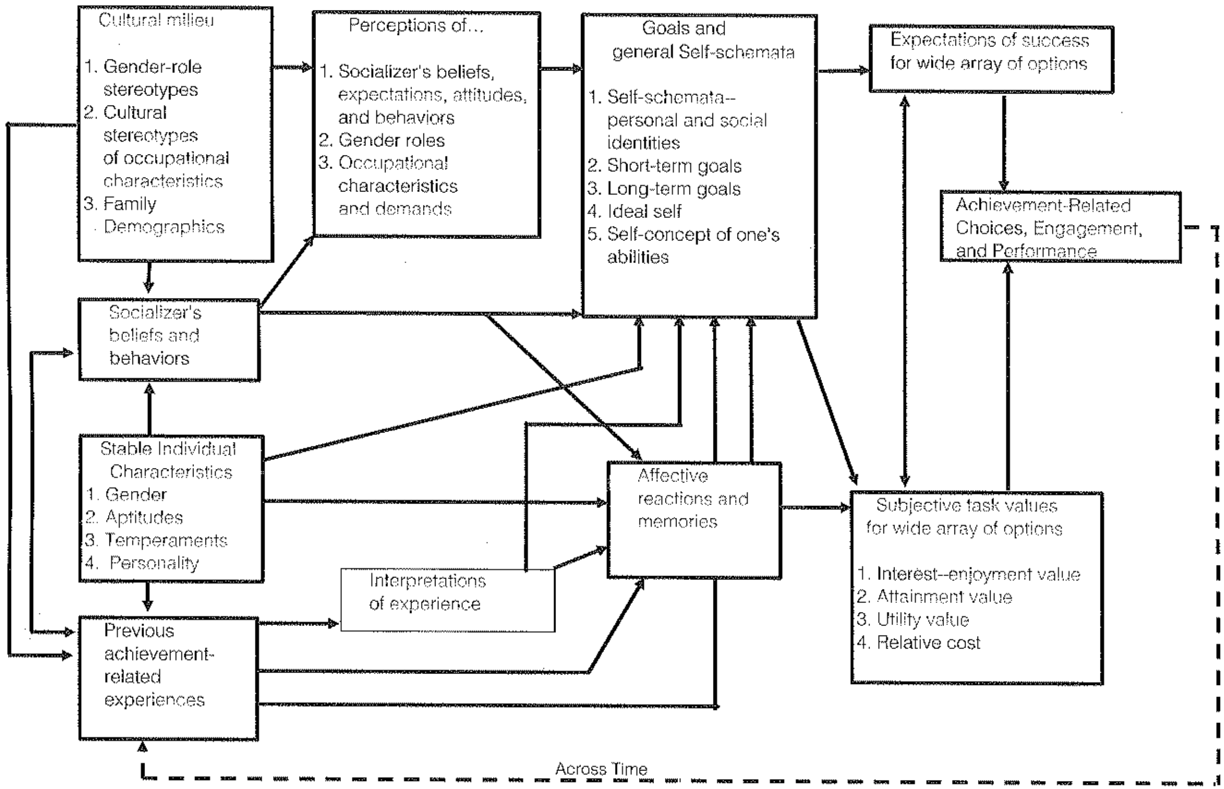

Figure 15.1. Eccles expectancy value model of achievement-related choices. Copyright 1983 by J. Eccles (Parsons). Printed with permission.

about gender differences in "natural talents" for various subject areas are likely to lead females and males to have different estimates of their own personal efficacies for physical science and engineering. It is quite likely that females will receive less support for developing a strong sense of their talent for these fields from their parents, teachers, and peers than males.

Likewise, our model specifies that the subjective task value of various majors is influenced by several factors. For example, does the person enjoy doing the related school work? Is this major seen as instrumental in meeting the individual's long- or short-range goals? Have the individual's parents, counselors, friends, or romantic partners encouraged or discouraged the individual from selecting this major? Does taking the major interfere with other more valued options because of the amount of work needed to be successful either in the major or in the future professions linked to the major? Again, as discussed in more detail later, it is quite likely that males will receive more support for developing a strong interest in physical science and engineering from their parents, teachers, and peers than females. In addition, it is absolutely the case that all young people will see more examples of males engaged in these occupations than females. Consequently, according to our model, the likelihood of even considering these occupations as appropriate is much lower for females than for males.

SUBJECTIVE TASK VALUE

As we developed our model in the mid-1970s, it became clear to us that the theoretical grounding for understanding the nature of subjective task value was much less well developed than the theoretical grounding for understanding the nature of expectations for success. Consequently, we elaborated our notion of subjective task value to help fill this void. Drawing on work associated with achievement motivation, intrinsic versus extrinsic motivation, self psychology, identity formation, economics, and organization psychology, we hypothesized that subjective task value was composed of at least four components: interest value (the enjoyment one gets from engaging in the task or activity), utility value (the instrumental value of the task or activity for helping to fulfill another short- or long-range goal), attainment value (the link between the task and one's sense of self and identity), and cost (defined in terms of either what may be given up by making a specific choice or the negative experiences associated with a particular choice).

Because I believe that the last three of these are particularly relevant for understanding gender differences in educational and occupational choices, I elaborate on these further now. My colleagues and I have argued that the socialization processes linked to gender roles are likely to influence both short- and long-term goals and the characteristics and values most closely linked to core identities (e.g., Eccles, 1992, 1994; Jacobs & Eccles, 1992). For example, gender role socialization is likely to lead to gender differences in the kinds of work one would like to do as an adult: Females should be more likely than males to want to work at occupations that help others and fit well into their family role plans. Males should be more likely than females to want future occupations that pay very well and provide opportunities to become famous (for reviews of evidence supporting these hypotheses, see Eccles et al., 1998; Ruble & Martin, 1998; for empirical support, see Eccles & Vida, 2003). There is also evidence that males are somewhat more interested than females in activities and jobs related to manipulating physical objects and abstract concepts, whereas females are more interested in activities and jobs related to people and social interactions. These differences are likely to influence the types of jobs that appeal to male and female adolescents as they are in the process of making related educational decisions. If so, then the utility value and attainment value of various high school courses and college majors should differ on average by gender, precisely because these courses and majors are linked directly to adult occupational choices.

Similarly, the perceived cost of different high school courses and college majors should vary by gender because of the relative importance attached to various options. The cost may also vary by gender because of average-level differences in such emotional costs as math anxiety and the fear of rejection for making nontraditional choices (see Eccles et al., 1998).

Three features of our approach that are not well captured by the static model depicted in Figure 15.1 are particularly important for understanding gender differences in the types of educational and occupational choices represented in this book: First, we are interested in both conscious and nonconscious achievement-related behavioral choices. Although the language we use to describe the various components makes it seem that we are talking about quite conscious processes, this is not our intention. We believe that the conscious and nonconscious choices people make about how to spend their time and effort lead, over time, to marked differences between groups and individuals in lifelong achievement-related patterns. We also believe, however, that these choices are heavily influenced by socialization pressures and cultural norms.

Second, we are interested in what becomes part of an individual's perception of viable options. Although individuals choose from among several options, they do not actively consider the full range of objectively available options. Many options may never be considered because the individual is either unaware of their existence or has little opportunity or encouragement to really think about a wide range of alternatives. Other options may not be seriously considered because the individual has inaccurate information regarding either the option itself or the individual's potential for achieving the option. For example, young people often have inaccurate information regarding the full range of activities associated with various career choices or inaccurate information regarding the financial assistance available for advanced educational training. Yet they make decisions about which occupations to pursue and then select courses in high school that they believe are important for getting into college and majoring in the subject most directly linked to their career aspirations. Too often these choices are based on either inaccurate or insufficient information. Finally, many options may not be seriously considered because the individual does not believe that a particular choice fits well with his or her gender role or other social role schemas. Again, inaccurate information about what occupations are actually like can lead to premature elimination of quite viable career options. For example, a young woman with excellent math skills may reject the possibility of becoming an engineer or a computer scientist because she has a limited view of what engineers and computer scientists actually do. She may stereotype engineers as nerds or as people who focus on mechanical tasks with little direct human relevance, when in fact many engineers work directly on problems related to pressing human needs. If so, she may well select herself, or be encouraged to select herself, out of a profession that she might both enjoy and find quite compatible with her life goals and values. As a culture, we do a very poor job of providing information to our children and adolescents about various occupations. As a consequence, they must rely on media portrayals and happenstance career counseling from their parents, mentors, and friends. Such portrayals are often quite gender and ethnically stereotyped.

Third, we assume that educational and occupational decisions are made within a complex social reality. For example, the decision to major in biology rather than computer science or engineering is made within the context of a complex social reality that presents each individual with a wide variety of choices, each of which has both immediate and long-range consequences that map in complex ways onto the full range of determinants of subjective task value. Furthermore, many options have both positive and negative components. For example, the decision to enroll in an advanced math course in high school is typically made in the context of other important daily-life decisions and long-term life decisions such as whether to take advanced English to study literature one enjoys, to take a second foreign language course to aid in one's future travel plans, to take a course with one's best friend or romantic partner to have an intellectual activity to share, or to take less demanding courses to spend more time enjoying the social aspects of one's senior year. Similarly, the decision to major in computer science or engineering versus something else is made in the context of a wide variety of options and life demands during the college years. The critical issues in our view are the relative personal value of each option and the individual's assessment of his or her relative abilities and potentials at the time the decision is being made. In addition, having narrowed the field to those options at which one feels confident about succeeding, we assume that people will then choose the options with the highest personal value. Thus, it is the hierarchy of subjective task values and expectations for success that matter rather than the absolute values of both of these belief systems that are attached to the various options under consideration. This feature of our approach makes within-person comparisons much more relevant to understanding individuals' decisions than between-group mean-level comparisons. Unfortunately, very little work has taken such a pattern-centered approach.

Consider two high school students, Mary and Beth. Both young women enjoy mathematics and physical science and have always done very well in these subjects, as well as in their other school subjects. Both have been identified as gifted in mathematics and have been offered the opportunity to participate in an accelerated math program at the local college during their senior year. Beth hopes to major in communications when she gets to college and has also been offered the opportunity to work part time at the local TV news station doing odd jobs and some copy editing. Mary hopes to major in computer science in college and plans a career as a research scientist designing educational software. Taking the accelerated math course involves driving to and from the college. Because the course is scheduled for the last period of the day, it will take the last two periods of the day as well as 1 hour of after-school time to take the course. What will the young women do? In all likelihood, Mary will enroll in the program because she both likes math and thinks that the effort required to master the material is important for her long-range career goals. Beth's decision is more complex. She may want to take the class but may also think that the time required is too costly, especially given her alternative opportunity to do an apprenticeship at the local TV station. Whether she takes the college course or not will depend, in part, on the advice she gets from her counselors, family, and friends. If they stress the importance of the math course, then its subjective worth is likely to increase. If the subjective worth of the course increases sufficiently to outweigh its subjective cost, then Beth will likely take the course despite its cost in time and effort. Studying these types of subtle processes is difficult with individual- and group-difference-oriented, variable-centered approaches.

In summary, my colleagues and I assume that educational and occupational choices (as well as other achievement-related leisure-time choices) are guided by (a) individuals' expectations for success on (sense of personal efficacy at) the various options, as well as their sense of competence for various tasks; (b) the relation of the options to their short- and long-range goals, to their core personal and social identities, and to their basic psychological needs; (c) individuals' culturally based role schemas linked to gender, social class, and ethnic group; and (d) the potential cost of investing time in one activity rather than another. We assume that all of these psychological variables are influenced by individuals' histories as mediated by their interpretation of these experiences, by cultural norms, and by the behaviors and goals of one's socializers and peers.

MICHIGAN STUDY OF ADOLESCENT LIFE TRANSITIONS: A STUDY OF THE ECCLES EXPECTANCY-VALUE MODEL OF ACHIEVEMENT TASK CHOICES

We have spent the past 35 years amassing evidence to support each hypothesis. The findings related to gender differences in the pursuit of careers in physical science and engineering are quite robust (see Eccles, 1992, 1994; Eccles et al., 1998, for reviews). Here I give just one example of our most recent findings. The analyses I report were done using data from the Michigan Study of Adolescent Life Transitions. This longitudinal study is being conducted by myself and Bonnie Barber. It began in 1982 with a sample of approximately 3,000 sixth graders in 12 different school districts in southeastern Michigan; these districts served primarily working-class and middle-class small-city communities. The sample is predominantly White but does include about 150 African American adolescents. We have now followed approximately 1,500 of these adolescents well into their early adulthood years, using standard survey type methods. All of the survey instruments reported here have been used in a variety of studies and have well-established reliability and good predictive and face validity.

First, we looked at the psychological predictors of enrollment in both the honor's mathematics track in high school and high school physics. We found no gender differences in enrollment in high school math courses until the 12th grade, when young women were slightly less likely than young men to enroll in a second-semester advanced math course. We used path analysis to determine whether this gender difference was mediated by constructs directly linked to expectations for success and subjective task value while controlling for the students' scores on the Differential Aptitude Test (DAT; Updegraff, Eccles, Barber, & O'Brien, 1996). As predicted, the gender difference in course-taking was completely mediated by these beliefs. Yet even more important, from my perspective, the gender difference was totally mediated by perceived importance or utility. It is interesting to note that neither 10th-grade enjoyment or interest nor self-concept of ability predicted number of courses taken once the DAT scores were included in the analyses.

We were particularly struck by the strength of the importance or utility construct. Recall the example I gave about the two young women deciding whether to take the college math course or not. I stressed there the perceived importance of the course for the young women's future plans. These data support that emphasis. At this point in these students' lives, they must begin to choose between elective courses. These findings suggest that they weigh the utility of the course for their future educational and vocational goals heavily in making these choices, and that gender differences in these course decisions are primarily due to perceived utility rather than either aptitude differences or differences in a sense of personal efficacy to succeed at mathematics. We found exactly the same pattern of results for gender differences in the number of high school physical science courses.

We next looked at the mediators of gender differences in career aspirations given their apparent role in course decisions. Here we used four sets of beliefs and values more directly related to career choices: (a) values regarding work, future success, relationships, and leadership (*lifestyle values*); (b) specific job characteristics adolescents may desire in their future occupational settings (*valued job characteristics*); (c) estimates of future success in different categories of occupations (*expected efficacy in jobs*); and (d) self-ratings of job-relevant skills (*self-perception of skills*; see Eccles, Barber, & Jozefowicz, 1999, for details on these scales and their psychometric properties). *Occupational aspirations* were assessed using the following open-ended probe: "If you could have any job you wanted, what job would you like to have when you are 30?" Analyses revealed fairly stereotypic gender differences: The young men aspired to science or math-related occupations, male-typed skilled labor occupations, and protective service jobs more than the young women. Conversely, the young women aspired to human service jobs, health professions, and female-typed skilled labor more than their male peers. However, the largest number of both males and females aspired to business or law occupations (31% and 30%, respectively).

We next analyzed which values, job characteristics, skills, and efficacy expectations best discriminated between adolescents who aspired to each of nine occupational categories (see Eccles et al., 1999, for full details). These analyses controlled for mathematical ability. Here I summarize the results for only two occupational categories: PhD-level or MD-level health careers and MS-level or PhD-level physical science-, engineering-, or math-related careers. First, as predicted by our model, both females and males who aspired to the health careers were more likely to expect to do well in health-related occupations and placed higher value on people or society-oriented job characteristics than those who did not aspire to health careers. The young women who aspired to these careers also rated their ability to succeed in science-related careers quite high as well. The young women, on average, were more likely to aspire to the health-related careers primarily because they placed higher value on a people- or society-oriented job than their male peers.

An even more interesting set of results emerged for the science-, engineering-, or math-related careers. Both the young women and men who aspired to these types of careers were more likely than their peers to expect to do well in science-related fields and to value math and computer job tasks. The young men who aspired to science-related careers also had high ratings of their computer and machinery skills and lower expectancies for doing well in business or law occupations than their male peers who did not aspire to these careers. Of interest, the young women who aspired to these types of careers placed much lower value on people- or society-oriented job characteristics than their female colleagues who did not aspire to these careers. This last effect was not evident for the young men.

These results are interesting for several reasons. First, they support the Eccles et al. model of achievement-related choices: For both males and females, occupational aspirations are mediated primarily by both expectancy beliefs and subjective task values. In addition, both approach-related (i.e., "I expect to do well in science, therefore I will choose a science career") and avoidance-related (i.e., "I do not value people- or society-oriented job tasks, therefore I will aspire to something else") beliefs predict the occupational choices for both males and females.

Second, there are intriguing gender and occupational category differences in the discriminating characteristics. For instance, expecting to do well in science-related occupations discriminates females who choose science-related or health careers from those who do not aspire to such careers. This is not true of males for whom only science-related expectancies discriminate between those males who choose science careers and those who do not. With regard to the females who choose science-related or health careers, it is important to point out that the value of people or society job characteristics also discriminates between those females who aspire to health, science, or math careers and those who do not. However, it discriminates in opposite directions for these two career options. That is, females who aspire to health careers place high value on people- or society-oriented job characteristics; in contrast, females who aspire to physical science-related careers place unusually low value on the people- or society-oriented aspects of jobs. Considering the fact that both groups of women expect to do well in science-related careers, it follows that one of the critical components influencing these women's decisions to go into a science- versus a health-related field is not science-related efficacy but the value they place on having a job associated with people and humanistic concerns. Thus, if we want to increase the number of females who consider entering physical science and engineering careers, it will be important to help females see that these careers provide opportunities to fulfill their humanistic and people-oriented values and life goals; such interventions are likely to be as successful, if not more successful than interventions designed to raise females' perceptions of their math-related abilities.

We have done comparable analyses on these young people's actual college majors and jobs at age 25 (Eccles & Vida, 2003). Again we sought to determine which beliefs and values distinguished those women and men who completed a physical science or engineering degree and who went into physical science and engineering careers from those who did not, controlling for actual mathematical ability. We found exactly the same pattern: As predicted by our model, both men and women who go into these professions have high expectations to succeed in these fields and place high subjective task value on doing the types of tasks inherent in these professions. Yet even more important, both the men and women who go into these fields place unusually low value on having a job that directly benefits other people or society. Although this effect is true for both men and women, the young women in this sample are much more likely than the young men to want jobs that provide direct benefits to society.

CONCLUSION

Our analyses suggest that the main source of gender differences in entry into physical science and engineering occupations is not gender differences in either math aptitude or a sense of personal efficacy to succeed at these occupations, rather it is a gender difference in the value placed on different types of occupations. Furthermore, our results suggest that these differences begin influencing educational decisions quite early in life. Finally, my own opinion is that these differences reflect, at least to some extent, inaccurate stereotypes about physical science and engineering that lead some young women and men to reject these careers for the wrong reasons. Many jobs in these fields do provide opportunities for individuals to fulfill humanistic and helping values. If we want to increase the number of females who aspire to and then actually go into these fields, we need to provide them with better information about the nature of these occupations so that they can make better informed decisions regarding the full range of occupations they might consider as they try to pick a career that fits well with their personal values and identity as well as their short- and long-term goals.

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