GENDER AND SCIENCE:
WHAT IS GENDER AND HOW DOES IT AFFECT SCIENTIFIC LEARNING IN THE MIDDLE SCHOOL CLASSROOM?

by

Chelsea Baker

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Chelsea Baker

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ABSTRACT

This study asked: How does gender affect student learning in the middle school science classroom? The education community extends after primary and secondary school to higher education and career fields. This is the community where we see the effects of poor teacher modeling and inappropriate science curriculum at the middle school level and beyond. Results of this literature review included this profound conclusion by Hearn and Husu (2011). Researchers concluded that with the increasingly complex definition of gender, new and more intricate questions concerning science have surfaced. These questions span the very nature of science and culture. It is always important to ask: “How do I understand gender, and what implications follow?” This understanding of gender must include an understanding of the culture in which these genders were assigned and perpetuated. Science learning is not linked to biological sex but to the cultural stereotypes of gender that are reinforced as children are educated.

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CHAPTER 1: INTRODUCTION

Introduction

Encouragement sends a powerful message to a child. Teachers encourage children in subjects they believe the children excel in, in fields they believe the children enjoy. Whether one conversed with Locke, Skinner, Piaget, or Vygotsky, encouragement was present in the simplest of reinforcements as well as in the most elaborate constructivist facilitations. Historically, women are absent in scientific career paths. Although the numbers have improved, women continue to be in the minority. After a thorough examination of the literature regarding girls in the middle school science classroom, questions surfaced about encouragement. Qualitative studies indicated that women who do not fit traditional gender roles were discouraged from pursuing science, when they would have been the very best candidates in the field. Quantitative studies which restricted their domain to binary gender roles were inconclusive and results varied wildly. So why wouldn't a teacher encourage a non-traditional female to pursue science? Some of the studies hypothesized about this. Teachers felt that the girls could not relate to the material, could not possibly understand the material, and therefore could not value the material. At home these girls were working on cars, building things, and testing ideas, a true scientific gold mine.

Controversy is no stranger to the discussion of science education and its intended audience. For the purpose of this discussion it is necessary to examine the development of science learning with all of its elements and boundaries during the most influential stage of adolescent development: middle school and junior high. These young adolescents reach a pivotal juncture in their education where they are influenced greatly by their teachers and the information they receive. They also go through a period where they begin to develop a social identity that is much more complicated than simply male or female.

How does gender affect student learning in the middle school science classroom? This answer matters in children's lives because the fate of their science education and their future feelings about scientific subjects are at stake.

Rationale

The education community encompasses more than just the middle school. This community extends after primary and secondary school to higher education and career fields. This is the community where we see the effects of poor teacher modeling and inappropriate science curriculum at the middle school level and beyond. We cannot begin to confirm changes in primary science education until we see numbers rising in all areas of the education community. Encouragement starts in middle school but it ends with success in the education community. This project intends to examine the very early stages of science education to determine how teachers decide whom they encourage and whom they do not.

The *New York Times* published an article in 2006 entitled "Dismissing 'Sexist Opinions' About Women's Place in Science" by Cornelia Dean. Dean interviewed an interesting member of the scientific community on the subject of gender bias in the sciences. Ben A. Barres, formerly Barbara, is a transgender person who is a professor of neurobiology at Stanford University. Barres said that "Of course. I was a very good math and science student, maybe the best in my high school. And despite all that, when it came time to talk to my guidance counselor, he did not encourage me. But I said, 'I want to go to M.I.T.; I don't want to go anywhere else.' So I just ignored him. Fortunately my parents did not try to dissuade me" (Dean, 2006). While Barres still expressed his gender to others as female, he was discouraged from studying at M.I.T.

Barres also said that "women who are really highly successful, they are just as bad as the men. They think if they can do it, anyone can do it. They don't see that for every woman who makes it to the top there are 10 more who are passed over. And I am not making this up, that's what the data shows" (Dean, 2006). This article described how many women are passed over for science careers. With this fact in mind, how can middle school educators encourage young girls in science? Are educators simply setting girls up to fail?

Barres notes that "in biology, something like 50 percent of the best postdocs are women. It's still very bad in physics and engineering and chemistry, but even in biology you don't see women making the leap to tenure. And this disturbs me greatly. These women have worked very hard. They have fulfilled their side of the social contract. I think what we've got is just a lot more highly trained, frustrated women." Women are making progress, but it is just simply not enough progress for change.

When asked to talk on the controversial point that men might just be biologically more competitive than women, Barres made the argument that in essence confirms the relevance of this research. He said, “When women are made to feel less confident, they are less likely to enter the competition. I think a lot of this is just the way men and women are treated from the time they are very young” (Dean, 2006). This idea of treatment at a young age is absolutely relevant in the education community. From parents, to teachers, guidance counselors, mentors, peers, friends, media, literature, culture, and advertisement, women and men are treated differently.

In addition to the idea that men are more competitive, there is also the controversy surrounding the idea of biological intelligence. Some scholars believe men are more intelligent than women on a physiological basis. These individuals often blame this fact for poor female science performance instead of the curriculum or teacher modeling.

In response to this, Barres said, “People are still arguing over whether there are cognitive differences between men and women. If they exist, it’s not clear they are innate, and if they are innate, it’s not clear they are relevant. They are subtle, and they may even benefit women. But when you tell people about the studies documenting bias, if they are prejudiced, they just discount the evidence.” The topics of controversy surrounding the effects of gender on science relate to how the issue is controlled in the education community and the middle school classroom.

There are clear grounds for relevance in the academic community and a solid base of controversy surrounding this topic. In addition, the body of literature on the topic is rich. Many studies surrounding gender and science at the middle school level are present. Some studies looked at specific populations of middle school girls and assessed their performance and their strategies for learning science learning. One study looked at urban middle school girls and their ability to merge their social world with their school world and develop strategies to engage in the science classroom. This author argued that this may be a positive thing for the world of science and the girls themselves. Barton looked at the implications of this on gender equity in the science classroom. This source will be very useful because it addressed the social learning aspects of many girls (Barton, 2008).

Other sources actually explored certain teaching models and their effect on science performance among young women. One of these studies explored design- based learning in the middle school classroom. The authors wanted to see if this narrowed the gap between high- and low-status students and if—specifically in science—it would help minority and female students to perform better. They found that this model does have the potential to increase students' desire to learn, enhance their success, and increase their interest (Doppelt, 2008).

Some studies examined the students, others looked at teaching models, and additional studies even examined specific parts of curriculum, such as the texts used in the science classroom, for gendered subject matter. The authors of one study used methods of quantitative analysis to look at chemistry and science textbooks for gender equity, among other factors.

They found the textbooks to be full of unfair gender representations. The textbooks failed to provide sufficient empirical evidence to be considered as gender equitable and inquiry-based (Kahveci, 2010).

Additionally, there is a wealth of studies that do not agree with the notion of gendered science curriculum at all. These studies represent various viewpoints of the controversy surrounding the issue. One source argued that most gender research has focused on females and that more research needs to be done on male students. These researchers referred to the “boy turn,” in which they challenged the feminist research with male-centered research. They suggested further research that could be done in this area (Weaver-Hightower, 2003).

Historical Background

The history of science tells a story of entitlement, a story about women and oppression. Women are historically absent from science history. There are some notable exceptions, like Marie Curie and a few others, but for the most part they are not considered noteworthy contributors to the science field. Much research has identified female contributors to the sciences, but their work remains unmentioned. This may be due in part to the masculine nature of the subject. There is something inherently masculine about controlling natural forces with rational knowledge (Watts, 2007).

During the scientific revolution in the sixteenth and seventeenth centuries, many gendered views were supported by the sciences. In text and images from scientific writings from the time, the masculine and feminine were always in competition. The male perspective incorporated ideas of mind, reason, and power, while the feminine view incorporated body, instinct, and nature as their defining perspective (Watts, 2007).

Being male was the superior state and was sought after as the correct route to scientific enlightenment. Even today, as society appears to have made much progress is this binary, gendered system, scholars in America must look again at the true reality.

During the 18th century, women were only able to practice certain types of science. They learned about science from conversations and in their own kitchens. These basic pathways were socially acceptable. There was a lack of substance with this type of learning, and most of the scientific knowledge obtained was oversimplified.

In terms of scientific education, the Unitarian community had a great effect on educational principles in the 18th century. This religious group was led by the scientist Joseph Priestley, who believed in progressive educational ideals. He was influenced by the philosophy of David Hartley and John Locke. These views asserted that the individual was not born with limitations but was made by her own educational experience. The mind was a blank slate at birth. Priestley believed that education should be provided to members of both sexes. However, as science attempted to legitimize itself as a field, women were pushed back out the door as the more depersonalized, serious thoughts of men took over (Watts, 2007). This was the case in the 19th century as well. Women played a prominent role in science education, but access to science was greatly affected by gender and class. Women made contributions and were learning about science in their lives, but they were never present in any location of scientific debate or advancement (Watts, 2007).

In the 20th century, especially in the late 1920s, advanced science courses became more available for men, but women were encouraged to confine themselves to domestic subjects. In the 1930s and 1940s women began to study pharmacy and biology. Many ultimately became nurses and some never got a degree and became assistant nurses. Through the gendered curriculum of the early 20th century, women were able to find gender-appropriate jobs (Watts, 2007).

In elementary schools domestic science began to look similar to housewife class, and the harder sciences women denied women at the high school level. Girls also spent statistically less time on mathematics, and as a result their achievement in the sciences suffered, which just seemed to prove that they did not have any ability in these fields. There were social, political, and economic reasons for this. As Charles Darwin developed his theories in the late 19th century, survival of the fittest became a powerful concept. The most fit and intelligent women were needed more than ever for breeding, and education once again became de-emphasized. In addition to this, Freud's psychological theories of development made women seem inferior (Watts, 2007).

In the late 20th century women's rights were on the rise and women made advances in the social and political realm, but education ran about 30 years behind the times and progress in gender equity in the sciences was stagnant at best.

This history has always looked at gender in a binary way, grouping all women together. Today gender is not defined as biological sex. A person's gender is a separate state that is self-identified. This has always been the case, but society is only beginning to acknowledge this. A person could be male, female, both, or neither, and this is entirely independent of their biological sex or their sexual orientation. With this in mind, how does modern society react to a biological woman who gender-identifies as a male? Society may not accept this initially, but it easier to understand than a man who wants to be a woman. Being male is associated with being powerful. Why wouldn't a woman want to have power, reason, and a sound mind? Conversely when a man wishes to self-identify as a woman, how does society perceive this event? Ultimately this person is received with hatred, disgust, and confusion. Why would any sane person choose body, instinct, and nature as qualities of one's self when she has the opportunity to be male? When these ideas are examined, our society appears more binary than ever. This is compounded by the fact that science fails to acknowledge gender identity at all.

Definitions

This research focuses on gender, science, science curriculum, and teacher modeling. It also has a parameter of middle school students. For the purposes of this research, gender must be defined in a binary way. It is clear that there is much more research left to be done on the transgender community and the effects of science curriculum and teacher modeling on science learning. Currently, the literature appears to align gender identity with biological sex, with the exception of a few studies that will make up the beginning of this literature review because of their important contribution. As a result, when this paper refers to *women*, *female*, *feminine*, or any terms of this nature, they can be linked to biological sex. *Masculine* and *male* can be linked to biological sex as well. This is a disservice to the transgender community, but a review of the literature is limited by the literature itself; at present the literature is in a static binary place in terms of gender identity.

For the purpose of this paper, the term *science* includes any subjects based on objective knowledge of physical matters, including but not limited to medicine, mathematics and technology (Watts, 2007). This definition also includes the biological sciences and chemistry.

The phrase *science curriculum* refers to a standardized list of grade-level expectations based on different components of science. However, districts and teachers are allowed much freedom when interpreting these standards and providing supportive material to teach these standards. It is in this supportive material and text where much gendered content can be identified. *Teacher modeling* refers to the type of teaching conducted in the classroom. Some traditional styles of science teaching might include direct instruction or a presentation model. Some newer methods described in the literature include cooperative learning and design-based learning. In addition, teacher modeling also includes teacher talk and encouragement of science learning and any strategies used to increase science learning in the classroom. Some of the literature is very explicit in describing these strategies.

The middle school period includes as students who are between grades five and nine. This may be a wider range than is usually accepted for this middle designation. But because of the differing organization of schools across countries, states in the United States, and even school districts, this age group most closely represents the targeted age level and allows for a broader and more complete scope of research.

Limitations

All of the studies in the body of this paper focus on the middle grade levels. These levels vary from study to study but all stay within the range defined in this paper, grades five to nine. In addition, it may be valuable to follow up with some studies from upper-level grades and the college level to further explore the need for this research and what the consequences are of gendered teaching.

The greatest limitation of this paper is the scope of the definition of the word *gender* in this body of research. Science education is in great need of studies that focus on children's gender identity as well as biological sex. Transgender students might be a minority population, but they can be researched on a case-by-case basis to compile some definitive evidence for this population. It might be natural to assume that transgender students face obstacles in science education similar to those faced by minority students, female students, and students of low socioeconomic class. But this has not been substantiated with evidence and must be further researched before a definitive answer can be asserted. In addition to transgender students, students who identify with their gender but don't fit the social norms must be examined qualitatively instead of grouped with other females.

This study was also limited in the number of teacher models that were analyzed. There are endless models of teaching and it would be impossible to include all in a literature review. The research literature examined for this review supports more progressive models as beneficial to science education that benefits young women. Some of these models may accomplish this by paying attention to the status of students in the classroom.

Only a few studies were found that actually evaluated classroom texts for gendered content. Because of this, the findings in this section are severely limited because they represent such a small portion of the texts used in classrooms overall. However, these studies still deserve consideration because of their surprisingly conclusive statistical findings.

The controversies in this field extend in every direction. They are so broad that it was difficult to pinpoint a handful of relevant ideas. Limits were imposed to include controversies that were relevant to the body of literature already found, so that comparison was possible.

Statement of Purpose

The purpose of this study is to examine gender and its effects on student learning in science. This area of research contains diverse studies with inconsistent conclusions. A clear evaluation of these sources is needed to begin to pinpoint what effects gender has on science learning, motivation, and encouragement from educators.

Summary

This chapter has provided a brief overview of the question: How does gender affect student learning in the middle school science classroom? The chapter examined the question from the point of view of members of the education community. One member was also a transgender individual and spoke of experiences during primary school, providing some insight to controversies surrounding the issue.

The research can be identified as a body of knowledge limited to grades five through nine with content that is binary and based on gender identities that align with biological sex. Research was found on both science curriculum and teacher modeling. There was also much research on individual groups of middle school children. Many of these were quantitative studies with empirical data.

This chapter examined the history of women and their role in science, beginning with the scientific enlightenment and continuing even today. This chapter sets the political, social, and cultural contexts for the future analysis of the literature and clearly defines all limitations and definitions of the material.

CHAPTER 2: CRITICAL REVIEW OF THE LITERATURE

Introduction

Chapter one of this review presented research addressing the question: How does gender affect student learning in the middle school science classroom? Research indicates a long history of disparity between males and females.

Chapter two will outline the current professional literature in three areas: gender roles, interest and motivation, and diverse cultures including parent involvement. A final section of chapter two will cover possible intervention strategies and curricular choices. This chapter will explain the importance, in the context of this study, of defining concepts like gender, interest, and motivation, and the links between culture and gender. The chapter also outlines strategies that have been employed to reach students in science education, though only two of the eight strategies actually succeeded in reaching middle school girls.

Gender Roles

The question of gender and its effect on student science learning is much more complex than current literature admits. The introductions to many of the studies reviewed here indicate that past research describes a relationship between gender and science performance, self-efficacy, motivation, attitude, and many other factors that affect science learning. The previous research often suggests that young girls and women of all ages are at a disadvantage in these areas. However, without some type of an intervention or explanation, the picture that is drawn by studies that focus on an analysis of gender in science classrooms begins to define this relationship in an unexpected way.

This section specifically focuses on defining gender roles in the science classroom. In the first study, Brickhouse, Lowery, and Schultz (2000) offered a complex qualitative case study of young girls with a range of non-traditional gender roles. They argued that current research is useless in its ability to explain the diversity that exists among students' gender identities. As a result they asserted that all conclusions drawn about science learning and gender were invalid. This study conveyed an image of strength in these non-traditional young women in their scientific aptitude and directly challenged binary views of gender. The second study in this section supports the first in a more traditional setting. Shmurak and Ratliff (1993) looked at middle schools and evaluated them for equity and bias trends related to gender. With a qualitative observational study they determined that math and science classrooms were the most equitable of any classrooms they observed. They did not observe female students withdrawing from math and science as they expected they would. In a third study Karaarslan and Sungur (2011) found no relationship between self-efficacy and gender. This puzzled them and also pointed to a more complex relationship than they expected.

Two studies offered an alternate explanation. Fouad et al. (2010) examined barriers and supports for math and science in terms of gender. They reported that females felt they had more barriers in science education at the middle school level. But these same girls also reported more supports than barriers overall. This research did not attempt to put women into a gender role, but rather asked them if they personally felt barriers in their classrooms. It is possible that all of these studies have found meaningful connections by not attempting to define gender prematurely. In another study Heilbronner (2008) also discovered some gender stereotypes in a qualitative case study. But it was concluded based on observational data that women are making progress in science, but there is still a gap in many fields. Heilbronner called for a new force of teachers that are committed to fostering a love of science for all of their students regardless of their gender.

The final study sums up this section with a call for a more complex analysis of gender and science leaning. Hearn and Husu (2011) analyzed how to understand gender and considered the various implications for science and technology. They concluded that, with the increasingly complex definition of gender, new and more intricate questions concerning science have surfaced. These questions span the very nature of science and technology itself. They encourage educators to ask: “How do I understand gender and what implications follow?” (Hearn, 2011, p.110).

Brickhouse et al. (2000) examined the personal identities of four middle school girls of color and determined that science teachers supported the girls who portrayed traditional gender roles in the classroom more than they supported girls who did not fit these gender roles. The researchers noticed that the current research surrounding science education and gender tended to stereotype male and female students by oversimplifying their identity into one homogenous representation of their preferences. These preferences were traditionally linked to a binary view of masculine and feminine qualities. They argued that this research was and still is useless in its ability to explain the diversity that exists among boys and girls. According to Brickhouse et al., research is needed that takes the complexity of the meaning of gender into account as well as the diverse ways gender is enacted.

Traditionally, researchers were concerned with whether students were internalizing science content and developing a useful scientific view of the world. However, this question was simply looking at the problem, not the source of the problem. Brickhouse et al. (2000) asserted that researchers should first look at whether students see themselves as the kind of people who would want to understand the world scientifically and thus participate in the kinds of activities that are likely to lead to the appropriation of scientific meaning.

Brickhouse et al. (2000) took a constructivist approach to research by conducting four case studies on students with a range of identities that do not fit the traditional gender science roles described in the literature up to this point. They told the stories of four middle school African American girls and their experiences in the science classroom. The authors clearly link identity formation with adults' expectations of how students learn science. They also explain how identity formation is influenced by societal constructs like gender. Brickhouse et al. stressed that the science teaching community needs to understand how students engage in the science classroom, but also how this engagement is connected to who students think they are. This can be accomplished if researchers pay close attention to the communities of practice that the students participate in as well as what communities they aspire to be a part of. Who are these students? How do they identify themselves? Are they ballplayers, good students, gossips? Who do they want to be when they grow up: nurses, teachers, mothers, gemologists, professional athletes? In order to learn science, students' personal identities must be compatible with scientific identities.

A further complication with this process in middle school is that students tend to change their communities and identities quite frequently during adolescence. This is because they do not yet possess a stable view of themselves. Traditional studies that examine one aspect of a child's character fail to address the multiple social identities of the student and how these identities overlap with views of science. The disparity among the genders comes in because Brickhouse et al. (2000) reminded us that identities are not constructed simply by choice. Students are not entirely free to be anyone they wish, because identity development is not only an individual process, but a socially situated one based on privilege.

Brickhouse et al. (2000) wanted to understand how female students form their scientific identities. They intentionally chose students that would be viewed by society as non- scientific learners: girls of color from poor or working class backgrounds. They attempted to understand those identities created by the girls for themselves and how those identities overlapped with scientific identities. The researchers collected their data from Plotkin Middle School, a large school of seventh and eighth graders. The school is approximately 35% African American and 65% White, and 15% of the students receive free or reduced lunch. Plotkin is considered a low-achieving school, and many well-to-do people send their children to private schools to avoid this school. Brickhouse et al. collected the data for 18 months from 12 middle school girls who expressed in their writing an interest in science. Researchers wanted to examine how the girls engaged in science both in and outside of the classroom. They documented their race and ethnicity as it was described to them by each student.

The cases illustrated a variety of girls and how they engaged in science learning. The researchers did detailed interviews with four of the girls who did not exemplify the traditional female gender role. All four cases seemed to disprove the stereotypical image of young women portrayed in the current research. These girls were not alienated from science in their lives, and they all said that they were good at science. Some of them were mechanically inclined and outspoken. They even chose to participate in science outside of the classroom. The two girls who took on easily recognizable social roles for girls—one was quiet and the other social—were the ones who had the fewest difficulties in constructing successful school science identities. Although all four of these girls constructed positive identifications with science, schools and teachers did not respond to these identities in value-neutral ways. The students who violated school-sanctioned gender norms had negative academic consequences. This was the case even when these students had skills that were actually valuable for success in science, such as being good with puzzles, showing assertiveness, and engaging in science outside of school.

Brickhouse et al. (2000) were concerned about the implication that students who do not fit traditional gender roles are not challenged or positioned as competent in the sciences. This was true even when these girls exhibited traits that were naturally useful in science fields. These findings indicate broader implications in terms of science tracking. They imply that students who resemble the dominant culture are moved forward in science while non-traditional students are left behind. These findings may clarify why many researchers have the overall perception that girls struggle in the sciences. Girls labeled as outside of their traditional gender role are not always nurtured and encouraged in this content area.

Shmurak and Ratliff (1993) conducted a study on gender equity and gender bias in the middle school classroom. The objective of the study was to begin to look at middle schools and evaluate them for equity and bias trends related to gender. Researchers visited 80 classes in 10 middle schools around central Connecticut. Classrooms at sixth, seventh, and eighth grades were observed. Researchers looked at social studies, math, science, and language arts classrooms.

Shmurak and Ratliff (1993) made the case that issues of gender equity are especially important during middle school. These years are marked by many developmental changes, and both girls and boys begin to deal with issues of gender identity. These years begin to place kids in tracking systems for academic success and ultimately college. This is also the time when interest in math and science begins to decline for all students.

Shmurak and Ratliff (1993) indicated that much research showed a decline in girls' view that they can be successful in math and science around sixth grade. It continues to drop through the remainder of their education. Something is happening to reduce girls' confidence in these subjects, and Shmurak and Ratliff set out to determine what this was.

During classroom visits extensive qualitative notes were taken, and at a later time behavior was categorized in terms of sexism or gender equity. The sexism categories were as follows: gender reinforcement, embedded discrimination, sex role stereotyping, gender domination, active discrimination, and explicit sexuality. There were also six pro-active gender equity practices identified. They were as follows: amelioration of inequitable practices, resistance to sex-role stereotyping, compensatory recognition of female achievement, sensitization to gender issues, affirmation of girls' skills and abilities, and positive instructional strategies.

Surprisingly, results indicated that math classes were the most equitable, while language arts classes showed the most extreme male dominance. Science, social studies, health, and foreign language were in between these. There were some forms of discrimination even present on the walls in the classrooms, such as science rooms with only male scientists, social studies classrooms with only male historical figures, and language arts rooms with only male writers. Researchers described these as embedded discrimination.

The most surprising findings in the study were that math and science classrooms seemed to be the most equitable. They were female-dominated as often as they were male-dominated. It appeared that male-dominated classes were primarily language arts and social studies classrooms. Based on this sample, researches did not observe female students withdrawing from math and science as research suggested they would. There was no active discrimination, sex role stereotyping, or gender domination in any science classroom.

Overall, this qualitative study may have been biased in its methods. There was no specific protocol for note-taking in the classrooms, and data was only categorized later. This raises concerns about what data recorders chose to collect, what they missed, and what they embellished. It would be difficult to transfer this study because of the lack of methods for note-taking, which brings the study's credibility into question.

Karaarslan and Sungur (2011) wanted to know how they could measure students' self- efficacy beliefs towards science and technology in relation to gender. A quantitative factor analysis showed that there was no significant grade level or gender difference in students' science and technology self-efficacy; however the mean scores revealed that there was a general decline only in students' confidence in science and technology ability (CST) and girls appeared to be more self-efficacious. The subjects were 145 students (83 girls and 62 boys) in an urban elementary school.

This study examined grade level and gender difference with respect to elementary students' science and technology self-efficacy. They defined self-efficacy as “beliefs in one’s capabilities to organize and execute the courses of action required to manage prospective situations” (Karaarslan and Sungur, 2011, p. 72). Self-efficacy centers on ability, specifically on one’s ability to perform. Self-efficacy also has a factor of judgment because students often base their self-efficacy on their own beliefs about their inherent abilities. The researchers make the connection that people who doubt themselves will often give up quickly, while people who believe in themselves show a very strong commitment to a task and do not give up easily. In this way self-efficacy directly affects success on a task.

Karaarslan and Sungur (2011) relate these ideas to the science classroom because most of the self-efficacy literature indicates that students’ beliefs in their own abilities to accomplish science work impact the choices they make during science-related activities. These self-beliefs can even influence their determination when faced with a difficult science task. Students who have confidence in their abilities in science generally put forth more effort towards success than those students who do not have strong faith in their science abilities. These students will try to avoid science activities and will put in little effort when they are forced to do such activities.

In relation to gender, these researchers examined the previous literature surrounding girls and self-efficacy. They found mixed results concerning gender. Some studies seemed to indicate that middle-level girls have higher levels of self-efficacy beliefs than boys. The researchers showed that self-efficacy was the only motivational variable predicting science success, and female students had more of this than boys. However some other studies implied that middle school boys were actually more efficacious in science than girls. Karaarslan and Sungur (2011) concluded that more research is needed. To account for this in their study they examined gender differences with respect to students' self-efficacy in science and technology.

To conduct this research they used 145 students (83 girls and 62 boys) in an urban elementary school in Ankara, Turkey. The student participants were from Grade 5 (n=44), Grade 6 (n=29), Grade 7 (n=39), and Grade 8 (n=30). Their age ranged from 10 to 15 years. Researchers used the Self-efficacy towards Science and Technology Scale developed in 2009 by Tatar, Yildiz, Akpinar, and Ergin to measure students' self-efficacy beliefs towards science and technology. There were 14 items that investigated students' background characteristics including gender.

Karaarslan and Sungur (2011) looked at the relationship between self-efficacy in science and gender by using a two-way MANCOVA quantitative analysis. They tried to control for students' prior achievement. In the analysis they looked at scores for self-efficacy in science, confidence in science, and coping mechanisms in science. These were the dependent variables. Gender was used as the independent variable. They used a p value of .05 when conducting their research, and they found that there was no significant interaction between gender and the dependent variables defined. However, by trying to control for prior achievement they realized that there was a relationship between prior achievement and the dependent variables.

When examining gender their test results showed a p value of 1.73 which is much larger than their p value of .05. How they differentiated between self-efficacy, confidence, and coping mechanisms is not clear, leaving open the question of which confidence and coping strategies interact with self-efficacy in some way. The relationship Karaarslan and Sungur (2011) found between prior achievement and their dependent variables are also somewhat questionable because they chose such a high p value. However, it does seem logical that there would be a relationship between prior knowledge and confidence.

Fouad et al. (2010) examined barriers and supports for continuing in mathematics and science in relation to gender and educational level differences. Fouad et al. asked what experiences and conditions were perceived by students to be advancing or hindering their choices to continue in math or science education as careers. How do these perceptions differ by gender and education level? And finally, what types of structures or conceptual frameworks best capture the perceptions of barriers and supports for students? Students at three education levels (Grade 8, Grade 10, and college) were studied from two locations in the Midwest and Southwest. Eighth grade students were recruited from one large, diverse middle school in the Southwest and from several eighth-grade math classes in the Midwest.

Students took a demographic questionnaire as well as a questionnaire covering science and math barriers and supports. A Likert scale (0-3) was used in the questionnaire. Computer implementation of the survey allowed for even further adaptation in terms of gender. Some of the gender assessment included issues like lack of teachers and students of the same gender, lack of role models of the same gender, and teachers' attitudes toward a participant's gender.

Analysis focused on five major questions. The research question related to gender was: How do the barriers and supports perceived by males and females in math and science differ? Analysis consisted of a mean analysis of variance. Significant differences were found between males and females in science and math learning. All groups reported more supports in these fields; however females felt they had more barriers in science education at the middle school level. A p value of .001 was used to analyze data.

This study did not manipulate curriculum in any way but simply administered a survey for different age groups and genders. However, the level of significance and internal validity were based on a p vale of .001, which is very accurate, and a Likert scale was used for analysis. In terms of external validity, conclusions were generalized based on one-dimensional connections, and further analysis is needed due to this limitation. The researchers provided a detailed taxonomy and literature review which increased the internal validity.

Heilbronner (2008) conducted a qualitative case study of a student in her classroom named Jill, in which Heilbronner provided Institute of Education Sciences (IES) recommendations for science education to narrow the gender gap for this middle school girl, as well as for other female students. Jill is presented as the ideal student. However, it is clear in Heilbronner's interactions with her that she hates science. Heibronner is forced to acknowledge that many of the female students in her classroom dislike science. It was observed that girls allowed boys to run the labs and that the girls often cleaned up their stations and wrote the lab write-up for their group.

Heilbronner's (2008) research suggested that women have high academic achievement and are well represented in many fields such as psychology, biology, and chemistry. However they continue to be greatly underrepresented in fields like math, computer science, physics, and engineering. This disparity also carries over into the workforce. Women represent half of the workforce but only 26% of the science and engineering workforce.

Heilbronner (2008) explored the teacher guidelines provided by the national Institute of Education Sciences for encouraging girls in math and science. Each recommendation by the institute was explored and analyzed against the case study of Jill and other female students in Heilbronner's classroom. The IES recommendations were to teach students that academic abilities are expandable and improvable, to provide descriptive, informational feedback, to expose girls to female role models who have succeeded in math and science, to create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science, and to provide spatial skills training.

Furthermore, Heilbronner's (2008) research suggests that teachers who show a passion for their subject and who connect with students on a personal level may have more success with students in their classrooms. Heilbronner noted that the benefits of implementing these recommendations in the classroom are great but that they will require a lot of effort on the part of the teacher to make her classroom more engaging, challenging, and enjoyable for all the students.

Heilbronner (2008) concluded that women are making progress in many areas of science, but that there is still a gap in many fields. The answer to this problem is a new force of teachers who are committed to fostering a love for science in their students. They can do this in part by helping students develop their abilities. In order to accomplish this, teachers need to move away from traditional classroom structures and begin to implement new ways of teaching.

This was a single case study of a student in Heilbronner's own classroom. Because of this, the research barely qualifies as a study of any kind. The research is clearly observational, though most claims are backed up with others' research. The fact that Heilbronner used a student in her own classroom is a point of critique. This is a case study with grounded theoretical positioning. However, the credibility is questionable because it is only one case study. The findings were confirmed with current research in the field. However, this case study would be impossible to confirm or transfer because of the lack of methods present in the article.

Hearn and Husu (2011) analyzed how to understand gender and considered the various implications for science and technology. Science and technology benefit from an analysis of gender on several levels. These levels are defined in terms of who does science and technology, how the fields are organized, and the construction of knowledge in the subjects. This study analyzes five underlying formulations of gender to inform policy interventions and theorizing about gender and science. Researchers evaluated gendered knowledge in science and technology and other gender relationships.

Hearn and Husu (2011) asserted that gender relations and power dynamics are a major piece of science and technology, but current research cannot agree on what this actually means. How these two issues intersect is a matter of much debate in the education community as well as in the scientific community. Not only did this study look to the surface to determine who participates in science, but it also examined the question of how those involved in these subjects are seen in the scientific community. Are they made into heroes? Are they ignored and their accomplishments downplayed?

Researchers also examined the overall organization of science. This was done by evaluating how some science organizations are managed. Researchers gave special attention to what issues, problems, and questions were chosen to be studied in the first place. Typically, researchers found that men's work was valued over women's. Women's work in the context of the study included domestic work, caring for dependents, the elderly, and people with disabilities. In institutions women were often found on the front lines while men were more centrally located in the institution.

Gendered knowledge in science and technology is a topic of much debate. Hearn and Husu (2011) looked at the relevance of gender for the construction of scientific knowledge. More specifically Hearn and Husu asked how the theories, concepts, logics, methodologies, and language used in science and technology are gendered. Researchers concluded that with the increasingly complex definition of gender, new and more intricate questions concerning science have surfaced. These questions span the very nature of science and technology itself. It is always important to ask: “How do I understand gender and what implications follow?” (Hearn, 2011, p. 110).

This study did not contain any methodology but there was a table of findings at the end of the article indicating some form of qualitative analysis. This study would be very difficult to replicate considering the lack of methodology, and thus its confirmability is weak. In terms of credibility, it does appear to align with current research. Claims made about the state of gender-science research were accurate based on the scope of research examined for this review of the literature.

Throughout this study of gender roles, researchers indicated a more complex realization of what gender means. This realization led Hearn and Husu (2011) to pose the question of this section: “How do I understand gender and what implications follow?” With the complex analyses of students that Brickhouse et al. (2000) and Shmurak and Ratliff (1993) provided, one can begin to define this relationship between gender and science learning in a more organic manner. Some researchers, like Karaarslan and Sungur (2011), have not taken this step yet, but they are noticing an inconsistency in the literature because they found no correlation between gender and self-efficacy.

Researchers like Fouad et al. (2010) and Heilbronner (2008) did find indications of gender bias and feelings of barriers in their subjects, but again it is clear even in these studies that women are making progress, that the relationship between gender and science learning is not simple. There are both supports and barriers for young women in science. These women and their perceptions of themselves, their upbringing, and how they identify all play a part in their ability to succeed in science.

Interest and Motivation Analysis

The last section focused on gender roles and science learning and emphasized the complex nature of gender identity. With this in the forefront it is clear that there may be some discrepancies in the research concerning interest and motivation. This section also includes two studies on attitudes which showcase this disagreement in the literature.

The first two studies done by Sorge (2007) and Elliott (2010) emphasize that lack of interest and motivation in science is not exclusive to girls in middle school. In fact, levels of interest and motivation are about equal among males and females. At this age, students' interest in science declines rapidly no matter what their gender identity. The third study, by Riegle-Crumb, Moore, and Ramos-Wada (2011) did note that all students' enjoyment in science declines in middle school but still found that white males enjoyed science more than females of any race. So are motivation, interest, and attitude affected by gender, or simply by adolescence? Perhaps it is a combination of both. But again, all of these studies measure gender in different ways, so it is unclear what conclusions can be drawn.

A study by Sevinc, Ozman, and Yigit (2011) concurs with Karaarslan and Sungur (2011) and finds no relationship between gender and self-efficacy; however, there were results that indicated a relationship between motivation and gender. They hypothesize that culture and parental messages may have something to do with this difference. This will be further addressed under a subheading titled Parent Involvement under the Diverse Cultures section.

Two studies on attitudes and gender reached conflicting conclusions. Kirikkaya (2011) looked at middle-level students and their attitudes towards science. Kirikkaya determined that different elements of science sparked different attitudes, and that these correlated with gender. But Sandoval and Harven (2011) found no statistical significance between attitude and gender on any level.

Sorge (2007) examined the attitudes of 1008 elementary and middle school students ages 9-14. The students were all from rural New Mexico. Sorge studied the change in science attitudes between the ages of 11 and 12 and how this correlated with the move from elementary to middle school. Age and gender were the primary dependent variables in this quantitative study. Sorge was interested in whether gender has a relationship with changing science attitudes.

Science attitudes in correlation with achievement have been studied extensively. The relationship between the two was established in many studies over time. Some studies, including Sorge (2007), have tried to become more specific in their inquiry and as a result focused on the age of students as well as gender in relation to attitude and achievement. Some of these more recent studies indicated that males exhibited a more positive attitude towards science. Sorge 2007 found that the relationship between attitude and achievement was strong for both genders but it was even stronger for females. This implies that females' lack of positive attitude is even more detrimental to their achievement than it is for male students.

Sorge's (2007) study involved three middle schools and six elementary schools. The data collected came primarily from a school-based science program and was collected over three years from 2003 to 2005. Methodology examined changes in various attitudes and knowledge in this particular program. Researchers used only pre-test data because this data was collected before students were exposed to the program. Researchers also conducted a survey to measure attitude. The survey contained 10 items which were intended to evaluate attitude with statements like "Science is fun." Researchers used a Likert scale to evaluate the surveys. The scale ranges from 1 (*very false*) to 6 (*very true*).

The researchers evaluated data using a two way factorial ANOVA in which gender and age were used as fixed factors. Attitude was used as the dependent variable. This method was used because there was a non-linear relationship between the identified variables. Reserchers determined that the relationship of gender on attitudes towards science was not significant. This was true for interaction between age and gender as well as gender related to attitude. Researchers used a p-value of .001.

Sorge (2007) observed clear drop in science attitudes between elementary school and middle school. This was a concern to the researchers because the students had only attended middle school for six weeks when they collected this data. Researchers determined that this decline in science attitude happened at the same pace for males and females. This study was further complicated by the fact that the students were going through many biological changes due to maturation during the data collection period.

Overall, Sorge (2007) was very transparent about the limitations of this study. Some limits included the fact that New Mexico has quite a different demographic than many other areas in the US. This might make it less than ideal as a sample population. The region also has a proportionally higher level of people living in poverty than the average in the United States. The poverty rate in New Mexico was 17% compared to 13% nationally. Researchers also reemphasized the fact that the students were maturing during the study. This could have caused some of the noted attitude changes. Recommendations include retesting with the goal to determine if maturation or culture influenced this attitude change. In terms of data analysis the researchers used a very accurate p value of .001, and they were clear about the reasons for using certain statistical tests. Their inquiry could be easily repeated.

Elliott (2010) studied the possible reasons why middle school students in Year 9 say they are not interested in school science. The study proposed that the decline in science participation was due to fundamental societal conditions rather than teachers or schools. Gender was taken into consideration during the study because a mix of single-sex and co-educational schools was included in the study. Questionnaires and surveys were used to determine when and why students disengaged with science.

After surveys and questionnaires were distributed to the students, focus groups were used to collect the data. The groups ranged from four to eight students, and guiding questions were used to keep the discussion moving forward. Researchers determined that many students believe that science is a hard subject. The study noted that this is also the case in society. Questionnaire results showed that students disengaged when the teacher used traditional methods of teaching such as lecture. Researchers also found that meaningful relevant curriculum played a role in engagement.

Overall this study determined that increasing students' engagement in science will require changes in content, pedagogy, assessment, and teacher-quality. The study determined that school science lessons do not match students' everyday lives. Science curriculum that does connect is almost exclusively focused on the dominant culture in terms of race, class, and gender. Elliott (2007) suggests teaching science through meaningful inquiry. Incorporating technology into the classroom may also lead to engagement. Other factors described included parental involvement and consideration for the lifestyles of adolescents.

This study would be extremely difficult to reproduce. The methods section is very vague and gives little insight to the questions researchers used or how those questions were evaluated. The conclusions drawn from the data collected were somewhat disconnected from the data. They were based on the researchers' world views and educational background rather than on the evidence collected during this study. Many of the claims were not backed up with any quantitative data.

Riegle-Crumb et al. (2011) explored who might want to have a career in science or math based on exploring adolescents' future goals based on measures like gender. The study looked at data comparing different gender subgroups to white males and how likely they were to choose a science or math career. Previous research suggests that participation and careers in Science, Technology, Engineering, and Math (STEM) fields were traditionally dominated by white males. Women and people of color are much less likely to enter these fields. There is a growing awareness that the point at which to reach students about careers in STEM fields is increasingly early on. Research suggests beginning in early adolescence.

The strongest indicator that a student will go on to work in a STEM-related field is the student's beliefs and attitudes about science. In terms of attitudes, the process by which females view themselves as less competent and have lower confidence in science begins long before high school. Riegle-Crumb et al. (2011) studied the results for fourth and eighth graders from 53 countries as reported in a cross-sectional study called Trends in International Mathematics and Science Study (TIMSS). Researchers looked at students in the United States at the eighth-grade level and examined their STEM-related career aspirations. To determine student attitudes, the independent variables of intrinsic interest and self-concept were analyzed. Results indicate that overall white males report that they strongly enjoy science and females of all races report lower levels of enjoyment in science than white males. Chi-squared tests indicate that all students report lower interest in math and science during eighth grade than in previous years.

Riegle-Crumb et al. (2011) concluded from their findings that even at an early stage in life students are already beginning to make choices about their future goals in STEM-related fields. There are established trajectories even in middle school and females show less interest in science across all races when compared to males. This is compounded by the fact that all students lose interest in science at this age. Researchers stress the need to insure STEM involvement with future generations. There is a great need for more research concerning how to prevent adolescents from prematurely closing the door on science-related careers and dreams. This is directly linked to their attitudes and views about these subjects.

Overall this study lacks both external and internal validity. Externally, the researchers chose to use research that was already conducted to compile their data, and they also did not report many methods in terms of their analysis techniques. It was briefly mentioned that a chi-squared analysis was performed. Although this study was based on quasi-experimental data, because it was simply collected from a database it only qualifies as observational data.

Sevinc et al. (2011) investigated primary students' motivation levels towards science learning. Participants included 518 students enrolled in sixth, seventh, and eighth grades in three different schools which are located in the center of Trabzon, which is a city in the Black Sea region of Turkey. A Likert scale was used to examine the motivation levels of students. Researchers defined *motivation* as a complex psychological concept that attempts to explain behavior and effort at different activities. Many researchers have examined gender in relation to motivation. Results seem to indicate that girls have a higher motivation for science learning than boys do in Turkish schools. Furthermore, students' motivation levels impacted their science attitudes and achievements.

A survey was used to collect data from the subjects. The schools were fairly homogenous in terms of socioeconomic class. This was done on purpose to limit the effects of class on the study. Mean ages are 13 at one of the schools and 12 at the other school. The survey had a scale of answers that ranged from strongly agree to strongly disagree. A two-way ANOVA was used to analyze the data. The study showed that gender has a significant effect on students' motivation towards science learning, with a $p<.05$. However, there was not a significant difference in self-efficacy scores. It was observed that female students' performance and achievement goals are higher than those of male students. Sevinc et al. (2011) speculated that families' perceptions of female and male students could have influenced the formation of motivational differences.

In conclusion, Sevinc et al. (2011) found that gender is a central factor in Turkish schools concerning motivation, and that academic success is also affected by gender. It was concluded that factors which affect students' beliefs about their individual competence are closely related to their success.

In terms of internal validity, the p-value was too high at .05, and some of the conclusions were not grounded by the research questions. However, the use of a Likert scale is strengthens transferability, and similar scales have been used consistently by other researchers in this field Kirikkaya (2011) investigated students in grades four through eight. Kirikkaya examines their attitudes towards science under the *liking school*, *independent investigator*, and *what I really think of science* titles. Researchers examined the effects of gender, grade level and science achievement on students' attitudes. Based on levels of achievement, schools were put into three groups during the study. The groups were designated *upper*, *middle*, and *lower*. Twelve primary schools were studied and a total of 540 students from all groups were analyzed. Students were chosen randomly. Kirikkaya (2011) defined *attitude* as the favorable or unfavorable response to things, people, places, events, or ideas.

This study was a quantitative survey using three different Likert scales. There were five subscales: liking school, independent investigator, science enthusiasm, the social context of science, and science as a difficult subject. Data was analyzed using many models, which included frequency, percentage, mean, standard deviation, t-test, variance analysis, and a Scheffe test.

Results indicated that different elements of the science lesson produced differing attitudes among genders. For instance, doing mathematical operations and using computer attitude survey scores were lower for girl students than boy students. T-test results show that this is significant ($p<.01$ (girls) and $p<.05$ (boys)). However, the mean *reading and writing in your science book* scores were higher for girls than for boys and these results were also statistically significant ($p<.01$) Kirikkaya (2011) reported this as "highly significant." Other survey answers showed some significance for gender difference. Notably findings indicate that girls enjoyed working in groups significantly more than boys. However, data also indicated that 11-year-old girls are better at science than boys.

Kirikkaya (2011) concluded that generally both male and female students liked being in school; however, there was a significant gender difference in what students favored at school. No further conclusions were made about gender differences found in the study and no call for further research was made. A point of critique in this study is its internal validity. The p-values used in this study range from .05 to .01 but never reach the level of .001. Kirikkaya designates statistical significance at the level of .01 as "highly significant," calling into question this study's grasp of statistical methods and analysis. In addition to this, conclusions drawn did not align with research questions or results found concerning gender. Because of this, external validity is questionable as well, because there are no conclusions concerning gender to compare with other research. Kirikkaya's conclusions are not valuable in terms of their contribution to the field and could be re-worked to match results more clearly.

Sandoval and Harven (2011) asked 129 seventh graders from five diverse, urban middle schools about their perceptions of specific inquiry tasks. This was done quantitatively with an expectancy-value framework. Sandoval and Harven evaluated student interest, utility value, and task difficulty. This data was also evaluated for interactions with gender as well as socioeconomic status. Pre-research was done on science learning. Researchers focused on attitudes, interests, and motivations. Historical research has focused on students' attitudes towards science learning as well as science itself. Research in this field has increased substantially in the last two decades. Researchers believe this may be due to overall negative attitudes toward science. Pre-research indicated that girls have historically been less likely to sustain an interest in science throughout their years in school. Research also indicated that students of color and students of low socioeconomic status are also underrepresented in the sciences.

The aim of the researchers was to find out how students perceived specific tasks of inquiry after they had participated in those tasks during a three-week unit on plant biology and adaptation. Sandoval and Harven (2011) pursued four specific questions: How do students perceive the value of specific inquiry tasks in relation to their usual coursework? Do students' perceptions differ by task? Do boys and girls differ in their perception of the value of inquiry tasks? And finally, Do the perceptions of task value differ by school or community?

A first glance by researchers of the mean ratings for boys and girls did appear to suggest some difference in gender. Researchers ran ANOVA analyses on the data and determined that there were no significant effects on gender in terms of ratings for interest, utility, or difficulty. There was also no significant difference between task and gender. Researchers were apprehensive about drawing conclusions from this analysis because of concerns that student perception in these activities may have been influenced by their activities in their typical science classrooms. Researchers also speculated that inquiry may be less common in more disadvantaged schools. Furthermore, researchers indicated that more research is needed to explore boys' and girls' perceptions of value. It was hypothesized that there was a lack of gender difference because of the unit topic. Women are well represented in biology compared to other science disciplines.

Sandoval and Harven (2011) called for much more research to be done concerning motivational consequences of engagement in inquiry curricula for students with varied backgrounds. Researchers speculated that inquiry-oriented curricula may combat "pedagogy of poverty" common to urban schools.

Statistical inference tests were performed with a p-value of .001. Testing was directly aligned with Eccles and Wigfield's expectancy-value theory of achievement motivation. ANOVAs tests were performed to compare means. This survey followed inquiry and was purely observational research. Internal validity was limited because of the subject matter of the unit.

Externally, results were not found to be statistically significant, suggesting that more research is needed to establish a clear gender link.

Sandoval and Harven's (2011) analysis of the data aligns with other researchers' findings (reviewed earlier in this chapter) simply because there is such a wide variation of findings in this section that do not agree with each other. This would tend to reiterate the idea that the overwhelmingly quantitative binary research in this section limits its credibility. Sorge (2007), Elliott (2010), and Riegle-Crumb et al. (2011) agree that all adolescents experience a period of declined motivation around middle school. However, they do not agree on whether there is a gender interaction involved in this decline. Sevinc et al. (2011) would argue that there is an interaction between gender and motivation, but in terms of attitude, Kirikkaya (2011) and Sandoval and Harven (2011) completely disagree on the interaction of gender. These studies were done in different locations, in different science classrooms, and with kids who were defined as either male or female, and these definitions were based on binary gender roles. Perhaps these conflicting results send the message that one cannot quantify gender and science learning in such a mechanistic way.

Diverse Cultures

In the last two sections of this literature review, gender roles were discussed and interests and motivations analyses were shown to be inconclusive. Both of these sections imply the need for cultural research to enlighten readers about the complexity of gender correlations. Most of the studies thus far were conducted in the United States, so it is important to see how the culture in the United States affects gender relationships in science education. The following studies provide this necessary data because they showcase research done in other parts of the world or in subcultures of the United States.

A study done by Neathery (1997) was conducted based on data from 20 countries. The research asked how gender affected student attitude in science. Not surprisingly, no correlation between gender and attitude or science achievement was found to be statistically significant. Data was different from all countries and could not be analyzed together. This is the first piece of evidence indicating the power of culture on students' gender identity and attitudes.

The next two studies, by Lai (2010) and Cavas (2011), were done in China and Turkey respectively. Both of these studies found females to be more competent and confident in science learning. Lai hypothesized that it was because in China females fit the centralized structure of schools better, and Cavas believed it had to do with constructivist ideas and group learning methods used in Turkish science classrooms. These two studies should help guide the research concerning curriculum change as a means to narrow the gender gap many believe exists in the United States.

A study by Dentith (2008), done in the United States, is included in this section on culture because it was qualitative research done solely on college-bound middle- and upper-class mostly white female students. These students would be considered the highest class of female students in the United States, and the results of this study were very interesting. The girls indicated much struggle and gender bias in their interviews; however, their achievement remained extremely high. They expressed a need to work even harder to prove themselves as females.

Two other studies compare European American students with Taiwanese and Latina students. Hong, Lin, and McCarthy Veach (2008) researched Taiwanese students from single-parent households and determined that extracurricular science helped girls in these families greatly. The structure of gender in Taiwanese culture is very similar to the US. Brown and Leaper (2010) compared Latina girls to European American girls and found that perception of sexism was much higher for Latina girls of all ages.

Neathery (1997) assessed students in 20 countries to determine if there was a relationship between gender and student attitude towards science as a subject. Results indicated that there was a statistically significant correlation between gender and one of the markers for attitude, but this was not enough for the researcher to definitively conclude that gender is a predictor of science achievement.

The students in 20 different countries, including the United States, took an assessment which asked them if they agreed with the following statements:

- Much of what is learned in science is useful in everyday life.
- It is important to know some science in order to get a good job.
- I am good at science.
- My parents are interested in science.

The students were given attitude scores based on this information. The score of 1 indicated a negative attitude and 7 indicated a positive attitude. Anything above a score of 5 was also considered a positive attitude. The test has a .9 reliability overall.

Neathery (1997) asked several research questions. First, she was interested to know whether any of the variables of gender, ethnicity, ability, and grade have a relationship with student attitudes towards science as a subject. She also wanted to determine if there is a significant relationship between the students' attitudes towards science and science achievement. In order to measure science achievement Neathery used scores on the science subtests the students took at the end of the academic year. These were subtests based on the standardized tests for the district. It was apparent from the data that a gender performance gap was present in nearly all of the countries. In fact there were only two countries in which the performance of males and females was equal: Jordan and Taiwan.

Neathery (1997) used an intercorrelational analysis applied to the means to analyze the data. This analysis showed a significant relationship between gender and attitudes towards science, but only on one of the five markers of attitude. It was determined with a .01 confidence level that science was rated as more exciting by males than females. Because gender only correlated with one of their five measured assessment questions, Neathery could not conclude that gender was a predictor of science achievement. The other finding of the study also indicated the need for further research. Neathery concluded that, in particular, further research is needed concerning a student's self-concept of the ability to perform in science and its relationship to achievement.

The findings of this study appeared to be legitimate. Neathery (1997) used a confidence interval of .01 for their gender relationship; however, the attitude rating scale only had a .9 reliability. This indicates that there may be some reliability issues with the assessment. It was reasonable for Neathery to conclude that gender was not an indicator of achievement even though there was one attitude correlation. That one correlation is not sufficient evidence to make a claim gender and achievement.

Lai (2010) researched the gender gap in math and science and examined a cohort of 7,235 middle school students in Beijing, China, by looking at standardized test results and a variety of other variables that were reported by the students. Lai concluded that females were more dominant in all subjects, although the gender gap narrowed as the students progressed in age, especially in the fields of math and science.

The gender gap is considered an important area of research in the United States. Lai (2010) argued that it should also be an important issue in China because it relates to educational inequality and the gender wage gap in the Chinese labor market. Lai noted that, though the gender achievement gap was examined and explained in detail in the United States and in many other countries, this is one of the first studies surrounding this topic in China.

Lai (2010) discovered that current research seems to indicate significant gender achievement gaps with boys generally outperforming girls in math and science and girls excelling in literacy subjects. These studies also indicate that the gender gap increased over time. However, this is exactly the opposite of the findings in Lai's research. Lai examined whether the gender achievement gap revealed by the Chinese data set is consistent with existing evidence in the US and other developed Western countries. Lai also attempted to give a possible explanation for this observed gender gap.

The subjects of Lai's (2010) research included a cohort of 7,235 middle school students in Beijing, China. Statistical analysis was performed on different test results data from the students. Lai determined that females were more dominant in all subjects, but boys began to gradually catch up during middle school, especially in the fields of math and science. Girls consistently outperformed boys throughout primary and middle school. Lai concluded that the gender gap only expressed itself in primary test scores at the end of middle school. There were no other factors that they measured which showed a clear gender gap. This could possibly be because researchers did not isolate other factors for measurement and analysis.

Results indicated that girls actually have superior non-cognitive skills as measured by the other variables like parent information, political affiliation at home, relationship with schoolmates, and relationship with teachers. Lai (2010) concluded that these skills more readily aligned with the centralized curriculum and the test-oriented curriculum. Lai concluded that girls fit more easily into the current education system than boys do. This research provoked other questions for Lai. Future research may examine whether these superior non-cognitive skills are desirable for improving the quality of education for all students, and whether the system itself, rather than the boys' attitudes, required change.

This study appears to be valid at first glance, but there is not much discussion of the descriptive statistics in this study. It is mainly a long list of claims that loosely refer to tables of reported data. The data in these tables is questionable. Some of the p-values were .57, .29, .04, and .36. These are much too high to be reliable, but the author used them to make inferences from the data.

Cavas (2011) examined Turkish primary students from sixth to eighth grade and their motivation towards science learning. Factors affecting this were determined. The participants included 376 students from five primary schools in the city of Izmir. Data was collected using Students Motivation Towards Science Learning questionnaire (SMTSL). Cavas also defined six subscales, which included self-efficacy, science learning value, active learning strategies, performance goal, achievement goal, and learning environment simulation. Students' science attitudes and achievement scores were also collected. Cavas examined gender and grade level in relation to this data.

Cavas (2011) described Turkish education as a constructivist system with the goals of enhancing all students' scientific literacy, helping students to strengthen scientific attitudes and values, and increasing students desire to continue their science studies both in and out of school. Therefore, Cavas concluded that motivation is also an important measure. Past research has investigated motivation with respect to gender in Turkey. Researchers found a significant difference in students' motivation based on gender.

In this study the SMTSL questionnaire was used for evaluation. A five-point Likert-type scale was used. Another tool used was the Scientific Attitude Scale (SAS). Reliability for this scale was found to be .83. The Cronbach alpha reliability coefficient for the whole instrument was .87, ranging from .54 to .85 for the scales. Cavas (2011) used descriptive statistical analysis in the form of a t-test, ANOVA, and Pearson correlation. Overall the research indicated that primary students have a high motivation to learn science and positive attitudes towards science. In order to determine if there was a gender relationship, independent t-tests were carried out. These indicated that in almost all variables females had higher scores than males. But not all of the t-tests were statistically significant. The ones that were had a p-value ranging from .007 to .014. Researchers concluded that girls were more motivated to learn science than boys. Female students also had higher mean scores on the science attitude scale.

This research indicates that females have more motivation in a constructivist environment and that motivation has a very strong influence on students' achievement in science. Cavas (2011) considered this quantitative study a first step. More qualitative research is needed to assess the interaction of different environmental and social factors.

A point of critique in this study is the p-values. They are above .001 and may indicate statistical significance when there is none. However, this study was very transparent with a clear research methodology, and this study could easily be duplicated based on the information given. The sample size was sufficiently large, and a wide range of students participated. Figures were very helpful and were explained thoroughly. This makes this research very transferable.

Dentith (2008) studied the limits of gender equity politics in early high school with focus groups of students at one suburban school. Although this study took place in the US it still belongs in the section on diversity because this researcher focused on only highly affluent suburban girls. It is important to see that gender does not affect science learning in the same way in different countries, cultures, and communities. This further supports the argument that there is more than just gender affecting science learning for young girls.

Interviews with focus groups were held in May 2004. A total of eight focus groups segregated by gender were held. Focus group data was transcribed verbatim. The groups were semi-structured with six questions. The interview questions were:

- What factors influenced your course selection in high school?
- How has the board of education's decision to apply weighted scores to courses influenced your decision to take these courses?
- What are the benefits and disadvantages of participating in these courses?

- Do you believe the incentive of weighted grades has affected the decision-making of boys and girls differently? Why or why not?

Then leading questions were asked like: “The actual pattern indicates that girls’ selection of AP classes more than doubled since weighting of grades began and for boys enrollment has not changed. Why do you think this is?” (Dentith, 2008, pp.150).

Interview data was coded and put into four themes: (a) incentive, teacher skill, and relationship; (b) merit and the politics of privilege; (c) problems of self-confidence and image; and (d) persistent gender constructs and bias. Qualitative analysis indicated that weighted grading gave many young women an incentive to take the rigorous courses. A grade-point average (GPA) is strongly related to elevated social status in this school; when youing women realized their GPA would be boosted, they had an extra incentive to take the course.

In each of the female groups it was clear that the students were all college bound; students expressed the need to take more rigorous courses in order to increase their competitiveness for college. Many of the females were white and middle class. Problems of self-confidence and self-image came out in all of the female groups in terms of their ability level in science. One of the females expressed the need to prove her intelligence to her male peers. Many of the girls expressed the desire to take the most difficult course they could handle. They directly expressed that this need to work harder was because they were girls.

There was a lack of recognition of their achievements and inadequate acknowledgement of their hard work according to the perception of all focus groups They might have meant recognition from peers, teachers, or society, it is unclear from the data. Girls felt they had to work harder and longer in order to gain acceptance or recognition that was readily afforded to boys. Another interesting finding was that girls viewed themselves as being in competition with each other. Debbie (one of the subjects) said, “When you compete with girls it is based on skills, when you compete with guys it is based on the fact that you are not a man.”(Dentith, 2008, pp.161).

The conclusions of this qualitative study began with the disclaimer that the study itself describes students who expressed many class-based social advantages that are not available to most other students in different schools.

Dentith’s (2008) study is very specific to the region and school. All of the females in the study were white middle-class females and had certain privileges. Much of their discussion included talk of college. Because of this, transferability would have to be done in a similar demographic. Dependability is in question because of the unique nature of this study; however, the methodology and credibility of this qualitative research were exceptional. The entire study was direct quotations from students and Dentith’s analysis. The process of the data-collection and focus-group information was very clear and is confirmable.

Hong et al. (2008) conducted a quantitative study on 28 eighth-grade Taiwanese students at a junior high school in Hualien city in eastern Taiwan. There were 16 boys and 12 girls, and a one-group pretest-posttest design was used to assess the effectiveness of an extracurricular science intervention. Hong et al. asked the following research questions: (1) Are there significant gender differences in self-worth, social skills, sexist attitudes, and learning in science? (2) Are there significant pre- and post-extracurricular science intervention differences in students' self-worth, social skills, sexist attitudes, and learning in science? and (3) Are there significant pre-and post-intervention differences in male and female students' science performance?

Hong et al. (2008) noticed the relationship between U.S. single-parent households and Taiwanese single-parent households. In the United States, studies indicated that students in single-parent households are at risk for poor developmental progress and lack of academic achievement. Similar results were found in Taiwan. Hong et al. investigated the effects of extracurricular science intervention on the junior high school students' performance, self-worth, social skills, and sexist attitudes.

In order to accomplish this analysis, Hong et al. (2008) interviewed students, created a questionnaire to which students responded, and gathered qualitative classroom observations. The classroom observations were used to triangulate the quantitative results collected during the research. Hong et al. justified this research because of the skyrocketing divorce rates in both Taiwan and the United States. Researchers hypothesized that single-parent households face more challenges; they also hypothesized that females would perform poorly in their science classrooms. In order to address both issues, Hong et al. developed, implemented and assessed the effects of an intensive 13-week extracurricular science intervention. The science intervention targeted minority students. The content included inquiry as well as demonstrations to dispel common science misconceptions. The intervention employed active and cooperative learning theory and included a field trip, lectures, speeches, an introduction to science-related careers, and hands-on curriculum. Each week of the intervention was a different unit.

To assess gender differences a MANOVA mean comparison was conducted. Significant gender differences were obtained for the variable of sexist attitudes on both the pre- and posttest. Male students were more sexist in both cases. Researchers also found statistically significant gender differences for quality of students' questions, frequency of questioning, and involvement in science learning at pretest but not at posttest. Researchers determined that boy students performed at significantly higher levels than girls at pretest, but after the intervention there were no significant gender differences on the variables. In terms of scientific learning, girls' test scores were significantly higher at posttest in all three categories. Researchers used a p-value of .01. Qualitative results also aligned with these findings.

This study was a detailed analysis which focused on elements of gender, culture, ethnicity, age, class, and geographic location. All variables were assessed for relationships that went beyond linear connections. The only point of critique would be the use of .01 as a p-value. This is high and may not produce accurate statistical results, which might affect the internal validity of the research. The design was complex, employing both qualitative and quantitative methods; generalizations were made only based on data and description, which shows external validity.

Brown and Leaper (2010) investigated Latina and European American adolescent girls, their experiences with academic sexism, and their self-concepts about mathematics and science. Girls ranged in age from13 to 18, and researchers had three sets of hypotheses. Researchers expected girls to have lower perceived competence in math and science as well as lower valuing in math and science. It was also hypothesized that the association between sexism and academic self-concept would be moderated by girls' age. Because of their minority status, Latina girls were predicted to be more sensitive to discrimination and have a stronger relationship between sexism and academic self-concept.

The population of students included 345 girls recruited from schools, camps, and summer programs. The sample was composed of 253 Latina and 92 European American girls. All of the girls completed surveys entitled *What It Means to be a Girl.* The survey had questions about demographics, self-concepts and grades relating to math and science, and perceptions of academic sexism. Items were ordered in terms of emotional response and there were no observations of difficulties in reading the survey.

Overall, European American girls had higher math and science grades. They also perceived themselves as more competent in math and science. They valued the subjects more. Overall rates for perceiving academic sexism were low for all students. However, many girls reported hearing discouraging comments about their math and science abilities at least a few times during the academic year. Ethnicity and age interacted with gender in terms of perceived academic sexism. Younger Latina girls perceived sexism the most. Data was analyzed with an ANOVA test and a p value of .05.

Brown and Leaper (2010) determined from data that perception of academic sexism depended on a girl's age and her ethnicity. As predicted, perceptions of academic sexism were more strongly present with Latina girls, and European American girls' perception of academic sexism increased with age. Older girls were more aware of the interaction. All of these observations indicated that, although infrequent, gender-based negative comments directed at adolescent girls concerning math and science are very important. They affect students' perception of their ability and awareness of sexism. As age increases, girls may become less confident in their abilities and performance in science and math may deteriorate. This emphasizes the importance of encouragement as opposed to negative comments. Overall, girls who are encouraged in math and science have a better chance to succeed no matter what their age or ethnicity. Consequently, society will benefit from this success.

This study was a sample survey and seemed to be externally valid based on other studies concerning minority females and perceptions about science. In terms of internal validity, methodology was not clearly communicated and statistical significance was measured at the .05 level. This level does not support the generalizations Brown and Leaper (2010) made in the article.

The analysis of the research in this Diverse Cultures section indicates that the effect of gender on science learning varies widely across cultures. This indicates that the effects of gender on these things go beyond the classroom and begin when the child is born in their own home. In the United States the data may vary so greatly because of the diverse populations present in schools and regions across the country. Neathery (1997) was unable to produce any findings because of the diverse subjects in that study. Lai (2010) and Cavas (2011) produced results that conflicted with many studies that took place in the United States. And comparisons to populations like the one in Dentith (2008) indicate, for example, that Taiwanese single-parent households are very similar in structure and gender roles (Hong et al., 2008), while Latina girls experience much more awareness of sexism than their European American classmates (Brown & Leaper, 2010). This data all seems to imply that gender identity is somewhat influenced by upbringing and that this effects science learning.

Parent Involvement

This section's primary focus is to analyze the effects of culture on gender and then in turn those effects on science learning at the middle level. It is clear from the studies already described that culture plays a part in gender and its effects on science learning. The following two studies analyze specific a cultural influence on children: their parents. The first study by, Kurtz-Costes, Rowley, Harris-Britt, and Woods (2008), tested the links between children's perceptions of adults' gender stereotypes about math and science ability, children's own stereotypes, and their perception of their own competence. The second study, by Turner, Steward, and Lapan (2004), researched family factors associated with sixth-grade adolescents' math and science career interests. Both studies show a relationship between family, gender, and science learning.

Kurtz-Costes et al. (2008) tested a model that linked children's perceptions of adults' gender stereotypes about mathematics and science ability, children's stereotypes, and children's perceptions of their own mathematics and science competence. Subjects included 302 fourth, sixth, and eighth graders. The mean age was 9.4 years. All of the students were from a rural school district in the southeastern region of the United States. A majority of the students were European Americans, with smaller percentages of African American, Hispanic, and Native American students.

A five-point Likert scale was used to measure children's perceptions of adult stereotypes. Children circled a number indicating how they thought adults viewed boys compared to girls in the subjects of math, science, music, writing, and sports. Children's beliefs about gender competence in math and science were measured with a scale that ranged from *not very good* to *very good*. Their self-concept was measured with a graph where children placed themselves somewhere between the best and the worst in the class. Students' math and science grades were also used in the analysis. A 2 (gender) x 3(grade) analysis of variance (ANOVA) was used with a p value of .05. Cohen values were d-.29 (boys vs. girls), .5 (fourth vs. sixth), and .27 (fourth vs. eighth). Findings indicated that only fourth-grade boys reported that adults hold typical math and science stereotypes. All of the groups viewed their gender as highly competent. Girls had a strong non-traditional stereotype about gender differences in math and science;

this was due to the fact that girls reported a relatively low rating of boys' competence.

The main goals of the study were to link children's perceptions of adult stereotypes, children's own stereotypes, and children's self-concepts and also to determine if these associations differed by grade and gender. In fourth grade, adult stereotypes were related to boys' assessments of girls' abilities. The more strongly boys reported that adults view boys as more competent than girls in math and science, the lower their rating of girls' abilities. This was statistically significant with a p value of .01. Assessment of girls' ability was related to their self-concept, with p=.05. The analysis of girls' data showed fewer significant paths overall.

In conclusion, Kurtz-Costes et al. (2008) determined that there was a greater correspondence between stereotypes and self-concepts for middle school boys than for any other group. With girls, stereotypes did not affect self-concept as much except in sixth grade. Researchers speculated that this may be due to the amount of adversity girls face and to negative stereotypes relating to their ability. In this way, girls demonstrate resilience.

This study was a survey and p values varied from .01 to .05. The internal validity was questionable because of this range and due to the variance among the many tested relationships. External validity seems to align with other related studies and objectivity was intact because of the uniform treatment of genders. Reliability is somewhat questionable due to the statistical analysis.

Turner et al. (2004) researched family factors associated with sixth-grade adolescents' math and science career interests. Participants included 318 sixth graders, of whom 234 were Caucasian, 65 were African American, 9 were Asian American, 3 were Hispanic, and 7 were "other." All were recruited by math and science teachers.

Two instruments were used in the study. These included the Science scale of the Revised Unisex American College Testing Interest Inventory (UNIACT) and a shortened version of Fennema-Sherman Mathematics Attitude Scales (FSMA). These scales measure many things, including interest levels in engineering and other applied technologies, in natural sciences and mathematics, and in social sciences such as marketing research and anthropology. Only part of this scale was used because many of the questions were not age appropriate. Five survey questions were selected.

Analysis was done with a SEM model with categorical data. P value was .023. The purpose of the study was to investigate the interactional effects of family support and gender-typing on self-efficacy in math and science and to see if there were any differences in gender. The results indicate that both mother and father support are valuable, but for young girls, the support of their mother is directly linked to their self- efficacy. Overall, Turner et al. (2004) showed clear links between self-efficacy and performance in both males and females.

This support from the family was presented in many ways, including offering concrete praise for an adolescent's accomplishments. Parents also gave support in the form of tangible rewards. Counselors also helped parents increase their support of adolescents. For example, counselors were able to help parents set, implement, evaluate, and adjust explicit support goals.

One of the challenges for researchers was their choice to use a mixed model analysis which violated some of the principles of SEM. However, Turner et al. (2004) felt the qualitative data was necessary to triangulate quantitative results. They used categorical data to apply the SEM model. Their internal validity may have been compromised because of this and their p value of .023. Externally this study was clear in method and execution. Results were clearly communicated and charts were clear. The survey method was adjusted to be age appropriate and shorter in length to match the needs of a sixth-grade audience.

The analysis of the research on parent involvement indicates that parents own stereotypes have an effect on children's stereotypes and their views about themselves, especially for young middle school boys (Kurtz-Costes et al., 2008). In Turner et al. (2004) this is further confirmed when family factors actually influence student career goals in math and science. These studies further emphasize the influence of culture on gender and its effects on science learning.

Possible Intervention Strategies

In the previous sections, gender bias, interest and motivation, and cultural diversity with an emphasis on parent involvement were analyzed. In this section, the research focuses on curriculum choices made with the intent to equalize gender differences; however they have been defined in each study. Many of the attempts actually helped male students more than female students or segregated students based on gender. Some had no effect at all. Only two studies provided curriculum choices that elevated female students. These two studies align with

Cavas' (2011) study of science education methods in Turkey. In addition to these studies, another subgroup of studies content and its relation to gender is included at the end of these subsections.

Interventions that Increased Disparity between Genders

This section includes all of the intervention techniques that were not effective for girls. They are still valuable studies because it is unclear why some of them did not work. Perhaps they can be altered in the future and tested again. The first study, by Park, Khan, and Petrina (2009), examined computer-assisted instruction (CAI). A study by Chen and Howard (2010) examined the effects of live simulation on students' science learning and attitude. The third study by Hayden, Ouyang, Scinski, Olszewski, and Bielefeldt (2011) examined a specific method designed to increase stem career participation among girls. All of these studies showed greater benefits for male students than for females. In these cases being female had a negative effect on science learning in these environments. The fourth study in this subsection was done by Friend (2006), in which students were segregated into female-only and male-only homogeneous science classrooms. This did not help female performance and also brought up issues of equality and segregation in the middle school.

Park et al. (2009) examined computer-assisted instruction and its effects on 234 Korean middle school students. Researchers noticed marked improvement with low-achievement groups after the use of CAI, but they determined that boys tended to perform better with CAI than girls did. They speculated as to why this might be in their discussion.

The purpose of this study was to examine CAI, which is a fairly new Korean education software. The focus was to explore the strengths and limitations of the software in order to determine its usefulness and ability to promote learning. Specifically, researchers looked at the software's ability to promote learning for low-achieving students and also any differences in the software's effectiveness when used by different genders. The study aimed to help determine how to provide and realize equal education in terms of equitable distribution of educational resources for all Korean students.

Park et al. (2009) used "time series quasi-experimental research design" because this model could provide a reliable picture of achievement before and after CAI was implemented. The study was quantitative, and the data was intended to provide a baseline so that future ongoing qualitative research could be performed. Researchers evaluated CAI using a pre- and post-questionnaire as well as a post-achievement test. The pre- and post-questionnaires related to attitudes as well as career goals. They used a Likert scale for evaluation. The scale levels were *strongly disagree*, *disagree*, *neutral*, *agree*, and *strongly agree*. The post-achievement test was multiple choice and short answer. It measured understanding of astronomy, which was the content used with the CAI.

Researchers analyzed the data using achievement groups based on their GPAs. Paired sample t-tests were used to compare the means in the pre- and post-questionnaires. Differences in achievement were analyzed with a one-way ANOVA using the achievement groups. The relevant results concerning gender were measured against a p value of .05. Girls who participated in the study did not show as much increase in achievement after CAI as boys did. The results indicated to researchers that this method of instruction did not have the same impact on girls' conceptual understanding of this science topic as it did for boys. Girls did show improvement, but it was not as much as boys. Park et al. (2009) speculate this may be because girls were often observed being excluded from manipulating the variables in the software because boys in their groups took over. Girls were reduced to simply being observers. The study still concludes that CAI benefits all students and increases their interest in science careers.

This study had some limitations as well as some questionable data-analysis techniques. In terms of limitations, it was reported in the study that students worked in groups and that teachers often observed female students being overpowered by males who wanted to perform the manipulation tasks of the software. The researchers did not explicitly evaluate the group work and look for possible interactions, which undermines their attempt to use the group work to examine individual growth. Also a p value of .05 is not ideal for a study like this one. A p value closer to .001 would provide more accurate results.

Chen and Howard (2010) examined the effects of live simulation on students' science learning and attitude. There were 311 participants, all of whom were students at the middle school level. Researchers used a pre/post design to compare science learning and attitude before the simulation as well as afterward. Not only did researchers examine teacher influence on science attitudes but also on gender differences in attitude. Chen and Howard asked whether a technology-supported simulation learning environment could improve students' positive attitudes towards science subjects and careers. Past research indicated that high-quality teachers are essential to improve teaching and learning. There was no prior research done on gender and science. However, these gendered relationships were found to be some of the most compelling relationships in the study.

Participants included 186 male and 125 female middle school students. The group was from West Virginia, Ohio, Pennsylvania, and New York. Students participated in the Challenger Learning Center, a space flight simulation in which students were asked to solve simulated real-life space flight challenges while in designated crew and captain roles. Previous research suggested that attitudes towards science were not a unitary construct but a large number of sub-constructs which contribute in varying proportions towards an individual's attitudes towards science. Researchers used a previously tested method of attitude assessment to account for this. The Test of Scientific-related Attitudes (TOSRA) was implemented.

A one-way ANOVA was performed comparing data before and after the live simulation. The results showed a significant gender difference on adoption of scientific attitudes and career interest. Male students showed significantly higher adoption of scientific attitudes than females ($p<.05$). Male students also showed significantly higher interest in science careers than female students ($p<.05$). A relationship was established between a teacher's content knowledge and students' attitudes towards science. This was true for males and females.

Chen and Howard (2010) concluded from this evaluation that live simulation should be supported in science curriculum even though it appealed to male students more than female students. Promotion of careers in STEM-related fields was cited as a rationale, although female students showed significantly less interest in the field. Post-research was completed to explain the gender differences. Researchers concluded that gender has been cited as the most significant variable concerning students' attitudes towards science. Researchers concluded that this model increased boys' interest in science and science careers, but more research is needed to determine how instructional content can lead to a significant increase for girls in the choice of science-related careers and increased positive attitude towards science.

This study was basically a survey. The question asked did not reflect the conclusions made concerning gender. It appears that the gender correlation may have been an afterthought, because additional research was added after the study was completed to explain gender differences. A point of critique for this study is the amount of male students involved. There were 61 more males in the study than females, although the research was done in a large number of regions. This is important because this activity may have been performed on a fieldtrip or other optional activity. Perhaps more boys with a predetermined interest in science chose to participate, although the pre-post model should have somewhat accounted for this. Overall, the gender implications in this study were in line with much of the research, although current research on this subject contains conflicting conclusions. Chen and Howard (2010) still endorsed this model of science learning, even though it only benefited male students.

Hayden et al. (2011) examined the iQUEST (Investigation for Quality Understanding and Engagement for Students and Teachers) project and its ability to promote student interest and attitudes towards careers in STEM fields. The subjects included seventh- and eighth-grade science classrooms that were composed of many Hispanic students.

Hayden's past research indicated that a lack of STEM-related skills will have a negative effect on women's and minorities' chances to compete for employment, wages, and leadership in all professional fields. Based on this past research, Hayden et al. (2011) concluded that it is important for education agencies to help develop the potential of these underrepresented populations. The iQUEST project was an attempt to accomplish this. The iQUEST program is funded by the National Science Foundation and brings technology-enhanced learning experiences as a type of intervention for middle school students, especially middle schools with high percentages of female and minority students. The principles of iQUEST include recognizing the need for technology savvy-teachers, teaching workforce skils, addressing individual needs in learning communities, engaging hands-on investigations, and fostering students' ability to see themselves as scientists.

Hayden et al. (2010) asked if this program increased interest in science and self- perception about competence in science. To assess this, the Test of

Science Related Attitudes (TOSRA) survey was used. This test was evaluated on a five-point Likert scale. Results showed that while both boys and girls showed increases in TOSRA scores over time, only the increases for boys were significant. The average increase over time was slightly greater than one half of the standard deviation. The p value reported was .05.

Hayden et al. (2010) concluded that iQUEST has the potential to increase student readiness to pursue STEM careers; however, at this point the potential is only significant for male students. More research is needed to increase access points in the program for female students. Some preliminary success was observed in iQUEST summer camps, so this may be an area for further research.

This study was observational and implemented a survey for quantitative analysis. A point of critique is the usage of a p value at only .05, which indicates a lack of internal validity. Other programs have shown responsiveness exclusively for male students, which indicates external validity.

Friend (2006) conducted quantitative research on same-gender grouping in eighth-grade science classrooms. There was also a qualitative component to the research. Friend hypothesized that male and female students enrolled in same-gender science classes would demonstrate more positive science academic achievement than their peers enrolled in mixed-gender classes, and that same-gender grouping of students would have a positive effect on classroom climate. According to research done by Friend, males in the US typically perform better than females on achievement measures in science and enroll in more advanced science classes. In addition to this, a higher percentage of males pursue careers in science. The purpose of this study was to determine if single-sex grouping was an effective strategy for improving academic achievement and increasing positive atmosphere in the classroom.

The middle school selected for this study was located in a suburban school district in the Midwest. Enrollment was approximately 500 students. Changes to instruction included random assignment of male and female students into separate science classrooms for the 2002-2003 school year. Two segregated science classrooms were studied: one male class with twenty male students and a male teacher, and one female class with twenty-three female students and a female teacher, as well as two mixed gender classrooms. The design included two manipulated classrooms with homogeneous sex groupings of students and two mixed-gender classrooms for comparison. Teachers used the same curriculum and all data collected during the school year was entered into the data program SPSS for statistical analysis. Results indicated that the mean scores of females in the same-gender class were higher than in the mixed-gender classes. However, this was not found to be significant at the .05 level. Male students also had higher scores in the homogeneous class, but again this was not found to be statistically significant at the alpha .05 level.

Qualitative data collected included interviews with teachers, comments from students on written surveys, and classroom observations. Female teachers felt there was more of a bonding in the same-gender class. Male teachers indicated a classroom with a hierarchy.

Results were not statistically significant and Friend's (2006) discussion indicated that there was an equity issue in terms of separating students by gender that was still up for debate in this particular school and community. The gendered classrooms also reinforced gender stereotypes heavily. Friend concluded that reform of school structure alone is not enough to create change in science education achievement and attitude. Friend referenced the historical phrase "separate but equal" and reminded readers that separate is inherently unequal because segregation sets up real opportunities for discrimination and stereotyping whether it is intentional or not. In conclusion, setting up same-sex classrooms in the area of science without any professional development for teachers about how to counter gender stereotypes has no positive effect on student achievement or attitude.

This study was a quasi-experimental correlational study with both quantitative and qualitative elements. Internal validity was weak, as no controls for history, maturation, or testing were in place. The results were not even statistically significant at the .05 level, but this still provided relevant conclusions concerning lack of effectiveness of gender segregation in middle school.

Interventions That Had No Effect on Gender

Two studies provided no conclusive evidence in favor of their curriculum choices. The first study, by Weinberg, Basile, and Albright (2011), examined four experiential learning programs and determined that this method was equally successful for males and females. Another study, by Doppelt, Mehalik, Schunn, Silk, and Krysinski (2008), examined a design-based learning approach which attempted to find gender interactions, though results indicated none.

Weinberg et al. (2011) evaluated the effects of four experiential learning programs on the interest and motivation of middle school students towards mathematics and science. Researchers used the Expectancy-Value model as a theoretical framework. Participants included 336 middle school students, with 158 males and 176 females. Weinberg et al. determined through previous research that there is an increased need for middle-level students to be exposed to stimulating science education. It is also very important for females to be exposed to and experience careers in the sciences.

In this study, qualitative and quantitative methods were used to explore student motivation before and after completing the summer program, in order to compare the two types of programs (residential and non-residential), to examine differences in motivational change based on student characteristics, and to explore the changes in student understanding of what mathematicians and scientists do.

Weinberg et al. (2011) justified using a mixed-methods study for three reasons. First, the exploration of outreach programs from multiple perspectives with a combination of quantitative and qualitative data offsets the limitations inherent in the use of only one data-collection strategy. Second, this approach allowed the researchers to consider a more diverse set of research questions.

Finally, a mixed method was used because the integration of the two approaches enabled the combination of statistical analysis with rich interviews and thematic analysis.

Results in terms of gender showed that males and females were equally represented in summer programs and there were no significant differences between males and females for math or science. Overall, students from both genders entered the program with science interest, thought topics were useful, noted that math and science played a role in how they defined themselves, and were generally neutral about the costs associated with being good at these subjects. No significant differences of any kind were noted for gender. This indicated that the programs were equally successful for girls and for boys.

Weinberg et al. (2011) indicated that there may be some validity problems with their study. Researchers speculated that the lack of change between pretest and posttest was due to short term shifts in students' self-perception.

Internal validity of this study is questionable because of the p-value of .01. Other than this flaw, the study was clear in its intentions and made a case for experiential learning. Researchers indicated the need for more research with parents and family members of children in this study.

Doppelt et al. (2008) researched the validity of a design-based learning approach with a quantitative case study of an urban, public middle school. Two science classrooms were examined as the teachers switched for the first time from a standard, scripted inquiry approach to a design-based learning (DBL) approach. Doppelt et al. asked two research questions. First, would students previously labeled high- and low-achievers become equally engaged by DBL? Second, would the traditional gaps in science achievement associated with race/ethnicity, gender, and socioeconomic status be increased or reduced?

Doppelt et al. (2008) determined through research that a major goal of reform in science education is to produce a curriculum that helps all students learn. This is the rationale for this design-based learning analysis. DBL provides the students with a reason to want to learn the science. Students engage in design in order to create a natural and meaningful venue to learn science and design skills. DBL is an active process that is usually implemented in teams so it promotes collaborative effort.

In order to incorporate technological design and systems thinking, researchers developed a new model for DBL. The framework components were purpose, input, solutions, choice, operations, and evaluation. This module was based on how engineers design new systems. It included assessing needs requirements, generating solutions, and making decisions. Because researchers created and studied this program, they had a built-in motive for wanting to show the success of the program.

Participants included 38 students in two science classes. The students were eighth-graders aged 13 to 14 who attended a public, urban middle school. One of the classes was considered a low-level class and the other was a high-level class. Three sources of data were analyzed: knowledge tests, oral presentation assessments, and analyses of student portfolios. In the first section, pre- and post-knowledge tests were compared in high- and low-level classrooms. In the second section, overall performance relative to gender and other factors was reported, and in the third section, portfolios were described for high- and low-level classrooms.

In terms of gender, no data was explicitly described in the analysis. One graph showed pre- and post-test knowledge performance, and there was a gender bar, but the data does not show any statistically significant trends. In the summary, Doppelt et al. (2008) indicated that African American and free/reduced lunch students benefitted from design-based learning. They used statistical analysis with a p-value of $p<.05$. Doppelt et al. assert that this data is evidence of a narrowing achievement gap. Again there is no mention of gender. Results from the knowledge test also did not show significant improvement from low-achievers to high-achievers. Further research is suggested.

There are many points of critique in this study. The statistical test used was not identified. It can be assumed that it was some type of means comparison, but it is never explicitly stated. Also, the researchers do not describe their findings in all cases. When analyzing performance, researchers must direct their readers to a graph and explain how to interpret it. The p-value is also quite high in this study at .05. A p-value of .001 is recommended for significance. The sample size in this study was very small. Fewer than 40 students were evaluated. Choosing only students in high- and low-achieving classrooms is not realistic, and the contrived homogenization of the students may have contributed to the lack of statistically significant evidence. The validity of this study is questionable given the lack of data reported and lack of discussion concerning this data.

Interventions That Elevated Female Students

These studies were effective with female students and showed promising results for future research. The first study by Werner and Denning (2009) looked at pair programming. Their analysis indicated that, in order to succeed in technology-rich environments, female students must be motivated to engage with complex materials and work with a peer. The second study, by Gerstner and Bogner (2009,) evaluated gender and concept map structure.

Werner and Denning (2009) qualitatively examined one hundred and twenty-six girls who were voluntary participants in an after-school and summer program called Girls Creating Games (GCG). All participants lived in a small urban community in central California and ranged in age from 10 to 14 years. Werner and Denning conducted a qualitative case study to determine what pair programming looks like for middle school girls and what kinds of pair interactions promote or undermine problem-solving for middle school girls. Werner and Denning concluded that success in technology-rich environments depends upon girls' motivation to engage with complex materials and their opportunities to work with peers.

Pair programming is an early intervention effort which attempts to improve the representation of women in the computer science and engineering disciplines. Werner and Denning (2009) is the first to attempt to use pair programming in the middle school classroom. Pair programming is an opportunity for students to engage in metacognitive acts. As an example, students must be able to summarize and explain what they know, respond to immediate feedback, take time to work through what they don't understand, and ask questions. Students also get the opportunity to collaborate with peers to solve problems. All of these skills involve high-level thinking and increase the students' ability to perform in the science classroom and self-monitor their progress.

This is why Werner and Denning (2009) believe that pair programming will be a promising method in the middle school classroom. Werner and Denning suggest that when middle-level girls work with a partner to collaborate, they are actually aligning their academic practice with their social development. It is theorized that many middle-level girls are more concerned with becoming young adults than they are about their careers. The idea of using an approach that will convince girls to take college prep courses and focus on their careers is a breakthrough. Girls get a chance to work in a social environment that fosters high level thinking.

Werner and Denning (2009) had one hundred and twenty-six girls who were voluntary participants in an after-school and summer program called Girls Creating Games (GCG). The girls all lived in a small, urban community in central California and ranged in age from 10 to 14 years (M=11.75, SD=1.0). The girls' self-reported ethnicity was mostly white (58%) and Hispanic/Latina (31%); thirty-five percent of all girls reported that they spoke a language other than English at home at least some of the time. In the GCG program, girls created computer games. The inspiration for the program came from a series of books in the 1980s called *Choose Your Own Adventure*, where readers select a path at key decision points in the story to create their own series of events.

During this computer game making activity which occurred several times during the program and with multiple groupings of girls, researchers used a coding method to identify the different interaction processes they noticed during the activity. From these findings they were able to examine communication patterns and problem-solving strategies when middle school girls work on the computer with a peer. They were able to determine which types of interactions promoted the problem solving strategies needed for CSE disciplines. They also identified some interactions that might undermine those problem-solving skills.

Overall, their findings seemed to align with the research from other studies concerning social learning, although theirs was the first to examine pair programming among middle school girls. Their findings have many implications for future curriculum development.

Gerstner and Bogner (2009) evaluated gender and concept map structure and its ability to indicate achievement in science. Gerstner and Bogner evaluated fifth-grade students in single-sex groups and determined that the number of nets in the concept maps were dependent on gender, which in turn affected students' success on science retention-tests. Gerstner and Bogner evaluated gender and concept map structure because previous research suggested many different findings that were not in agreement with each other. Some of the studies determined that girls had less knowledge gain from concept maps than boys. Other studies determined that female students produced more complex concept maps than males. Previous research also indicated that it is very important to teach science materials in a way that promotes meaningful learning.

In terms of gender, the Gerstner and Bogner (2009) wanted to know first if the structure of the concept maps made were influenced by gender, and then if the concept map structure itself was a reliable indicator of students' success in learning. Subjects included one hundred and forty-nine high-achieving fifth-grade students from five German secondary schools. Their average age was 10.5 years. Gender was controlled for by placing students in small single-sex groups to produce concept maps.

In order to analyze the concept maps, researchers defined three different types of concept map structures: *spokes*, *chains*, and *nets*. In order to assess students' short and long-term learning success, researchers gave a multiple-choice science knowledge test in a pre-, post-, retention-test design. Statistical tests such as MANOVA, one-way ANOVA, and t-tests were used to identify any differences in gender.

Analysis indicated that females had more *net* structures in their concept maps. Results also showed that these nets were the only true indicator of meaningful learning based on their retention-test results. This interaction between gender and the number of nets per concept map revealed a significant effect on students' long-term learning success. The statistical results reported that males produced significantly fewer nets (19%; n=25) than their female colleagues. The p-value was reported as .001. In addition, an analysis of the structural types within each concept map failed to identify gender effects regarding *spoke* and *chain* structures. Furthermore, when female groups produced *net* structures, they created two nets per concept map in most cases, while males only created one net per concept map in a majority of cases.

This research indicated that only *net* structures are a crucial indicator for meaningful learning and there is actually a balance. If students do not have enough net structures their performance goes down, but also if students have too many net structures their performance goes down as well. This indicates that quality of connections is important when making a concept map. These results also indicate that females tend to produce more complex concept maps than their male colleagues. These results were measured with a p-value of .001, which is fairly reliable, and conclusions were drawn appropriately based on these results.

This analysis of the research on intervention strategies outlined many models of instruction that were not beneficial to females, like computer-assisted instruction (Park et al., 2009), live simulation (Chen and Howard, 2010), the iQUEST program (Hayden et al., 2011) and same-gender groupings in middle school science classrooms (Friend, 2006). Several models did not affect gender, like experiential learning programs (Weinberg et al., 2011) and design-based learning (Doppelt et al., 2008).

However, both pair programming (Werner and Denning, 2009) and concept mapping (Gerstner and Bogner, 2009) showed promising results for young women in the United States. It is interesting that both of these methods align with constructivist models described in Turkish research where girls excel in math and science (Cavas, 2011). An additional subsection follows on actual subject matter and its effects on gender in the classroom.

Science Curriculum and Gender

In the previously reviewed studies, researchers tried out many different types of science instruction. However, rarely was the actual science content analyzed for effects on males and females. In this brief subsection, curriculum is compared. In the first study, Wilhelm (2009) analyzed gender differences in lunar-related scientific and mathematical understandings in an astronomy curriculum. In the second study, Yost and Gonzalez (2008) conduct an exploration of coral reefs as part of a biology curriculum.

Wilhelm (2009) analyzed gender differences in lunar-related scientific and mathematical understandings. Wilhelm examined 123 students, which included 70 females and 53 males. These middle school students used observation, sketch, journaling, two- and three-dimensional modeling, and classroom discussion to explore the moon. The lessons were all from the program Realistic Explorations in Astronomical Learning (REAL).

The general method of teaching for the subjects was inquiry-based, and most student groups were self-selected and gender-mixed. The study was quantitative and involved the collection and administration of the Lunar Phases Concept Inventory (LPCI) and the Geometry Special Assessment (GSA). Both had a pre- and post-project implementation.

Results indicated that males scored significantly higher on the science and math domains. GSA results found both male and female groups to have a significant increase in their test scores overall. It was concluded that both scientific and mathematical understanding was significantly improved for both sexes through the use of spatially focused, inquiry-oriented curriculum such as REAL.

Points of critique in this study include the fact that the results of the LPCI and the GSA were inconsistent. Also, the spatial projection domain was inadequate for accurate representation. The questions on the GSA did not appropriately filter out spatial projection concepts.

Yost and Gonzalez (2008) qualitatively addressed the claim that teachers must encourage the majority culture to recognize that the contributions of minority cultures are essential for the wellbeing of a democratic society. This was done through an exploration of middle-level students and their participation in science lessons that surrounded the coral reef as an analogical model to promote collaborative learning on cultural and ethnic diversity in science.

Yost and Gonzalez (2008) define *diversity* as distinct ethnic, racial, religious, or cultural groups. They add that in conversation, in the workplace, and in official documents diversity can include class, ethnicity, gender, age, sexual orientation, or disability status. The researchers conducted two science exercises. One focused on biological diversity and the other on cultural diversity with first semester college students.

During the biological diversity activity, students were randomly assigned a number which they then used for identification on all of their materials for the lesson so they could be blindly evaluated by the researchers. Then researchers asked the question, "What does diversity in science mean to you?" During the cultural diversity lesson students used library resources to identify historical and contemporary scholars on biological diversity by their race, cultural heritage, and gender.

The researchers provided the students with much of the academic language in this lesson because it was clearly above instructional level for many students. Definitions were written on the whiteboard for words like *diversity* and *culture*. There was also intentional inclusion of more resources targeting minorities and women. To assess the students, Yost and Gonzalez (2008) revisited the question, "What does diversity in science mean to you?" after the exercise. The students were told to indicate in their answers if their views had not changed. Researchers found that, although some of the students continued to hold onto their old responses, many student viewpoints changed significantly. The study concluded that connecting interactions of scientists with reef organisms is an effective way to create critical thinking and activate the discussion about cultural diversity within the context of science education.

This study was rather unclear in the methodology section. It would be difficult for another researcher to perform this analysis again. Strengths include the meticulous introduction and background research that was collected prior to the analysis.

Interestingly enough male students performed better during the astronomy curriculum (Wilhelm, 2009) and issues of diversity were addressed more clearly during the biology activity (Yost and Gonzalez, 2008). This may offer some explanation as to why females are beginning to have high representation in the biological sciences.

Summary

This research indicates many areas for further analysis. In gender roles, it is clearly determined that gender is a more complex topic than initially thought. In order to define gender in any meaningful way, qualitative research must be done. This was the same conclusion for interest and motivation. The research in this section produced conflicting results because of the attempt to quantify the unquantifiable. How can one define gender, attitudes, motivation, or interest? These are subjective labels with different meaning for every person.

The research clearly showed a link between culture and gender and linked this to parent involvement. This cultural link identified a society in which girls excelled. Pedagogy based on constructivist theory was present in the two interventions that conclusively benefited middle school girls. These studies were on pair programming and concept mapping. In addition, this section highlights the importance of the biological sciences because biology affords a useful analogy for human cultural diversity.

CHAPTER 3: CONCLUSION

Introduction

Chapter one of this review presented much past research addressing the question: How does gender affect student learning in the middle school science classroom? The previous research indicated a long history of disparity between males and females. Chapter two outlined the professional literature in sections on gender roles, interest and motivation, and diverse cultures including parent involvement. There were also sections on possible intervention strategies and curricular choices. This chapter explained the difficulty in defining concepts like gender, interest, and motivation. It clearly linked culture to gender. The chapter also outlined strategies that have been employed to engage students in science, but only two of those eight strategies actually succeeded in reaching middle school girls.

Finally, chapter three provides a section-by-section summary of the findings in chapter two with strengths and weaknesses of the studies. It also will describe classroom implications, suggestions for future research and a conclusion.

Summary of the Findings

Gender Roles

This section contained many major findings with great implications for future research. It was perhaps the most profound section of the literature in terms of impact on future studies. Many of the studies in this section were qualitative and results were presented in observational analyses. These studies identified complex gender identities and levels of ability in science. This success in breaking gender stereotypes may be due to the qualitative nature of the research. When the environment and subjects are not heavily quantified and controlled, their true nature can surface.

In the articles on gender roles, Brickhouse et al. (2000) studied a variety of girls and how they engaged in science learning. All four case studies seemed to disprove the stereotypical image of young women portrayed in the current research. These girls were not alienated from science in their lives, and they all asserted that they were good at science. Some of them were mechanically inclined and outspoken. They even chose to participate in science outside of the classroom. This competent view of female science learners is further confirmed in Shmurak and Ratliff's (1993) study, which reported that math and science classrooms seemed to be the most equitable. They were female dominated as often as they were male dominated. Based on this sample, researchers did not observe female students withdrawing from math and science as research suggested they would.

Findings in Brickhouse et al. (2000) are by far the strongest in the section. Limitations of the research were clearly defined; considering the nature of middle school students and their tendency to change their communities and identities quite frequently during adolescence, a qualitative case study was the most appropriate for this subject matter. Although Shmurak and Ratliff (1993) aligned with Brickhouse et al., the methods were weaker and there was not a clear method for taking observational notes during the study. As a result one must wonder if the researchers experienced any bias in the field when recording their observations. Similarly, Karaarslan and Sungur (2011) reported non-statistically significant findings. This is intriguing but could also be due to researcher error or the very quantitative nature of the study.

Both Fouad et al. (2010) and Heilbronner (2008) found gender bias in their studies. Fouad et al. (2010) very accurately conveyed quantitative research. The significance was based on a p value of .001 and simply distributed a survey to students without manipulating their environment in any way. Findings that indicated females reporting barriers in science education must be taken seriously given the meticulous accuracy of the study. Heilbronner (2008), on the other hand, while performing qualitative research, provided little methodology and used a student from her own classroom as a case study. Her findings concerning female progress are more questionable even though they are still supported by the other research.

There were many trends in these studies. Most were done on students from diverse racial backgrounds, and all but one were conducted in the United States in various regions. Most of the qualitative research focused solely on female students, with the exception of Shmurak and Ratliff (1993). The few quantitative studies in this section used scaled analysis to review survey results. Both used similar formats that resembled Likert scales, which quantify levels of responses. Many of the studies suggest that females both have more complex gender roles and vary in their ability levels in science more than would be expected.

Interest and Motivation Analysis

This section of the literature differs starkly from the previous section. Not only is the data primarily quantitative, with the exception of Elliott (2010), but the studies were all based on binary gender groupings with gender roles based on biases.

Sorge (2007) reported a clear drop in science attitudes between elementary school and middle school. This was a concern to the researchers because the students had only attended middle school for six weeks when they collected this data. Sorge determined that this decline in positive science attitude happened at the same pace for males and females. Elliott (2010) reported similar findings. However, the studies used very different methodology to come to this conclusion.

Sorge (2007) did do a quantitative study but was very transparent about the limitations of the study. Sorge mentioned the erratic development of adolescence as a factor that affects all middle school studies. Research was conducted and analyzed with a p value of .001 which produced very statistically significant results. Elliott (2010) conducted a qualitative study. However, the conclusions drawn in the study were not entirely supported by observations, even though this research aligned with Sorge. Elliiott’s conclusions were weaker.

Riegle-Crumb et al. (2011) indicated that white males commonly report that they strongly enjoy science, and females of all races report lower levels of enjoyment in science than white males. However, all students report lower interest in math and science during eighth grade. This study was quantitative and the analysis was not as methodical as Sorge (2007). Both external and internal validity are questionable. Similar practices were employed when Sevinc et al. (2011) conducted research on motivation and found a relationship with gender. This was analyzed with a p value of .05 and internal validity was questionable.

The last two studies, by Kirikkaya (2011) and Sandoval and Harven (2011), indicated directly conflicting results. Kirikkaya's results indicated that different elements of the science lesson produced differing attitudes among genders. For instance, doing mathematical operations and using computer scores were lower for girl students than for boy students. T-test results show that this is significant ($p<.01$ and $p<.05$). However the mean *reading and writing in your science book* scores were higher for girls than for boys, and these results were also statistically significant ($p<.01$) Researchers reported this as "highly significant." Sandoval and Harven determined that there were no significant effects of gender in terms of ratings for interest, utility, or difficulty. There was also no significant difference between task and gender.

Both of these studies produced weak findings. Sandoval and Harven (2011) found no statistically significant findings at all, and Kirikkaya (2011) produced a wide range of findings which were determined based on high p values. Overall, the strongest findings in this section were presented by Sorge (2007), which indicated that all students show less interest in science during adolescence.

The most notable trend in the interest and motivation studies is that they were almost exclusively quantitative data. This is completely different than the research presented in the section on gender roles. Much of the data collected was analyzed poorly with p values that were too high. The only exception to this was Sorge (2007). Demographics varied in these studies, which only added further complication when trying to compare their one-dimensional quantitative results.

Diverse Cultures

This section of the literature is a compilation of differing findings. This was the expected outcome, considering that all of these studies were conducted in diverse communities across the world. The most interesting findings involved the studies that compared cultures to European Americans.

Brown and Leaper (2010) determined from data that perception of academic sexism depended on the girl's age and ethnicity. As predicted, perceptions of academic sexism were more strongly present with Latina girls, and European American girls' perception of acdemic sexism increased with age. Hong et al. (2008) determined that boy students performed at significantly higher levels than girls at pretest, but after the intervention there were no significant gender differences on the variables. In terms of scientific learning, girls' test scores were significantly higher at posttest in all three categories. Researchers used a p-value of .01. Qualitative results also aligned with these findings.

Brown and Leaper (2010) used a simple survey, but statistical analysis findings were weak with limited methodology reported. Hong et al. (2008) produced a thorough study with both qualitative and quantitative results. Quantitative results were highly statistically significant, and the qualitative results were used to triangulate the data.

Dentith's (2008) research reported that girls felt they had to work harder and longer in order to gain acceptance or recognition that was readily afforded to boys. Another interesting finding was that girls viewed themselves as being in competition with each other. Debbie (one of the subjects) said, "When you compete with girls it is based on skills, when you compete with guys it is based on the fact that you are not a man."(Dentith, 2008, pp.161). But the study indicated that girls were performing above average despite the many obstacles they claimed to face. This research was also meticulously done. Evidence was all direct quotations from focus groups, and generalizations were made only based on these observations.

Cavas's (2011) research indicated that Turkish females have more motivation in a constructivist environment and that motivation has a very strong influence on students' achievement in science. Lai (2010) indicated that Chinese girls have superior non-cognitive skills as measured by the other variables like parent information, political affiliation at home, relationship with schoolmates, and relationship with teachers. Lai concluded that these skills more readily aligned with the centralized and test-oriented curriculum. Lai concluded that girls fit more easily into the current education system than boys do. However both Cavas (2011) and Lai (2010) provide only weak findings at best, because their statistical analyses in both studies were very weak and their methods were incomplete at best. Both external and internal validity were questionable.

Neathery (1997) had sound methods in quantitative form but was unable to produce statistically significant findings. This was support in itself for the importance of culture on gender development and identity.

In terms of trends, there were not many to report in this section. Because the section was based on diverse cultural samples, the research was geographically widespread. The only notable trend was the comparison to European Americans in a few of the studies (Hong et al., 2008; Brown and Leaper, 2010).

Parent Involvement

This subsection on parent involvement produced similar findings in each study. Kurtz-Costes et al. (2008) found that in fourth grade adult stereotypes were related to boys' assessments of girls' abilities. The more strongly boys reported that adults view boys as more competent than girls in math and science, the lower their rating of girls' abilities. This was statistically significant with a p value of .01. But these findings were somewhat weak. This study was a survey and p values varied from .01 to .05. The internal validity was questionable because of this range and due to the variance among the many tested relationships.

Turner et al. (2004) indicated that both mother and father support are valuable, but for young girls the support of their mother is directly linked to their self-efficacy. Overall self-efficacy was shown to be linked to performance in both males and females. Although external validity was intact, this was also weak evidence because of statistical analysis methods.

Overall, all of the studies that focused on diverse cultures had consistently poor statistical analysis, but the two parent studies align with each other, which may suggest stronger findings. Trends in this section include quantitative analysis and two studies relating parents to children's perceptions and goals.

Possible Intervention Strategies

This section provided many findings that indicated classroom teaching methods that may be doing female students a disservice. It also indicated studies that did not help or hinder. There were only two studies that produced strong evidence of pedagogy that supported female students and their science learning.

Interventions that increased gender disparity. Park et al. (2009) found that girls who participated in the study did not show as much increase in achievement after computer-assisted instruction as boys did. Chen and Howard (2010) concluded that live simulation increased boys' interest in science and science careers, so more research is needed to determine how instructional content can lead to a significant increase in the choices of science related careers and increased positive attitude towards science for girls. Hayden et al. (2011) showed that while both boys and girls increases in TOSRA scores over time, with the iQUEST program only the increases for boys were significant. Friend (2006) found that pairing girls in their own science classroom provided results that were not statistically significant, and Friend's discussion indicated that there was an equity issue in terms of separating students by gender that was still up for debate in this particular school and community.

In these four studies, none of the research indicated any usable strategies to increase positive effects of gender on science learning. In terms of strength of the research, the findings in these studies were all based on weak statistical analysis. It appeared that many of them attempted to manipulate statistical evidence to push their own curriculum agendas. This was very apparent in Chen and Howard (2010) and in Hayden et al. (2011); both studies indicated that their programs were highly effective even though they did not help female students.

Interventions that had no effect on gender. These studies had weak results without any statistical evidence related to gender interactions of any kind. Doppelt et al. (2008) made no mention of gender results even though they were a part of the research design, and Weinberg et al. (2011) presented results in terms of gender showing that males and females were equally represented in summer programs and there were no significant differences between males and females for math or science. Internal validity of this study is questionable because of the p-value of .01. Other than this flaw, the study was clear in its intentions and made a case for experiential learning. Researchers indicated the need for more research to be done with parents and family members of children in this study.

Interventions that elevated female students. The final two studies in this subsection show strong results in favor of pair programming and concept mapping as intervention strategies to elevate the female gender in science education. Werner and Dennings' (2009) findings seemed to align with the research from other studies concerning social learning, although theirs was the first to examine pair programming among middle school girls. Their findings have important implications for future curriculum development and indicate that to succeed in technology-rich environments, female students must be motivated to engage with complex materials and work with a peer. Gerstner and Bogner's (2009) analysis indicated that females had more net structures in their concept maps. Results also showed that these nets were the only true indicator of meaningful learning based on students' retention-test results.

Science curriculum and gender. Wilhelm (2009) and Yost and Gonzalez (2008) analyzed gender in relation to two different parts of science curriculum. Strong findings indicate that diversity issues are better presented in a biology curriculum and that boys tend to do better with astronomy concepts.

There were interesting trends in this section on intervention. First, the studies that showed promise for female students were based on constructivist learning theory. Also, in the curriculum section, research confirms the new data which shows women as leading forces in the study of biology and why that might be. The study of biological diversity mimics cultural diversity.

Implications for Teaching

This research was focused around the question: How does gender affect student learning in the middle school science classroom? This question was answered in many studies of students from different cultures and regions of the United States and the world. Some researchers focused on gender itself and the definition of gender in different settings and cultures. Others attempted to quantify motivation and interests by grouping students into binary gender roles and analyze them based on these roles without considering culture.

Many decided that there was a gender gap, even with the conflicting research, and attempted to close this gap with different teaching models; in the end only two were successful in doing so.

The point of much of this research was to determine some implications for teaching. The goal was to clearly define the relationship between gender and science education and with this to create learning communities of equality. Much of the research was unable to accomplish this goal. But in thinking about implications for teaching, Hearn and Husu's (2011) question is central to future teaching practice: "How do I understand gender and what implications follow?"

One of the difficulties in this literature review was the fact that each researcher defined gender in her own way. The studies were from different cultures and regions, and they were conducted in different types of science classrooms with different teaching methods. Shmurak and Ratliff (1993) describes middle school as a time when identity is changing often. Teachers who have adolescent students must be empathetic towards the changes their students are experiencing. With the increasingly complex definition of gender, new and more intricate questions concerning science have surfaced. These questions span the very nature of science and technology itself (Hearn and Husu, 2011).

Teachers cannot assume anything about their students. As Brickhouse et al. (2000) descried, there are many females who do not fit into the traditional gender roles. In this study teachers did not encourage girls with non-traditional gender roles, even though they demonstrated high ability in the science.

Teachers need to be aware of their own cultural encapsulation and give specific praise to all students, not just to those who fit their schema.

The motivation and interest studies were primarily quantitative research. This brings up an important point for teacher practice. The United States is a culture of standards in public education. There is something to be said for statistical evidence, but it was clear in this review of the literature that these studies were at a disadvantage when attempting to make claims about science learning. The very act of quantifying people requires one to simplify their existence into categorical data ranked on a Likert scale. By doing this, researchers begin to miss the many intricate details that make a young woman who she is. These details hold the keys to success and a future in the sciences. In the classroom, rather than solely quantifying generic test scores, teachers must attempt to differentiate and meet the needs of each student with assessments that are not uniform.

The studies from different cultures have emphasized the great power family function and culture play in the classroom. This research stresses the need for multicultural awareness and consideration by classroom teachers. Teachers can also incorporate multicultural education into their science classrooms as a way to reach students. Some useful elements can be taken from the Turkish culture, where women seem to excel in the sciences because of the constructivist nature of the curriculum (Cavas, 2011).

Suggestions for Further Research

There were a wide range of weaknesses identified in this research. One of the primary concerns was the use of quantitative research to define this issue of gender and science education. Gender is a complex topic and almost all of the studies chose to define it in binary terms with categories for male and female. This was a problem that led to many inconclusive and conflicting results across studies, especially for studies concerning issues of motivation and interest.

It is difficult to quantify these ideas, and many of the studies did not define them in the same way. This calls for qualitative research that makes meaningful observations of students and their specific cases rather than trying to group all students together. This will lead to proper gender identity definitions as well as some indicators of motivation.

As an example, Sorge (2007) performed a quantitative study on attitudes towards science in middle school. As a way to make this qualitative, Sorge could have done an observational study in addition to his survey as a way to triangulate his findings and offer additional insight in terms of the identities of his students. This identity includes their culture, gender identity, and goals.

Conclusion

Chapter one examined the reasons for a review of the professional literature regarding gender and how it affects science learning in the middle school classroom. This chapter portrayed the historical context of gender in the United States and described inequality over time. The power of encouragement was addressed and there was clear rationale for this study. Chapter one was grounded in past research that clearly defined the gender gap in science, but as more current literature was analyzed the picture of gender and science education became more complex. This issue is not as easily defined now as it was in the history presented in chapter one.

Chapter two outlined the professional literature in sections beginning with gender roles, interest and motivation, and diverse cultures including parent involvement. There were also sections on possible intervention strategies and curricular choices. This chapter explained the difficulty in defining things like gender, interest, and motivation. It clearly linked culture to gender. The chapter also outlined strategies that have been employed to reach kids in science, but only two of those eight strategies actually succeeded in reaching middle school girls.

Chapter three provided a more detailed explanation of the results of each study and their strength in terms of both external and internal validity. It also outlined their usefulness in addressing the question of research. This chapter explored connections between the literature and classroom practice. It also provided a space to describe future research that must be done in light of this analysis.

With the increasingly complex definition of gender, new and more intricate questions concerning science have surfaced. These questions span the very nature of science and technology itself. Questions concerning science are not the only focus, but also questions of culture and its influence on learning in science. The diverse studies examined in this review indicate that regions as well as cultures change the way that girls respond to science. So in conclusion it would be difficult to link science performance to biological sex in any way. Clearly science performance is linked to societal constructs of gender and what these roles consist of.

So how does gender affect science learning in middle school? A better question might be, How does gender not affect science learning in middle school? Research shows gender interaction in curricular choices, classroom teaching styles, and sometimes in studies of motivation, interest, and attitude. The reality is that gender is one way we choose to measure who we are. When we begin to see gender as more than just male and female but as a complex expression of who we are on a continuum, gender becomes involved in all of our learning and choices. We must also begin to see gender as something imposed on us by our culture of origin. With this in mind it is impossible to group all females together and say that they feel one way about science. The fact that this has been done in the past with any significance could be due to statistical inaccuracies, which almost all of the quantitative studies in this review contained.

Overall, much more quality, detailed, and honest research is needed to understand the complexity of this topic. As a starting point, it might be useful to spend some time focusing on gender roles in United States public education system and simply working towards a detailed case study on this topic. This understanding is necessary before any analysis of learning can occur. Science performance in the US is linked to “gender” as it is defined here. But is this because of physiological differences between the sexes? This review of the literature says no. In fact this performance gap is created by the actions of educators, test book writers, test scorers, and any other person who has a specific idea about what it means to be female in America and imposes this idea on young women as they learn and grow. Science learning is not linked to biological sex but to the cultural stereotypes of gender that are reinforced as children are educated.

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