The Gendered Brain

An Honors Thesis (HONRS 499)

By

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Abstract

Education has become an important issue in political and social debates. Federal policies and school and teacher accountability has changed how America looks at curriculum, pedagogy, and standardized testing. President Bush’s No Child Left Behind Act has set the expectation that every child has the same opportunity to succeed and perform in school despite differences like race, gender, and socioeconomic class. Although striving for every child to succeed is a noble goal, the current structure of this program often causes individual needs to be buried under testing preparation. All students may have the ability to succeed, but differences among children can affect the ways they learn. Gender is one difference that has caused gaps in student performance. Schools are failing students by not looking at why boys and girls struggle in different subject areas. Researchers have purposed understanding biological differences between boys and girls’ brain development. Once there is an understanding of how brains function and develop differently between genders, observable classroom behaviors are easier to explain. Schools and classrooms can also be restructured to account for biological differences in order to eliminate gender gaps and give every student the opportunity to succeed.
Acknowledgements

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The Gendered Brain

"Boys will be boys." It is a common phrase, heard in classrooms and from parents everywhere. The idea that boys will perform, act, or act out in predictable ways is a common contemporary belief. This is often used as an excuse for why boys may not read or write as well in the classroom, or to explain away distractive behavior. Yet, what if the gender in this saying was reversed? What if "girls will be girls" was used to explain why a girl was struggling in math? The common response is outrage at an assumption that girls are not as capable as boys at something. In recent years, researchers and educators have made great efforts to come to the defense of girls in schools. The outcome is inspiring, as girls are encouraged to join math and science fields and the gender gap in test scores is narrowing. But what about boys? How can there still be casual remarks made dismissing and excusing why boys are struggling?

In many classrooms, gender differences are apparent but often ignored. In their book Brain Sex, authors Anne Moir and David Jessel (1991) state, "Most of us intuitively sense that sexes are different. But this has become a universal, unshared, guilty secret" (p. 10). Educators see the differences, but it has become taboo to draw attention to them. Boys and girls should be treated the same. Yet best practice today says that teachers should teach to the individual and individual needs. In recent years, extensive research has been done looking at the biological differences that exist in the brain between males and females. These differences impact how the two genders learn and act in the classroom. The research findings connect to the way boys and girls are being failed by schools. When using those findings to rethink classroom practices, teachers can create classroom environments that allow both genders to succeed and keep those excuses like "boys will be boys" out of schools.
How Schools are Failing Girls and Boys

By not giving attention to gender differences, schools have allowed themselves to “fail” their students. Within common school arrangements and practices, both boys and girls are missing valuable support, and their needs are not being met. Giving attention to the ways girls are failed has been the loudest of these discourses in recent years. One of the strongest voices in the fight for girls has come from the AAUW report *How Schools Short Change Girls*. The study starts by pointing out the current state of girls’ self esteem. Although girls enter school with confidence in skills and high ambitions, by the time they leave these two things have decreased in intensity, with a significant loss in math and science skills and overall self esteem (AAUW, 1995). Studies show that boys are an average of two to four points ahead of girls on standardized math and science tests (Gurian and Henley, 2001). Boys outscore girls in SAT-Math on an average 498 to 455 (AAUW, 1995).

The gender gap is not exclusive to test scores. What is worse is girls, no matter how they perform, are being discouraged from pursuing careers in mathematic and scientific fields: “even girls who take the same mathematics and science courses as boys and perform equally well on tests are much less apt to pursue scientific or technological careers than are their male classmates” (AAUW, 1995, 25). Even though the gender gap has narrowed on assessments and test scores, it still exists in how encouraged girls are in pursuing futures in these subjects.

Girls are failed in schools in other ways besides performance and support in mathematics and science. Female students also are at a disadvantage when looking at common characteristics of curriculum and teacher management. As a trend, boys tend to be gain teacher attention through loud, more physically aggressive behavior. This takes attention away from girls, who are often overlooked (Gurian and Henley, 2001). Many times teachers do not realize or reflect
upon management practice to recognize the female oversight. Language arts curriculum can also
affect the success of girls and their feelings of self worth. Schools that value classic texts,
minimize the impact of female authors by focusing on the male dominated cannon (Gurian and
Henley, 2001). By doing this, teachers are missing opportunities to encourage and empower
female students.

Although the findings by the AAUW and other research have prompted change in
schools for how the needs of girls are met, it is only recently that boys have gotten any attention
for the disadvantages they face in education. Because of the consideration it has been given, the
gender gap in math and science test scores has narrowed, but a significant gap still remains
between the genders on reading and writing scores: “The typical boy is a year and a half behind
the typical girl in reading and writing…” (Sommers, 2000, 60). There is a significant difference
in male and female performance on reading and writing, and this gap needs to be given the same
attention as mathematics and science. Other alarming statistics relate to student grades and drop
out rates: “Boys dominate dropout lists, failure lists, and learning disability lists” (Sommers, 61).
Boys make up 70-80% of the D’s and F’s assigned in schools. They account for 90% of the
discipline problems and 80% of the drop out rates. Two thirds of the students diagnosed with
learning disorders are males, as well as 90% of behavior disorders, and nearly 100% of severe
disability diagnoses (Gurian and Henley, 2001).

With these kinds of statistics, blame has to be shifted back to the institution, and teachers
and schools need to reflect on how they are teaching and interacting with boys. Some research
makes the claim that the school structure places boys at this disadvantage: “…girls appear to
have an advantage over boys in terms of their future plans, teachers’ expectations, everyday
experiences at school and interactions in the classroom” (Sommers, 2000, 70). Schools are
structures around time schedules, facts and rules, and there is predominance over verbal
instruction (Sousa, 2001). For the majority of boys this places them at a disadvantage based on
how they biologically process and interact with information, which will be looked at in detail
later.

These statistics of drop outs, failures, and disabilities, may contribute to current male
trends in post-secondary education. Although they achieve higher scores on college entrance
exams, males are less likely than females to go to college. In 1996, reports conducted by the
Department of Education reported that 8.4 million women enroll in college to only 6.7 million
males (Sommers, 2000). With the current research done on boys, many recognize the
importance of fighting for the success of boys in school. In her article “The War Against Boys,”
Christina Hoff Sommers (2000) calls for a balance when dealing with boys and girls: “We
should call for a balance, objective information, fair treatment, and concerted national effort to
get boys back on track” (p. 74). In today’s schools, both boys and girls are being failed by the
current structure and curriculum.

After recognizing the need to help both boys and girls in the classroom, some researchers
have turned to analyzing what makes the genders different and how this affects learning. Using
gender brain research has become a controversial topic in recent years. Very few people feel
comfortable acknowledging that there may be biological differences that give boys and girls
advantages over one another. After looking at the current state of males and females in schools,
though, action must be taken to change common practices to help students succeed. Gender
brain research presents possible causes for the problems boys and girls are facing and leads to
achievable solutions as well.
Some Items to Note

Due to the controversial nature of this topic, it is important to clarify some aspects of the research before presenting the findings. First, identifying differences and advantages within the biological make-up of male and female brains is not used to discourage one sex or the other from pursuing a certain field or to convince them they are not capable of success. These findings do not excuse the gender gap in test scores and classrooms, but can be used as a tool to teach students to their individual needs so that both genders have equal opportunities for success.

Researchers are also quick to point out that these are "statistical averages" (Durden-Smith and deSimone, 1983, 62). The findings do not say that every brain of every male or female develops and operates in definite ways. Most researchers see gender brain studies as a spectrum or averages, and "there will always be the exception to the average" (Moir and Jessel, 1991, 15). Not every child is going to fit into one type of brain or the other, but will fall somewhere in between. One of the leading names in gender brain research, Michael Gurian from The Gurian Institute and Patricia Henley (2001), explain, "Brain development is best understood as a spectrum of development rather than two poles, female and male" (p. 16). They describe the spectrum as the extreme male brain, the extreme female brain, and admit most children fall in between, favoring one side over the other. There are also males and females that are split equally between the two extremes. Gurian and Henley (2001) remind readers that the research is not used to stereotype genders but to gain wisdom. In his book, The Essential Difference, Simon Baron-Cohen goes as far as making the claim that the sex of a person does not determine the "gender" of their brain. He explains the spectrum as the systematizing brain (which is traditionally associated with males) on one end and the empathizing brain (which is traditionally associated with girls) on the other end. Baron-Cohen (2003) describes the brain as favoring one
of these two types of thought processing, and again acknowledges most people fall somewhere in the middle of these two extremes.

Before delving into the findings, there also must be an explanation of the history and process of the research done. Investigators looked at brains in different stages of development and in different cultures. Jo Durden-Smith and Diane deSimone (1983) explain, "Some of these differences...appear extremely early in life. And others are more obvious after puberty. But the fascinating thing is that they seem to be independent of culture" (p. 59). Males and females from around the world were studied and the findings were consistent despite cultural differences. Two decades later, The Gurian Institute studied thirty cultures to check and counter check their findings and found once again, the gender brain differences to be consistent throughout the world (Gurian and Henley, 2001).

Looking inside the brain for gender differences is a contemporary study. Historically behaviorists were relied upon to explain brain functioning. What was going on inside was determined by outside actions. The 1990's was declared the "Decade of the Brain," and new technology was used to research the brain internally. This technology consists of computerized tomography (CT) scans, positron-emission tomography (PET), and magnetic resonance imaging (MRI). CT scans help to detect malformations in the brain. PET scans show where brain activity occurs and MRIs show the changes in the brain. A greater understanding of neurotransmitters has also contributed to brain research. Neurotransmitters are brain chemicals associated with various brain functions. (Sousa, 2001) These new understandings and new technologies have greatly enhanced the knowledge available concerning the brain and have allowed discoveries in the biological differences in the minds of boys and girls.

* See Appendix 3: "Areas of the Brain" for more information about the parts of the brain.
Understanding Gender Brain Differences: The Lateralized Brain

Understanding gender differences within the brain starts with an understanding of its structure. The human brain is divided into two hemispheres, left and right, the analytical left and holistic right (Durden-Smith and Diane deSimone, 1983). Each of these hemispheres is credited with different roles and skills. The left side of the brain is considered responsible for verbal abilities and analytical processing. Skills that are said to be controlled by this hemisphere are speaking, writing, reading, language, and logical, sequential processes. The right side is accountable for visual processing. It handles spatial reasoning and skills like sense of direction, understanding the “Big Picture,” basic shapes and patterns, abstract thought processes, and certain emotional responses (Moir and Jessel, 1991). In the Essential Difference, Baron-Cohen (2003) explains the right hemisphere as specialized in systemizing and the left hemisphere specialized in empathizing. According to Baron-Cohen (2003) systematizing is “the drive to analyze, explore, and construct a system.” Empathizing is defined as “the drive to identify another person’s emotions and thoughts, and to respond to them with an appropriate emotion.” (Baron-Cohen, 2003, p. 2)

When looking at the two hemispheres in the brain and their specialized roles, the tendency of many is to assign genders to each side. Boys are thought to be “right brained” and girls “left brained,” which correlates with common gender behaviors and a male-math advantage or a female-language advantage. One theory for why genders seem to rely on one hemisphere over the other is the Hormone Theory (Sousa, 2001). Fetal brain studies show that the surges of testosterone during pregnancy impact the development of brain hemispheres. Larger amounts of testosterone increase the development of the right hemisphere and decrease the growth and
development of the left hemisphere (Baron-Cohen, 2003). Males receive more testosterone during those pre-natal months, which may account for the male-right brain preference.

Dividing the brain in half and assigning each to a gender, though, is not enough to explain differences in boys and girls. Researchers have taken a deeper look at the brain to discover it is more than a hemisphere preference. How information is processed within and between the left and right brain plays a significant impact as well. Boys and girls’ brains respond differently when processing information: “PET scans and fMRIs...indicate that males and females use different areas of their brains when accomplishing similar tasks” (Sousa, 2001, 173). How boys and girls use and store information is very different. Studies using subjects who had damaged part of their brains added insight into how the male and female brains work. In studies of both men and women who had damaged the left side of their brains, men performed poorly on verbal tests, while women seemed unchanged. Similarly, when looking at subjects with right brain damage, males had trouble performing spatial tasks while, again, women seemed unaffected. Further studies showed it took damage to both hemispheres to affect female performance (Durden-Smith and Diane deSimone, 1983). These studies, and others like it, led researchers to conclude men have more lateralized, or specialized, brains. Males have specific areas for language and spatial skills, where as females use both sides of their brain for these abilities.

Part of what accounts for these differences is the development of the corpus callosum in boys and girls. The corpus collasum is a “thick cable of over 250 million nerve fibers” that connects the right hemisphere to the left hemisphere (Sousa, 2001, 19). The corpus callosum is up to 20% larger in women than it is in men (Gurian and Henley, 2001). This allows more connection and “cross talk” between the two hemispheres. Lateralization of the male brain and
the advantage of the female corpus callosum also relates to how girls and boys process emotional, or emotive, information. When exposing males and females to visually-emotional materials on both sides of their heads, women responded each time to the material. Men only responded when viewing the material on the left side of his head, which is controlled by the right brain. Because of their lateralized brain, men have trouble expressing emotions, a right brain process, through language, a left brain process. Women have trouble, on the other hand, separating emotion from reason since they use both sides mutually for each task (Moir and Jessel, 1991).

Other Gender Brain Differences

Besides how and where information and skills are processed or controlled, other differences exist in the brain and in brain development that make distinctions between the male and female brain. Hormones, neurons and neurological connections, and other structural differences account for the gendered brain. The male hormone, testosterone, and female hormones estrogen and progesterone impact brain development. Testosterone, as mentioned before, increases development in the right hemisphere which is connected to enhanced visuo-spatial skills in boys, whereas estrogen and progesterone depress visuo-spatial skills in females (Moir and Jessel, 1991).

Testosterone also increases aggressive behavior in males and a tendency towards social dominance, which differs from the bonding hormone progesterone in females which places value on attachment in social relationships first (Gurian and Henley, 2001). This sex hormone causes many boys to establish relationships through domination and aggression. Unlike females who go through hormone cycles each month, males receive up to seven surges of testosterone per day,
which affects mood changes throughout the day (Gurian and Henley, 2001). Female hormones enhance coordination in girls and help with fine motor coordination and finger dexterity (Durden-Smith and Diane deSimone, 1983). Estrogen and progesterone increases at puberty and causes growth in the female hippocampus, which can lead to better memory (Gurian and Henley, 2001).

Neurological and sensory differences in the brain can contribute to gender differences as well. Neurologists have observed that the male brain enters a “rest state” when not engaged in order to “recharge and reorient itself.” This occurs many times throughout the day. Girls’ brains are able to do complete these tasks without rest states. Often the rest states result in boys falling asleep during lectures or tapping their pencils to “wake their brains up” (Gurian and Stevens, 2004). Serotonin levels in the brain also impact student behavior. Boys secrete less serotonin in their executive decision making area of the brain, the pre-frontal cortex. Serotonin is a calming neurotransmitter and lower levels can make males fidget and be more impulsive (Gurian, 2006).

The female brain, due in part to cross-talk, is organized to receive more sensory information. This allows girls to make more connections to information, and, like with the bonding hormone, place more emphasis on personal relationships and communication (Moir and Jessel, 1991). Also, stronger neural connections in the female temporal lobes increase listening skills, auditory discrimination, and results in a sensually detailed memory (Gurian and Stevens, 2004). Females process more emotional stimuli through the senses and are able to verbalize emotions quickly. They move emotive material to the upper brain for processing, which is the area responsible for complex thought. Males move emotive information down to the brain stem, where fight or flight takes place. This results in slower emotive processing and boys becoming either aggressive (fight) or withdrawn (flight) (Gurian and Henley, 2001).
Further structural and developmental differences set male and female brains apart. These differences impact how, where, and when boys and girls process information. On average the female brain matures earlier. Girls acquire complex verbal skills about one year earlier than boys. A preschool girl reads faster and with a larger vocabulary than her male classmates (Gurian and Henley, 2001). Females also start talking approximately one month earlier than boys (Baron-Cohen, 2003). Development in the prefrontal and occipital lobes occurs earlier for girls, and their prefrontal lobe remains more active than males’ prefrontal lobes. This leads to more sensory processing, executive decision making, and self-monitoring skills (Gurian and Henley, 2001). Structurally, where boys and girls process language skills differs. Grammar, spelling, speech, and punctuation skills are concentrated in the front part of the female brain. These functions are located in both the front and back of male brains, placing boys at a disadvantage with these skills since they have to pull from two different areas (Moir and Jessel, 1991).

The Gendered Brain in the Classroom

All of differences found in the brains of boys and girls have significant impact on how they perform in the classroom. In academic discourse, the focus has been on mathematics and language. Gender brain differences provide many explanations for these behaviors, but they also account and express themselves in students’ social interactions, how they process information, their types of reason and actions. Understanding first how the brains of boys and girls are structured enhances understanding of their observable behaviors.

Due to the importance placed upon them by curriculum, testing, and now in federal agendas, considerations for math and language differences are a priority in gender brain research.
Brain lateralization and development help explain the gender gaps. Looking at left and right brain functions can account for gender strengths in different types of math. The analytical left brain, which girls favor, helps female students succeed in sequential math and arithmetic calculations (Sousa, 2001). Males’ increased visuo-spatial abilities allow them to excel in higher-level abstract math (Moir and Jessel, 1991). As abstract, visual learners, boys are more successful at calculating without having to see or touch objects. Girls often have trouble visualizing and rely on manipulatives (Gurian and Henley, 2001). As mentioned before, Baron-Cohen’s (2003) theory of the systematizing male brain also helps males analyze and pull apart mathematical processes. It is difficult for male students to verbalize their mathematic reasoning, since the two skills are located in different parts of the brain. Females, however do better representing mathematical reasoning through language, since the skills are performed in the same areas of the brain (Moir and Jessel, 1991).

Brain research can also account for language differences in the classroom. When speaking and writing, girls tend to verbalize to a greater extent and at a higher fluency than boys (Sousa, 2001). Girls also take in and make connections to more sensory elements, which result in more detailed writing and explanations, including colors, emotions, and other descriptions (Gurian, 2006). They are able to empathize and read the emotions in others better through cross-talk, which helps in understanding the feelings of characters in literature (Baron-Cohen, 2003). Boys find coded language and jargon more interesting for its visual appeal, whereas girls prefer language that they can conceptualize in usable everyday experiences (Gurian and Henley, 2001). As visual and spatial learners, boys rely more on pictures and moving objects for words in order to make connections (Gurian 2006). They also tend towards symbolic texts diagrams and graphs.
and can grasp an author's patterns of symbolic imagery. As abstract thinkers, boys prefer making theoretical arguments and philosophical and moral debates. (Gurian and Henley 2001).

Beyond math and reading, gender differences shed light on other ways students deal with information. Gender differences in the brain contribute to how reasoning and logic is used by boys and girls. Boys tend to be deductive learners, taking apart concepts and reasoning from general principles. This helps them with multiple choice and times tests. Girls generally use inductive reasoning, beginning with a specific example and building to a general theory. This type of reasoning gives them an advantage on essay and short answer tests. (Gurian and Henley, 2001).

Boys and girls differ in their use to logic and evidence as well. Due to their cross-talk in the brain and greater sensory input, female students hear more of what is being said and are receptive to a variety of details. They are confident using a complex flow of conversation, yet have less of a need to dominate discussions. On the other hand, since they receive fewer sensory details and lateralize language and reason, boys hear less of what is being said and ask for more clear evidence to support a claim (Gurian and Henley, 2001).

Differences in the brain can also correlate to observations made on student behavior and classroom management. How students carry out procedures, interact with one another, and behave in the classroom can relate back to the make-up of the male and female brain. Girls tend to be better at self-managing boredom, sitting still, listening, multitasking, and transitioning between lessons. Boys need more varying stimulants to offset boredom, which can result in them either acting out or giving up. Due to their lower serotonin rates and higher metabolism, boys use constant movement to stimulate the brain and manage impulsive behavior. As spatial learners, use of space plays a large role in boys’ classroom behaviors. They tend to use more
space when learning, which often results in them talking over of the space of a neighboring female classmate. (Gurian and Henley, 2001). Boys also like to move objects through space, like throwing a ball or dramatic play. In relation to their lateralized brains, male students also are task-oriented in their discussions and interactions (King and Gurian, 2006). One other male behavior apparent in boys is the need for competition, which actually stimulates learning through the onset of hormones like testosterone (Gurian, 2006).

Boys and girls also vary in their social interactions, which again can relate to biological brain functions. Girls value relationships and bonding, making it easier for them to master cooperative grouping. They are able to learn while attending to codes of social interaction. Many of the relationships formed by girls are done so through verbalization. Boys, on the other hand, are more aggressive and competitive. They tend to arrange themselves in a pecking order, which can be dangerous for boys low in rank. This order is determined by physical size, verbal skills, personal abilities, and personality. Males are more likely to fail if they are seen as unpopular due to the stress hormone cortisol. The hormone is at higher levels when boys have feelings of worthlessness. The male brain must first attend to emotional and survival stress before dealing with learning. (Gurian and Henley, 2001)
### PRESCHOOL AND KINDERGARTEN (continued)

<table>
<thead>
<tr>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Games involve bodily contact, tumbling, continuous flow of action</td>
<td>• Games involve turn taking and indirect competition most of the time</td>
</tr>
<tr>
<td>• Primarily interested in objects and things</td>
<td>• Primarily interested in people and relationships</td>
</tr>
<tr>
<td>• Saying good-bye to mom takes approximately thirty seconds</td>
<td>• Saying good-bye to mom takes approximately ninety seconds</td>
</tr>
<tr>
<td>• Uses dolls for attack weapons and warfare</td>
<td>• Uses dolls for playing out domestic scenes</td>
</tr>
<tr>
<td>• More speech problems</td>
<td>• Fewer speech problems; seems to differentiate sounds better</td>
</tr>
<tr>
<td>• Picks same-gender peers for friends</td>
<td>• Picks same-gender peers for friends</td>
</tr>
<tr>
<td>• Expresses emotions through action</td>
<td>• Expresses emotions through words</td>
</tr>
<tr>
<td>• Less sensitive to social and personal context</td>
<td>• More sensitive to social and personal context</td>
</tr>
<tr>
<td>• Less attention span and empathy</td>
<td>• Greater attention span and empathy</td>
</tr>
</tbody>
</table>

### GRADES 1–3

<table>
<thead>
<tr>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Takes longer to attain reading mastery</td>
<td>• Reads better and sooner than boys</td>
</tr>
<tr>
<td>• Superior at certain visual tasks in bright light</td>
<td>• Superior at seeing in low light</td>
</tr>
<tr>
<td>• Better at test requiring circling of answers</td>
<td>• Superior at hearing</td>
</tr>
<tr>
<td>• Hypothalamus functions to keep hormonal levels even</td>
<td>• Better at test requiring listening to questions being read</td>
</tr>
<tr>
<td>• Better general math</td>
<td>• Hypothalamus functions to fluctuate hormone levels</td>
</tr>
<tr>
<td>• Better at three-dimensional reasoning</td>
<td>• Better verbal ability</td>
</tr>
<tr>
<td>• More rule-bound than girls</td>
<td>• Better at grammar and vocabulary</td>
</tr>
<tr>
<td>• 95 percent of hyperactive children</td>
<td>• Less bound by arbitrary rules</td>
</tr>
<tr>
<td>• More able to separate emotion from reason</td>
<td>• Only 5 percent of hyperactive children</td>
</tr>
<tr>
<td></td>
<td>• Less able to separate emotion from reason</td>
</tr>
</tbody>
</table>

### GRADES 4–6

<table>
<thead>
<tr>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hormones begin to increase at age ten</td>
<td>• Affected by hormone changes earlier than boys</td>
</tr>
<tr>
<td>• Primarily focused on action, exploration, and things</td>
<td>• Primarily focused on relationships and communication</td>
</tr>
<tr>
<td>• More likely than ever to use aggression to resolve differences</td>
<td>• Unlikely to settle differences with hitting</td>
</tr>
<tr>
<td>• Better at reading maps and deciphering directions</td>
<td>• Better at fine-motor skills and coordination for fine tasks</td>
</tr>
<tr>
<td>• Better at chess</td>
<td>• Better at learning a foreign language</td>
</tr>
</tbody>
</table>

Figure 1 (Gurian & Henley, 2001, P. 36)
<table>
<thead>
<tr>
<th>GRADES 4–6 (continued)</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td><strong>FEMALE</strong></td>
</tr>
<tr>
<td>• More likely to need remedial reading</td>
<td>• More likely to sing in tune</td>
</tr>
<tr>
<td>• Solves math problems without talking</td>
<td>• Solves math problems with language help</td>
</tr>
<tr>
<td>• Channel surfs on TV</td>
<td>• Watches one program for longer period</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIDDLE SCHOOL</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td><strong>FEMALE</strong></td>
</tr>
<tr>
<td>• Testosterone develops body at ratio of 40 percent protein to 15 percent fat</td>
<td>• Estrogen develops body at ratio of 23 percent protein to 25 percent fat</td>
</tr>
<tr>
<td>• Testosterone indisputably an aggression-inducing chemical</td>
<td>• Estrogen generates greater activity in the brain (first phase of menstruation, increased concentration)</td>
</tr>
<tr>
<td>• When talkative in class, often attention-seeking</td>
<td>• When quiet in class, often confident</td>
</tr>
<tr>
<td>• 50 percent more likely to be held back a grade than eighth-grade girls</td>
<td>• 50 percent less likely to be held back a grade than eighth-grade boys</td>
</tr>
<tr>
<td>• Amount of male hormone relates directly to success at traditional male tasks</td>
<td>• Amount of female hormone relates directly to success at traditional female tasks</td>
</tr>
<tr>
<td>• More likely to be victim of physical abuse</td>
<td>• More likely to be victim of sexual abuse</td>
</tr>
<tr>
<td>• Hypothalamus functions to fluctuate levels based on a twenty-eight-day cycle</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HIGH SCHOOL</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td><strong>FEMALE</strong></td>
</tr>
<tr>
<td>• Concentration on things directed at career considerations</td>
<td>• Concentration on more intimate personal relationships</td>
</tr>
<tr>
<td>• Focus on strength and muscularity for sexual attractiveness (fearing weakness)</td>
<td>• Focus on slender appearance for sexual attractiveness (fearing obesity)</td>
</tr>
<tr>
<td>• Social acceptance based on physical strength and athleticism</td>
<td>• Social acceptance based on peer relationships and beauty</td>
</tr>
<tr>
<td>• More likely to be involved in criminal behavior</td>
<td>• Less likely to be involved in criminal behavior</td>
</tr>
<tr>
<td>• In one study 69 percent of males suggested “fighting” as best way to resolve conflict</td>
<td>• In one study 69 percent of females suggested “walking away or talking things out as the best way to resolve conflict”</td>
</tr>
<tr>
<td>• Social hierarchies tend to be stable (boys “know their place”)</td>
<td>• Social hierarchies tend to be fluid</td>
</tr>
<tr>
<td>• Pursuit of power a universal male trait</td>
<td>• Pursuit of comfortable environment a universal female trait</td>
</tr>
<tr>
<td>• Achieves far greater academic success after puberty</td>
<td>• Higher-than-normal estrogen level produces certain intellectual disadvantages</td>
</tr>
<tr>
<td>• IQ scores rise dramatically between fourteen and sixteen</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 2 (Gurian & Henley, 2001, p. 37)*
Accounting for Gender Differences in the Classroom

Just acknowledging that differences in the brain account for gender gaps and variations in the classroom is not enough. Understanding boys and girls' brain functions does not make excuses for why boys and girls are struggling. These findings need to be used to change common practice in schools and differentiate instruction to meet individual gender needs. In their book *Boys and Girls Learn Differently!* Michael Gurian and Patricia Henley (2001) present ideas for how to structure for gender specific teaching.

The first change Gurian and Henley suggest is restructuring the school day and the school year. They believe that finding the best schedules highly impact student (p. 127). Through research they have done, Gurian and Henley conclude that year round schooling and a later start time can assist in gender success. Year round schooling will help both genders by minimizing the break time when brains are not engaged with these subjects. A later start time will extend the school day until 3:30, which cuts into the hours of 3:00 PM and 6:00 PM. Studies have found there are the most common times for delinquency and risky behaviors. This could help reduce the number of discipline problems and drop out rates common with boys.

Another way to help students of both genders is to minimize the student to teacher ratio. Smaller class sizes or more one-to-one teacher time encourages brain development and helps with bonding, which both males and females need for their emotive processing. Unfortunately this is not something that can automatically be achieved in all schools. Yet, even when class size is uncontrollable, pulling in teacher assistants, volunteers, and inviting other teachers in to the classroom can help achieve the results of smaller classrooms: “A learning brain that...experiences the presence of more than one teacher in a classroom for a least part of the day, enjoys more neurological variety in learning and cultural experience” (130). Inviting
community members and other teachers into the classroom, gives students more individualized attention and increases bonding. Even asking for volunteers to read to the class can encourage learners, especially inviting fathers and grandfathers, who can provide positive role models for boys.

Peer mentoring is also a way for individualized attention. Having a “buddy” from another grade, gives younger students the opportunity to form emotional attachments while learning. It also gives older students confidence as they teach their little buddies. These same types of principles can be seen in multigenerational classrooms as well, which provide peer teaching and peer bonding opportunities everyday.

Bonding and attachment is important because brains learn better when they have a feeling of stability: “Young children learn best when they learn from someone with whom they are intimately attached” (Gurian and Henley, 2001, p. 75). More individualized attention is one way of forming those attachments to reach all students. Other interactions impact attachment as well. Commonly, male students receive more attention throughout the day from teachers, yet often, the bond between boys and teachers is negative. Girls receive, and tend to seek, less attention, but form positive bonds. Teachers must rethink procedures and management to counter-act these findings. Some suggestions include giving all students time for feedback on how they are doing, or what activities they liked or disliked from the previous day. Teachers also need to form personal relationships with each student, giving attention to their interests and abilities. Teachers can also increase bonding in the classroom by providing opportunities for students to meet after-school with them for an activity or club.

Although these ideas for attachment increase emotive stimulus in the brains of both genders, they cannot eliminate emotional stress in the classroom. Girls’ brains process
emotional stress more quickly due to cross talk and can verbalize problems better. They also deal with stress in their upper brains, allowing for more complex thought about the emotions they are feeling. Handling their emotional stress is something that can generally be done without distracting the rest of the class. Boys' brains, however, have trouble verbalizing their emotional stress. Because emotive processing is done at the brain stem, where fight or flight takes place, boys take longer to process emotional stress, cannot learn as well when dealing with stressor, and will become withdrawn or aggressive. This is often expressed when boys act out or “blow up” in the classroom. Some suggestions for handling emotional stress are to allow for movement, give opportunities for talk, and teachers guiding students through solutions. When students are about to “blow,” sending them on errands or allowing them to go to a buddy classroom where they feel stable can help male students manage their stress. Teachers are also encouraged to use a timer rule when dealing with highly emotional students. Set the timer to allow the student to calm down, explain to the student that when the timer goes off he or she will talk about his or her problem or behavior.

Acting out or becoming aggressive while trying to process emotive information is one of the reasons boys find themselves at the end of many discipline referrals. When teachers do not understand why a male student is behaving in a certain way, they are less likely to know what needs are not being met. Becoming aggressive or acting out is not beneficial for class as a whole, and understanding brain processing should not allow or give excuses for male students to be harmful. It can help teachers re-think their classroom management and discipline, though. Gurian and Henley (2001) make the point that often “boy” behavior does not require discipline action, but rather rethinking an activity, re-engaging the student, or providing an alternative outlet. When students do act out, teachers should express disappointment and work with the
student to understand how to handle emotions or behaviors. Boys and Girls Learn Differently! (2001) also offers techniques for teachers to use when students have committed an offending act. The first step is teacher-student contact. Teachers should ask students why they think they are being pulled aside or what might have been wrong about the behavior. Asking students to write about their behavior is also beneficial, especially for male students who must focus on pulling their emotions over to their verbal and reasoning side of the brain. Since this is not a naturally easy task for them, teachers need to make sure they allow the boys enough time to write and process. After this step, if problems persist, the teacher should make contact with the parent, then notifies the principle if this step does not eliminate the behavior. If there still is not a change, the teacher should go to the support personnel and only exclude the student as a last possible step. (Gurian and Henley, 2001)

Rethinking the traditional classroom can also help cut down on some of the gender problems addressed. The outdoor classroom is one way Gurian and Henley suggest restructuring schools. Using the outdoors as a place of learning can benefit both genders. Brain growth is connected to physical activity and natural environments, both available through the outdoor classroom. It also allows movement for boys to manage their high energy and metabolism. Outdoor activities give girls opportunities for socialization and talk, which is directly related to their processing and learning.

Another suggestion for classroom set-up, is an increased use of computers and media. Using technology can combat male setbacks such as attention span and can increase imagination and reading and writing functions. Boys are shown to be at an advantage when dealing with media and computers, favoring systemizing and deductive thinking. Exposing girls to these technologies, especially computers, is important for their development. Computer use and visual
media can help girls increase their spatial awareness, which can cross over into other disciplines like math and science.

Adding cooperative and competitive learning to the classroom can help boys and girls learning as well. Cooperative learning benefits both males and females. It stimulates the growing brain through verbal and physical interactions. Cooperative learning also is able to impact different students in different ways, allowing for individual needs in the classroom. The same can be said for competitive learning. Although currently considered a “bad” word in schools, competition is actually positive for male learning. Competition stimulates neurotransmitters and hormone releases in boys, enhancing learning. It is also important that both males and females learn the importance of “fairness” in the classroom setting.

Like structural and discipline changes, rethinking approaches to academics can allow teachers to give their students the best opportunities for success. When instructing in both language arts and mathematics, teachers need to keep in mind gender variables and differentiate instruction to meet the needs of boys and girls. Allowing students to draw while the teacher is reading or in response to a text, is one way male students can benefit in the language arts classroom. Often boys benefit from creating storyboards as a part of pre-writing, which allows them to get ideas out in a spatial format before having to transfer them to a more difficult mode of communication (King and Gurian, 2006). Also, using manipulatives like magnetic letters and index cards gives visuo-spatial dominate males the opportunity to engage with text through methods in which they are most confident. Teachers also need to understand the importance of wait time when asking language arts questions in class. Male students take longer to process emotive information and transfer it into language. Giving them time to go through this process can increase their ability to answer and develop thinking. Stimulating other senses during
language arts instruction can also help males during language arts instruction. Females automatically take in more sensory information, which can be seen in the details of their writing. Playing music while students are working or even providing a snack, activates other sensory information in boys, moving them closer to the female advantage.

Though girls tend to be more successful in the language arts classroom, they can not be overlooked when developing academic practices. Providing a variety of learning modalities can benefit girls in reading and writing. Girls learn best when given a variety of ways to learn, such as tutoring, journaling, debate, and cooperative grouping. Due to their greater and often more complex emotive processing, girls also need more encouragement in the classrooms. Some teachers have observed that calling on “every girl, every day” increases female confidence and abilities to achieve. Giving verbal feedback also supports girls in their development, as well as providing positive female role models in literature and non-biased materials. Females can benefit from separate sex learning, as well. Separating sexes can allow female students, who have less of a need to dominate conversations, more opportunities and confidence to talk and discuss literary ideas.

As with the language arts classroom, teachers can rethink how they teach math and science in relation to brain differences to help both genders be successful. Visual and spatial elements can be added to reading and writing to increase the success of male brains. Likewise, verbal concepts and activities can be added to math and science to help girls learn and develop in these areas. Gurian and Henley first suggest externalizing the thought process in math, which requires working “outside the students’ heads” (181). Talking out strategies along with use of visuals can benefit boys and girls. Female students are able to engage in abstract ideas through a comfortable mode, and boys are able to increase their verbal abilities when discussing ideas they
have and advantage in understanding. Other ideas for a gendered math classroom are incorporating writing and role play into instruction, peer tutoring, providing concrete and tactile experiences, and building confidence. Female students also greatly benefit from manipulatives for abstract math ideas and the use of group work, which allows for more talk and verbal processing.

Conclusions

Rethinking classroom structure, teaching strategies, and management procedures allows students from both genders to be successful. Teachers have often noticed a difference in gender behavior but have never been given an explanation. Understanding the brain helps teachers to see there are biological differences in how their students process and approach a variety of information. Observable behaviors can be connected to these differences, and both are used to construct classrooms more equipped for the success of boys and girls. Recognizing differences and understanding the brain does not mean excusing gender gaps. The research that has been done in this area give teachers and schools tools for teaching to students' individual needs and differentiating instruction. The goal of gendered classrooms and brain findings is to narrow and even eliminate the gender gap in student success and give both boys and girls equal opportunities to achieve.
Appendix 1: The Arts in a Language Arts Classroom

“We have never discovered a culture on this planet, past or present, that doesn’t have art. Yet there have been a number of cultures—even today—that don’t have reading and writing” (Sousa, 2001, p. 214). Before children can read or write, they are able to sing, draw, and dance, making these art skills natural parts of human maturity that develop cognitive areas, gross motor skills, engage the senses, and enhance emotional well being (Sousa, 2001). In today’s schools, though, art programs are being cut from the curriculum due to funding while more money is given to developing reading and writing programs. Schools and teachers are being held accountable for their students test scores in reading and writing, making these disciplines a priority. Research has shown, though, that art is crucial to a child’s cognitive development and can actually improve student achievement in reading and writing.

Advocates for art-based literacy programs believe “drama, dance, music, and visual art should be integral to literacy instruction because they are essential means of constructing meaning” (Cornett, 2006, 235). Gender research shows that male and female brains process information in different ways. The arts provide multiple ways of constructing meaning in reading and writing, allowing for biological differences in learning and helping to decrease the gender gap in language arts assessment.

There are a number of general findings about art-based literacy that account for its success in the classroom for both genders. Claudia E. Cornett (2006) points out that, “Without the arts, learners are limited to reading, writing, speaking, and listening to process ideas” (p. 235). Brain studies show that lateralized male brains struggle with these skills, contributing to lower test scores and overall achievement in language arts. Without taking into account gender differences, educators can look at male performance in the classroom in areas of reading,
writing, listening, and speaking and assume that boys are “just not getting it.” Eisner (2000) argues, though, “the limits of our language do on define the limits of our cognition” (p. 8, as quoted in Cornett, 2006, p. 236). Brain studies show that male brains have trouble verbalizing reasoning and emotion because the process requires transferring information from one side of their brain to another. Their responses in language, then, may not provide a full picture of their understanding. Art-based literacy assists boys in reading and writing by providing opportunities to respond and communicate verbally and nonverbally (Cornett, 2006). Students are able to express their thoughts and emotions through movement, drama, music, or visual imagery, rather than being limited to reading, writing, or speaking. This helps females in language arts as well because, as mentioned above, they benefit from having multiple learning modalities.

Incorporating visual arts into the classroom is one way for teachers to engage their students in art-based literacy. Students can both respond and create visual art to engage in reading, writing, and learning. Using imagery or mentally visualizing objects and events is a crucial way the brain stores new information (Sousa, 2001). The internal visual processing system used when engaging with visual art can “recall reality or create fantasy with the same ease” (Sousa, 2001, p. 214). Using visual art to teach language arts allows students to engage with text at a greater complexity and gives the brain more options for processing and storing information. When students are given the option to create visual art in response to a text, male students are able to process their thoughts and emotions through visuo-spatial modes, which eliminates crossing hemispheres to communicate ideas in language. Once initial processing has occurred, it becomes easier to transfer the information to the left side of the brain for written or spoken responses. This also explains why it is better to allow students, especially male students, the opportunity to create story boards before writing. They can formulate ideas visually first,
before using language. Girls also benefit from responding to text through visual art because it requires them to practice mental visualization to increase visuo-spatial processing skills.

Responding to visual art improves students’ language arts skills, as well. Asking students to “read” a painting requires them to look at the imagery first, which “sharpens the students’ analytical skills and enriches language in the classroom” (Ehrenworth, 2003, p. 45). Reading a painting asks students to make observations and interpretations, just as they would with a text. Students think about what ideas and emotions the artist was trying to portray and how the artist was able to express them to the audience. Thinking analytically about visual art comes easier for males than thinking about written text because of same-side processes. Practicing analytical skills through visual art is a stepping stone for thinking and interpreting text (Enhenworth, 2003).

Poetry is often used to transition students from responding to visual art to using words in writing. Poetry is creating imagery through words, but with a limited dependence on language, by attempting to say the most through the least (Ehrenworth, 2003). Poetry and visual art both “begin with looking and do not assume a certain level of literacy in order for children to be successful as writers” (Ehrenworth, 2003, p. 44). Using poetry to transition emergent writers helps to develop voice, add details, use patterns, and engage in symbolic thought.

Music is another way the arts can be used to make connections for students. Music is an important part of development because certain structures in the auditory cortex respond only to music (Sousa, 2001). Music can impact learning when students engage in listening and composing. Listening to music produces signals in the auditory cortex in the right side of the brain that process pitch, melody, and harmony, which is then connected to emotions, past experiences, and thoughts (Sousa, 2001). Stimulating the brain through music can help students to make connections and create meaning. Composing music provides another mode for students
to respond to literature using a right brain function and can also increase spatial-temporal reasoning, which is developmentally valuable to female brains. Music also benefits language arts instruction because it is a whole brain activity. Although music processing is found in the right side of the brain, rhythm is processed in the left side of the brain (Gurian and Henley, 2001). Music activates both sides of the brain, which assists cross-hemisphere language processing in lateralized brains.

Drama is another art form that can increase success for all learners in the language arts classroom. Dramatic play impacts all students as they engage with text and adds to the complexity of their reading and writing. Drama satisfies the need for movement many boys have due to their high metabolism and fidgeting. It also provides them with another way to connect verbal skills and emotions through the cerebrum. The cerebellum coordinates motor functions and, when activated, sends signals to areas of the cerebrum that stimulate attention, memory and spatial perception (Sousa, 2001). There are also specialized areas of the cerebrum that deal with acquisition of spoken language and connect to the limbic system to add emotional components to language (Sousa, 2001). Reader’s Theater and performance readings help male students who favor systematic thinking and struggle with empathy to understand characters. These activities ask students to take on the role of a character and try to think how the character is thinking or feeling. Movement and drama stimulate emotional responses and connects the reader to the text.

Using dramatic play can also help students to add details and complexity to their writing. Deborah Wells Rowe, Joanne Deal Fitch, and Alyson Smith Bass (2003) discuss using “Toy Stories” in their language arts classrooms as a part of a writing work shop. Students were allowed to “play” with toys to gain ideas for characters and stories. They found students’ writing to be more reflective, detailed, and aware of their audiences’ reactions (Rowe, Fitch, & Bass,
2003). Toy stories ask students to experience stories kinesthetically before requiring them to write. This experiential re-writing, allows time for brain activity to stimulate emotion, sensory details, and thoughts and transfer them to language.

Using drama, music, poetry, and visual arts give students a variety of modes to respond and engage with texts. In many ways the arts are a more natural part of development than reading or writing, and participating in art activities can be done with confidence. The arts provide entry points for students to interact with text and add complexity to these interactions. Both genders benefit from art-based literacy to improve reading and writing. Even if art programs are being cut from schools, it is important that the arts make their way into every language arts classroom.
**Appendix 2: Autism and the Male Brain**

When looking at gender brain research, some findings have led to explanations for certain abnormalities related to the brain. In his book, *The Essential Difference*, co-director of the Autism Research Center at Cambridge University, Simon Baron-Cohen (2001), describes one of those abnormal brain conditions, autism, as the “extreme male brain” (p. 133). He sets up polar male and female brains as systematizing and empathizing brains, and is able to add insights about autism through these definitions.

Like other researchers, Baron-Cohen (2001) acknowledges that male and female brains are a spectrum, with polarized ends and combinations in between. He also points out that sex gender is not a direct link to brain gender, though studies show that the male sex aligns more often with the male brain and the female sex with the female brain. As a result males are stronger at systematizing and most females at empathizing. (Baron-Cohen, 2001)

The female, empathizing brain is defined by Baron-Cohen (2001) as “the drive to identify another person’s emotions and thoughts, and to respond to them with an appropriate emotion” (p. 2). He explains that there is biological and social evidence to support the claim that females are more equipped to show and process information through empathy. Empathizing is “done in order to understand another person, predict their behavior, and connect or resonate with them emotionally” (Baron-Cohen, 2001, p.2). One biological connection Baron-Cohen provides centralizes around the functions of the limbic system in the brain. The amygdala, a region that is part of the limbic system, attaches emotional significance to stimuli and becomes active when a person is responding to the emotions of others. Due to the large amounts of testosterone receptors in the amygdala, males have less complex patterns of emotive processing. (Baron-Cohen, 2001)
Behaviors show further, external evidence for the female, empathizing brain. Female brains are observed to be stronger at certain tasks or more likely to express particular behaviors related to the biological empathizing brain. Empathizing children are also more likely to express concern or comfort, judge emotions, establish altruistic, reciprocal relationships, and communicate through cooperative and collaborative speech. In the classroom, they are more likely to show Theory of the Mind, which is the ability to understand the feelings and motivations of literary characters. (Baron-Cohen, 2001)

Male, systematizing brains struggle with the traits shown by the empathizing brain. Baron-Cohen (2001) defines systematizing as “the drive to analyze, explore, and construct a system. The systemizer intuitively figures out how things work, or extracts the underlying rules that govern the behavior of a system” (p. 3). A systemizer is drawn to analyze the features of a system and is gives detailed observations of rules and regularities in a system. The world is comprised of technical, natural, abstract, social, organizible, and motoric systems, all of which the male brain is more prone to understand and investigate. (Baron-Cohen, 2001)

Baron-Cohen (2001) acknowledges hormonal impact and the laterality of the brain, discussed previously, as biological reasoning behind male systematizing. When testosterone surges in pre-natal development increase right-brain development, the hormone also increases right-brain skills like special reasoning, abstract thought, and understanding basic shapes and patterns. These abilities contribute to analyzing systems. Since male brains also tend to be lateralized, the specialization of thought processing contributes to male deductive reasoning involved with taking apart systems in order to gain understanding. (Baron-Cohen, 2001)

Like with empathizing, there also observable behaviors that connect males to systematized thinking. Infant males are more likely to be stimulated by toys rather than people.
Males tend to form hierarchal relationships to organize and systematize friendships. They are apt to lack empathizing communication skills, declaring right and wrong verbal interactions rather than considering the feelings of others. Males also show more aggression and dominance in their styles of play. (Baron-Cohen, 2001)

Understanding systematizing and empathizing brain types is important in order to understand Baron-Cohen's insights on the autistic brain. He begins this discussion by providing background information on autism, Asperger Syndrome, and the Autism Spectrum. Baron-Cohen (2001) explains that autism is diagnosed when "a person shows abnormalities in social development and communication, and displays unusually strong obsessional interests from an early age" (p. 134). Children with autism often function at a low IQ and develop speaking and language later than other children. Asperger Syndrome is one step beyond high-functioning autism. People diagnosed with this syndrome show social and communication difficulties and obsessional interests like those with autism, but test for normal to high IQs and develop speech at a normal age. The Autism Spectrum places classic autism on one end, Asperger's on the other end, and high-functioning autism in between. Other information provided by Baron-Cohen is that autism is strongly genetic in origin, occurs more often in males than females, has 10:1 high-functioning ratio, and is neurodevelopment—starting early in life and affecting the development of the brain. (Baron-Cohen, 2001)

Baron-Cohen (2001) describes autism in terms of a low-empathizing, super-systematizing brain. Autism can be called "the extreme male brain" because it operates on the far systematizing end of Baron-Cohen's gender brain spectrum. He describes autism as an empathy disorder. People who are autistic have difficulty making sense or predicting the feelings of others. They can naively hurt others, but are shocked to discover the impact their actions have
made. Interestingly, they are often the strongest defenders of someone they perceive to be suffering from an injustice. Although lacking in empathy, people with autism excel in systematic thinking at tremendous levels. They generally pay close attention to detail, to such extremes that they are able to make acute distinctions between things others may view as unimportant. People with autism are drawn to patterned information and enjoy making patterns. They also thrive on predictable patterns in their lives, controlling their surroundings, and tend to impose “sameness” when forced to join unpredictable environments. (Baron-Cohen, 2001)

When looking at autism in light of systematizing and empathizing, new insights are discovered. How the brain works is a fascinating and complex study. The findings that have taken place add depth to understanding boys and girls in the classroom and the individual needs, like autism, that teachers may encounter.
Appendix 3: Areas of the Brain

In order to better understand the implications of gender brain research, there must be a basic understanding of the brain. In his book *How the Brain Learns*, David Sousa (2001) explains the structure and specialized areas of the brain. He first differentiates between the outside and inside brain and then goes over the jobs of each area.

Sousa (2001) explains that the outside brain is composed of the frontal, temporal, parietal and occipital lobes, as well as the motor cortex and the cerebellum (see Figure 3). The frontal lobes are responsible for planning and thinking, the left temporal lobe for speech, and both temporal lobes process sound and long term memory. The occipital lobe is accountable for visual processing, and the parietal lobe coordinates orientation, calculation, and recognition. The motor cortex is the band that runs over the top of the brain from ear to ear. This part of the outer brain is responsible for movement and motor skills. (Sousa, 2001)

![Some Exterior Parts of the Brain](image)

*Figure 1.1 This diagram shows the four major lobes of the brain as well as the motor cortex and the cerebellum.*

Figure 3 (Sousa, 2001, p. 16)
According to Sousa (2001), the inside brain is comprised of the brain stem, the limbic system and the cerebellum (see Figure 4). The brain stem is the first part of the inside brain, and, of “the 12 nerves that go to the brain, 11 end in the brain stem…” (Sousa, 2001, p. 17). The brain stem is also responsible for body functions—like heartbeat, respiration, and digestion—and alertness. The Limbic system contains the thalamus, hippocampus, and amygdala and is in charge of interchange between reasons and emotions. The thalamus is a receptor for sensory information, the hippocampus converts working memory into long term storage, and the amygdala processes emotions. The final part of the inner brain, the cerebellum, houses the corpus callosum, which connects the two hemispheres in order for there to be communication between the left and right brain.

Figure 1.2 A cross section of the human brain.

Figure 4 (Sousa, 2001, p. 17)
Sources


