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The Impact of Gender and Pedagogy on the Development of Self-Regulated Learning Strategies in Undergraduate Engineering Classrooms

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THE IMPACT OF GENDER AND PEDAGOGY ON THE DEVELOPMENT
OF SELF-REGULATED LEARNING STRATEGIES IN
UNDERGRADUATE ENGINEERING CLASSROOMS

by

Jennifer Walter

A Thesis

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ABSTRACT

The purpose of this paper is to examine ways in which pedagogy and gender of instructor impact the development of self-regulated learning strategies as assessed by the Motivated Strategies for Learning Questionnaire (MSLQ) in male and female undergraduate engineering students. Pedagogy was operationalized as two general formats: lecture plus active learning techniques or problem-base/project-based learning. One hundred seventy-six students from four universities participated in the study. Within-group analyses found significant differences with regard to pedagogy, instructors' gender, and student gender on the learning strategies and motivation subscales as operationalized by the MSLQ. Male and females students reported significant post-test differences with regard to the gender of instructor and the style of pedagogy. The results of this study showed a pattern where more positive responses for students of both genders were found with the same-gendered instructor. The results also suggested that male students responded more positively to project and problem-based courses with changes evidenced in motivation strategies and resource management. Female students showed decreases in resource management in these two types of courses. Further, female students reported increases in the lecture with active learning courses.

Chapter 1

Introduction

According to the National Center for Education Statistics, in the year 2008, the percentage of bachelor's degrees (in any field) earned by women was 57.3% and the percentage of bachelor's degrees earned by males (in any field) was 42.7% (<http://nces.ed.gov>). Despite the fact that more female students are earning bachelor's degrees than male students, 69,724 males received a bachelor's degree in engineering, while only 14,129 female students earned a bachelor's degree in engineering (<http://nces.ed.gov>). While this number of female engineering graduates may seem like a very small amount, consider that only 146 bachelor's degrees in engineering were awarded to women in 1966 (National Science Foundation, 2010). When looking at the percentage distribution, 0.1% of women who were awarded a bachelor's degree in 1966 received an engineering degree. In 2006, 1.6% of women received a bachelor's degree in engineering (National Science Foundation, 2010). While the actual number of women receiving degrees in engineering has increased by ten thousand percent, the percentage of the distribution of the engineering degrees awarded to women has changed minimally.

In engineering and science fields, data from 2006 showed that women constituted 64% of psychologists, 41% of biological and life scientists, 26% of computer scientists, but only 11% of engineers. Further data found that women scientists and engineers who are managers in business or industry comprise only 8% of engineering management and only 11% of natural science management. In 2006, 690,000 females with a bachelor's degree were employed in a science or engineering occupation, while 2,911,000 men with a bachelor's degree were employed in a science or engineering occupation (National Science Foundation, 2010).

Statistics examining undergraduate education, graduate education and the work force consistently show major disparities between the numbers of males and females in science and engineering fields. What is the cause of these discrepancies? The question is one that has been debated by researchers for the past fifty years.

The purpose of this study is to examine how different types of engineering learning environments contribute to the development of lifelong learning skills among engineering undergraduates, with a specific focus on the interaction of instructor's gender with that of the student and within particular pedagogies. The independent variables of instructor gender and pedagogical style were specifically targeted and the questions asked were whether male and female students respond differently to different learning environments or to the gender of their instructors, with differences examined in the area of self-regulated learning. Examining differences associated with the cognitive, behavioral, motivational and contextual factors that lead to the development of self-regulated learning should lead to a greater understanding of the learning environments that promote the development of these necessary skills and the role that gender plays in this development. The information gained from this study provides opportunities for instructors to consider how they might design their learning environments so that both male and female students can be successful, which ultimately, may help to increase retention among talented female engineering students.

Prior to investigating the ways in which male and female students respond to differing learning environments, it is necessary to examine the ways in which one's gender is developed. Freud's theory of psychosexual development (1896) which is considered to be the first psychoanalytic theory was once a forerunner of its time. Because of the lack of acceptance of psychoanalytic theory, cognitive developmental theorists attempted to explain gender differences

by examining the ways in which children make sense of the world around them. According to cognitive developmental theorists, children come to understand gender differences through gender constancy (Golombok & Fivush, 1994). Gender constancy is the understanding that one's gender is fixed and irreversible. Gender schema theory is developed from Kohlberg's cognitive developmental theory of gender development. Gender schema theory examines the ways in which children organize and develop their knowledge of gender differences as they grow older and more mature (Golombok & Fivush, 1994).

Social learning theory analyzes the influence that others, such as family, peers and teachers, have on a child's gender development. Social learning theory emphasizes the importance of reinforcement and modeling to gender development (Golombok & Fivush, 1994). Social cognitive theory is an extension of social learning theory in that it closely examines the ways in which gender "appropriate" and gender "inappropriate" behaviors are modeled (1994). Social cognitive theory argues that gender development occurs due to three main modes of influence: modeling, enactive experience, and direct tuition. Although modeling is often thought of as mimicry, social cognitive theory states that after the underlying principles surrounding the behavior are taught, a child can then move beyond the principles and create his or her own new behavior patterns. Enactive experience refers to the reactions of others in a child's immediate social environment in response to the child's understanding of gender. Lastly, direct tuition occurs when a child observes members of his or her immediate social environment engage in gender-typed behaviors and then internalizes these actions (Bussey & Bandura, 1999).

Self-regulated learning (SRL) is a process in which the learner is an active participant in his or her own learning process (Pintrich, 2004). Self-regulated learners select their own goals, select and organize their learning strategies, and self-monitor their effectiveness. Like the social

cognitive view of gender development, the social cognitive view of self-regulated learning emphasizes the impact of the environment and behavioral influences, as well as personal processes. Social cognitive theorists assume that there are three sub-processes involved in self-regulation: self-observation, self-judgment, and self-reaction (Zimmerman, 1989).

According to classic social learning theory, children are more likely to imitate models of the same gender as themselves (Golombok & Fivush, 1994). Although this idea is still accepted today, it is considered simplistic. Modified versions of social learning theory argue that children learn about appropriate and inappropriate gendered behaviors through observations of many adult males and females. Golombok and Fivush (1994) state “Children then use these abstractions of gender-appropriate behaviors as models for their own imitative performance. In other words, children imitate behaviors that they have observed to be typical of their own gender” (p. 85). Given this argument, the research question guiding this study is: will male and female students be more likely to imitate the behaviors of their same-gendered instructors? Unfortunately for female students in the science, technology, engineering and mathematics (STEM) fields, there are considerably fewer female faculty members for them to observe and emulate. It is important therefore to understand whether the instructional environment influences students in ways beyond the potential influence exerted by the instructor.

As a means of understanding the influence of instructor gender and instructional environment on student development, one hundred seventy-six undergraduate engineering students and four engineering instructors from four different universities participated in this study on self-regulated learning. One hundred three male and seventy three female students participated in the study. Data was collected from 11 courses over a two year period. Students responded to the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith,

Garcia, & McKeachie, 1991) at the beginning and end of each semester. The Motivated Strategies for Learning Questionnaire assesses college students' use of specific learning strategies and motivation orientation for college courses. Between and within group analyses were conducted to assess the development of self-regulated learning strategies using the MSLQ subscales as the dependent variables.

Chapter 2

Review of the Literature

Theories of Gender Development

In order to more fully understand why there is such a discrepancy in the number of women and men in the science, technology, engineering and mathematics fields (STEM), it is necessary to first examine the theories surrounding the topic of gender development. Gender development theories began in the late 1800's and have evolved and changed in accordance with advancing research. Although these theories look very different today than they did in the past, each theory adds its own unique perspective of how biological, social, and personal factors blend together to help one distinguish whether they are "male" or "female."

There are several major theoretical perspectives that have influenced our thinking on gender development through the years. Each has contributed in distinct ways to our understanding on the topic and each has its own research paradigm. What follows is a brief presentation of a few of the more influential theories on the topic followed by empirical research on several of the explanatory variables for gender development advanced by these theoretical orientations.

Psychoanalytic theory made a tremendous impact on developmental psychology in the 21st century, despite the fact that there is little empirical evidence to support its premises (1994). Sigmund Freud's psychoanalytic theory stresses the importance of early childhood experiences on human development. Freud's stage theory placed great emphasis on a child's identification with the same-sexed parent, which figures prominently in the third psychosexual stage called the phallic stage. In this stage, children become aware of their bodies, the bodies of other children,

and the bodies of their parents. Children become aware of anatomical characteristics that make a person either male or female. Psychoanalytic theorists believe that during the phallic stage, boys become sexually interested in their mother but fear their father will castrate them as a form of retaliation (Golombok & Fivush, 1994). This is known as the Oedipal conflict. Psychoanalytic theory argues that boys begin to identify with their father when they realize that as they get older, they will have access to a female sexual partner, just as their father does. According to Freud, feelings of inferiority, resentment over being deprived of a penis and fear of retaliation from their mother due to sexual feelings for their father cause girls to identify with their mother (Golombok & Fivush, 1994).

While psychoanalytic theory was a forerunner of its time, there is no empirical evidence to support the notion of identification with the same-sexed parent (1994). Although several revisions have been made to psychoanalytic theory, none of the reformulations have ever been empirically validated. For these reasons, psychoanalytic theory is not particularly accepted among research psychologists. In response to the lack of acceptance of psychoanalytic theory, cognitive developmental theorists such as Piaget and Kohlberg began to examine the ways in which children try to make sense of the world around them and the ways in which they construct ideas and hypotheses regarding gender.

Kohlberg's cognitive developmental theory of gender development is based on the idea of gender identity (Kohlberg, 1967). Kohlberg believed that children go through three stages in coming to understand gender. Initially, children develop gender conceptions based on what they hear and see around them and they are not yet aware that gender is an unchanging characteristic. Bandura and Bussey (1999) state that "once children achieve gender constancy – the belief that their own gender is fixed and irreversible – they positively value their gender identity and seek to

behave in ways that are congruent with that conception” (p. 677). Kohlberg describes gender constancy as biologically based, rather than superficially developing through association with items such as clothing and hair styles. Leading up to the development of gender constancy are the development of gender identity, gender stability, and gender consistency. Gender identity is the least mature of the three levels of gender understanding and occurs at about the age of two years old. In this level, children have the ability to recognize their own gender as well as the gender of others but they base this classification on physical characteristics, such as length of hair. At about three or four years old, a child accomplishes gender stability in which he or she understands that gender remains constant over time. In the third and most mature stage of gender constancy, gender consistency, a child has the ability to recognize that gender remains constant despite changes in appearance, dress or interests. Kohlberg believes that children generally develop consistency around the age of seven years old.

Gender schema theory was developed in line with Kohlberg’s cognitive-developmental theory of gender development. Essentially, a schema is an organized body of knowledge which can be considered similar to a gender stereotype (Golombok & Fivush, 1994). According to Golombok and Fivush (1994), gender schema theory “describes and explains the developing content and organization of gender knowledge” (p. 99). Gender schema theory argues that as children learn more about gender throughout childhood, they begin to organize this knowledge in complex ways. Further, children develop distinct dimensions of gender schemas which provide gender-related information about issues such as behaviors, occupations, roles and traits (Golombok & Fivush, 1994). Martin and Halverson (1981) found that there are associations between and across dimensions. For example, typical ways to describe women are as nurturing (trait), as enjoying indoor activities such as cooking or sewing (behaviors) and as becoming elementary teachers (occupation) (Golombok & Fivush, 1994). Further, there is an association

between gender-related behaviors such as “likes to play football” and “likes to be outdoors” as being male-related behaviors. Golombok and Fivush (1994) found that across dimension associations link behaviors from different categories of knowledge such as female-related behaviors (cooking) and female-related roles (mother).

According to gender schema theory, preschool children almost always rely on gender labels (Golombok & Fivush, 1994). For example, they will predict that if an individual is a girl, she will like to play with dolls. Gender schema theory suggests that children have a tendency to want to be like others of their own sex, which is referred to as gender-labeling. For example, dolls are labeled as a ‘girl toy’ and ‘I am a girl’ which means dolls are for me (Martin & Halverson, 1981). As children grow older, they will make more complex predictions. For example, if they are told about a girl who likes to play with cars, they will predict that she will like to play with toolboxes also. In addition, older children have more detailed knowledge about their own gender and may begin to make inferences about gender-related behaviors based on limited information (Golombok & Fivush, 1994).

When analyzing theories of gender development, it is important to consider the impact of the social environment. Parents, teachers, friends and the media have a tremendous influence on gender development in children. The influence of social environments on learning is the topic of social learning theory. Social learning theory has been applied to gender development primarily by Mischel (1970) and Bandura (1974). According to social learning theory, behavior is acquired through reinforcement and modeling (Golombok & Fivush, 1994). Reinforcement results in behaviors that are likely to be repeated because of the favorable consequences. Conversely behavior that has unfavorable consequences is less likely to be performed again. For example, in more traditional circles, girls might receive a more favorable response to playing with a doll than

they might if they were playing with a dump truck. This favorable response reinforces the behavior of playing with the doll. Social learning also occurs through observation and imitation of others, which is known as modeling. Golombok and Fivush (1994) state that modeling of same-sex individuals is also considered important for gender development. It was once thought that children are more likely to imitate models of the same sex as themselves, particularly the same-sexed parent (Golombok & Fivush, 1994). While this belief is still accepted, it is considered simplistic. Social cognitive theory of gender development expands on this principle and provides the most current perspective on modeling.

Social cognitive theory argues that gender differentiation occurs due to three major modes of influence: modeling, enactive experience, and direct tuition (Bussey & Bandura, 1999). Although modeling is often thought of as simple mimicry, social cognitive theory argues that modeling from an exemplar can result in learning. When a behavior is modeled and the observer extracts the rules and structure underlying the patterned behavior, he or she can then create new patterns of behavior that go beyond the behaviors that were modeled (Bussey & Bandura, 1999). Kanfer, Deuerfeldt, Martin, and Dorsey (1971) found that observers are more likely to pay attention to and learn more about modeled behaviors that are personally relevant to them. Further, Bandura and Bussey (1984) found that children are more likely to choose a same-sexed model to pay attention to and learn from when given the choice of a male or female.

Enactive experience refers to people's reactions to the gender-linked behavior of children (Bussey & Bandura, 1999). For example, if a father walked into a room and saw that his son was playing with a doll, the father's immediate reaction would be remembered and internalized by the son as either favorable or unfavorable. In line with social learning theory, if the reaction was unfavorable, it is less likely that the son would continue to play with the doll. If the father's

reaction was favorable, the son would be more likely to continue to play with the doll. Through enactive experience, children witness these reactions from different people and integrate this information into guidelines for their behavior (Bussey & Bandura, 1999).

The third mode of influence is direct tuition. In this mode of influence, Bussey and Bandura (1999) state that “gender conceptions are drawn from the tutelage of person’s in one’s social environment” (p. 689). Similar to the two other modes of influence, direct tuition is most effective when the gender role receives social support (Bussey & Bandura, 1999). In other words, if a child is exposed to gender stereotypes in his or her immediate social environment and the same stereotype is practiced and acknowledged by others outside of this environment, he or she will be more likely to adopt these gender stereotypes.

Finally, it is impossible to examine gender development without acknowledging the impact of biological factors. Our physical appearance of either being male or female has a tremendous impact on the way in which we view the world and on the way in which the world views us. At the time of conception, a female egg containing 23 chromosomes joins a male sperm, which also contains 23 chromosomes to form a single cell with 23 chromosomes pairs (Golombok & Fivush, 1994). Sexual differentiation typically begins at six weeks.

Golombok and Fivush (1994) report that prenatal sex hormones are not generally thought to play a major influence on gender identity, but that they do play a part in the development of gender roles. For example, it appears as though prenatal androgens influence us towards masculinity (Golombok & Fivush, 1994). Further, progesterone can influence both masculinity and femininity on sex role behavior (Golombok & Fivush, 1994). However, it has been found that nonandrogenic progesterones have a feminizing effect particularly for girls (Golombok & Fivush, 1994). It is important to note that prenatal sex hormones set the foundations for later sex

role behaviors but their effects are often changed due to the social environment in which the child is raised.

In order to closely examine gender development in children, it was first necessary to review the major theoretical perspectives regarding gender development. Psychoanalytic theory provided us with early insights into the development of gender. Cognitive developmental theorists provided us with information regarding the ways in which children construct schemas and gender identity to make sense of the world around them. Social learning theorists examined the role of the social environment, such as parents, teachers, friends and the media in regards to gender development through reinforcement and modeling. Social cognitive theory developed out of social learning theory and takes a closer look at the ways in which a child's gender develops through modeling others, direct tuition and enactive experience. Finally, it was important to consider the role of biological factors in laying a foundation for gender development. The different theoretical orientations have, in some cases, led us to empirical research. An examination of the research coming out of these theories may lead to possible explanations to understand the discrepancies in the number of male and female students in the STEM fields. What follows is a closer examination of some of the empirical research that attempts to explain this phenomenon.

Explanatory Factors

Parents' perceptions. Researchers have examined social reasons why there are considerable differences in male and female performance in the sciences and mathematics. According to Bleeker and Jacobs (2004), "one of the most consistent findings in this work has been the important role played by parents as socializers of their children's academic achievement including gender differences in ability perceptions, course selection and college major" (p.98).

Eccles-Parsons, Adler and Kaczala (1982) conducted a study to examine if parent's perceptions about their child's mathematical ability played a role in their child's beliefs about their own mathematical ability. The sample of students came from 22 fifth to eleventh grade classrooms in a midwestern city. The students came from mostly middle to upper class families. The sample was 53% female students and 47% male students. The parent sample consisted of mothers and fathers of the children. The student questionnaire consisted of questions regarding the following: difficulty of the students' current math course, difficulty level of the students' future math courses, students' expectations of their performance in their current math course, future expectations about future math courses, ratings of ability and performance in math, and ratings of effort perceived to be necessary to do well in math. In addition to being asked questions regarding their level of mathematics ability, the highest math course that they had ever taken, and their occupation, parents were asked questions about the following: parents' perceptions of their child's math ability, parents' perceptions of the importance of math to their child, parents' perceptions of the effort needed by their child to do well in math, parents' perceptions of how difficult math is for their child, and parents' expectations for their child's performance in future math courses. School record data included the child's current and previous two math grades, as well as state achievement test performance.

Results of the study found that fathers, when compared to mothers, were more likely to report that they were and are currently better at math, that math is and was easier for them, that they expend less effort to do well in math, that they enjoy math more both in the past and in the present, and that math is currently and has always been more useful to them. Fathers reported a more positive attitude towards math and an overall higher belief in their mathematical abilities than the mothers did. Mothers, on the other hand, reported that they had higher grades while in school.

When comparing the student samples, Eccles-Parsons, Adler, and Kaczala (1982) found that “despite the fact that boys and girls performed equally well in math the previous year and their most recent standardized math test ($p < .05$), the sex of the child has a significant effect on the parents’ perceptions of their child’s math ability, as well as their perceptions of the various high school courses” (p. 316). Parents of sons indicated that math was more important than other subjects for their child, while fathers of daughters indicated that American history and English were more important subjects for their daughters. This study also found that the parents of the daughters did not rate their daughter as having significantly lower mathematical ability than parents of sons, but they did indicate that math was harder for their child and that their child had to work harder to do well in math.

When the researchers examined the student sample, they found that “children’s self-perceptions, expectancies, and perceptions of task difficulties, related consistently to both their parents’ beliefs and expectancies, and to the parents’ actual estimates of their children’s abilities. Parents who think that math is hard for their children and who think their children are not very good at math, have children who also possess a low concept of their math ability, see math as difficult, and have low expectancies for their future performances in math” (p. 316). These results were found for both male and female students.

Researchers then hypothesized that perhaps children had low self-perceptions and expectancies due to previous poor performance in math. The researchers used a path analysis to examine whether the parents’ perceptions were influencing the child’s self-perceptions or if, in fact, the child’s previous poor performance in math was influencing their perceptions. Results of the path analysis indicate that “the children’s self-concepts and task concepts were more directly

related to their parents' beliefs about their math aptitude and potential more than their own past performance or their sex" (p. 320).

Tenenbaum and Leaper (2003) conducted a similar study to the Eccles-Parson et al. (1982) study, except that they examined gender stereotypes regarding science interest and ability, rather than math. Prior to conducting the study, Tenenbaum and Leaper made the following hypotheses: (1) parents will rate daughters lower than sons in science interest and ability, (2) parents' gender-stereotyped attributions will be more pronounced toward adolescents than toward younger children, and (3) the correlations between parents' ratings and children's self-concepts will be stronger for mothers than fathers (p. 37). The student sample consisted of 13 sixth-grade girls, 13 sixth-grade boys, 13 eighth-grade girls and 13 eighth-grade boys from the San Francisco and coastal areas of California. Mothers of participating children were aged from 32 to 53 years old. Mothers' education level ranged from having completed some college to having a professional or graduate degree. Fathers ranged in age from 34 to 55 years old. Fathers' educational level ranged from having completed 11th grade in high school to having a professional or graduate degree. Significantly more fathers (n=16) than mothers (n=5) were employed in science or technology-related fields. Researchers visited participants' homes and participants were asked to do four tasks and complete a questionnaire. The four tasks were in the areas of biology, physics, computer technology and interpersonal reasoning tasks. Parents and their child were asked to complete the tasks in a room by themselves (without the researchers) with a video camera recording their interactions. Parents were then asked to complete the Science Attribution Questionnaire (Eccles 1980), as well as two measures that were used to infer the parents' view of their child's science ability. The children answered questions about their self-efficacy regarding each of their subjects in school, as well as questions about their academic aspirations and interests. The students' teachers were also asked to complete questions regarding

each child's grades in science and mathematics. After the questionnaires were completed and the videotapes transcribed, two trained undergraduate students coded the interactions. Researchers found that evidence supported or partially supported their three hypotheses. They found that "In general, parents held gender-stereotyped expectations regarding their children's science and interest ability...In contrast, there were no significant differences between boys and girls in their grades, interest or self-efficacy in science" (p. 42). Further, Tenenbaum and Leaper found that "parents of daughters believed that their child was interested in science less than did parents of sons. Further, parents of daughters believed that science was more difficult for their child than parents of sons. However, parents of daughters did not believe that their child had to try hard to do well in science more than parents of sons" (p. 42). The researchers hypothesized that parents' gender-stereotypic attributions would be more pronounced for older children than for younger children, but this hypothesis was not supported. Tenenbaum and Leaper also hypothesized that there would be a strong relationship between parents' attributions about how difficult and interesting their child found science and their child's self-efficacy and interest in science. This hypothesis was confirmed. These findings are very similar to Eccles-Parsons, et al.'s (1982) findings regarding children's self-efficacy and interest in mathematics.

Crowley, Callanan, Tenenbaum, and Allen (2001) examined discourse patterns between children and their parents at an interactive science museum. The study was held at a California children's museum and the interactive displays consisted of information about biology, physics, geography, psychology and engineering. The study consisted of 298 interactions, each from a different family. Families consisted of the following combinations: fathers with 1 or more boys (n=65), fathers with 1 or more girls (n=34), mothers with boys (n=78), mothers with girls (n=54), mothers and fathers with boys (n=42), and mothers and fathers with girls (n=25). Ages of the children ranged from 1 year to 8 years old. Video recordings captured each child from the time

that the child engaged in a display until the time that the child disengaged from the display. Conversations were coded for whether the parents explained an exhibit, gave directions or talked about evidence, in other words provided information about visual, tactile, or auditory information about the display.

When examining nonverbal measures of the children's activity, researchers found no significant differences between the sexes in the following areas: initial engagement of a display, manipulation of the exhibit, and the length of time the child was engaged at the exhibit. Researchers did find significant differences in the amount of explanations that parents provided for their children. In 29% of the interactions, parents provided explanations for boys while in only 9% of the interactions were explanations provided for girls. According to the researchers, "these findings were particularly noteworthy because differences were found in the rate of parents' explanation to children as young as 1 to 3 years old, suggesting parents may be involved in creating gender bias in science learning years before children's first classroom science instruction" (p. 260).

A common factor among these studies was the parents' belief that their son or daughter was or was not capable of mastering the domains of math and science. As children, we internalize our parents' subtle cues regarding our own capabilities. Children whose parents encourage a sense of mastery of a particular domain are, often unknowingly, promoting self-efficacy and self-confidence in their child. Having a strong sense of self-efficacy, self-confidence and interest in a particular domain ultimately can have a serious impact on a child's academic and career choices. The results of these studies show the importance of parents becoming sensitive to their own gender biases and the impact that these biases can have on their children's educational future.

Education. Research has found that males and females perform, on average, equally when given a standardized intelligence test (Halpern, 1997). While there are no differences in overall intelligence, Denmark, Rabinowitz, and Sechzer (2005) found that there are specific patterns of abilities that differ between males and females. In terms of verbal abilities, females have been found to have higher levels of verbal fluency, writing ability, and reading comprehension. Sex differences also appear in verbal analogies in which males are favored (Halpern, 1997).

While girls show higher levels of mathematical computation throughout elementary and middle school, sex differences are most prevalent in mathematics when comparing males and females in the very highest levels of ability. Denmark et al. (2005) report that “many more males than females score in the mathematically gifted categories, with ratios ranging from 3:1 to 8:1 in favor of males” (p. 192). Geary (2007) found that “boys and men have posted higher average scores and outnumbered girls and women at the high end on standardized mathematics and science tests that include novel (i.e., not directly taught in school) problems such as Scholastic Achievement Tests-Mathematics” (p. 174). With regard to mathematical abilities, sex differences vary with the type of mathematical concept being analyzed. Several studies have shown that male students, on average, tend to perform better on arithmetical word problems. More specifically, the largest sex differences appear to be in computational fluency and spatial abilities (Casey, Nuttall, & Pezaris, 1995; Geary, 1996). Lummis and Stevenson (1990) conducted a study with 236 college students that examined gender differences in arithmetical computations, arithmetical reasoning, mental rotation, and intelligence. The hypothesis of the study was that spatial abilities contribute to the ability to solve mathematical word problems. After administering standardized measures, the researchers found that males do in fact have greater levels of spatial cognition. Results of the study showed that males, regardless of their IQ, have

greater three-dimensional spatial competencies than their female counterparts. Females with higher IQs tended to have the same three-dimensional spatial competencies as males, but not females with lower IQs. The authors stated their belief that these skills may be more inherent for males and more learned for females which can ultimately lead to the likelihood that males are more successful in solving mathematical word problems.

Kleinfeld (1998) found that from preschool to college, teachers of both sexes report giving more attention to male students than female students. Denmark et al. (2005) state that “in elementary school, teachers check boys’ work more often, call on them more often, and praise, criticize, and punish them more often than they do girls” (p. 198). While it may seem that male students are receiving preferential treatment, the reality is that male students receive more of the teachers’ attention because they are more likely to display behavior problems. Sadker and Sadker (1994) found that in one study of elementary and middle school students, boys were eight times more likely to call out than girls. Interestingly, when the boys called out the teacher was more likely to listen to the comment; whereas when girls called out, teachers were more likely to correct them for their action rather than listen to their comment. Teachers’ expectations also have a tremendous impact on students’ performance. In general, teachers have higher expectations for male students than they do female students, despite girls’ higher grades (Sadker & Sadker, 1994).

There is an abundance of research that suggests that a high percentage of female students start college with a science major, but frequently ‘switch’ to a non-science major. For example, Strenta, Elliott, Matier, Scott, Fuchs, and Tamkins (1993) found that the persistence rate for males entering college as a science, mathematics, engineering or technology major and actually completing a degree with their original major was 61% for highly selective universities and 39% for national samples, while the persistence rates for women were 46% and 30%, respectively.

Brainard and Carlin (1998) found that a majority of women who drop out of engineering programs do so in the first two years of the program. The results of their longitudinal study indicated that 25% of female students who were currently enrolled in a science, mathematics, engineering or technology major feel that a lack of self-confidence is a significant barrier to their success. This percentage rises to 44% in their senior year indicating that despite success in their coursework throughout college, many female students continue to feel a lack of self-confidence in their majors (Brainard & Carlin, 1998).

From the findings of these studies, it can easily be argued that teachers from elementary school to postsecondary education play a critical role in helping to shape a child's educational future. Teachers, as well as parents, are capable of leaving lasting impressions on a child's future career choice.

Gender schemas. According to Martin and Halverson (1987, p. 123) gender schemas are "hypotheses about what it means to be male or female, hypotheses that all people share, male and female alike. Schemas assign different psychological traits to males and females". Basically, traditional gender schemas paint the image of a female as being motherly, nurturing and expressive while males tend to be more task and action-oriented. Not only do gender schemas paint an image of 'typical' male or female characteristics, but they can lead to incorrect assumptions about a person's competence, by either over or underestimating another person's abilities.

In 2004, Heilman, Wallen, Fuchs and Tamkins conducted a study which investigated reactions to a woman's success in a male gender-typed job. The researchers' hypothesis for this study was that "in a male gender-typed job, women will be rated as less competent and less achievement oriented than men when information about performance outcome is ambiguous but

not when success is clear” (p.417). Forty-eight undergraduate students participated in the study (20 men, 27 women and 1 person who did not indicate his or her sex). During the experiment, each subject was exposed to manipulations of two different levels of independent variables: sex of stimulus person (male or female) and clarity of performance of outcome (unclear or clearly successful). Subjects in both conditions reviewed both a male and female target in the 2x2 factorial designs with repeated measures on the sex of stimulus person variable. Four dependent measures were included in the study. The first two were two different measures of competence. The competence composite was based on three 9-point bipolar adjective scale ratings describing the stimulus person (competent-incompetent, productive-unproductive, and effective-ineffective). A composite liking score was based on one adjective rating scale (likeable or non likeable). Composites were also created in a similar manner to characterize achievement-related attributes and interpersonal hostility.

Twenty-four subjects were randomly assigned to each of the two clarity of performance outcome conditions. Researchers manipulated the clarity of performance outcome by indicating whether or not the stimulus person had an annual review. In the unclear performance outcome, the stimulus person was said to be undergoing his (her) annual performance review. In the clear success condition, the stimulus person was said to have already undergone the annual performance review and was said to be a top performer in the organization.

Each participant was handed a stimulus packet which provided information about a large company where three employees held the same position. Information was provided to the participants about each person and about the job. The first job that was described to the participants was assistant vice-president of sales at an aircraft company. Descriptions of the duties of the job were purposefully male gender-typed. The researchers also included that 8 men

and only 2 women were being evaluated, to further gender-stereotype the position. In addition to the stimulus packets, participants were handed descriptions of each stimulus person which provided background information as well as information about the stimulus person's annual review. Participants then rated all three stimulus persons. After reviewing the information about both the male and female employees, the participants indicated who they thought was more competent and who they found to be more likeable.

The results showed that "women were viewed as less competent and characterized as less achievement oriented than men only when there was ambiguity about how successful they had been; when the women's success was made explicit, there were no discernible differences in these characterizations" (p. 420). However, when success was made explicit, there was differentiation between women and men in how they were viewed interpersonally, with women deemed to be "far less likeable and more interpersonally hostile" (Heilman et al., 2004, p. 420).

Norton, Vandello, and Darley conducted a similar study to the one previously mentioned, also in 2004. Ninety-three male undergraduates completed a questionnaire that asked them to take part in an employee selection process as a head of a construction company. The researchers stated that the candidate had to have a strong engineering background and years of experience to be considered for the position. Participants were then asked to rank candidates in their order of preference. Researchers manipulated the information given to the participants so that 2 out of the 5 candidates were clearly qualified for the position. Of the two candidates that remained, one candidate had more experience (9 vs. 5 years) and one candidate had more education (degree and certification vs. degree). In the control group, participants were only given the first initial and last name of the candidates, so that the gender of the candidate remained ambiguous. In both of the experimental conditions the full names of the candidates were given to the participants, which

allowed the participants to know the gender of the stimulus individual. In one of the experimental conditions, the female candidate was said to have more years of experience than the male candidate, but the male candidate was said to have more education than the female candidate. In the second experimental condition, the male candidate was said to have more years of experience but less education than the female candidate. After the participants ranked the stimulus individuals, participants were asked to justify their decision.

The results of the study show that participants in the control group, often viewed the stimulus individuals as males, even though they were only given the first initial and last name of the person. Thirty-four percent of male participants spontaneously used male pronouns when describing the individual, while only 3% used female pronouns. Researchers also found that “in the control condition, as expected, there was a strong preference for the (and presumed male by our participants) educated candidate (76%) and we observed this same strong preference when the male candidate was more educated (75%). When the female candidate was more educated, however, only 43% of participants picked the educated candidate. Thus, although education was seen as more important in the decision, participants still selected the male candidate the majority of the time even when he was less educated” (Norton et al., 2004 p. 821). In the control group, 48% of participants indicated that education was more important than experience, as did the male-educated experimental group (50%). In the female-educated experimental group, a strong preference was shown for experience with only 22% of participants indicating education was more important, which justifies participants’ selection of the experienced male. When asked if sex played a role in their candidate preferences, very few candidates stated that it did, although the results clearly indicate that sex, did in fact, play a role in their decisions.

After reviewing the literature presented, one can see the tremendous impact that parents, educators, and society as a whole have on an individual's gender development. Although often inadvertently, children are exposed to a number of models in their homes and communities which give them clues as to what behaviors are and are not acceptable for their gender. Children not only internalize these responses, but they also use these notions to create their own thoughts and actions. Findings from the literature presented suggest that children whose parents and teachers provide them with messages that support the development of a strong sense of self-efficacy, confidence and interest in the fields of mathematics and science are more likely to be interested and successful in these fields. But what happens when the child enters into the university setting? What cognitive, motivational and behavioral factors are necessary for a student to be successful in one of the science, mathematics, technology, or engineering? What follows is a review of the methodology and relevant conclusions drawn from studies about college student learning in general and engineering students in particular. First, self-regulation and self-regulated learning are described and explained. After these descriptions, current literature regarding self-regulated learning is reviewed.

College Student Learning

While personal factors play an important role in women's involvement in the STEM fields, the instructional environment is equally as important. In general, there are two different models that have developed as a means to analyze instructional environments at the college level. The student approaches to learning (SAL) model is a bottom-up model which is frequently derived from in-depth qualitative interviews. It is most frequently used in Europe and Australia (Pintrich, 2004). The self-regulated learning (SRL) model which is formulated from the information processing (IP) approach is more frequently used in the United States and is a top-

down model. The IP model uses theory from both cognitive and educational psychology and is derived from quantitative data (Pintrich, 2004). The difference between the two is that the SRL model uses updated research and theory and has a stronger empirical base (Pintrich, 2004).

Self-regulated learning. Self-regulated learning is a process in which the learner is an active participant in his or her own learning process (Pintrich, 2004). According to Zimmerman (1989), “a student can be described as self-regulated to the degree that he or she is a metacognitively, motivationally, and behaviorally active participant in his or her own learning processes” (p. 329). Zimmerman (2002) describes self-regulated learning as an active event in which the learner takes control of his or her own learning in a proactive way, rather than as a reactive event. Students take control of events such as acquiring new resources, information, or skills, rather than relying on their instructors or teachers to do it for them. Throughout the learning process, self-regulated learners plan, set goals, self-monitor and self-evaluate (Zimmerman, 1990). Self-regulated learning includes not only cognitive factors, but also motivational, affective, and social contextual factors (Pintrich, 2004).

According to Boekarts, Pintrich and Zeidner (2000), there are four assumptions of self-regulated learning models. The first assumption is that learners are active participants in constructing meaning from information available in the environment in combination with what they already know. SRL models assume that students use prior knowledge as well as external resources to formulate their own learning strategies and goals. The second assumption of SRL models is that learners can control and regulate aspects of their thinking, motivation, behavior and in some instances their environment. While this is not always possible due to situational constraints, SRL models argue that there is often *potential* for students to monitor, control and regulate these aspects. The third assumption of SRL models is the goal, criterion or standard

assumption (Pintrich, 2004). This assumption presumes that learners compare their progress toward a goal against some criterion and this comparison informs learners of the status of progress towards their goal. This comparison allows learners to monitor whether the learning process should continue as is or whether the learning process needs to be adjusted or changed. Finally, SRL models assume that self-regulatory activities are mediators between personality and cultural characteristics and the performance or eventual achievement (Pintrich, 2004).

Social cognitive view of self-regulated academic learning. In accordance with social learning theory, the social cognitive view of self-regulated learning argues that learning is not solely determined by personal processes, but is also influenced by environmental and behavioral events (Zimmerman, 1989). Bandura (1974), who is credited with developing the concept of reciprocal determinism, states that “the term *determinism* is used to signify the production of events by effects, rather than in the doctrinal sense that actions are completely determined by a prior sequence of causes independent of the individual. Because of the complexity of interacting factors, events produce effects probabilistically rather than inevitably” (p. 345). Further, the influences exerted by personal processes and environmental and behavioral events vary according to differences in personality characteristics of individuals as well as situational factors.

Social cognitive theory assumes that self-efficacy is a crucial component of self-regulated learning. According to Zimmerman (1989) “self-efficacy refers to perceptions about one’s capabilities to organize and implement actions necessary to attain designated performance of skill for specific tasks” (p. 329). Bandura (1993) states that “efficacy beliefs influence how people feel, think, motivate themselves and behave” (p. 118). Research shows that students with high self-efficacy display more of the behavioral and environmental determinants of SRL, making self-efficacy critically important (Zimmerman, 1989). Further, Bandura (1991) found that

students with a greater sense of perceived self-efficacy were more likely to set higher goals for themselves and have a firmer commitment to them. Self-efficacy beliefs produce diverse effects through cognitive, motivational, affective, and selection processes (Bandura, 1993).

In addition to the important role that self-efficacy plays in self-regulation, social cognitive theorists also assume that there are three sub-processes involved in self-regulation: self-observation, self-judgment, and self-reaction (Zimmerman, 1989). These three sub-processes are also reciprocal in nature. Self-observation refers to the learner systematically monitoring his or her own performance. In line with Bandura's (1974) concept of reciprocal determinism, in which personal processes, behavioral and environmental events are interconnected, Zimmerman (1989) states that "self-observation is influenced by personal processes such as self-efficacy, goal setting and cognitive planning as well as by behavioral influences" (p. 333). One common method of self-observation is through quantitative recording of the amount of work that one completes. The second sub-process, self-judgment, occurs when a learner systematically compares his or her own performance against a standard or goal. Zimmerman (1989) states that two common ways that learners engage in self-judgment is by using checking procedures and rating their answers in relation to those of another student. The third sub-process, self-reaction, occurs when a learner reflects on his or her performance. Ultimately, not all forms of self-reaction lead to self-regulation (Zimmerman, 1989).

Phases of self-regulation. Social learning psychologists view the structure of self-regulatory processes in terms of three cyclical phases. The forethought phase occurs before learning takes place, the performance phase refers to the processes that occur during the learning, and the self-reflection process refers to processes that occur after a learning opportunity has taken place.

Two categories compose the forethought phase: task analysis and self-motivational beliefs. More specifically, task analysis involves goal setting and strategic planning. Goal setting occurs when an individual decides upon specific outcomes of learning or performance. According to Zimmerman (2000), “the goals systems of highly self-regulated individuals are organized hierarchically, such that process goals operate as proximal regulators of more distal outcome goals. These process subgoals are not merely mechanical check points on the path to attaining highly valued outcomes; instead they become invested with personal meaning because they convey evidence of progress” (p. 17). Strategic planning in task analysis involves developing purposive personal processes and actions aimed at developing or displaying a skill.

Self-efficacy, outcome expectations, intrinsic interest, and goal orientation are all self-motivational beliefs in the forethought phase. Self-efficacy refers to beliefs about an individual’s ability to perform a task. Zimmerman (2000) stated that, “a person’s willingness to engage and sustain their self-regulatory efforts depends especially on their self-regulatory efficacy, which refers to beliefs about their capability to plan and manage specific areas of functioning” (p. 18). Outcome expectations refer to the beliefs about the ultimate ends of performance (Bandura, 1997). For example, a student in medical school may be going to medical school because he/she has an expectation to have a desirable occupation after medical school. Intrinsic interest refers to motivation to complete a task that is based on the enjoyment of the task itself, rather than the external rewards that surround it.

The second phase of the self-regulation process is the performance control phase. There are two major types of performance control processes: self-control and self-observation. Self-control processes involve self-instruction, imagery, attention focusing, and task strategies. The purpose of self-control processes is to help individuals focus on the task at hand. Self-instruction

refers to the deliberate process of describing to one's own self explicit details of how to execute a task. Imagery is a frequently used self-control process in which an individual imagines him or herself executing a task successfully. Attention focusing is the third form of self-control and is a purposeful effort to reduce distractions and increase one's concentration level. The last form of self-control is task strategies. Self-regulated students use task strategies to break a task into smaller, more essential chunks and reorganize them into a meaningful order.

The second type of performance process is self-observation. Self-recording and self-experimentation compose self-observation. According to Zimmerman (2000), "self-recording is a common self-observational technique that can increase greatly the proximity, informativeness, accuracy, and valence of feedback" (p. 20). Self-recording techniques can be used by individuals who run marathons. Often these individuals keep track of the distances that they have run, how they felt after the run and what they had to eat on that particular day. A runner could engage in self-experimentation by varying the type of exercise that they do on a particular day such as sprints versus distance runs.

The last process in self-regulation is self-reflection, which also involves two sub-processes, self-judgment and self-reactions. Zimmerman (2000) explains that "self-judgment involves self-evaluating one's performance and attributing causal significance to the results. Self-evaluation refers to comparing self-monitored information with a standard or goal" (p. 21). For a marathon runner, self-judgment could occur when a runner looks back on the marathon and evaluates his/her performance. Causal attributions (which fall under the sub-process of self-judgment) could be positive or negative, depending on the situation and the individual. For example, a runner may attribute an unsuccessful marathon run to not having trained enough days to be completely prepared.

Self-satisfaction and adaptive inferences are two types of self-reactions. Adaptive inferences are conclusions an individual makes as to how best to alter his/her self-regulatory processes in the future. Self-satisfaction reactions increase an individual's self-efficacy and intrinsic interest in the task (Zimmerman, 2000).

Self-regulation in the instructional environment. Vermunt and Vermetten (2004) describe different teaching functions that can promote student learning and self-regulation. Their work suggests that different teaching strategies fall on a continuum of strong teacher-regulation to shared teacher-student regulation to loose teacher-regulation. Learning environments that are structured to be more loosely teacher-regulated require students to self-regulate more often than learning environments that are strongly teacher-regulated. The instructor's teaching strategies as well as the student's learning strategies help to determine how the student will navigate through the internal and external regulation demands. Vermunt and Vermetten (2004) state that, as a student attempts to navigate between the interplay of self-regulation and external regulation, congruence or friction may occur. Congruence occurs when the instructor's teaching strategies and the student's learning strategies are compatible; friction occurs when this is not the case (Vermunt & Vermetten, 2004). There are two types of friction: constructive and destructive. Constructive friction causes students to adopt learning strategies that they might not have used prior to this learning experience. This may lead to a student making use of new learning strategies and to an increase in self-regulation. Destructive friction occurs when the level of self-regulation that the instructor expects from the students is considerably different from the actual level of self-regulation that the students' possess (Vermunt & Vermetten, 2004). Destructive friction can, ultimately, lead to frustration for the student and it may decrease the amount of thinking and types of learning strategies that the student employs (Vermunt & Vermetten, 2004).

Motivation and self-regulation. The theoretical framework for conceptualizing motivation and self-regulation is an adaptation of the general expectancy-value model of motivation. According to this model, three components of motivation may be linked to three components of self-regulated learning: an expectancy component, a value component and an affective component. The expectancy component of student motivation involves the students' beliefs about their ability to perform a task and the acknowledgement that they are responsible for their own performance. The value component involves students' goals and beliefs about the importance of the task as well as their interest in it. The third component involves students' emotional reactions to the task.

Current Research Regarding Self-Regulated Learning

The most current literature surrounding self-regulated learning examines instructor practices in the classroom and the ways in which these practices affect the development of self-regulated learning among students.

In 2010, Reeves and Stich conducted a mixed-methods study which examined whether an undergraduate course based in the theory of self-regulated learning contributed to students' development of self-regulated learning strategies. The intervention used in this study was called "Methods of Inquiry" which was a semester-long course at a large, public university in the Northeast. The theoretical framework for this course intervention was Iran-Nejad's theory of self-regulation (1990). The purpose of this course was to improve undergraduate learning experiences and increase the number of students persisting through degree completion (Reeves & Stich, 2010). The course had two components. The first component was twice weekly lectures from an instructor where participants received direct instruction in self-regulated learning strategies. The second component of the course required students to apply the study skills and

techniques they learned in the course in their other academic courses. This component also required students enrolled in the course to attend a once weekly thirty minute meeting with an undergraduate peer monitor. Reeve and Stich (2010) stated that the purpose of the peer monitor was to assist students with self-assessment of study skill implementation.

One hundred eighty-six students participated in this study in the spring of 2009 and 57 students participated in the study in the spring of 2010. Students were asked to complete the Dynamic and Active Learning Inventory Revised (DALI-R; Iran-Nejad & Chissom, 1992) which is an instrument based on Iran-Nejad's theory of self-regulation (1990). Students were also asked to complete a voluntary online survey which gauged students' perceptions of the impact of the intervention and whether the students' felt that the intervention was implemented as they had expected. After the survey was completed, raters coded the answers searching for themes and connections within the data.

According to Reeves and Stich (2010), the study found "both qualitative and quantitative evidence of the intervention's effect on participants' growth as self-regulated learners – of growth, more specifically, in both the "skill" (active self-regulation) and "will" (dynamic self-regulation) aspects of this important educational construct" (p. 13). Further, quantitative analyses resulted in similar amounts of growth in all students, regardless of gender or ethnicity. Researchers attributed the success of this course to staff expertise in the area of self-regulation. Despite the success of the course, the authors' did note several logistical considerations, including the importance of having staff available to complete the one-to-one peer monitoring program. Further considerations include the importance of a solid theoretical background built into the course, providing effective instruction in self-regulated learning, and conducting on-going program evaluations (Reeves & Stich, 2010).

Learning environments in today's society look much different than they did a hundred years ago. Learning environments can exist anywhere, anytime with the use of online courses. Not surprisingly, many students have initial difficulties with online courses because they require a certain amount of self-regulation in order to be successful. In 2004, Azevedo and Cromley examined the effectiveness of training students in ways to regulate their learning when using hypermedia. The researchers asked two primary questions: "(1) does training students to regulate their learning influence their ability to shift to a more sophisticated mental model of the circulatory system and (2) how does SRL training influence students' ability to regulate their learning from hypermedia control and non-controlled conditions" (p. 525). One hundred thirty-one (96 women and 35 men) undergraduates participated in the study. None of the students were biology majors and the pre-tests administered confirmed that participants knew little, if anything, about the circulatory system. The pretest asked students to (a) match 16 words to their corresponding definition related to the circulatory system, (b) label a picture of the heart, (c) draw the path of blood throughout the body, and (d) write down everything they knew about the circulatory system on a separate sheet of paper (Azevedo & Cromley, 2004).

Azevedo and Cromley (2004) provided students that were in the SRL training condition with a script that contained the following information: "(a) a copy of Pintrich's (2000, p. 454) table of phases and areas of SRL, (b) a one-page diagram illustrating the experimental session (based on Butler, 1997, p. 3) and (c) a two-page table with a list of SRL variables, based on Azevedo, Guthrie, and Siebert (2004)" (p. 526). Students in the SRL training condition were individually trained by Azevedo for 30 minutes during which time he presented and instructed students in information that was found on the script. Participants had access to the instructions during the learning session. All students were given 30 minutes to complete the post-test. Students that were in the control condition were read a basic script and asked to learn as much as

they could about the circulatory system using the computer program. They were provided with no other instructions or directions.

According to Azevedo and Cromley (2004), results of the study showed that “hypermedia can be used to enhance learners’ understanding of complex topics if they are trained to regulate their learning” (p. 529). With regard to the first research question, results of the study reported that students who were trained in SRL developed a deeper conceptual understanding of the circulatory system than students did who were in the control condition (Azevedo & Cromley, 2004). With regard to the second research question, researchers reported that “our extensive think-aloud protocols indicate that not only did the learners in the SRL training condition gain a deeper conceptual understanding but they also more frequently deployed SRL processes taught to them to effectively regulate their learning with hypermedia” (p. 530). Results indicate that participants regulated their learning through planning, monitoring, and deployed strategies such as summarizing and note taking (Azevedo & Cromley, 2004).

In 2005, Young took a different approach. Rather than helping students develop self-regulated learning strategies, he examined students who already had these strategies, but to varying degrees. He examined these strategies in students who were enrolled in a marketing program at a Midwestern university. The author made the following six hypotheses: “(1a) extrinsically motivated students will use superficial learning strategies, (1b) intrinsically motivated students will use deep cognitive and metacognitive strategies, (2a) high ego-social orientation will be positively associated with extrinsic motivation, (2b) high task mastery orientation will be positively associated with intrinsic motivation, (3a) the effect of classroom-environmental factors on motivation will be mediated by achievement goal orientation, and (3b) the effect of classroom environmental factors on motivation will be mediated by perceived

autonomy and competence” (p. 29). The sample of 257 students responded to a four page self-report questionnaire. The researcher administered parts of the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1991), the College Students’ Self-Regulated Learning Questionnaire (Hwang & Vrongistinos, 2002), and the Self-Regulated Learning Questionnaire (Somuncuoglu & Yildirm, 1999). The purpose of these questions was to examine students’ use of different types of strategies including superficial, deep cognitive and metacognitive strategies. Superficial strategies were assessed using the rehearsal subscale. Deep cognitive strategies were assessed using the organization, elaboration, and critical thinking subscales. Finally, metacognitive strategies were assessed using the planning, monitoring, and regulating subscales. Young (2005) used the Academic Motivation Scale (Vallerand et al., 1992) to assess intrinsic and extrinsic motivation among the college students. Student’s global level of autonomy was assessed using two questions on a seven point strongly agree/disagree scale. Five perceived self-efficacy questions were created and students were asked to indicate the confidence with which they could perform these skills on a ten-point scale. Finally, the classroom climate was assessed using the Learning and Performance Orientations in Physical Education Classes Questionnaire (Papaioannou, 1994). The author tested his hypotheses using a path analysis.

According to Young (2005) results indicated that “superficial learning strategies were linked to extrinsic motivation, while intrinsic motivation determined deep cognitive and metacognitive strategy use” (p. 36). Results also found that intrinsic motivation was increased in students who perceived that they were competent (Young, 2005). Further, results indicated that “active application oriented experience delivered by enthusiastic faculty members who provide a high personal interaction, along with supportive feedback, clear goals and expectations, emphasizing learning over grades will increase the use of self-regulated learning strategies” (p. 36). Important implications regarding motivation and self-regulated learning were found in this

study. For example, the author encourages faculty members to emphasize the learning process and to encourage participation (Young, 2005). A second implication of the results is the importance of raising students' awareness of metacognitive strategies such as planning, monitoring, and regulating in their own learning (Young, 2005). Third, in order to enhance intrinsic motivation in students, instructors are encouraged to support student autonomy, perceived competence, and task mastery goal orientation (Young, 2005). Instructors can do this by providing students with a number of chances to practice, learn and master the skills necessary to be successful in the course (Young, 2005).

Chapter Summary

In conclusion, many factors can be attributed to the discrepancies between the number of male and female students in the STEM fields. Psychoanalytic, cognitive, gender schema, social learning, social cognitive and biological theories serve as a base for empirical research that examines this phenomenon. Possible explanations for these gender discrepancies include parents' perceptions that inadvertently steer their daughters away from STEM fields, educational differences between male and female students, and traditional gender schemas.

One way to understand these gender differences is to analyze characteristics of students who are successful in STEM programs and characteristics of the classroom environments that might produce these differences. There are many ways in which instructors can explicitly and implicitly assist students' development of these strategies, including mechanisms of social learning and social cognitive learning. Instructional environments also foster the development of these skills, and may provide opportunities for both male and female students to be successful in STEM programs.

Chapter 3

Methods

Introduction

The purpose of this study was to examine if male and female students respond differently to learning environments that vary by pedagogy and gender of instructor. Five of the courses examined in this study can be categorized as lecture with active learning components; two can be described as project-based; and four can be described as problem-based. By studying learning environments and analyzing the impact of the instructors' gender, we are better able to understand the ways in which male and female students develop cognitive learning strategies and motivational orientations in engineering education environments.

Participants

One hundred seventy-six undergraduate engineering students and four engineering instructors from four United States universities participated in study. Data was collected over a two year period. The instructors and students of the universities participating in the study came from a small, private, specialty engineering school with the number of male and female students being close to equal; two small, private liberal arts universities where the number of male students was greater than the number of female students with each course having a small student-to-instructor ratio; and one large, public university with a gender and student-to-instructor ratio typical of a large engineering program. Two of the universities were located in the northeastern United States and the other two universities were located in the western United States. The following four courses were included in the study, one time each: electrical circuits, heat transfer, statics and senior design. An engineering materials science course was taught twice but by two different instructors at different universities. The following courses were included twice in

the study, taught by the same instructors but in different semesters: failure analysis and prevention, thermal systems and metals and alloys. One instructor was a professor of chemical engineering, two instructors were professors of mechanical engineering, and one instructor was a professor of electrical engineering. Three instructors were male and one instructor was female. According to the National Science Foundation (2008), 365,281 (82.5%) male students were enrolled in undergraduate engineering degrees and 77,671 (17.5%) female students were enrolled in undergraduate engineering degrees. Figure 1 shows the number of male and female students in each course as well as the students' year of study.

Table 1.

Number of male students, female students, and year of study for each course.

Course Title	Male	Female	First-year	Sophomore	Junior	Senior
Heat Transfer	12	4	0	0	16	0
Thermodynamics	18	2	0	0	0	20
Failure Analysis	1	9	0	3	5	2
Metals and Alloys	3	6	0	3	1	5
Statics	10	8	0	14	3	1
Circuits	10	6	0	14	2	0
Materials Science	11	11	0	8	12	2
Failure Analysis	6	9	0	10	4	1
Senior Design	12	4	0	0	0	16
Statics	15	8	1	22	0	0
Materials Science	5	6	3	0	4	4
Total	103	73	4	74	47	51

Context

The eleven courses being examined fall into one of three categorizations: lecture with active learning, project-based or problem-based. The lecture with active learning courses tend to be more content oriented and emphasize students acquiring new content knowledge to add to the students' growing knowledge of the field of engineering. The courses that are project- and

problem-based require that the students engage in activities that use content knowledge to solve problems that mimic real world experiences. In some instances, students in the project-based courses did engage in real world experiences with clients. Table 2 shows the categorizations of each course.

The eleven courses examined in this study also follow along a continuum of teacher- to student- centered. Teacher- centered courses involve the instructor making decisions, such as what content will be covered in the course, methods of evaluation, and group assignments. Student- centered courses involve students sharing (with the instructor and each other) decisions regarding the course. These decisions could include deciding what content will be covered throughout the semester, how class time should be spent, group assignments, as well as evaluation procedures. Table 2 also illustrates which courses can be categorized as teacher-centered, moderately student-centered or student centered.

Table 2.

Description of courses

Lecture with Active Learning/More Teacher Centered	Problem-Based/Moderately Student Centered	Project-Based/Student Centered
Thermodynamics	Heat Transfer	Failure Analysis
Statics	Materials Science*	Senior Design
Statics		Failure Analysis
Circuits		Metals and Alloys
Materials Science*		

*indicates two courses with the same title but taught by different instructors

Courses and Instructors

Instructor 1 . ME-303 *Thermal Systems* was a junior and senior level required course for mechanical engineering students. The course was taught in a lecture format (there was no

associated laboratory), with homework sets, quizzes, and midterm and final exam. Student-centered learning techniques involved in-class problem solving through the use of a clicker, as well as peer-to-peer instruction. Classes consisted of a brief lecture (less than 10 minutes) which was followed by example problems. Example problems included conceptual as well as calculation problems. Instructor 1 taught thermal systems twice over the data collection period.

ME-211 *Statics* was a sophomore level class that is required by several majors (mechanical, civil, aerospace, industrial and manufacturing, and biomedical engineering) and serves as an elective for several other engineering majors. This course was an applied physics course in which students learned to apply the concepts of mechanical (force) equilibrium to study structures and machines that are in static equilibrium. As with thermal systems, this class consisted of a brief lecture (less than 10 minutes) which was followed by example problems. Student-centered learning in the course consisted of in-class problem solving techniques with the use of a clicker as well. Students were asked to turn to another student sitting near them to discuss questions posed by the instructor. Instructor 1 taught statics twice over the data collection period.

Instructor 2. ELEC 201 *Electrical Circuits* was a sophomore level class. This is the first required course in the major for electrical engineering students. The class included weekly homework assignments, two midterm exams and a final exam. This course was taught in a lecture with active learning format including in-class problem solving and cooperative learning homework teams. Most class meeting periods included at least one problem where the problem statement was included in the notes along with whatever supporting information was necessary (e.g. circuit diagrams). A blank space was provided for students to work out solutions. Students were then asked to ‘turn to a helpful neighbor’ with whom they could work collaboratively to

solve the problem. During this time, the instructor circulated to answer student questions. Students were assigned to collaborative homework groups (3 to 4 students) at the beginning of the semester. Each student was required to have a team role for each assignment which included recorder, checker, monitor or coordinator. Team roles rotated each week between students in the homework group. All students were periodically asked to complete effort assessments in which they rated their group members' participation and effort. Most homework groups met once a week during which significant student-to-student interaction occurred.

ENG 311 *Engineering Materials Science* was a junior level course. Students in this course are introduced to the fundamentals of materials science and engineering. Several types of materials were considered and students were encouraged to recognize the properties between structure and properties. Students were asked to actively participate in the course which involved in-class problem solving of sample problems and homework teams. This course involved weekly homework assignments, three midterms and a final exam. As in the Electrical Circuits course, homework was completed in groups (3 to 4 students) assigned by the instructor and each student was assigned a team role.

Instructor 3. CHEG300 *Heat Transfer* was a required course for chemical engineering juniors. The course had three hours of lecture, one hour of recitation, and a two hour lab each week. The course was taught in a problem-based learning format and included open-ended homework problems and laboratory assignments. Assessments included graded problem and laboratory assignments, peer assessment of individual student contributions and traditional quizzes and exams. Lectures were "student driven" meaning that they generally only occurred in response to students' posted questions. On days when there were no questions (or few questions) the bulk of the class period was spent in small group work. As with the lecture, only a fraction of

the scheduled lab time was spent on traditional laboratory work. During formal laboratory work, student teams collected data in the laboratory, primarily under the supervision of a graduate student. The actual laboratory time typically took no more than 1 hour and the remaining hour was spent in group meetings. The instructor also held 30 minute individual team meetings, answering technical questions and soliciting student feedback. These meetings occurred several times throughout the semester.

CHEG410 *Senior Design* was a course that sought to enhance the range of learning experiences in engineering and provided an opportunity for students learning about topics that can be difficult to address routinely in the core curriculum courses. The specific goals of this course were that each student develop teamwork and project management skills in the context of a realistic setting. Students also worked with a client to develop suitable project goals and provided tangible results associated with those goals within the constraints of time, space and budgets. Students practiced skills needed to understand a problem, develop a plan of work to address that problem and execute that plan of work to address that problem and communicate findings clearly in both written and oral forms. Finally, students worked with teammates, supervisors, and clients to understand and solve problems associated with projects in the course. In the beginning of the semester, students were asked that their team propose and develop a project for the semester, devise a plan that would address the issues presented by that project and then carry out that plan and evaluate the results. The semester was divided into three phases of work during which students were required to provide summary details on in the form of oral and written reports.

Instructor 4. ENGR3820 *Failure Analysis and Prevention* was a project-based, upper-level elective course for engineering students. Student evaluation was based on project deliverables (case study reports, oral presentations, and posters), team evaluations, and written

self-reflections. There were no exams in the course. Student development in the course was focused on professional-level competencies and application of self-directed learning skills. By organizing and carrying out failure investigations of real-world components and systems and through analysis of published case studies, students learned failure analysis by doing failure analysis. The student-directed projects emphasized the interdisciplinary nature of failure investigations, and the class devoted significant time to discussions of contextual factors that contribute to engineering decision-making. Learning in the course was centered on failure analysis projects, and students typically completed 3-4 failure investigations in the semester. Student teams formed around common interests (e.g., mechanical failures, electrical failures, corrosion failures), and they selected a failed component or system that they wished to analyze. Each project was necessarily different, since each team was studying a unique failed product. The teams established their own project goals, timeline, and investigative strategies. They designed their own experiments, and they identified information resources appropriate to their particular project. Most projects culminated in the preparation of a failure analysis case-study style report; some projects ended with a poster presentation. Once the report had been submitted, students self-assessed their report in several competency areas (e.g., communication, qualitative analysis, diagnosis); they reflected upon their own self-directed learning processes; and they evaluated their teaming behaviors and skills with self- and peer-assessments. Failure analysis was taught twice over the data collection.

ENGR 3899 *Metals and Alloys* was a course that used a flexible, project-based approach that emphasized student self-direction and alignment of learning strategies with personal goals. Individuals or small teams created a self-designed project to investigate a topic in the production, processing, properties, applications, or broader context/impact of metals and alloys. Students surveyed a range of topics in modern metals and alloys through assigned readings and class

discussions. Semester-long projects were used to tie together materials science theory, engineering applications, and broader contextual considerations. Course assessments were based on six competency areas: Qualitative Analysis, Quantitative Analysis, Contextual Understanding, Communication, Teamwork, and Lifelong Learning. Half of the overall grade in the course was based on student self-assessments or peer-assessments of learning. Ten percent of the overall evaluation was in a competency area determined by individual students. This ten percent could be applied to any of the assignments in the course, or to self-defined course-related activities and efforts. Students could choose to add the ten percent to a competency area that was already measured in this course, or they could identify a different competency area (e.g., diagnosis or design) and incorporate appropriate activities through which they could develop and assess the competency in this course. For the major project deliverables which consisted of reports and posters, the instructor provided detailed feedback in the relevant competency areas. In addition, students provided a self-evaluation of their work in each project. Students also evaluated their own lifelong learning skill development through self-reflective essays, and the instructor provided his perspective on students' lifelong learning skills based on observations throughout the semester.

SCI1410 *Materials Science and Solid State Chemistry* was an introductory materials science course that provided a project-based learning experience. The course was divided into three phases that lasted approximately five weeks each. Each phase was organized around a hands-on project. Students' gained conceptual understanding of materials science primarily through the project work, and assigned readings and problem sets in the first two projects enabled connections to supporting materials science theory. Given a list of project constraints and broad learning goals, students selected the problem to be investigated in each project. Students created an analytical plan to study materials-related aspects of a technology, topic, or product of their

own choosing. The projects provided for gradually decreasing instructor control and gradually increasing student discretion and responsibility. Early in the semester, instructors provided laboratory training and assistance with experiments, assigned materials readings and problems relevant to the project work, opportunities for informal and formal teaming feedback, online and library resources, informal classroom feedback sessions, on-demand lectures to support project work, detailed rubrics for all formal assessments, and detailed feedback on project deliverables. As the semester progressed, these supports were loosened or removed, facilitating students' transitions from more structured learning to autonomous learning.

Variables

For the purposes of this study, the independent variables consisted of gender of instructor and the instructional environment. Instructional environment was operationally defined as: lecture with active learning, problem-based and project-based. The lecture with active learning courses tended to emphasize students acquiring new content knowledge and were, in general, more content-oriented. The courses that were project-based integrated students' existing content knowledge and required students to engage in activities that mimic real world work experiences. The courses that were problem-based required that students learn new content but also required students to engage in activities that mimicked real world work experiences. The dependent variables consisted of the 9 learning strategies and 6 motivational orientations as operationalized by the Motivated Strategies for Learning Questionnaire.

Procedure

A brief description of the study was given to the students by their instructor on the first day of class. Informed consent handouts listing potential benefits, concerns, and contact information of the primary investigator were given to each student. Students had the choice of

whether or not they wanted to complete the surveys, be audiotaped, videotaped, and if they wanted to participate in focus group sessions. Data was collected from the students prior to taking the course and after the course was completed. Quantitative data was collected via Survey Monkey. Instructors did not deviate from their typical pedagogical style in any way.

Instruments

Students responded to the Motivated Strategies for Learning Questionnaire (MSLQ, Pintrich, Smith, Garcia, & McKeachie, 1991) at the beginning and end of each semester. Data was submitted electronically via Survey Monkey. The Motivated Strategies for Learning Questionnaire (MSLQ) is an 81 item self-report questionnaire designed to measure motivational orientations and the use of cognitive learning strategies in college students. The questionnaire is designed in a 7 point likert format. An indication of 1 on the likert scales represents 'not at all true of me' and a 7 indicates 'very true of me.' The MSLQ has 15 subscales including the following: 6 subscales address motivation (intrinsic goals, extrinsic goals, task value, control of learning beliefs, self-efficacy, and test anxiety) and 9 subscales address learning strategies (rehearsal, elaboration, organization, critical thinking, self-regulation, time and study environment, effort regulation, peer learning and help seeking). The survey has high predictive validity, internal consistency, and reliability. Pintrich, Smith, Garcia, McKeachie (1991) found the following motivation subscale reliabilities: intrinsic goal orientation (.74), extrinsic goal orientation (.62), task value (.90), control of learning beliefs (.68), and self-efficacy for learning and performance (.93). The following Cronbach's alphas were reported for the learning strategies subscales: rehearsal (.69), elaboration (.76), organization (.64), critical thinking (.80), metacognitive self-regulation (.79), time and study environment (.76), effort regulation (.69), peer learning (.76), and help seeking (.52). The MSLQ can be used in whole or in part. For the

purposes of this study, the test anxiety subscale was eliminated because tests were not given in all of the courses participating in the study. Additionally, the wording in several of the test items was modified to more accurately reflect the learning environment of the courses. For example, specific references to “study” or “studying for the course” were replaced with “prepare” or “preparing for the course” and a reference to “lecture” was replaced with “class discussion.” Therefore, students participating in the study responded to a 76-item MSLQ with the deletion of the items regarding test anxiety.

Analyses

Quantitative data were submitted to SPSS and analyzed. Paired samples *t*-tests were completed in which gender was analyzed with regard to the instructors’ gender. Next, paired samples *t*-tests were completed in which gender was analyzed with regard to the instructional environment. Between groups differences were analyzed at post-test using analysis of variance, in regards to students’ gender without regard to instructional environment. Data was examined on the MSLQ using Analysis of Covariance (ANCOVAs) on subtests where there were differences at pretest and Analysis of Variance (ANOVA) for all others. Similar analyses were conducted in which post-test differences were examined in regards to students’ gender with regard to instructional environment (lecture with active learning, project-based, or problem-based) as well as gender of instructor.

Chapter 4

Results

Between-Groups Differences

Instructor gender effects. The first question of the study was whether the development of self-regulated learning skills in male and female students differed when considering the instructors' gender.

Female instructor. A significant pre-test difference was found in the strategy of organization between male and female students when taught by a female instructor. Analysis of covariance (ANCOVA) was used to statistically control this pre-test difference; ANOVA was used to test for post-test differences in all other areas. ANCOVA resulted in statistically significant post-test differences in the strategy of organization, $F(1,35) = 10.076, p = 0.003$, partial $\eta^2 = .224$ with female students reporting higher means than male students. Analysis of variance (ANOVA) resulted in no significant differences at post-test. Means and standard deviations are reported in Table 3.

Table 3

Means and Standard Deviations for Significant Between-Group Differences on MSLQ

MSLQ Subscale	Females		Males	
	M	SD	M	SD
Organization	5.41	0.78	4.18	1.14

Male instructor. When comparing male and female students in a course taught by a male instructor, significant pre-test differences were found in self-efficacy, extrinsic goal orientation and help seeking. Analysis of covariance (ANCOVA) was used to statistically control for pre-test differences in these four areas; ANOVA was used to test for post-test differences in all other areas. ANCOVA resulted in statistically significant differences at post-test in extrinsic goal orientation, $F(1,135) = 5.71, p = .018, \text{partial } \eta^2 = .041$ with male students reporting higher mean scores than female students. ANCOVA resulted in no statistically significant differences in self-efficacy and help seeking. ANOVA resulted in significant post-test differences in organization, $F(1,135) = 5.83, p = .017, \text{partial } \eta^2 = .041$ with female students reporting higher mean scores than male students. Means and standard deviations are reported in Table 4.

Table 4

Means and Standard Deviations for Significant Between-Group Differences on MSLQ				
MSLQ Subscale	Females		Males	
	M	SD	M	SD
Extrinsic Goal Orientation	3.89	1.60	4.86	1.15
Organization	3.96	1.18	3.59	1.20

Pedagogy effects. The second question in this study was whether the development of self-regulated learning skills in male and female students differed when considering the style of pedagogy.

Project and problem-based courses. A significant pre-test difference was found in extrinsic goal orientation in the project and problem-based courses. ANCOVA was used to control for this pre-test difference and found a statistically significant difference at post-test in

extrinsic goal orientation, $F(1,75) = 7.68, p = .007$, partial $\eta^2 = .093$, in which male students reported higher mean scores than female students. Where no pre-test differences were found, ANOVA was used to test for post-test differences. No significant post test differences were found. Means and standard deviations are reported in Table 5.

Table 5

Means and Standard Deviations for Significant Between-Group Differences on MSLQ

MSLQ Subscale	Females		Males	
	M	SD	M	SD
Extrinsic Goal Orientation	3.70	2.90	4.52	2.16

Lecture with active learning. When analyzing the lecture with active learning courses, significant pre-test differences were found in critical thinking, help seeking, self-efficacy, and rehearsal. ANCOVA controlled for these pre-test differences and produced no significant post-test differences in any area. Where no pre-test differences were found, ANOVA was used to test for post-test differences. ANOVA reported significant differences at post-test in peer learning, $F(1,97) = 4.66, p = .033$, partial $\eta^2 = .05$. Female students reported higher mean scores on the peer learning subscale. Means and standard deviations are reported in Table 6.

Table 6

Means and Standard Deviations for Significant Between-Group Differences on MSLQ

MSLQ Subscale	Females		Males	
	M	SD	M	SD
Peer Learning	4.36	1.40	3.65	1.66

Within-Groups Differences

Instructor gender effects. The third question in this study was whether there were within-group differences in the development of self-regulated learning skills in male and female students when considering the instructors' gender.

Female instructor. Dependent *t*-tests were used to determine pre to post-test within-group differences. Within-group differences were found for both genders when taught by a female instructor. Males and females reported increases in the strategy of organization, $t(20)=-2.87, p=.009, d=1.13$; $t(16)=-4.66, p=.000, d=0.63$; respectively. Females reported an increase in intrinsic goal orientation, $t(16)=-2.23, p=.04, d=0.54$. Females reported an increase in control of learning beliefs $t(16)=-2.25, p=.039, d=0.55$. Males reported a decrease in help seeking, $t(20)=2.61, p=.017, d=0.57$ and task value $t(20)=2.09, p=.05, d=0.46$. Means and standard deviations are reported in Table 7.

Table 7

Means and Standard Deviations for Significant Within-Group Differences on MSLQ

MSLQ Subscale	Females		Males	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
Intrinsic Goal Orientation	5.10 (0.97)	5.47 (1.06)		
Organization	4.53 (1.12)	5.41 (0.77)	3.74 (1.17)	4.18 (1.14)
Help Seeking			5.12 (1.08)	4.68 (1.02)
Control of Learning Beliefs	5.15 (0.88)	5.51 (0.94)		
Task Value			5.49 (1.02)	5.06 (1.21)

Male instructor. With male instructors, females reported decreases in organization, $t(55) = 2.33, p = .024, d = 0.25$, and time and study environment, $t(55) = 2.09, p = .041, d = 0.28$. Males reported increases in metacognitive self-regulation $t(81) = -3.18, p = .002, d = 0.35$ and peer learning, $t(81) = -2.04, p = .045, d = 0.22$. Means and standard deviations are reported in Table 8.

Table 8

Means and Standard Deviations for Significant Within-Group Differences on MSLQ

MSLQ Subscale	Females		Males	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
Time and Study Environment	5.37(0.81)	5.18 (0.88)		
Organization	3.97(1.18)	3.61(1.28)		
Metacognitive Self-Regulation			4.43 (0.87)	4.64 (0.78)
Peer Learning			3.72 (1.33)	3.98 (1.56)

Pedagogy effects. The fourth question in this study was whether there were within-group differences in the development of self-regulated learning skills in male and female students when considering the style of pedagogy.

Project and problem-based courses. In the project and problem-based courses, females reported decreases in time and study environment, $t(37) = 2.80, p = .008, d = 0.45$; while males reported increases in rehearsal, $t(38) = -2.20, p = .034, d = 0.35$, and peer learning, $t(38) = -2.28, p = .028, d = 0.36$. Means and standard deviations are reported in Table 9.

Table 9

Means and Standard Deviations for Significant Within-Group Differences on MSLQ

MSLQ Subscale	Females		Males	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
Time/Study Environment	5.40 (0.76)	5.11 (0.78)		
Rehearsal			2.97 (1.30)	3.44 (1.37)
Peer Learning			4.30 (0.89)	4.71 (1.16)

Lecture with active learning courses. In the lecture with active learning courses, no significant differences were found for either males or females.

Chapter 5

Discussion

Gender Influences

When comparing post-test reports between male and female students, instructor gender was observed to have differential effects. Female students reported that they used reading strategies such as highlighting and organizing key information as well as integration of new material with previously learned information more than did the male students in the presence of both female and male instructors.

When taught by a male instructor, male students reported that they participated in tasks associated with the course for reasons such as competition, receiving a higher grade than others, or a positive evaluation from others more frequently than female students. According to Golombok and Fivush (1994) these findings can be linked to gender stereotypes, in which males are often seen as more instrumental, assertive and competitive than females.

The results of the within group analyses show a pattern in which male and female students reported statistically significant increases in using learning strategies and adaptive motivational orientations when in the presence of a same-gendered instructor.

Same-gendered instructor. Over time, female students reported that their reasons for engaging in a course taught by a female instructor were due more to curiosity or challenge, rather than reasons such as receiving a high grade. Female students also reported that they felt that their efforts to learn would likely result in a positive outcome when taught by a female instructor. Further, female students reported an increase in their organizational abilities relative to the course. Although this reported increase is considered to be a small effect size it is more robust

than many of the other results (organization partial $\eta^2 = .224$). These findings could be a result of the female students modeling motivational orientations and learning strategies from the female professor. The effect sizes show that female students took advantage of the opportunity to have a course with a female instructor and gained both motivational orientations and learning strategies in this environment.

Male students, in a course taught by a male instructor, reported that, over the course of the semester, they engaged more in systematic planning, monitoring and regulating of their behaviors. Male students stated that they collaborated with their peers more frequently.

Different-gendered instructor. When in the presence of a female instructor, male students reported the course to be less interesting, less useful or less important over time. Male students reported relying less on each other for help at the end of instruction. However, male students reported being more organized with their work at the end of the semester than they were at the beginning of the semester with a female faculty member.

In the presence of a male instructor, female students reported that they spent less time organizing their study environments in these courses. Female students also reported that they spent less time using strategies to help them organize their reading assignments.

The increase in organizational abilities in courses taught by the female faculty member was the only area where male and female students responded similarly to any instructor. This finding could be attributed to the high degree of organization that this female instructor displayed herself in her instructional practices. For example, this instructor assigned each student to a homework team. Each student in the homework team was assigned to a different role each week and the students knew they needed to provide verification that each role was carried out in order to receive credit for the work. This instructor placed a high premium on being explicit with her

students about the expectations for them and in so doing provided substantial support to them in being able to meet expectations through her own organizational abilities.

A possible explanation for the finding that males tended to rely less on each other for help over time when taught by the female instructor might be tied to their enhanced organizational strategies. As previously mentioned, both male and female students in the course taught by a female instructor reported increases in their levels of organization as a result of the courses taught by the female instructor. It could be hypothesized that as the students are becoming more organized, they are less likely to need the help of others. The individual items that are included in the help seeking subscale reveals that three out of the four items ask whether the student seeks the help of other students in the class, rather than the help of the instructor.

The combined results of this set of analyses can be explained by the social cognitive view of learning, in particular, the impact of modeling. According to Bussey and Bandura (1999), "Modeling is one of the most pervasive and powerful means of transmitting values, attitudes, and patterns of thoughts and behaviors" (p. 686). Further, Deuerfeldt, Martin, and Dorsey (1971) found that children are more likely to model behaviors of those that they view as similar to themselves. The results of this study are consistent with previous research in that a similar pattern of positive responses to the instructor of the same gender as themselves were reported by both male and female students. Further differences were found when instructional environment was examined independent of instructor gender.

Pedagogy Influences

According to Penderson and Liu (2003), “Problem-based learning is an approach where students are presented with a challenging problem for which they do not have all of the information that they need to develop a solution. They must identify what they need to know, find and use the resources that will help them to meet these learning needs, and consider how their findings inform their solutions” (p. 304). Interestingly, there seem to be gender differences in the way male and female students respond to these intriguing instructional environments.

When comparing post-test reports between male and female students, male students in the problem and project-based courses reported having more of an extrinsic goal orientation than female students. One possible explanation is that the male students in these courses, in emulating the behavior of their same-gendered instructor, were seeking the approval of their male professors. Another explanation could be the individuated self-concept of the male students in these courses. Golombok and Fivush (1994) report that males, in general, tend to have more of an individuated self-concept than females. An individuated self-concept refers to an individual that focuses on his or her own goals, rather than the goals of a group of people. Perhaps the male students in this group were focused on an individual goal, such as a high grade. It is possible that these self-concepts may encourage competitiveness in the male students.

Female students reported higher levels of peer learning than males in the lecture with active learning courses. One possible explanation for this finding is that females, in general, tend to be more relationally-oriented than males (Golombok & Fivush, 1994). A relationally-orientated individual refers to one who is focused on achieving success for a group of individuals rather than on individual success. Female students reported utilizing the strategy of peer learning in order to be successful in the lecture with active learning courses.

Results of the within group analyses reveal that female students in the problem and project-based courses reported statistically significant decreases in the amount of time that they spent studying for these courses. Although this result is reported as a decrease, it is expected given the design of the problem and project-based courses. The time and study environment subscale refers to the amount of time a student spends studying and the arrangement of the environment in which a student studies. Because students in the problem and project-based courses are not generally required to study in a traditional sense, it is not surprising that some students reported decreases in this subscale.

A central feature of problem and project-based courses is their use of collaborative teams. According to Ronteltap and Eurelings (2002), “Two basic elements for PBL are (1) the analysis of authentic problems in a professional context as a starting point for learning and (2) communication among peers” (p. 12). It is interesting to note that while male students in these courses reported statistically significant increases in the use of peer learning, female students did not. Golombok and Fivush (1994) explain that females often have a relationally-oriented self-concept whereas males have an individuated self-concept. Because of this, female students may be more accustomed to working collaboratively with their peers and the instructional environment would only take advantage of this natural tendency rather than enhance it. Although considered to be a small effect, these findings are could be attributed to the real world experiences that students gained from these courses ($d=0.36$). These students may have felt that the problem and project-based courses were particularly beneficial to their long term goals.

Male students in the problem and project-based courses reported using the surface strategy of rehearsal. These results are somewhat unusual given that rehearsal is not generally a learning strategy that would be utilized in the problem and project-based courses. Given the

design of the problem and project-based courses, increases in learning strategies such as peer learning would be more expected than an increase in rehearsal.

Limitations and Recommendations for Future Research

There are several limitations to this study that should be addressed in future research. Although the ratio of female to male faculty in the field of engineering is fairly proportionately represented in this study, that this study only included one female professor as part of the design is problematic. It is difficult to determine whether the gender effects that were found should be attributed to gender or to this particular professor. If more female instructors are used, interaction effects could be examined with more confidence that effects found are attributable to the interaction of gender with pedagogy rather than the interaction of this one instructor's style with pedagogy. It is recommended that future studies examining the impact of professors' gender on student outcomes in science, technology, engineering and mathematics (STEM) fields include more than one female instructor as part of the design. Female instructors who teach problem and project-based courses should be included in future studies as this study included only male professors teaching these courses. Further, future studies should consider tightening the internal validity of the design by adding control over the independent variable of pedagogy. By designing the exact nature of the instruction, the treatment would be more controlled and more definitive statements could be made regarding the effects of these different instructional environments on student outcomes. Finally, a larger, more random and diverse sample of instructors should be used in future studies. Studies that work to control the independent variable of instructional environment matched with a larger and more diverse set of instructors could provide a finer-grained analysis to this complex topic of gender and environment effects on student outcomes by

allowing the examination of interaction effects of instructor gender with instructional environment.

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