Six Degrees of Separation: What Teachers Need to Know about the Emerging Science of Sex Differences

by Leonard Sax

I entered the Ph.D. program in psychology at the University of Pennsylvania in 1980. Back then, we were taught that most of the differences psychologists observe between girls and boys are "socially constructed"—in other words, that those differences result from differences in the way that girls and boys are raised. No serious person back then imagined that there might be innate sex differences in how girls and boys see and hear.

Throughout the 1980s and 1990s, a number of researchers published reports demonstrating the existence of sex differences in cognitive function and language skills.[1] The average girl's vocabulary is slightly larger than the average boy's, for example, while the average boy performs slightly better on tests of spatial rotation than does the average girl. As a general rule, the variation within the sexes on those parameters is usually far greater than the small differences between the sexes.

Sex Differences in Sensation and Perception

Only in the past five years have researchers begun to look systematically for sex differences in noncognitive parameters that are nevertheless relevant to how children learn: for example, sex differences in the organization of the retina, the cochlea, and the autonomic nervous system. In August 2005, I had the privilege of hosting a symposium at the annual convention of the American Psychological Association: our topic was sex differences in hearing, vision, and smell. At this symposium, we heard from scientists who have been in the vanguard of research on sex differences in how males and females hear and see and smell.

Until recently, it had never occurred to anyone that the eye itself might be organized differently in males and females. The first person to cut open the eyeballs of dead animals and look for sex differences in the organization of the retina was Dr. Edwin Lephart, director of the

Neuroscience Center at Brigham Young University. In 2001, Dr. Lephart reported dramatic differences in how the eye itself is built in male and female laboratory animals.[2] Dr. Lephart was joined at the symposium by Dr. Janice Juraska of the University of Illinois/Urbana-Champaign. She presented research showing that girls acquire binocular vision at a much earlier age than boys do and that the visual cortex appears to be organized in fundamentally different ways in females and males.[3] Perhaps the most striking presentation at our symposium was that of Dr. Pamela Dalton, of the Monell Chemical Senses Center in Philadelphia. She presented research showing that under certain circumstances, a woman's sense of smell is at least 100,000 times more sensitive than a man's. A woman may find a particular room absolutely nauseating, reeking of an intolerable smell, while a man may not smell anything objectionable in the room at all. In Dr. Dalton's study, there was an enormous difference between the sexes—five orders of magnitude with no overlap.[4]

Girls are born with a sense of hearing significantly more sensitive than boys', particularly at the higher frequencies most important for speech discrimination. Those differences grow larger as kids get older. I present the educational applications of these hard-wired differences in my book *Why Gender Matters*: for example, some boys labeled as slow learners may actually just need teachers to speak LOUDER.[5]

Sex Differences in Autonomic Function

Although dozens of studies published in the past five years have demonstrated dramatic sex differences in autonomic function, to my knowledge the educational literature has not emphasized those studies and their potential significance for education.

The autonomic nervous system is responsible for maintaining blood pressure, body temperature, and internal homeostasis in general. The autonomic nervous system has two major divisions: the sympathetic nervous system and the parasympathetic nervous system. The sympathetic nervous system is responsible for the "fight and flight" response the adrenaline-mediated cascade of accelerated heart rate, vasoconstriction, dilated pupils, etc., triggered by violence or confrontation—that prepares the organism to fight or to run away. The parasympathetic nervous system, also known as the "rest and digest" nervous system, mediates digestion and underlies the slower heart rate, vasodilatation, and increased cutaneous blood flow (flushing) that in turn affect the response to higher ambient temperatures.

Until the late 1990s, no one suspected that fundamental sex differences in the organization of the autonomic nervous system might exist. In this decade, however, an avalanche of studies has demonstrated just such differences. The female autonomic nervous system in humans has been shown to be influenced more by the parasympathetic nervous system,

Table 1

	Girls	Boys
Stress response is influenced more by the . . .	Parasympathetic division of the autonomic nervous system	Sympathetic division of the autonomic nervous system
Primary neurotransmitter is:	Acetylcholine	Norepinephrine
Primary humoral factor is:	Acetylcholine	Adrenalin
Activation of the system often results in:	Dizziness, mental slowing or "freezing" "I just couldn't think —or even move!" "I felt paralyzed."	Sharpened senses, arousal, excitement "I've never felt so alive."
Activation of the system is experienced as:	Stressful, unpleasant, even nauseating	Thrilling, arousing— "Let's do that again!"

whereas the sympathetic nervous system plays the greater role in controlling autonomic responses in men.[6]

Equally important is the different affective valence associated with those two divisions of the autonomic nervous system. When most young boys are exposed to threat and confrontation, their senses sharpen, and they feel a thrill. When most young girls are exposed to such stimuli, however, they feel dizzy and "yucky." They may have unaccustomed trouble expressing themselves with just the right words.

Some ten-year-old boys will spend their last pennies to play video-arcade games in which enemies shoot at them. Few ten-year-old girls find simulated combat worth spending their money on. That is not to say that girls are never violent: just that girls seldom enjoy physical violence the way boys do.

But how is all that relevant to education?

Best Practices for Teaching Boys

I have visited all-male elementary schools where teachers apply that principle—not because they have read the latest articles from the

Journal of Applied Physiology, but because over the past 200 years or so of working with boys, teachers at such schools have figured out what works and what doesn't. The teacher is constantly moving and speaking in a loud tone of voice. He may move right in front of a boy and say loudly, "What's your answer, Mr. Jackson? Give it to me!" Far from being intimidated, the boys are energized by this teaching style. They know that the teacher cares for them and is not trying to humiliate or embarrass them. They are eager to participate and to answer the teacher's questions. Indeed, I have seen boys, once labeled with "attention deficit disorder" in coed classrooms, who became above-average pupils—without any medication—after their parents transferred them to boys' schools that employed appropriate teaching principles. Those boys don't need drugs like Ritalin, Adderall, Concerta, Metadate, or Strattera. They need teachers who understand that learning is different for girls and boys.

Six Degrees of Separation

Another application of the new research has to do with the ambient temperature of the classroom. One of my colleagues last year visited an elite all-male private boarding school. This school, founded almost 200 years ago, caters to the sons of some of the wealthiest families in the United States. Tuition is almost $30,000 per year, and the school's endowment is more than $170 million. But when my colleague entered the main building, she found it uncomfortably chilly. "Excuse me," she said to the headmaster. "Please forgive me for saying so, but with all the money you charge for tuition, and your enormous endowment, can't you afford to heat your school properly? It's cold in here!"

"If you turn up the heat, the boys go to sleep," the headmaster answered. "Not literally asleep, but they might as well be. If it's too warm in the classroom, the boys get sluggish and their eyelids get heavy. If you keep it just a little chilly, the boys learn better." We've heard similar remarks from many other heads of all-male schools. Understanding that the sympathetic nervous system predominates in boys and that the sympathetic nervous system is tuned to react best in the cold helps to put this observation in context. Recall the last photo you saw of a "polar bear club"—a group of people who enjoy jumping into ice-cold lakes in the wintertime. Such clubs are almost entirely male. Few women regard jumping into freezing water as an enjoyable pastime.

Ergonomics specialists have found that the ideal ambient temperature for young men is about 71° F, versus 77° F for young women. In this particular study, both women and men wore the equivalent of bathing suits.[7] In regular school clothes, the ideal temperature would likely be about 2° F lower for both girls and boys. In other words, the ideal ambi-

ent temperature for boys is about 69º F, and about 75º F for girls— "six degrees of separation," with apologies to the play of the same name.

At least two disclaimers attach to that statement. First, all subjects in this study, and others like it, were of normal weight. The researchers deliberately excluded subjects who were obese or severely underweight. For obese children, both girls and boys, the ideal ambient temperatures would no doubt be lower. In addition, the subjects in the study were young people. When a woman approaches menopause, her tolerance for warm rooms may diminish.

Some writers who are aware of gender differences in how girls and boys learn nevertheless insist that properly trained teachers can apply those principles in a coed classroom. Those writers insist that we don't need single-sex classrooms to accommodate the different learning styles of girls and boys; we just need properly trained teachers.[8] However, as a rule those writers are simply not aware of new research showing, for example, that the ambient room temperature for learning differs for girls and boys. There is no way to implement that finding in a coed classroom. A classroom can either be 69º F or 75º F, but not both simultaneously.

I recently had the privilege of hosting a conference on best practices for single-sex education. The 272 educators in attendance came from all around the United States—from Alaska to southern Florida, from Massachusetts to Southern California—as well as from Spain, Iceland, Canada, Mexico, and Australia.[9] Many of them have had the experience of teaching all-female, all-male, and coed classrooms. They told me how differently they speak in the boys' classrooms compared with the girls' classrooms.

With boys, they speak loudly and in short, direct sentences with clear instructions: "Put down your papers. Open your books. Let's get to work! Mr. Jefferson, that includes you." With girls, they speak much more softly, using more first names with more terms of endearment and fewer direct commands: "Lisa, sweetie, it's time to open your book. Emily, darling, would you please sit down for me and join us for this exercise?" One teacher told me how he once "forgot" to change voices for the girls' classroom after a morning with the boys and used his "boys' classroom" voice: "All right, let's get moving! Open your books now! No dawdling!" The girls' eyes widened. One of them looked as if she would cry. Finally one girl raised her hand. "Mr. Johnson, are you mad at us?" she asked.

Conversely, if you speak in a quiet tone of voice in an all-male classroom, the boys may daydream or drift off to something close to sleep. One teacher complained that none of the boys in her all-male classroom paid any attention to her. She was astonished when a more experienced teacher came into the classroom and immediately commanded the attention of every boy—merely by speaking in a much louder voice than the boys were accustomed to. Again, such differences in teaching style are nearly impossible to implement in a coed classroom. How can a teacher speak simultaneously in both a loud voice and a soft voice?

Does Single-Sex Education Lead to Improvements in Academic Performance?

The scholarly literature on single-sex education is mixed, to say the least. Various studies have found benefits for girls but not boys; benefits for boys but not girls; benefits for both girls and boys; and benefits for neither girls nor boys. In October 2005, the United States Department of Education published a review of research on single-sex education, along with a "score sheet" listing each study's results as favoring or not favoring single-sex education.[10] The authors of the DOE review made no attempt to account for the variation in the results, although one of the authors has assured me that they are working on a separate paper to address the variation in the results.[11]

The most obvious explanation for the variation obtained when educators introduce the single-sex format is that merely placing girls and boys in separate classrooms accomplishes little. For the single-sex format to lead to improvements in academic performance, teachers must understand the hard-wired differences in how girls and boys learn. In particular, teachers need to understand the importance of differences in how girls and boys hear, see, and respond to different learning styles, as well as the differences in autonomic function we have considered here. Most of the studies reviewed by the DOE involved merely segregating girls and boys, with no attempt made to incorporate best practices for

all-female classrooms and best practices for all-male classrooms. Indeed, the authors of most studies reviewed by the DOE showed no awareness of research demonstrating that girls and boys do learn in different ways.

The first mission of the association I head, the National Association for Single Sex Public Education (NASSPE), is to share such research with interested educators. At our conference on single-sex education mentioned earlier, the variation in results reported by our twenty-seven presenters was much smaller, and the results were almost uniformly positive. Most of those educators are knowledgeable about the hard-wired differences in how girls and boys learn; they apply their knowledge in designing curriculum, in training teachers, and even in heating buildings and lighting classrooms. At the conference, we heard many stories of dramatic improvements in academic achievement after adopting the single-sex format. For example, at the Ella Stewart Academy for Girls in Toledo, Ohio, only 19 percent of the girls had scored "proficient" on a state test in the year before the single-sex format was implemented. After two years of the single-sex format, 91 percent of the girls scored proficient on the state examination—despite the fact that there was no change in class size and no change in per-pupil funding.

Likewise, we heard from teachers at the Woodward Avenue Elementary School in DeLand, Florida, where pupils were assigned to either a coed classroom or a single-sex classroom. Among fourth-grade pupils assigned to the coed classroom, 59 percent of the girls scored proficient in writing on the FCAT (Florida Comprehensive Assessment Test), while only 37 percent of the boys scored proficient on the same test. There's the familiar gender gap: most boys aren't proficient in writing. But among pupils assigned to the single-sex classrooms, an astonishing 86 percent of the boys and 75 percent of the girls scored proficient in writing on the FCAT. The single-sex format improved performance significantly for both girls and boys and abolished the gender gap altogether—with no change in class size or per-pupil funding. Many more such examples, and more information about the effectiveness of single-sex education in North America, are available online at the NASSPE Web site, <http://www.singlesexschools.org>.

"Write about How You Feel"

Deborah Yurgelun-Todd and her associates at Harvard University have used sophisticated MRI imaging to examine how emotion is processed in the brains of children between the ages of seven and seventeen. In young children, the researchers found, negative emotional activity in response to unpleasant or disturbing visual images seems to be localized in primitive areas deep in the brain, specifically in the amygdala. That may be one reason why it makes little sense to ask a seven-year-old to tell you why she is

feeling sad or distressed. The part of the brain that does the talking, up in the cerebral cortex, has few direct connections to the part of the brain where the emotion is occurring, down in the amygdala.

In adolescence, a larger fraction of the brain activity associated with negative emotion moves up to the cerebral cortex. That's the division of the brain associated with our higher cognitive functions, such as reflection, reasoning, and language. So a seventeen-year-old is able to explain why she is feeling sad, in great detail and without much difficulty (if she wants to).

But that change occurs only in girls. In boys, the locus of brain activity associated with negative emotion remains stuck in the amygdala; there is no change associated with maturation.[12] Asking a seventeen-year-old boy to discuss why he's feeling glum may prove no more productive than asking a six-year-old boy the same question. Likewise, asking a teenage boy to write an essay about his feelings is not likely to produce results. He will probably write an essay embodying what he thinks you want to hear. There's no genuine connection between what he's feeling and what he's writing. Emotions—both positive and negative—are simply processed differently in girls' brains than in boys'.[13] In *Why Gender Matters,* I share a number of gender-specific techniques teachers have used in all-male schools to encourage boys to get excited about literature.[14]

The Lesson of Jean-Pierre Rampal

In spring 2004, I visited the Clear Water Academy, an independent school in Calgary, Alberta. The previous fall, the school's leadership had reinvented the school as a dual academy: girls in one wing, boys in another. All classes and activities became single sex—including the school band.

During all the years that the school was coed, its trumpet players were always boys, and its flute players were always girls. That didn't happen because the instructor told the boys to play trumpet or the girls to play flute; it happened because whenever girls and boys are together, their behavior inevitably reflects the larger society in which they live. Boys aren't supposed to play the flute—at least not when there are girls around.

Once the school's format was changed to single sex, though, the gender stereotypes crumbled. "If we're going to have a band, some of you boys are going to have to switch to the flute," the instructor, Andrew Bolen, told his boys. Several boys volunteered. Likewise, a handful of girls volunteered to learn to play the trumpet. To Mr. Bolen's surprise, some volunteers were much more talented with their new instruments than with the old ones. One boy who had been a mediocre trumpeter turned out to have great talent for the flute. He hadn't been enthusiastic about practicing the trumpet, either, but now he carried his flute with him everywhere and practiced at every opportunity. Likewise, a girl who had been only so-

so with the clarinet showed great natural aptitude for the trumpet, developing a pure, clear tone on the instrument almost immediately.

Had the band remained coed, it's doubtful whether that girl would ever have taken up the trumpet or that boy a flute. I was so impressed by what was happening at the Calgary school that upon my return home, I immediately ordered biographies of two of the greatest flute players of the past century—both men, and sure enough, both trained in all-boy ensembles: James Galway in Belfast, and Jean-Pierre Rampal in Marseilles.[15] Had those men been born and raised in our era and attended only coed schools, it's unlikely they would ever have touched a flute. And who knows what female trumpet or saxophone artists we have lost through the same practices?

That finding has been confirmed and broadened by a recent scholarly paper from the University of Virginia. The researchers found that boys who attended all-male schools are subsequently more than twice as likely to study subjects such as art, music, and foreign languages, compared with boys of comparable ability attending comparable coed schools.[16] Likewise, girls who attend all-girls schools are much more likely to study subjects such as computer science and physics than are girls of comparable ability attending coed schools.[17]

I have become convinced that this is the most important benefit of single-sex education—not that single-sex education can improve grades and test scores, although it can do that, but rather that single-sex education can broaden educational prospects for both girls and boys. It is a great paradox: coed schools tend to reinforce gender stereotypes, while single-sex schools, properly led, can break down gender stereotypes. At coed schools, computer science is for boys, and advanced foreign languages are for girls. At single-sex schools, girls can learn to love computer science, and boys compete to see whose French accent is best. At single-sex schools, girls can play the trumpet, and boys can play the flute.

Notes

1. This work is very capably reviewed by Diane Halpern in her book *Sex Differences in Cognitive Abilities* (Mahwah, N.J.: Lawrence Erlbaum Associates, 2000).

2. David Salyer, Edwin Lephart, and associates, "Sexual Dimorphism and Aromatase in the Rat Retina," *Developmental Brain Research* 126 (2001): 131–136.

3. See Christian Kaufmann, Gregor Elbel, and associates, "Frequency Dependence and Gender Effects in Visual Cortical Regions Involved in Temporal Frequency Dependent Pattern Processing," *Human Brain Mapping* 14 (2001): 28–38; Penny Seymoure and Janice Juraska, "Vernier and Grating Acuity in Adult Hooded Rats: The Influence of Sex," *Behavioral Neuroscience* 111 (1997): 792–800; Shinsuke Shimojo, Ellen Birch, Jane Gwiazda, and Richard Held, "Development of Vernier Acuity in Infants," *Vision Research* 24 (1984): 721–728; and Jane Gwiazda, F. Thorn, and associates, "The Development of Eye Alignment, Convergence, and Sensory Binocularity in

Young Infants," *Investigative Ophthalmology and Visual Science* 35 (1994): 544–553.

4. Pamela Dalton and associates, "Gender-Specific Induction of Enhanced Sensitivity to Odors," *Nature Neuroscience* 5 (2002): 199–200.

5. Leonard Sax, *Why Gender Matters: What Parents and Teachers Need to Know about the Emerging Science of Sex Differences* (New York: Doubleday, 2005). See especially chapters 2 and 5. You can find a list of some of the scholarly references relevant to sex differences in hearing at this link: <http://www.genderdifferences.org/hearing.htm>.

6. For example, Professor Joyce Evans and her associates, studying young women and young men, found "a predominance of *sympathetic* vascular regulation in men compared with a dominant *parasympathetic* influence in women." See their paper, "Gender Differences in Autonomic Cardiovascular Regulation: Spectral, Hormonal, and Hemodynamic Indexes," *Journal of Applied Physiology* 91 (2001): 2611–2618. See also Kevin Shoemaker and associates, "Gender Affects Sympathetic and Hemodynamic Response to Postural Stress," *American Journal of Physiology: Heart and Circulatory Physiology* 281 (2001): H2028–H2035. In this study, men showed significantly more sympathetic nervous system activity in response to postural stress and cold pressor stress than women did. Regarding parasympathetic nervous system activity, see S. M. Ryan and associates, "Gender- and Age-Related Differences in Heart Rate Dynamics," *Journal of the American College of Cardiology* 24 (1994): 1700–1707. These investigators, studying sixty-seven women and men, found significantly more parasympathetic influence in women's heart-rate dynamics than in men's. A related finding was subsequently reported by investigators in Leuven, Belgium: see D. Ramaekers and associates, "Heart Rate Variability and Heart Rate in Healthy Volunteers," *European Heart Journal* 19 (1998): 1334–1341. These investigators, studying 276 healthy women and men, found less sympathetic influence on heart-rate dynamics in women compared with men. See also Sheila Barnett, Lewis Lipsitz, and associates, "Effects of Age and Gender on Autonomic Control of Blood Pressure Dynamics," *Hypertension* 33 (1999): 1195–1200. In this study of eighty-nine healthy women and men, investigators found that women consistently demonstrated an "autonomic profile of reduced sympathetic and enhanced parasympathetic activity" compared to men (page 1199).

7. M. Y. Beshir and J. D. Ramsey, "Comparison between Male and Female Subjective Estimates of Thermal Effects and Sensations," *Applied Ergonomics* 12 (1981): 29–33.

8. The writer I am thinking of here is Michael Gurian, who has insisted that we don't need to replace coed classrooms with single-sex classrooms, we just need to train teachers in gender-specific teaching strategies. For example, he recently told the *Palm Beach Post* that single-sex education is "unrealistic": "I do not see a world where we will replace coed education with single gender." *Palm Beach Post,* "Separate but Better?" September 30, 2005, also available online at this link: <http://www.oxfordpress.com/life/content/shared/living/stories/GENDER_0916_COX.html>. Likewise, Mr. Gurian told the *Washington Times* that schools "would be better served by training teachers and parents to optimize learning for boys, rather than trying to separate them from girls." "Schools Learning about Boys," published October 10, 2005, in the *Washington Times,* available online at this link: <http://www.washingtontimes.com/metro/20051009-101240-2227r_page2.htm>.

9. You can learn more about our conference and request audio CDs of the various sessions at this link: <http://www.singlesexschools.org/conference.html>.

10. U.S. Department of Education, Office of Planning, Evaluation, and Policy Development, Policy and Program Studies Service, *Single-Sex versus Secondary*

Schooling: A Systematic Review (Washington, D.C., 2005). Although the five authors of this study describe their publication as a review, it is better understood as an annotated bibliography: the authors make no attempt to account for the variation in the papers they list, and their tabulation of their results is seriously flawed. The flaws in the design and execution in this study are described online at <http://www.singlesexschools.org/EdDeptStudy.htm>.

11. Personal communication from Alexander Alonso, October 24, 2005.

12. William Killgore, Mika Oki, and Deborah Yurgelun-Todd, "Sex-Specific Developmental Changes in Amygdala Responses to Affective Faces," *Neuroreport* 12 (2001): 427–433. The same group reported in a subsequent paper that the functional significance of amygdala activation in women appears to be different than it is in men. Specifically, they found that males and females "showed *opposite* patterns of lateralized amygdala signal intensity changes in response to happy faces." William Killgore and Deborah Yurgelun-Todd, "Sex Differences in Amygdala Activation during the Perception of Facial Affect," *NeuroReport* 12 (2001): 2543–2547.

13. Tor Wager and associates reviewed every study published between 1992 and 2002 that concerned brain areas activated by emotion. Although the character of brain activation varied depending on details of the experimental situation, one general finding was that emotions are processed in male brains differently than they are in female brains. Emotions are processed in male brains in more focal and lateralized regions (i.e., in the left hemisphere *or* the right hemisphere, but not both), whereas emotions are processed in female brains more globally and bilaterally. See Tor Wager, Luan Phan, Israel Liberzon, and Stephan Taylor, "Valence, Gender, and Lateralization of Functional Brain Anatomy in Emotion: A Meta-Analysis of Findings from Neuro-Imaging," *NeuroImage* 19 (2003): 513–531.

14. See especially chapter 5 of Sax, *Why Gender Matters*.

15. See Jean-Pierre Rampal with Deborah Wise, *Music, My Love* (New York: Random House, 1989); and also James Galway, *James Galway: An Autobiography* (London: Coronet, 1979).

16. Abigail Norfleet James and Herbert Richards, "Escaping Stereotypes: Educational Attitudes of Male Alumni of Single-Sex and Coed Schools," *Psychology of Men and Masculinity* 4 (2003): 136–148.

17. For documentation of this point, please see <http://www.singlesexschools.org/computers.html>.

Leonard Sax, M.D., Ph.D., is the executive director of the National Association for Single Sex Public Education (NASSPE). His book Why Gender Matters: What Parents and Teachers Need to Know about the Emerging Science of Sex Differences *was published by Doubleday in 2005 and reissued in an expanded softcover edition by Random House in February 2006.*