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By

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ABSTRACT

TITLE: Biological, Cognitive and Psychosocial Variables Associated with Female Students' Pursuit of STEM or non-STEM Major in College

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In the United States a disproportionately small number of women entering the field of science, technology, engineering and mathematics (STEM). This results in women missing out on job opportunities with better earning potential, and influence over the products they use. The current study examined variables involved in *female college students' choice of STEM or non-STEM majors* in college. The predictive variables of interest included <u>biological factors</u> (i.e. the relative length of finger digits 2 and 4, and maturation rate as indicated by puberty onset, *menarche*), <u>cognitive abilities</u> (i.e. *mental rotation* and *quantitative performance scores* on college entrance exams), and <u>psychosocial variables</u> of gender role orientation (i.e. current *gender role orientation* and *feminine gender intensification* during middle school).

Cognitive abilities and psychosocial variables were predictive in the pursuit of STEM majors among a sample of 169 female college/university students. The odds to select a *STEM degree* was 3.10 times higher for participants who performed better on the *quantitative section of the Standardized tests* compared to the reading section. *Mental rotation* ability was marginally significant in predicting a *STEM degree*. Participants who were relatively higher on their *masculine sex role identity*, were 6 times more likely to pursue a *STEM degree*. Potential contributions to the field is a better understanding of variables that influence female students' academic pursuits, which will help identify how to best increase the representation of females in STEM majors, and subsequently STEM jobs.

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Introduction

Women today obtain more than half of all bachelor's degrees awarded in the United States, yet a disproportionately small number of women enter the fields of science, technology, engineering, and math (STEM) (U.S. Department of Education, 2011; Blickenstaff, 2005; Ceci & Williams, 2011). While the number of women who earn bachelor's degrees in engineering, and engineering technologies has increased from 1% in 1970 to 16.5% in 2010, this number is still small compared to men who earned 83.5% of all bachelor's degrees in engineering in 2010. Women obtain only 12% of computer science degrees and 19% of physics degrees (U.S. Department of Education, 2011). With women making up half the population, and smaller numbers of women pursuing STEM occupations, it is important to consider some of the potential consequences. Science, technology, engineering and mathematics are required for the production of most things used in our society. Additionally, women are consumers of these products to the same, and sometimes even greater extent than men. For example, women are the fastest growing segment of buyers for new and used cars. Women buy 60% of all new cars sold in the U.S., 52% of all used cars and influence 80% of all automotive purchases. This means women influence over $300 billion worth of spending on cars annually. The car industry is aiming to increase the percentage of women employed in the engineering and design of cars, but the disproportionately low number of women pursuing engineering in college, limits their ability to do so

(Alliance of Automobile Manufacturers, 2013). Although women today fill 48% of all jobs in the U.S. economy, they hold less than 25% of STEM jobs (Beede et al., 2011).

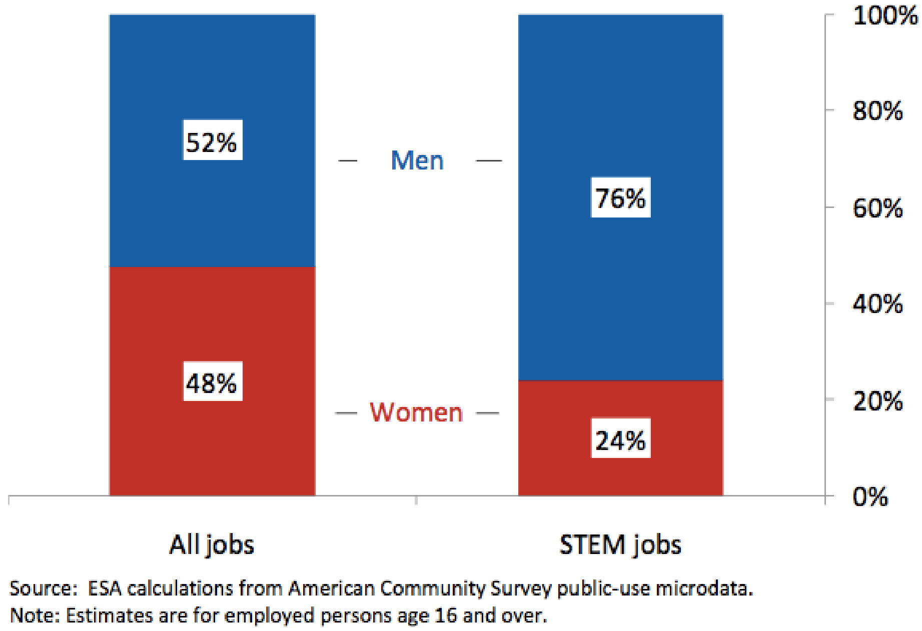

Figure 1. Gender Shares of Total and STEM Jobs, 2009

This is a problem considering that women who do hold STEM jobs earn more than women who work in non-STEM jobs. In other words, the gender wage gap is smaller in STEM jobs than in non-STEM jobs, as women in STEM jobs earn on average 33% more than women in non-STEM jobs. For every dollar a man earns in STEM jobs, a woman earns 14 cents less, compared to in non-STEM jobs where women earn 21 cents less than men for every dollar earned (Beede et al., 2011). The disproportionately small number of women entering STEM fields means that women are missing out on job opportunities that would provide them with better earning potential, and influence on the products they need and use. The following literature review will discuss possible explanations for the gender discrepancy in the pursuit of STEM majors and occupations. In order to discern the contributing factors to the sex discrepancy in the pursuit of STEM degrees, this literature review will focus on four areas of research. They include:

1. Sex differences in academic performance.
2. Sex differences in spatial abilities.
3. Biological variables influencing cognitive abilities and academic performance.
4. Socio-cognitive factors influencing early maturing girls' cognitive abilities and academic performance.

Background: Academic Sex Differences

The old adage of "Boys are better at math and science, and girls are better at reading and writing," is something that has been commonly expressed and generally accepted. Notions such as this were likely further reinforced after Maccoby & Jacklin (1974) identified 4 differences between the sexes. They are as follows:

1. Girls have greater verbal ability than boys.
2. Boys excel in visual-spatial ability.
3. Boys excel in mathematical ability.
4. Males are more aggressive.

Maccoby & Jacklin (1974) found that during the period from preschool to early adolescence, the sexes are very similar particularly as it pertains to both their verbal and spatial abilities. However, Maccoby & Jacklin (1974) also clarified that the above-mentioned differences became more apparent during, and after adolescence.

That is, as both sexes mature, the disparity begins to emerge and is often demonstrated in the scores on college entrance exams, especially on the quantitative sections. In 1966-67 females showed a modest 5-point advantage, (545) compared to males (540) with respect to verbal abilities on the *critical reading* sections of the Scholastic Aptitude Test (SAT). However, as of 2010 that slight advantage possessed by females over males reversed, with males taking a slight 5-point lead (503) in *critical reading* scores over their female counterparts (498). It is equally noteworthy that there was a significant decline in *critical reading* scores by both males and females by 2010. Consistent with the developmental trajectory of growing disparity between the sexes on academic performance, the 2009-2010 findings regarding the recently introduced *writing section* of the SAT, revealed that females (498) possessed a 12-point advantage over males (486) in the writing section (U.S. Department of Education, 2006; 2011). While there were some slight sex differences with respect to verbal and writing skills on the SAT, females did not consistently outscore males. The disparity between the sexes on the verbal sections was fairly minuscule, compared to the more divergent scores on the quantitative sections of the SAT's where males outperformed females.

When the quantitative section of the SAT was included in the analysis, a sex difference favoring males by 40-points was found. In 1966-67, males (535) significantly outperformed females (495), on the quantitative section (U.S. Department of Education, 2006; 2001). This profound sex difference in mathematical performance persisted in 2010 (males, 534; females 500) (U.S. Department of Education, 2006; 2011).

Although, not at the same level of statistical significance seen with the SAT's, similar trends were depicted on the American College Test (ACT), in which males had higher scores on the math (Males 21.6 vs. Females 20.5), and science sections (Males 21.4 vs. Females 20.5) (U.S. Department of Education, 2011; Sawyer, 2013). While these differences might appear quite negligible, the trends are supportive of earlier claims regarding the trend for increasing disparity of sex differences favoring males, found on quantitative and science sections of standardize tests, at a later age. This timeframe is consistent with late adolescence/early adulthood, which is when individuals transition from high school to college.

However, there are other proponents who speculate that the loss of low scoring males, contributed to the perceived male advantage in mathematics and science on college entrance exams, particularly as was seen with the 34-40 point sex differences on the quantitative section of the SAT (Hyde et al. 1990). Accordingly, the U.S. Department of Education (2012) reported higher dropout rates in high school for males (33%) as compared to females (16%), such that fewer males took college entrance exams, as compared to their female counterparts. Therefore, it is conceivable when looking at the college entrance exams data, that we are comparing high scoring males to a more heterogeneous sample of variably scoring females, resulting in a male advantage on the science and quantitative tests.

The Gender Similarities Hypothesis

However, research suggests that general academic sex differences, which appear to interact with age and maturation, do not tell the whole story in delineating why fewer females gravitate toward STEM areas of study. Contrary to the findings of Maccoby and Jacklin (1974), Hyde, Fennema and Lamon (1990) concluded that within the United States, there is only a negligible sex difference in academic performance. In fact, it is the supposition of Hyde (2005) that when taken together across time, that there may be many similarities between males and females in these early formative years. Hyde (2005) refers to this as the *Gender Similarities Hypothesis*. It states that males and females are similar on most variables concerning their performance in mathematics and science. There are some differences that vary across ages, but they depend on the context in which measurements occur. In the area of mathematics and science, when differentiating between specific skills and age groups, females have a slight advantage in computation in elementary school, and males develop an advantage especially for problem solving in high school and college. They found 78% of the effect size for academic sex differences were small or near zero (Hyde & Linn, 2006). The National Assessment of Educational Progress (NAEP) tests achievement in mathematics and science on thousands of students across the United States. They concluded that males outperformed females in science in all three grades assessed

(4^{th}, 8^{th} and $12^{th)}$ in 2005. When looking closer at the data it was evident that while the difference was statistically significant due to the large sample size, the magnitude of the differences was small, with an effect size, *d*, of only 0.12. When gender differences in mathematics and science are overemphasized they reinforce the stereotype that girls do not have the aptitude in science and mathematics (Hyde & Linn, 2006).

Accordingly, while the above mentioned sex differences on college entrance exams, particularly as was seen with the quantitative SAT's, may be statistically significant, according to Hyde & Linn (2006), even very small differences in scores between the sexes is likely to result in statistical significance, due to the large number of students in each group. Therefore, if Hyde & Linn (2006) are correct in their supposition that there may be greater similarities across the sexes with respect to academic proficiency, which contradicts some of the other significant empirical findings, illustrating a slight advantage by males in the domains of the math and sciences, it is unclear how much of the accounted predictive variance is attributable to just academic sex differences on standardized test scores, when trying to predict why fewer women pursue STEM majors, as compared to their male counterparts. This taken together with potential selection bias among male standardize takers, compared to the more heterogeneous sample of female standardize test takers, may leave one to wonder what other significant predictive factors may be at play in predicting why fewer females enter STEM fields of study. Additionally, total SAT scores have been found to not be very predictive of academic success in STEM majors in college, where every point increase in total SAT scores, was associated with only 0.3% increase in retention in STEM fields in college (Rohr, 2012). Therefore, while it is likely more valuable to look at the performances on the quantitative and science sections separately from the total score, it may be too simplistic to attribute the discrepancies in the pursuit of STEM majors solely to academic sex differences. This is especially the case given the other potentially confounding factors involved with developmental trajectory that seems to mediate the variability of when these academic sex differences tend to emerge, and in which academic domains, given that differences on the verbal ability standardize tests seemed to be less pronounced. Instead, it stands to reason that the underrepresentation of women in STEM may also be attributable to other cognitive, biological and/or psychosocial determinants that may be associated with developmental trajectory.

Sex Differences in Spatial Abilities

One such cognitive determinant of interest when studying the pursuit of STEM education is *spatial ability*. Spatial ability is involved in many forms of problem solving and higher order thinking in both science and mathematics, all of which are skills involved in engineering and technology. Therefore, it is not surprising that spatial ability is predictive of academic success in STEM areas in general, and in engineering courses in particular (Shea et al., 2001; Field, 2007). However, the research concerning sex differences in spatial cognitive abilities is varied. In a literature critique, Caplan, MacPherson and Tobin (1985) concluded the failure to clearly illustrate sex differences is in part due to methodological variations in how spatial abilities are tested.

In response to Caplan et al.'s findings, Voyer, Voyer and Bryden (1995) proposed dividing the tests into three categories: Tests of *Spatial Perception*, tests of *Spatial Visualization*, and tests of *Mental Rotation Ability*. *Spatial Perception* was defined as the ability to evaluate how things are arranged in space, and investigate their relations in the environment in spite of distracting information. *Spatial Perception* includes tests such as the <u>*Rod-and-Frame Test*</u>, which requires subjects to select a vertical rod despite distracting information due to a tilted frame, and the <u>*Water Level Test*</u> in which subjects are required to indicate the orientation of liquid in a tilted container. S*patial visualization* is the ability to visualize 2-dimensional and 3-dimensional figures, and subsequently engage in a variety of mental manipulations, which may or may not include a mental rotation task. Thus, *spatial visualization* is a broader category, which encompasses a variety of mental manipulation tasks that must be preceded by being able to visualize them. For example, some tests require participants to determine shapes that can be drawn with fragmented lines, indicating what an unfolded shape would look like when folded, finding a simple figure in a complex pattern, and/or the Block Design subtest of the Wechsler Intelligence Scale, all of which require multiple and various mental manipulations.

Therefore, *mental rotation tasks* can serve as one of the mental manipulations seen in *spatial visualization*. Additionally, given that Voyer et. al. (1995)

identified a preponderance of studies that used this very specific isolated task of *mental rotation*, they proposed a final category of *mental rotation* when doing their meta-analysis discerning sex differences on spatial abilities. This category of mental rotation included studies that had used the following tests: Card Rotation Test (CRT), generic mental rotation task (GMR), Mental Rotation Test (MRT) and Primary Mental Abilities – Spatial Relations (PMA-SR). Thus, *mental rotation* involves viewing two- or three-dimensional objects, proceeded by quickly and accurately mentally rotating them, in one or more directions. Using these three categorizations of *spatial perception*, *spatial visualization*, and *mental rotation* as indicators of cognitive spatial abilities, which are paramount to STEM areas of study, Voyer, Voyer and Bryden (1995) demonstrated in their meta-analysis of 286 effect sizes, in 268 studies, compelling sex differences, favoring males, on tests of *mental rotation* (effect size for all ages, $Z = 4.63$). However there were less consistent sex differences on tests of *spatial perception* ($Z = 2.25$), and non-significant sex differences on tests of *spatial visualization*.

Voyer et. al. (1995) also reported noteworthy findings suggestive of a main effect of age maturation illuminating the development of sex differences in spatial abilities. That is, for all three categories of spatial tests, the effect sizes increased with age of study participants. Additionally, early sex differences in spatial ability were found only for *mental rotation tests*, whereas sex differences did not emerge until later adolescence for the other two spatial abilities (i.e. *spatial perception* and *spatial visualization* abilities). For subjects under the age of 13, the *mental rotation* *tests* were the only spatial orientation tests to yield a significant effect size ($r=.33$, $z= 2.00$, $p<.05$). There was no support for sex differences in the other two categories of spatial ability (i.e. *spatial perception* and *spatial visualization*) before puberty. This was further suggestive of the differential cognitive development in spatial abilities correlated with the onset of puberty. Significant sex differences did emerge later in age on the other spatial ability tests of *spatial perception* and *spatial visualization* at different ages; after the age of 13 on tests of *Spatial Perception,* and over the age of 18 on tests of *Spatial Visualization* (Voyer, Voyer & Bryden, 1995). These findings indicated the relevance of maturation on the development of various spatial cognitive abilities. Given the lack of, or invariable findings for when sex differences in spatial abilities emerge on the latter two domains (i.e. *spatial perception* and *spatial visualization*), subsequent discussion will focus on *mental rotation*, which has been noted to reveal the most significant and consistent sex differences across time/development.

As indicated earlier, *mental rotation* involves a cognitive process of mentally rotating two- or three-dimensional objects in a direction. Peters, Manning & Reimers (2007) found performance on *mental rotation tests* peaked for both sexes in the 20 to 30-age range. *Mental rotation* performance was also positively correlated with educational level, in which both men and women with a university education demonstrated the best performance. The effect size for sex differences also increased with age, in which mean sex differences were the largest in the 30 to 40-age range. In addition, the significant sex differences in which men out performed women remained stable across all education levels after primary school (Peters, Manning & Reimers, 2007). While the latter discussion indicates that some spatial abilities, particularly as it pertains to *mental rotational* abilities, are associated with sex differences, there is also a clear indication that maturation plays a significant role in these sex differences. It is therefore, conceivable that the more pronounced sex differences in spatial abilities, particularly as it pertains to mental rotation tasks, which emerge over time, are a function of biological maturation and development.

Puberty Onset as an Indicator of Maturation and its Correlated Spatial abilities.

There are two biological factors that are related to, and potentially underscore the sex differences found to be correlated with spatial abilities in both males and females: maturation rate as indicated by puberty onset, and 2D:4D ratio. Several studies that have found that puberty onset, as an indicator of maturation, is also related to advantages and disadvantages in certain cognitive abilities, such as spatial and verbal abilities, regardless of sex. Waber (1976) was able to show that possible cognitive sex differences may be related to differential rates of physical maturation. She found that early maturing adolescents performed better on tests of verbal ability, and that late maturing adolescents performed better on spatial ability, regardless of sex. Waber (1977) was able to publish data from a study involving a larger sample of girls (n=40) and boys (n=40). This study confirmed the previous findings that early maturing adolescents performed better on verbal than spatial tasks, and late maturing adolescents performed better on spatial as compared to verbal tasks. They found spatial scores to be systematically related to rate of maturation, regardless of sex ($p < .001$), where late maturing adolescents had higher scores, but they did not find a relationship between rate of maturation and verbal scores.

In a later study Waber, Mann, Merola, and Moylan (1985) were unable to replicate support for a relationship between maturation rate and spatial performance among a sample of third grade girls and fifth grade boys, but they did find associations between maturation rate and preferred cognitive processes where later maturing adolescents made use of more advanced visual information, and utilized better visual organization when partaking in spatial processing,. Late maturing adolescents performed better than early maturing adolescents on a mental rotation test that involved advance visual information, and the stimuli were rotated to a higher degree. Late maturing adolescents also demonstrated better organization of their replications of a complicated line drawing, the <u>Rey-Osterrieth Complex Figure</u>, than early maturing adolescents did. Preferred cognitive processes are of importance when looking at the relationship between maturation as indicated by *age of menarche,* and choice of college major, as it would be reasonable to speculate that preferred cognitive processes are factors influencing mental rotation ability. If students are able to utilize more advanced visual spatial processing, they may have an advantage in mental rotation, and subsequently be more likely to successfully pursue of a STEM major.

Sanders and Soares (1986) also found maturation-related differences on a mental rotation test in their study of 194 female, and 80 male undergraduate students. This study presented not only evidence that late maturing adolescents scored higher than early maturing adolescents on a *mental rotation test*, regardless of sex, but also that the maturation-related differences in mental rotational abilities persisted into adulthood, as their sample involved college students. They did not, however, look into how the lasting maturation related differences affected subsequent educational choices or performance (Sanders & Soares, 1986).

When looking solely at females, Brenner-Shuman and Warren (2012) were interested in finding out if the relationship between maturation rate and cognitive abilities would be reflected in female students' pursuit of college majors. Brenner-Shuman and Warren (2012) found that female college students who entered puberty before the age of 12 were significantly less likely to choose a STEM major in college compared to female college students who entered puberty at or after the age of 12. Brenner-Shuman & Warren, (2012) found that for each 1-year increase in age at menarche there was a 54% increase in the odds of selecting a STEM major, significant at the .01 level. In finding that the effects of early puberty extended into the college years, and is associated with a reduced likelihood of pursuing a STEM major, one may ask why this is indeed the case.

Puberty and the Developing Brain

Thus, if maturation as indicated by pubescent onset, plays an important role in the emergence of one's abilities regarding spatial abilities, and even more specifically with regards to mental rotation and other advanced special skills, it is important to understand how puberty affects the developing brain. The human brain continues to develop well into our twenties. Puberty itself affects the developing brain and reorganizes neuronal circuitry. When puberty happens earlier, there is "*premature plasticity decay*" (Yun, Bazaar & Lee, 2004). "*Premature plasticity decay*" refers to a reduction in plasticity during and after puberty due to synaptic pruning, whose purpose is to remove unnecessary and unused neuronal structures from the brain, in which simpler associations formed at childhood are replaced by more complex structures by pubescent onset. The implications of synaptic pruning is that due to environmental experiences, and potentially limited exposure the brain becomes more hardwired to be receptive to specific stimuli and less receptive to infrequent stimuli. The implications of premature plasticity decay is that if young females who enter puberty earlier than others are assumed to be incapable of higher order information processing of visual stimuli as seen with spatial ability tasks such mental rotation, which are required for the STEM fields, and are subsequently not exposed to such tasks, premature plasticity decay can inherently reduce the likelihood of such females having any proclivity for such spatial abilities tasks and or interest in STEM fields that require them.

It is also theorized that *age of puberty*, affects lateralization of the brain (Diamond et al. 1983; Sanders & Soares 1986; Waber 1976; Frederici et al., 2008). Males generally have greater lateralization than females, meaning that there is greater differentiation between the two hemispheres, so that language is more clearly governed by the left hemisphere, and spatial tasks are more clearly governed by the right hemisphere. While the effect sizes in these studies were small, lateralization of language to the left hemisphere is a salient issue because then language is subsequently less likely to interfere with visual spatial processing in the right hemisphere. Thus, continued plasticity in the developing brain, and greater lateralization, which is considered to be a more masculinized brain as a function of delayed pubescent onset, allow for enhanced parallel cognitive processing in the brain, and thereby improves spatial processing, which is paramount to skills necessary for excelling in the STEM majors.

Waber (1977) was able to show independent of sex, that later maturing 8^{th} grade girls and 10^{th} grade boys were more strongly lateralized for speech perception compared to those who had matured earlier. As indicated previously, increased lateralization, which results in dual concurrent cognitive processing in both hemispheres, is suggestive of improved spatial ability due to decreased linguistic interference with spatial tasks. An explanation offered by Waber (1977) is that lateralization of the brain increases as the brain is developing. When puberty starts, lateralization is inhibited resulting in a relatively longer lateralization period for late maturing adolescents compared to early maturing adolescents. Thus, if later maturing adolescents have better spatial abilities as demonstrated on mental rotation tests, it may be due to both a longer period of plasticity and greater lateralization. Accordingly, the simple fact that boys on average enter puberty later than girls may explain both the male advantage on mental rotation tests, and why boys have greater lateralization than girl.

Timing of Puberty

As just mentioned, when discussing onset of puberty and its impact on cognitive abilities, it is important to note that girls on average enter puberty earlier than boys, and it is possible that the sex differences found in cognitive abilities are functions of maturation, as indicated by pubescent onset. It is difficult to pinpoint a specific event as indicative of boys' onset of puberty, but on average males enter puberty between the ages of 12 and 14. Females, on the other hand, are said to enter puberty between the ages of 10 and 12. But the first physical signs of puberty in girls happen even earlier, in the development of breasts, also known as *thelarche*. The mean onset of *thelarche* in the U.S. is 10-years of age for European American girls, and 9-years of age for African American girls (Steingraber, 2007). However, *menarche*, the age at the time of the first menstrual period, is commonly used as an indicator for self-reported onset of puberty in girls. In 1920 the mean onset of menarche was 13.3 years of age for all race-groups in the U.S. In 1980-89 the average age of menarche in the United States had declined to 12.4 years of age (McDowell, 2007). The decline was greatest for non-Hispanic Black females, changing from 13.6 years to 12.2 years. For Mexican Americans the onset of menarche reduced from 13.2 years of age to 12.2 years of age, and for non-Hispanic white girls it reduced from 13.3 years of age to 12.5 years of age (McDowell, 2007; Frisch & Revelle, 1971).

Digit Ratio, a Biological Variable associated with Spatial Abilities

In addition to the delay maturational indicators resulting in greater lateralization, studies have consistently replicated the notion of prenatal testosterone exposure resulting in more masculine behavioral patterns. Genetic female rhesus monkeys exposed to testosterone during gestation showed masculinized behavior such as increased mounting behavior, and rough play compared to a control group (Wallen, 2005). Wallen (2005) suggested the latter part of gestation is especially sensitive to hormonal exposure and an important period for brain organization and behavioral differentiation. Hines et al. (2002) were able to show a link between levels of testosterone during gestation and gender role behavior in preschool girls. By measuring levels of testosterone in blood samples of pregnant women and comparing this to the gender role behavior in their offspring at the age of 3.5 years (N= 337 females, 342 males), they found a significant linear relationship such that as maternal testosterone levels increased so did masculine-typical gender role behavior in girls. No such relationship was found for boys. Girls who have been overexposed to prenatal testosterone have also been shown to exhibit more “tomboyish” behavior (Constantinescu & Hines, 2012).

Lust et al. (2011) in a longitudinal study found in a sample of six-year old children (n=67) that prenatal testosterone exposure as measured by radioimmunoassay in utero amniotic fluid, was related to an increase in language lateralization to the left hemisphere. As alluded to earlier, such findings especially with regard to language lateralization were important given that Lust et. al. (2011) proposed that lateralization of language to one hemisphere, most often the left hemisphere, may be an advantage by decreasing the level of interference in visual spatial processing in the right hemisphere. With both language and visual spatial processing localized in separate hemispheres of the brain it would allow for both processes to occur concurrently with little or no interference from the other, and thereby more specifically enhance spatial processing. Thus, it stands to reason that increased prenatal testosterone exposure, would improve the odds of female students pursuing a STEM degree, whereby parallel cognitive processing, and improved spatial ability are likely to be an advantage. The proposed study will not examine prenatal testosterone exposure per se, but will instead measure the associated variable of D2:D4 ratio.

In humans, the relative length between the index finger and the ring finger (2D:4D) has been suggested to be associated with prenatal testosterone exposure (Manning, 2002; Hönnekopp & Watson, 2010). Men on average have a lower 2D:4D ratio (longer ring finger than index finger) than women, who on average have greater 2D:4D digit ratio (equal length or a longer index finger). A lower digit ratio (i.e. anything less than one) as indicated by a longer ring finger compared to the index finger, is hypothesized to suggest that these individuals have experienced greater “masculinization” in utero.

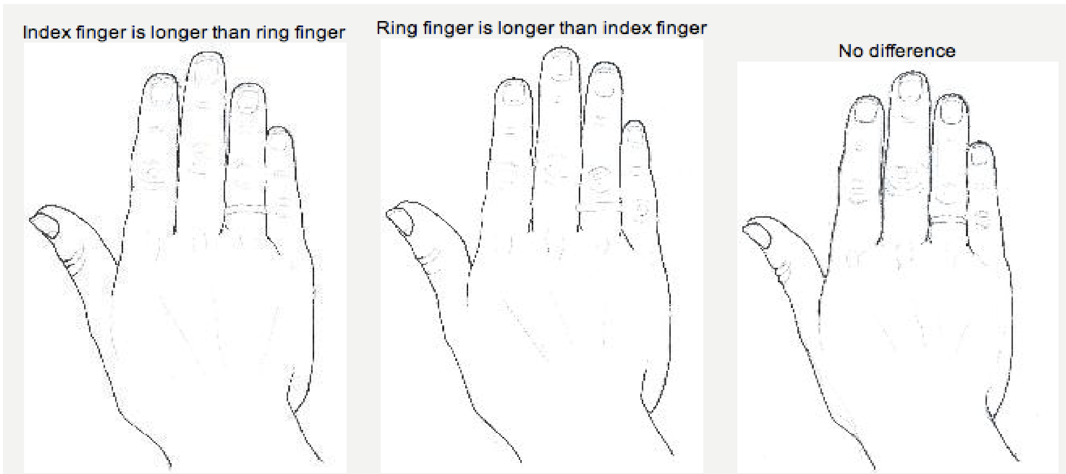

Figure 2

For example, Brown, Hines, Fane and Breedlove (2002) found that females with congenital adrenal hyperplasia (CAH), a condition where they have been exposed to higher than normal levels of adrenal androgens prenatally, had a significantly lower 2D:4D ratio than females without CAH. Although, the research so far has been correlational and not able to show that digit ratio in humans is dependent on prenatal testosterone, there is research indicating that low 2D:4D ratio was associated with higher fetal testosterone (FT) levels, and that high 2D:4D ratio was associated with low fetal testosterone and fetal estradiol (FE) in a study that measured digit length in children at the age of 2-years old ((N=18 males, 15 females) and compared this to the FT and FE levels obtained from amniocentesis while they were in utero (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer and Manning, 2004). Additionally, Zheng and Cohn (2011) were able to provide experimental evidence that D2:D4 ratio is a lifelong signature of prenatal hormone exposure in mice. The balance of prenatal testosterone and prenatal estrogen determined D2:D4 ratio in mice, such that fetal sex differences in mouse D2:D4 were established between embryo day 12.5 and 17. By inactivation of androgen and estrogen receptors and the use of receptor antagonists they were able to show that 2D:4D ratio was determined by a balance of prenatal testosterone (PT) and prenatal estrogen (PE) acting on the fourth digit, where higher levels of PT relative to PE resulted in increased length of the fourth digit, and higher relative levels of PE to PT resulted in higher D2:D4 ratio (decreased growth of digit four).

Lower D2:D4 ratio in humans is associated with improved cognitive performance on tasks of *targeting* (i.e. moving a mouse cursor from the center of the screen to a target), *figure-disembedding* (i.e. finding a smaller simpler form that is part of a larger complex figure), and *perceptual discrimination* (i.e. object recognition task) (Falter, Arroyo & Davis, 2006). Accordingly, correlations have been found between digit ratio (2D:4D) and performance on standardized tests. With respect to males, a negative correlation between 2D:4D and numeracy was such that lower digit ratio was correlated with an increased ability to reason and apply simple numeric concepts, such as arithmetic. Additionally, for both males and females, a lower digit ratio was significantly correlated with higher mental rotation scores compared to individuals with higher digit ratio (Peters, Manning & Reimers, 2007). However, Falter, Arroyo & Davis (2006) did not find a significant association between digit ratio and mental rotation performance with their limited sample size (N=69) nor did Beaton, Magowan and Rudling (2012) in a more recent study with another small sample size (N=68). Beaton, Magowan and Rudling (2012) speculated that a larger sample size was required to reveal significant associations between digit ratio, and mental rotation performance. This speculation seems reasonable given that the mean sex differences regarding their digit ratio were very minute in both studies. The 2D:4D difference within each sex sample group was actually greater (range difference of 0.06" for females and 0.08" for males) than the between group sex differences (mean difference between the sexes of 0.012" in the first study, and 0.029" in the latter). Peters, Manning and Reimers (2007) on the other hand, had access to a sample of 255,100 men and women from all over the world by sampling over the Internet, which likely helped them find significant correlations between 2D:4D digit ratio and mental rotation performance. And again, the effect size for the sex differences was not large, Cohen's *d* of .53.

Biological determinants of D2:D4 ratio, may conceivably also be associated with puberty onset for both boys and girls. Some research has suggested that lower D2:D4 is associated with later puberty onset, as indicated by later onset of menarche for girls (Matchock, 2008). This study of 206 female college students found a significant association between the right-hand 2D:4D ratios (but not left-hand) and a delayed menarche (mean age at menarche = 13.05, SD=1.257). A later study by Helle (2010) was unable to replicate these results in a study with 282 post-reproductive Finnish women (aged 50-60 year). They also found a stronger correlation between right hand D2:D4 ratio and age at menarche (X^2=2.49, p=.12) compared to left hand D2:D4 and age at menarche (X^2=0.95, p=.33) but the correlation did not reach a significant level.

It is conceivable that lower D2:D4 will indirectly have significant implications for spatial skills proficiency, which could inevitably influence success in the STEM fields, by an association with delayed menarche. However, the converse could also be true that females with early puberty onset, and higher D2:D4 ratio, may develop less proficiency in spatial skills relevant to STEM fields, and thereby may be less apt to select STEM fields of study in college. Both biological factors of D2:D4 ratio and onset of menarche, which appear to be associated with cognitive factors (spatial skills/mental rotation tasks), may also be associated with psychosocial influences.

Psychosocial Determinants & Stereotype Threat

One cannot ignore the psychosocial consequences affecting girls who enter puberty earlier than their peers, who are likely to demonstrate a more stereotypically feminine identity. Accordingly, gender social role theories speak to how men and women are told to view themselves within the context of societal gender role norms and expectancies, and whether or not males and females conform to those societal ideals for what it means to be a man or a woman. Such explanations become even more plausible when we consider that when sex differences are found on academic performance and spatial orientation, specifically mental rotation tasks, that they are more pronounced in later years approaching young adulthood. Young adulthood marks the time when one's concept of self and identity has been formulated and solidified, and self concept and identity are highly influenced by societal gender role norms and expectancies (Harter, 1990).

Consistent with such notions, Steele, (1997), and Major, Spencer, Schmader, Wolfe, & Crocker (1998) point to the notion that often being primed to think about either one's race or one's gender, can serve as a highly influential factor in performance on academic achievement tasks such as mathematics, sciences, and the standardized quantitative rubrics for the SAT and ACT. This phenomenon is known as *stereotyped threat*. Accordingly, several studies (Nosek, Banajii & Greenwald, 2002; Steele, 1997; Steele & Ambady, 2006) have shown that *stereotype threat* impacts females' performance in mathematics and science in a negative direction. *Stereotype threat* is influenced by females' gender orientation and self-perception. Females who stereotype mathematics as a male domain, and associate themselves as being stereotypically female, tend to have more negative implicit and explicit attitudes about math (Nosek, Banajii & Greenwald, 2002). *Stereotype threat* is especially prominent in performance on more difficult tests. However, it is not performance anxiety about one's ability that causes reduced performance for women. Rather, it is the situational pressure that challenges women's sense of belonging and acceptance to a domain they care about, that creates the threat and reduces performance (Steele, 1997). Researchers Fredrickson et. al. (1998) studied college students who were asked to try on either a sweater or a swimsuit in front of a full-length mirror and then take a math test while wearing the sweater or swim suit. In this experiment, young women wearing swimsuits performed significantly worse on the math test than did the women wearing sweaters. This study did not refer to the effects on math performance as *stereotype threat*, but instead referred to “objectification correlating to attentional disruption and mental performance.” The other variables investigated were self-objectification, body shame, restrained eating and sex differences, but they did not measure any other cognitive abilities in order to control for mathematical performance. However, they did have participants complete a questionnaire about their math background including past standardized test scores.

Even subtle gender primes were found to shift both the implicit (those attitudes outside of our awareness) and explicit (those within our conscious awareness) attitudes of women influencing performance in mathematics, and the arts in a stereotypical direction (Steele & Ambady, 2006). Because e*xplicit attitudes* are those that individuals are aware of, they are able to self-report. *Implicit attitudes* on the other hand while not explicitly endorsed by the individual, can still influence their behavior. Females may be unaware of their attitudes or unwilling to reveal that they endorse such attitudes that …”*girls are not supposed to be good in math and science*,” or “*girls can’t be engineers*.” Implicit stereotypes can be measured with the <u>Implicit Association Test (IAT).</u> The IAT is a measure where participants associate words into categories, and the differential time it takes for them to associate for example “science” with male as opposed to female, is measured.

Nosek et al. (2009) researched the relationship between implicit stereotyping of gender-science attitudes and science and math scores among 8th graders using the Implicit Association Tests (IAT) in 34 different countries. With a sample of almost 300,000 individuals self-selecting to take the IAT test, Nosek et. al. (2009) found that general gender inequalities and explicit stereotyping in different countries cannot solely explain gender gaps in science and math. Instead, their results showed that implicit gender-science stereotyping is correlated with national gender differences in 8th grade science and math achievement, and accounted for as much as 19% of the science gap, and 24% of the math gap between men and women in the countries studied (Nosek et al., 2009). The implications of the Nosek et. al. (2009) study highlights the importance of not only trying to change explicit stereotyping when it comes to women in math and sciences, but also changing social realities, and implicit stereotyping in order to increase women's participation in Science Technology Engineering and Mathematics (STEM) education.

Psychosocial Development in Adolescence

As evidence by the research on *stereotyped threat*, Halpern (2004) suggests that there are a host of psychosocial variables that influence female students' cognitive abilities during adolescence, which may influence whether females pursue STEM fields. Hill and Lynch (1983) proposed that both *cognitive abilities* and *social influences* from family and peers influence girls' self-concept formation with respect to sex roles and activities, and maturation rate plays a part in this self-concept formation. Specifically, it is important to examine the academic consequences early maturing girls are facing, and how sex role concepts affect girls' psychosocial development.

Academic Consequences for Early maturing Girls

There are likely many factors contributing to the finding that early maturing girls are less likely to pursue a STEM major in college. The most obvious factor is the academic difficulty many early maturing girls encounter. It seems the transition into high school is especially difficult for early maturing girls, and they have more academic problems as they progress through high school (Cavanaugh, Riegle-Crumb & Crosnoe, 2007). In 9th grade, early maturing girls have lower GPAs, and are 34% more likely to have failed a course compared to later maturing girls. This academic failure at the beginning of high school helps explain the early maturing girls' lower academic success at the end of high school, consisting of early maturing girls being more likely to drop out of high school, while those who graduate, have lower cumulative GPAs by the end of 12th grade (Cavanaugh, Riegle-Crumb & Crosnoe, 2007).

Long-term effects of pubertal timing, however, are sometimes not evident in girls' course grades in 12th grade, as some studies have not found a lower GPA for early maturing girls in 12th grade. This could be because most high school students can chose the courses they take, and it may be that early maturing girls are choosing easier courses (Dubas, Graber & Peterson, 1991). Early maturing girls report less interest in academic subjects, and are less likely to pursue college education, while late maturing girls (i.e. 75.5% of late maturing girls) are significantly more likely to complete a bachelor's degree than girls who enter puberty earlier (i.e. 33.2% of early maturing girls) (Graber, Seeley, Brooks-Gunn & Lewinsohn, 2004; Mendle, Turkheimer & Emery, 2007).

Being late in timing of puberty shows a particularly strong effect on course grades, but in an opposite direction for boys, as compared to girls. Late maturing boys show the lowest course grades in language arts, literature and social studies, while early maturing girls show the lowest course grades in those same subjects (Dubas, Graber & Peterson, 1991). Timing effects on achievement orientation does not present until 8th and 12th grade. With respect to "on-time maturers," both males and females had the highest orientation towards achievement, while for girls only, "*early maturers*" had the lowest orientation toward achievement (Dubas, Graber & Peterson, 1991). Thus, suggesting that low orientation towards achievement is another indication that early maturing girls have an academic disadvantaged compared to later maturing girls, and are thereby less likely to pursue a STEM degree.

Variations in academic achievement related to maturation rate whether late or early, is likely associated with several different factors, with the relative experience of being different from one's peers due to the development of secondary sexual characteristics earlier or later than other girls, being one important factor. For example, late maturing girls may spend more time studying because they are not maturing at the same rate as their peers, and this may make them less popular, thereby resulting in them having less busy social lives (Dubas, Graber & Peterson, 1991; Mendle, Turkheimer & Emery, 2007). Early pubertal timing on the other hand, has been found to negatively affect female students' academic performance as a function of four negative influential outcomes which include: depression, premature adult self-concept, risky behaviors, and problematic peer group association (Cavanaugh, Riegle-Crumb & Crosnoe, 2007). There is literature supporting the notion that puberty affects psychological functioning mainly through how it impacts the change in physical appearance (Collins & Steinberg, 2007). The change in body image by the development of feminine secondary sexual characteristics, likely affects both self-conception and social interactions. It has been found that increased feminine gender role orientation during adolescence contributes to girls' increased risk for a depressed mood (Wickstrom, 1999; Stice, Presnell & Bearman, 2001). Early maturing girls are more likely to be more self conscious about their bodies and to develop poor body image. This poor body image persists for early maturing girls even after their peers also reach puberty, affecting their self-perception and self-confidence negatively for a longer time than expected (Graber et al., 2004). Early developing girls are more likely to get the attention of older boys and become involved in social groups that are beyond their emotional maturity (Cavanaugh, Riegle-Crumb & Crosnoe, 2007).

Gender Self-Concept: (*Gender Intensification* and *Gender Role Orientation).*

It is likely that the differing social and academic circumstances early and late maturing girls find themselves in, contribute to more or less *gender intensification,* which shapes their self-perception and gender self-concept as would be seen in their level of feminine or more masculine *gender role orientation. Gender roles* are societal norms dictating what types of behaviors are considered appropriate for a person based on their actual or perceived sex. There are many variables affecting gendered expectations ranging from cultural variations, social norms and biological factors. The *gender intensification hypothesis* (Hill & Lynch, 1983), states there is acceleration in gender differential socializing during early adolescence. Each gender will identify more strongly with their gender stereotype during puberty, and if puberty happens earlier it likely has a greater influence on them.

There is another way gender role orientation may influence girls' relative performance in mathematics and science classes. Teenage girl's spatial ability can be predicted by perceived masculinity of the ideal self at the age of 11, which is positively correlated with a later age at menarche (Newcombe & Dubas, 1992). Spatial ability at age 16 was predicted by perceived masculinity of the ideal self at the age of 11, which in turn was positively correlated with a later age at menarche. Interestingly, spatial ability at age 11 also predicted spatial activity between the ages of 11 and 16, supporting Newcombe & Dubas'(1992) hypothesis of self-selection. In other words, girls who had higher spatial ability when they were 11 years old selected more spatial activities. Naturally with more practice it can be assumed they would also have higher spatial abilities at age 16 and possibly longer (Newcombe & Dubas, 1992).

Gender role orientation impacts both girls and adult women's performance on mental rotation tasks. In a Meta analysis of 12 published studies that examined gender-role identity, as measured by the BEM sex-role inventory, and performance on mental rotation tests, Reilly and Neumann (2013) found an effect size for masculinity for women of $r = .23$. In other words, the probability of women scoring average or higher on tests of mental rotation was 61.5% for women who perceived themselves as more masculine or androgynous, compared to 38.5% for women who perceived themselves as more feminine. The results of this study support the supposition that masculine gender-role orientation contributes to the development of spatial ability, and it also indicates a persistence over time of this association, as the studies involved in the Reilly and Neumann's (2013) analysis were from three decades of research. Given that gender role orientation has consistently been shown to be correlated with mental orientation ability one may surmise that the assessment of gender-role orientation may also be an additional contributing factor when identifying variables affecting female students' pursuit of STEM majors, and subsequently STEM jobs

Summary

In summation, there are many factors influencing female students' academic pursuits. The disproportionately fewer number of women in the field of STEM is likely due to a combination of cognitive, biological and social factors. Academic and cognitive sex differences seem to be consistent in the United States and while there are minimal sex differences on verbal abilities there is more disparity with respect to the mathematical and science performance with males taking the lead, and the literature point in the direction that that these sex differences become more pronounced with time, as girls and boys develop from elementary school to high school. Spatial ability is an important predictor for academic success in STEM fields. There are sex differences where males are shown to have an advantage, especially on mental rotation tasks. Yet, there is research suggesting that biological maturation, as indicated by menarche onset, may be a significant determinant of mental rotation ability, along with another biological factor: a lower D2:D4 ratio. Both these biological factors in turn likely influence gender role socialization, where a more masculine gender role orientation for women is associated with increased mental rotation ability. Female college students who enter puberty before the age of 12 are significantly less likely to choose a STEM degree in college, and age of entering puberty is related to advantages and disadvantages in certain cognitive abilities such as gender role orientation and mental rotation abilities. 2D:4D ratio has been shown to be a predictor of performance on mental rotation ability and is suspected to also influence gender role orientation. However, it is difficulty to say which came first, the biological factors or the associated gender role orientation and mental rotation ability? The *gender intensification hypothesis*, states there is acceleration in gender differential socializing during early adolescence. Each sex will identify more strongly with their gender stereotype during puberty and the relative age of girls when they enter puberty may affect this gender intensification making early maturing girls more likely to be negatively affected by stereotype threat. Could it be that we as a society prematurely foreclose on our females by hardwiring their brains (premature plasticity decay) to not be open and receptive to STEM fields of interest due to limited environmental exposure to math, sciences, spatial orientation at early ages, because we relegate such domains to boys, and not girls. Does early maturation and greater gender intensification, associated with greater femininity limit female's exposure to spatial orientation tasks, math, and sciences, so that they are less likely to pursue interests associated with STEM fields of study? Or do these biological determinants establish early maturers versus late maturers, and the resulting gender intensification and gender role orientation. The very real phenomena of stereotype threat offer some suggestions that these very strong and compelling data findings in which females are cued to think about their gender role orientation prior to performing on stereotypically male dominated activities, results in a lack of interest and pursuit of STEM fields.

Based on the above review of the literature, several factors have been identified that may be associated with female students' pursuit of a STEM education. Biological influences such as 2D:4D ratio and maturation rate are associated with spatial abilities, gender intensification and gender-role orientation. Together with psychosocial variables, they likely influence cognitive outcome variables such as performance on standardized college entrance exams, mental rotation ability, and ultimately female students' pursuit of STEM or non-STEM majors in college. Later onset of *menarche* is expected to positively correlate, with scores on the *quantitative section* of college entrance exams, *mental rotation performance* and *masculine gender role orientation*, and negatively correlated with *early feminine gender intensification* and an increased likelihood of pursuing a STEM major in college. A lower *digit ratio* is expected to negatively correlate with scores on the *quantitative section* of college entrance exams, *mental rotation performance* and *masculine gender role orientation*, and positively correlate with *early feminine gender intensification* and an increased likelihood of pursuing a STEM major in college. Consequently, earlier onset of *menarche*, a higher *digit ratio,* lower scores on the *quantitative section* of college entrance exams, lower *mental rotation performance* and *feminine gender role orientation*, and higher *feminine gender intensification* are all expected to predict a reduced likelihood of pursuing a STEM major in college.

The Proposed Study

The proposed study sought to assess if two *biological* variables *age of menarche* and *2D:4D ratio* independently or jointly predicted *female college* *students' choice of STEM or non-STEM majors* in college. The variance attributed to the biological variables was separately partialed out to determine both the individual predictive variance of *age of menarche* and *2D:4D ratio* as well as, the combined interactional effects as predictors of female students' choice of STEM major.

In addition, the study sought to determine if these biological variables were significantly correlated with two *cognitive outcome* variables and one *psychosocial* variable. The cognitive outcome variables were *mental rotation ability* and the *relative performance on the quantitative sections of standardized college entrance exams*. The psychosocial variable of *gender role orientation* consisted of *current perceived gender role orientation* and self-reported *gender-intensification during middle school,* defined as a tendency to identify more strongly with female gender stereotypes. The variance attributed to the biological, cognitive and psychosocial variables was separately partialed out to determine both the individual predictive variance of each of these constructs as well as, the combined interactional effects as predictors of female college students' choice of STEM or non-STEM majors in college.

It was anticipated that the present study would add to the body of literature by clarifying the contributing predictive variance of biological, cognitive and psychosocial variables to the disproportionately low number of women pursuing STEM majors in college. If we can decipher the explanatory variables that contribute to the relationship between age of menarche, and a pursuit of STEM or non-STEM majors we will be better able to implement interventions to more effectively encourage women into the STEM field.

In order to be consistent all variables that were categorical or ratios were coded so that a higher value indicated a more masculine presentation. While in the literature a D4:D2 ratio indicates a longer ring finger, in our data we coded a longer ring finger with the higher value, 2, and a longer or equally long index finger as 1, and named this variable *digit ratio*. This allowed for describing the correlations in the hypothesis as positive correlations when they were moving in the same direction.

Hypothesis

- ❖ H1. There will be a positive relationship between *digit ratio* and *age at menarche*.
- ❖ H2. There will be a positive relationship between *mental rotation ability, the relative performance on the quantitative section on* standardized tests, *age at menarche,* and *digit ratio*.
- ❖ H3. *Perceived masculine relative to feminine gender role* will have a positive relationship with *age at menarche* and with *digit ratio,* and *feminine gender intensification* will have a negative relationship with *age at menarche* and with *digit ratio*.
- ❖ H4. *Age at Menarche (early vs. late)* is expected to have a significant main effect on *Mental Rotation ability*, *Relative scores on the quantitative section on Standardized College Exams, Perceived masculine relative to feminine*

gender role and *Feminine Gender Intensification*. Participants who enter menarche later are expected to have higher rotation ability, higher relative quantitative scores, more masculine gender role identity and less feminine gender intensification.

- H5. *Digit ratio (low vs. high)* is expected to have a significant main effect on *Mental Rotation ability*, *Relative scores on the quantitative section on Standardized College Exams, Perceived masculine relative to feminine gender role* and *Feminine Gender Intensification*. Participants with a higher (more masculine) *digit ratio* are expected to have higher rotation ability, higher relative quantitative scores, more masculine gender role identity and less feminine gender intensification.
- H6. The following variables will predict an increased likelihood of a choice of STEM major without nursing in college: a higher *age at menarche*, higher *digit ratio*, higher *mental rotation ability*, higher *relative quantitative standardized scores*, higher *perceived relative masculine gender role* and less *early feminine gender-intensification* scores.

Method

Study Design

The current study was a combination between groups and correlational design. Initially the two independent biological variables of AGE of MENARCHE and DIGIT RATIO were used as independent variables for the dependent variables of cognitive outcome as measured through *mental rotation ability,* relative performance on *the quantitative section* on standardized college entrance exams, and for the psychosocial outcome as measured through *Gender Role Identity* and *Gender Intensification.* In the second level of analysis of this study, ultimately all theses variables were used as predictor variables for the criterion variable of a *choice of STEM without nursing major in college*.

Study Participants

This study included nonclinical female college/university students ages 18 years and older across the United States. An estimated total sample size of at least n = 250 participants were attempted to be recruited. Power analyses were conducted using the computer program G*Power 3.1.5. The following options were selected for the G*Power 3.1.5 program: z tests, Logistic regression: One tailed, odds ratio of 1.54, and Power = 0.80. G*Power 3 yielded a suggested sample size n=214 to afford sufficient power for testing the proposed study hypotheses. The odds ratio for this power analysis was based on the findings from the previous published study concerning female students' age of menarche and choice of STEM versus non-STEM majors in college (Brenner-Shuman & Warren, 2012). This study found that for each 1-year increase in age at menarche there was a 54% increase in the odds of selecting a STEM major, significant at the .01 level.

Participants were mainly recruited from the South Eastern regions of the United States, but some were also recruited from the Northeast. Students from a private, Southeastern University, were recruited via the Universities' Sona Systems online web application and students enrolled in humanities classes were informed about the study by their professors and encouraged to participate. Additional participants were recruited through social media (e.g. the social networking website Facebook). As a recruitment incentive, participants were offered the opportunity to be entered into a drawing for a $30 Amazon eGift Card as compensation for their involvement in the study. Students who access the survey through the University Sona Systems received course credit for participating.

Procedure

Approval from the Florida Institute of Technology (FIT) Institutional Review Board (IRB) was obtained prior to the collection of data. Informed consent was obtained from each participant at the onset of the online survey questionnaires (Appendix B). Participants reporting being younger than 18 years of age or older, were not able to move on past the informed consent page to complete the questionnaires. Participants completed the *Qualtrics* online survey, which features a larger study that sought to examine demographic information, paternal involvement, athletic involvement, highest level of mathematics reached in high school, sexual orientation/debut and academic preference and performance. The portion of the larger online survey that pertained to the present study consisted of 94 items across nine measures assessing *age at menarche, digit ratio, college major selected, standardized test score on college entrance exams, early feminine gender* *intensification, BEM gender role inventory*, and *Purdue Mental Rotation test.* The online survey was estimated to take approximately 40 minutes to complete. The four sections of the survey involving the following measures: *standardized test score on college entrance exams, early feminine gender intensification, BEM gender role inventory*, and *Purdue Mental Rotation test* were programmed through Qualtrics to be presented in random sequencing in order to counter balance effects due to order of presentation.

Measures

Demographic Measures

Participants provided information regarding their race/ethnicity, as well as the race/ethnicity of each of their parents. Race/ethnicity was divided into five categories, as follows:

1. Caucasian
2. Black (African American, African Caribbean, African)
3. Hispanic
4. Asian
5. Pacific Islander, Native American

Respondents also provided information about their parents' educational and occupational status, according to the Hollingshead Index scales:

OCCUPATIONAL SCALE
1. Major Executives of large concerns, major professionals, and proprietors.
2. Lesser professionals and proprietors, and business managers.
3. Administrative personnel, owners of small business and minor professionals.
4. Clerical and sales workers, and technicians.
5. Skilled trades.

6. Machine operators and semiskilled workers.
7. Unskilled employees.

EDUCATIONAL SCALE

1. Professionals (Master's degree, doctorate or professional degree).
2. College graduates.
3. 1-3 years college or business school.
4. High school graduates.
5. 10-11 years of schooling.
6. 7-9 years of schooling.
7. Under 7 years of schooling.

The following formula was utilized for determining social class for each parent: (Occupation Score X 7) + (Education Score X 4). Scores ranging 11- 17 is considered Upper Class; 18-31, Upper-Middle Class; 32-47, Middle Class; 48-63, Lower Middle Class; and 64-77, Lower Class (Stewart & Schwartz, 2003).

Independent Measures

Age at menarche was determined by the self-reported age at the time of the respondents' first menstrual period. In addition to the interval variable of *Age at Menarche* in full years, age of menarche was then operationalized onto two levels, *Early* and *Late Menarche*. As mentioned in the literature review, the average age of menarche in the United States is 12.6 years of age, and for this sample, the average age of menarche was 12.46 years of age (SD=1.49). Participants who entered menarche before the age of 12 were considered "early" and those who entered at the age of 12 or later would be considered "on time or late". From here on *Early Menarche* will refer to participants who entered menarche before the age of 12.

After being presented with a pictorial representation of the 3 types of 2D:4D ratios, *digit ratio* was self-reported by the respondents where they indicated the relative length of their index and ring fingers. The survey provided them with three sketches to exemplify the different relative finger lengths: one where the index finger was longer than the ring finger, one where they were of equal length, and one where the ring finger was longer than the index finger. As suggested by the literature, women on average have a longer index finger or equal length of the index and ring fingers, and males on average have a longer ring finger. Therefore, this variable, *digit ratio*, was categorized into two levels suggestive of masculinity and femininity. The *masculine direction* was the instance in which the ring finger was longer than the index finger (the middle box in figure 3), and the *feminine direction* was the instance in which the fingers were of equal length (the third box in figure 3), or the index finger was longer (the first box in figure 3). The sample item is shown in figure 3.

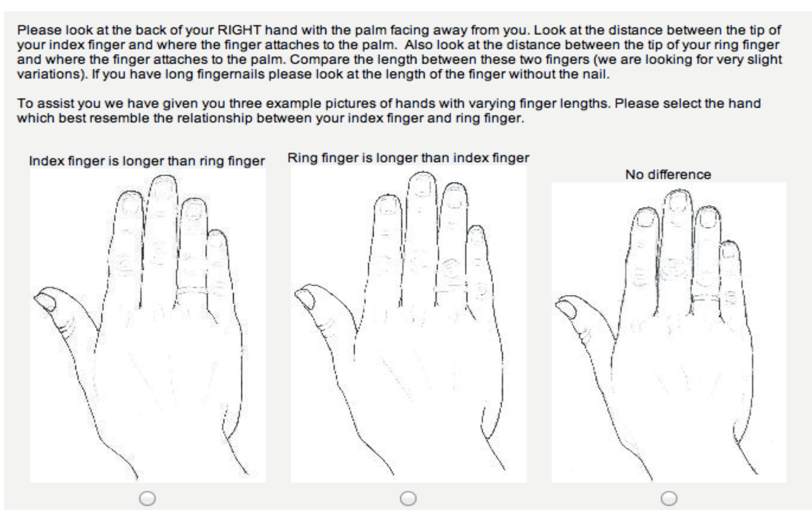

Figure 3.

Dependent Measures

Mental rotation ability, *relative performance between the verbal and quantitative sections on the Standardized College Entrance Exams*, *perceived feminine sex role orientation* and *sex intensification* were dependent variables which were used for assessing group differences with respect to high and low AGE of MENARCHE and high and low DIGIT RATIO. However, all the aforementioned dependent variables also functioned as predictor variables together AGE of MENARCHE and DIGIT RATIO in relations to the outcome variable of *female students' selection of STEM versus non-STEM major in college*.

Mental rotation ability was measured by the Revised Purdue Mental Rotation Test (PSVT:R). This test has often been used in educational research concerning spatial ability in general and in STEM disciplines in particular (Contero et al. 2005; Field 2007). Mental rotation can be measured with several different instruments, and the Purdue Spatial Visualization Test: Visualization of Rotation (PSVT:R) is often used to predict engineering students' success (Maeda, Yoon, Kim-Kang & Imbrie, 2013). This test is found to generate significant sex differences in which males outperform females, and this sex difference becomes even larger when time limits are implemented. Maeda and Yoon (2013) found that the largest effect size (0.67), for sex differences was generated when the time was limited to 30 seconds per item, as compared to an effect size of 0.57 when there were no time limits. The cognitive ability measured by the PSVT:R is related to abilities required for tasks in STEM disciplines (Yun, 2004). The measure is a psychometrically sound instrument with good reliability, as seen through Cronbach's alpha ranging from 0.80 to 0.86. There have also been with weak to moderate correlations found between the Revised PSVT:R scores and engineering students' academic aptitude test scores, such as SAT and/or ACT mathematics as well as composite scores, ACT science scores, and high school overall GPAs (Maeda & Yoon, 2013). The PSVT:R is available free of charge and is easy to score. Permission to use this measure has been granted by the author, Dr. So Yoon Yoon, Ph.D., at Texas A&M University. The measure has 30-items consisting of figures of three-dimensional objects drawn in two-dimensional form. The respondent is presented with a sample figure displayed in its original direction, then displayed in a rotated direction. It is the job of the respondent to determine the type of rotation that has taken place, and find a similar rotational figure relationship in the next figure presentation amid 5 options. In other words, the respondent will then be presented with a 2nd figure, then asked to use the same rotational relationship from the 1st pair presented, to determine the corresponding figure match among 5 options, for the 2nd presented figure. A sample item is shown in figure 4.

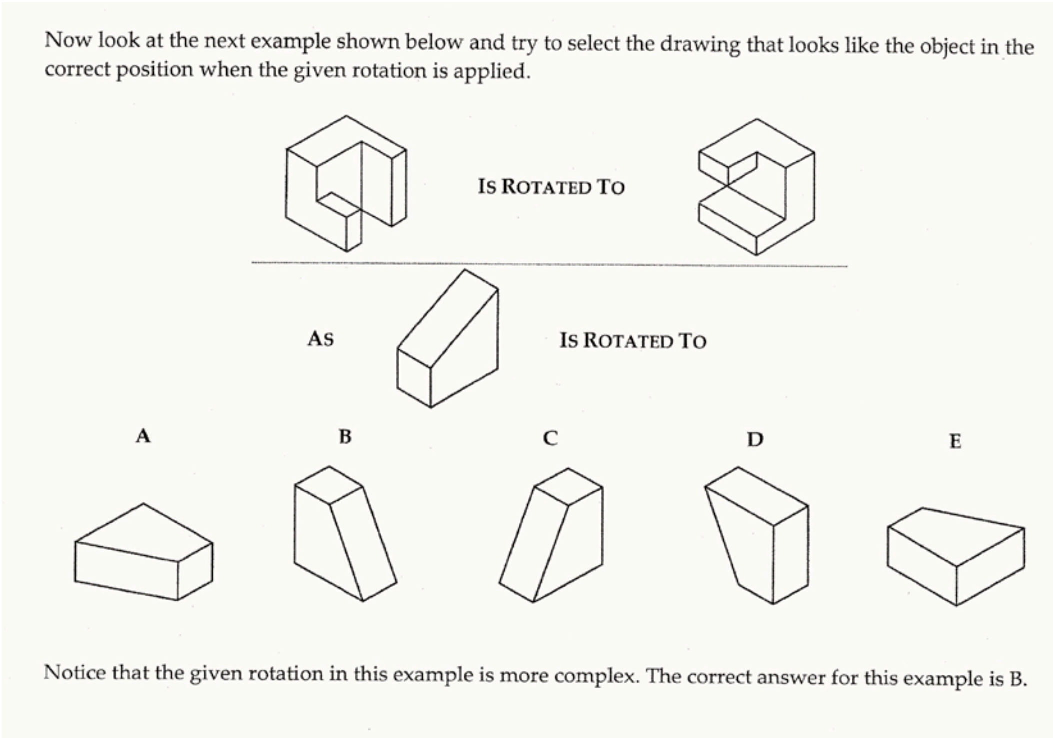

Figure 4.

In order to limit the administration time, the total number of items were reduced from 30 to 15 items from the Revised PSVT:R and a total time limit of 10 minutes set. According to the Meta analysis by Yoon (2013) of studies using any version of the Purdue Mental rotation test, there was no standardized administration of these measures, although the majority of the measures included in their Meta analysis, reduced the number of items administered in some way. However, they did not specifically elaborate on their exact methodology. The lack of standardization makes it difficult to know how to select the items when needing to reduce the number of items administered. Maeda and Yoon (2011), studied the validity of the Revised PSVT:R in measuring spatial ability and looked at the following:

1. How reliable are scores on the Revised PSVT:R for first-year engineering students?

2. To what extent do characteristics such as item difficulty and item discrimination vary across the items in the Revised PSVT:R?

3. To what extent is the Revised PSVT: R supported by the criterion-related validity evidence?

4. To what extent is the Revised PSVT:R supported by the construct-related validity evidence?

This study identified the items that had the highest discrimination ability in differentiating examinees by their level of spatial visualization ability. The study also presented evidence that all items in the Revised PSVT:R contributed to measuring one of the subcomponents in spatial ability, i.e. spatial visualization, and listed the factor loading for each item. Based on these statistics 15 items with the highest discrimination ability, and the highest factor loadings, were selected. The statistics for the 15 selected items are as follows in table 1 (Maeda & Yoon, 2011):

Table 1.

Item	Item discrimination	Item Factor Loading	Item Difficulty Level
6	.421	.642	85.0%
10	.401	.618	84.3%
11	.438	.624	76.2%
12	.464	.656	72.5%
14	.426	.649	81.5%

18	.383	.590	84.6%
19	.377	.542	77.3%
20	.444	.654	78.5%
21	.391	.572	75.0%
25	.403	.572	69.7%
26	.523	.709	65.3%
27	.495	.686	65.8%
28	.375	.536	70.8%
29	.368	.515	58.3%
30	.391	.596	36.2%

As seen in table 1, the first column list modest *item discrimination* (r=.375 to .523)*,* which is defined as the point-biserial correlation between responses of a particular item with the total raw scores, such that higher correlations were indicative of being more useful in differentiating examinees, by their levels of spatial visualization ability. The second column lists the modest (.515 to .709) *factor loadings*, which indicated the extent to which each item loaded on the single factor of spatial visualization ability. The final and third column lists the *item difficulty* according to *Classic Test Theory* (CTT). The greater the percentage of examinees that successfully answered a particular item correctly was suggestive of easier items, while lower percentages were indicative of fewer examinees who were able to answer the item correctly, suggestive of greater item difficulty. Most of the 15-items selected tended to be relatively easier in difficulty, with exception of the last two items (#29 & #30) which had the greatest difficulty.

As mentioned earlier, Maeda and Yoon (2013) found in their Meta analysis that the largest effect size (0.67) for sex differences, was generated when the time was limited to 30 seconds per item, and others studies have found that women on average took approximately 30 seconds to complete each item. Because the purpose of the current study is to investigate spatial ability differences among female students who may have more or less “masculinized” cognitive abilities, a total time limit of 10 minutes for 15-items was selected. This time limit was based on the optimal average time limit of 30 seconds per item to generate the largest effect size for gender differences, plus one additional standard deviation of 7.5 seconds, resulting in 37.5 seconds per item. For 15-items this resulted in a total time of 562.5 seconds, equaling 9.38 minutes, which was subsequently rounded up to an even 10-minutes.

Several other studies using the Revised PSVT:R measured both a total raw score for correct responses, and also an adjusted score in which incorrect responses were subtracted from the correct responses in order to account for guessing, which would yield greater errors in responding (Brownlow et al., 2003; 2011). Accordingly, a study by Goldstein et al. (1990) calculated a ratio score representing the number of correct responses among the items attempted within the time limit, in addition to the total raw score. As such the current study’s aim will calculate three scores that will account for a variety of factors to include determination of participants guessing, or performing accurately with slower response times. Therefore, the three calculated scores were as follows:

1. A raw score in order to assess number of correctly completed items,
2. An adjusted score to account for guessing

3. The ratio of correct scores relative to attempted items, in order to account for those participants who may have performed accurately, but slower than the mean.

The *performance on the SAT or other standardized test* with a verbal and quantitative section was self-reported. The participant will be asked which standardized test they have taken given a choice as to which one they would like to provide their scores for. They were provided with a likert scale where all possible scores for that particular test were available. An example of this is provided in Appendix C. If the participant could remember any standardized score they had the option of stating if they usually performed better on the verbal or the quantitative sections of the test. The reasoning is based on the finding that male students score significantly higher on the quantitative section compared to the verbal section on standardized entrance exams. Female students on the other hand have essentially commensurate scores on the two sections. If the participants could remember their scores, they might have been able to remember which section they had higher scores on, and a higher score on the quantitative section compared to the verbal section was considered a more "male" performance pattern compared to an equal or higher performance on the verbal section commensurate with a more "female" performance pattern. Subsequently, participant were either coded as having a masculine pattern vs. a feminine pattern with respect to the standardize test scores and used for subsequent analyses. The sections of the standardized College entrance exams were categorized as Reading section and Quantitative section. The scores on each section was compared and a categorical variable, *standard score ratio*, was computed, where 0 represented participants who's reading score was better or the same as the score on the quantitative section, and 1 represented participants who's scores on the quantitative section was better than the scores on the reading section.

Gender role orientation was measured with the Bem Sex Role Inventory 20-item Short Form. The original form of the BSRI (Bem, 1974) asked respondents to rate themselves on 20 stereotypically feminine traits, on 20 stereotypically masculine traits and 20 filler items. Psychometrically the BSRI displays good internal consistency and reliability. For females the coefficient alpha for the Femininity scale is .75 and .87 for the Masculinity scale. For males, the coefficient alpha for the Femininity scale is .78 and .87 for the Masculinity scale. The BSRI has good test-retest reliability and the Femininity and Masculinity scales seem to be uncorrelated. The BSRI has since been revised and several shorter forms have been developed (review by Lippa, in Mental Measurement Yearbook nr 9).

The original short form of the BSRI contains 30-items in which 10-items relate to *masculinity traits* that are traditionally viewed as more desirable for men, 10-items related to *femininity* traits that are traditionally viewed as more desirable for women, and 10 additional filler items that were originally developed to measure social desirability. In the 20-item short form, these 10 filler items have been removed leaving only the *femininity* and *masculinity* items. The 20-item short form yielded comparable or even more reliable scores than the 40-item long form.

Cronbach alpha for the *masculine* items was .82 (compared to .85 on the long form) and for the *feminine scale* alpha was .89 (compared to .81 on the long form). They also found higher fit indices for the two-factor model on the short form, .88 (goodness-of-fit index, or GFI) (compared to .73 on the long form) and .87 (comparative fit index or CFI) (compared to .61 on the long form) X^2 (169, N=791) = 922.96 indicating the short 20-item form had more utility for future research (Campbell et al., 1997). Choi, Fuqua and Newman (2009) found even higher Crombach alphas; for the *masculine* items alpha of .84 for a college sample and .89 for a sample of adult Certified Public Accountants (CPA). For the *feminine scale* alpha was found to be .92 for college students and .91 for the adult CPA sample (Choi, Fuqua & Newman, 2009).

Participants were asked to indicate on a 7-point scale how well each of the 20 characteristics describes them. The scale ranged from 1 ("Never or almost never true") to 7 (Always or almost always true") and was labeled at each point. An example of this measure is provided in Appendix D. To score the BSRI, the first step was the calculation of each subject's *Femininity* ("a") and *Masculinity* ("b") scores, which were the averages of the subject's ratings of the *feminine* and *masculine* adjectives on the BSRI (Bem, 1978, 1981). The average of each participants' femininity and masculinity ratings were transformed into standard scores. The lowest possible total score on each of the two scales of the BSRI was 10 and the highest possible score was 70. Additionally, a ratio variable was computed, *BEM ratio*, to account for the relative feminine and masculine scores on the BSRI, where *BEM masculine* was divided by *BEM feminine*, resulting in a ratio of less than 1 if *BEM feminine* was higher than *BEM masculine* and higher than 1 if *BEM masculine* was higher.

Gender intensification during middle school was measured with the <u>Early Feminine Identification Scale (EFIS)</u> (Brenner-Shuman, Chavez, Abbott, Durham, Anderson and Drvoshanov, 2015) developed for the purpose of this study, and designed to assess to which extent the respondent behaved in a stereotypically feminine manner during adolescence. This measure consisted of 20 statements with 15 indicating behavior or attitudes often seen in girls who perceive themselves as very feminine, and 5 reversed items. A likert-type scale with the following rating scale of "0" (never), "1" (rarely), "2" (sometimes), "3" (often), and "4" (most of the time) was used to assess how much they endorse each item. An example of this measure is available in Appendix E. Regarding psychometrics, the data collected from this study was used for the purpose of validation for this newly designed measure. Items for this scale were generated through focus group sessions with several graduate students and one faculty member exploring behaviors and attitudes that would indicate premature feminine attitudes and behaviors in middle school. Based on the factor analytic structure of the newly designed measure, (described in the analysis section), four scales emerged, the *EFIS Flirty* scale consisted of 8 items, the *EFIS popular* scale consisted of 4 items, the *EFIS Not-Nerdy* scale consisted of 3 items, and finally the *EFIS Fashion Trendy* consisted of 3 items. The lowest possible score on each item of the EFIS was 1 and the highest was 5.

Because each scale had a different amount of items, the mean for each scale was used in place of the total score.

Choice of STEM or non-STEM major in college was the ultimate dependent variable. The selected college major was self-reported as a text entry. After reviewing each reported major, they were categorized as either *STEM* or *non-STEM* according to Xie and Shauman's (2003) taxonomies, which include engineering, architecture, physical sciences, mathematics, computer sciences, and life/biological sciences as STEM. However, nursing is traditionally a stereotyped female occupation, and the observed discrepancy between women and men seen in other subfields of STEM are not seen in life sciences. Women obtained a majority (56%) of life sciences bachelor's degrees in 2010 (National Science Board, 2010). For this reason, another categorization for STEM or non-STEM was created where participants who had declared nursing as a major were not included in the STEM group, but instead included in the non-STEM group, *STEM non-Nursing.*

Results

Survey Response Rates

A total of 287 people logged into Qualtrics to participate in the survey. Two people after giving consent to participate, logged out before answering the initial screening question regarding their sex/gender. Thirteen of the participants answered "no," to the question if their sex was female, and were subsequently taken directly to the end of the survey. Therefore of the 287 participants who initiated the survey, 272, or 94.8% met the screening criteria for being female and 18-years old or older, and proceeded onto the study. Of the remaining 272, only n=157, which was 57.7% of the initial sample (n=287) who first went to Qualtrics, proceeded to complete the survey in its entirety. However, a majority completed the measures for the main variables of interest: *STEM or non-STEM major* (N=239, 87.9%), *Age of Menarche* (N=230, 84.6%), *Digit Ratio* (N=196, 72.0%), *BEM Sex Role Inventory* (N=188, 69.1%), *EFIS* (N=185, 68.0%), *Standardized test scores* (N=184, 67.7%), *PSVT-R* (N=169, 62.1%).

As suspected, different recruitment strategies seemed to influence the motivation for the students to complete the survey, where the students who accessed the survey through the SONA system at FIT were more likely to complete the entire study (n=85, 93.40% of SONA participants), as compared to participants who were recruited through social media (n=72, 47.40% of non-SONA participants). A Chi Square analysis indicate a significant effects regarding *SONA or non-SONA* participants and *completion of the last item in the survey* [$x^2(1)=52.76$, $p<.01$]. This difference is likely due to the difference in incentive, where the FIT students who accessed the survey through SONA were given class credit for participation, while the participants from social media were provided a chance to win a $30 dollar gift card. Therefore, there would also be an effect of University, whereby most participants who completed the study were from FIT.

Participants

Participants were current or past students from a variety of institutions. A majority, 38% were from FIT, and accessed the survey through the SONA system.

The remainder of the respondents were recruited through Social media, and were divided into nine groups based on the number of participants from each institution, where Other Public University and Other Private University refer to any institution with less than three participants (table 2).

Table 2. Universities in to 9 groups

University/College	Number of Participants	Percent
FIT	90	38.0%
Ivy League	20	8.4%
FSU	12	5.1%
UCF	9	3.8%
NESCAC (Amherst)	8	3.4%
Universities with religious affiliation	8	3.4%
UF	5	2.1%
Other Public University	52	21.9%
Other Private University	33	13.9%

A majority of the participants (n=142) were or had pursued a non-STEM major in college (59.8%), compared to those who were or had pursued a STEM major (40.2%). As FIT is a university specializing in technology and STEM majors, a significantly larger percentage of the participants from FIT were pursuing a STEM degree (50%) compared to participants from other universities (34%). This distinction of FIT as a technological college became the basis for how to categorize the different universities. There was only one other participant from a technological university (Ogeechee Technical College). The remainder of universities was classified as Liberal Arts Universities, and this classification became the basis for the preliminary analysis below, for identifying *University type* as a covariate.

The age of respondents ranged from 18 to 60 years of age, with the mean age of respondents being 24.21 years of age. Participants from FIT tended to be younger, ranging in age from 18 to 37 years (M=20.88 years, SD=3.26), while participants from other universities ranged in age from 19 to 60 years of age (M=26.21, SD=7.95). Again, a significant difference between the mean age of respondents [$F(1, 241) = 37.11$, $p<.01$] was found when comparing participant from FIT and other universities.

The majority of participants were Caucasian (75.9%), and the second largest representation were Asians (10.3%), closely followed by Black participants (7.4%) and Hispanic (4.1%), and finally Native Americans or Pacific Islanders (1.2%). With respect to type of University Institution, Caucasians were in the majority at both FIT (57.8%) and the Liberal Arts Universities (88.2%). However, most notably, the distribution of Asian students was reversed, in which Asian students had a larger representation of the total participants from FIT (21.1%) compared to the participants from Liberal Arts Universities (3.9%) (figure 5).

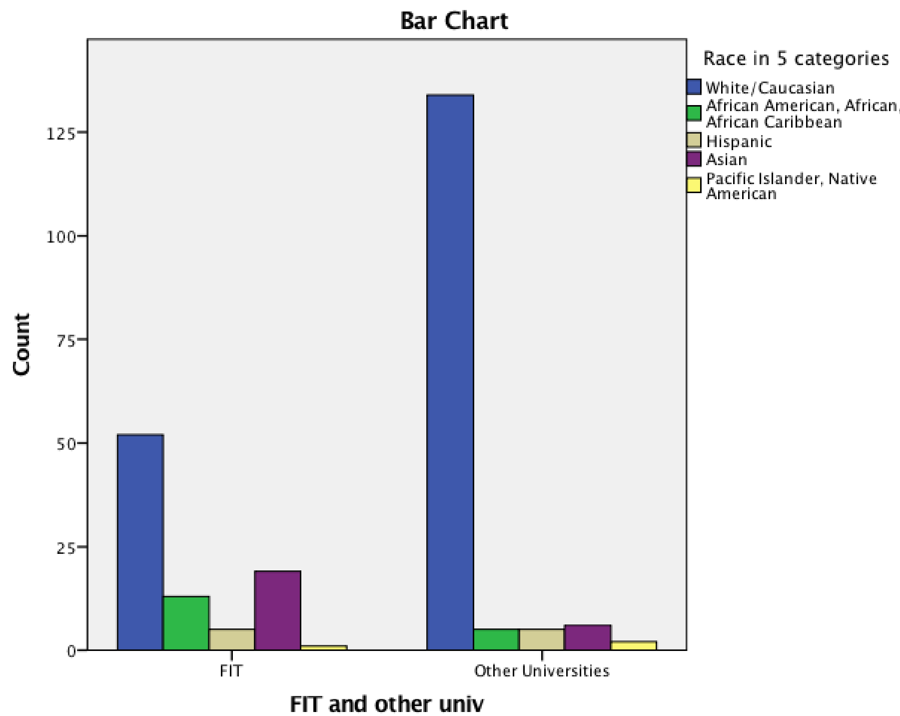

Figure 5. Representation of Race at FIT and Other Universities.

Respondents provided information about their parents' educational and occupational status, according to the Hollingshead Index scales. A majority of participants were Middle Class (37.8%), and Upper Middle Class (37.4%), followed by Lower Middle Class (12.6%), Upper Class (10.9%) and Lower Class (1.3%).

The mean age of menarche was 12.46 year of age (n=230, SD=1.49). The ages of menarche ranged from a minimum or 8-years old, to 18-years of age. The participants were divided into two groups, those who entered menarche before the age of 12 and considered *Early Menarche* (n=57, 24.8%), and those who entered menarche at the age of 12 or later were considered *Late Menarche* (n=173, 75.2%).

The majority of participants had a longer ring finger than index finger (n=104, 53%)_indicating a more male presentation. The remainder of participants had either equal length of the index and ring fingers (n=47, 24%), or a longer index finger (n=45, 23%) indicating a more female presentation. After computing, *digit ratio*, with two categories, participants were fairly equally divided between the two groups, those with a more masculine presentation (n=104, 53.1%), and participants with a more feminine presentation (n=92, 46.9%).

The scores on the feminine BSRI scale, *BEM feminine*, ranged from 30 to 70 (n=188, *M*=53.74, *SD*=8.83), and on the masculine BSRI, *BEM masculine*, the scales ranged from 27 to 70 (n=188, *M*=47.65, *SD*=8.32). The scores on the *BEM Ratio* variable ranged from a minimum of 0.47 to a maximum of 1.94 (n=188, *M*=0.91, *SD*=0.23). %).

Individual participant mean scores on the *EFIS Popular* scale ranged from 1.25 to 5.00 with the mean for the sample being M=3.31 (n=186, *SD*=0.85). Individual mean score on the *EFIS Flirty* scale ranged from 1.00 to 4.00, with the sample mean being *M*=2.10 (n=186, *SD*=0.65). Individual mean score on the *EFIS Not-Nerdy* scale ranged from 1.00 to 4.67, with the sample mean being *M*=2.54 (n=186, *SD*=0.73). Individual mean scores on the *EFIS Fashion Trendy* scale ranged from 1.00 to 5.00, with the sample mean score being *M*=2.45, (n=186, *SD*=0.88).

A total of 184 participants reported their *standardized scores* and the majority declared they had higher or equal scores on the reading section (n=116, 63%) compared to the quantitative section (n=68, 37%). A total of 169 participants completed the *Revised PSVT:R*. The *mental rotation* scores were as mentioned above calculated in three ways, total raw score, adjusted score, and ratio score. The lowest possible total raw score was 0, and the highest possible total raw score was 15. The total raw score ranged from 1 to 15 (M=5.59, SD=2.83), the adjusted score ranged from -13 to 15 (M=-3.02, SD=5.77), and the ratio score ranged from 0.07 to 1 (M=0.4, SD=0.2). %). For the purpose of the following data analysis the *PSVT:R adjusted* score was used as it accounted for testing fatigue resulting in many participants guessing the correct answers.

A total of 143 participants' college majors were categorized as *non-STEM* (59.8%) and 96 participants' college major were categorized as *STEM* (40.2%), according to to Xie and Shauman's (2003) taxonomies. This categorization included those who declared nursing as a major in the *STEM* category (n=6). A total of 149 participants' college majors were categorized as *non-STEM* including Nursing (62.3%) and 90 participants' college major were categorized as STEM non-Nursing (37.7%).%). The variable, *STEM non-Nursing* was used for the analysis below.

Preliminary Analysis

In order to ensure the most parsimonious level of analysis and suitability of using a MANCOVA, a Pearson r bivariate correlation matrix was performed, utilizing the independent measures of all relevant demographic variables

(*University Type, Race, Age,* and *Social class*) and dependent measures of *STEM without nursing* or *non-STEM including nursing* major in college (table 3).

Table 3. Descriptive Statistics And Correlations for Independent *demographic variables* **and Dependent Variable** *STEM or non-STEM major in college without Nursing*

Variable	*M*	*SD*	1	2	3	4	
1. *University type*	1.62	.48	_				
2. *Race*	1.51	1.05	-.31**	_			
3. *Age of participant*	24.20	7.06	.36**	-.15**	_		
4. *Social Class Continuous*	32.90	13.23	.03	.09	.10	_	
5. *STEM w/o nursing*	.38	.49	-.83**	.23**	-.18	**.10	_

** Correlation is significant at the .01 level (2-tailed).

A significant negative correlation was found between *STEM without nursing or non-STEM including nursing* degree and *University type* (*r*= -.18, *p*<.01), where participant from *Technology Universities* were more likely to pursue a *STEM without nursing* degree compared to participants from *Liberal Arts Universities*. Because of this, a Chi squared analyses was performed for the demographic variable of *University type,* and the dependent variable of *STEM without nursing* or *non-STEM including nursing*. Significant effects were found regarding *University type* and *STEM without nursing or non-STEM including nursing* [$x^2(1)=7.95$, p<.01] that echoed the previously stated correlational findings, suggestive of greater differences in the participants from *Technology Universities* or *Liberal Arts Universities*, in which participants from *Technology Universities* were more likely to pursue a *STEM without nursing* degree.

A significant positive correlation was also found regarding *Race* and *STEM without nursing* (*r*= .23, *p*<.01), and Chi squared analyses were performed for demographic variable of *Race* and the dependent variable of *STEM without nursing*. Significant effects were found regarding *Race* and *STEM without nursing* [$x^2(4)=22.64$, $p<.01$], suggesting *Asian and Black* participants were significantly different from the other races in that a majority pursued *STEM without nursing* (76% and 55.6%) compared to the *Caucasian* (31.3%) and *Hispanic* (20%) participants where a minority pursued *STEM without nursing*.

The *age of the participants* was negatively correlated with the selection of a *STEM without nursing* degree ($r= -.18$, $p<.01$), where older participants were less likely to have pursued a *STEM without nursing* degree compared to younger participants. An independent-samples t-test was conducted to compare *age of participants* who were pursuing a *STEM without nursing* degree, and the *age of participants* who were pursuing a non-*STEM with nursing* degree. Significant findings [$t(237) = 2.82$, $p <.01$] suggested that participants who were pursuing a *STEM without nursing* degree (M=22.5, SD=6.02), tended to be younger, as compared to their *non-STEM with nursing* counterparts (M=25.2, SD=7.52). This was more than likely due to the preponderance of FIT students who were recruited via SONA, being current college students, who were also in the early stages of their academic pursuits, and thereby younger, as well as attending a technological university, thereby increasing the likelihood of pursuing a STEM major.

Social Class, as indicated by the continuous *Hollingshead Index Scales*, was only marginally associated with *STEM without nursing* major selection. That is, participants who's parents were higher in socio-economic status were marginally more likely to pursue a STEM major as indicated by an independent sample t-test [t (237)=1.64, p = 0.10]. Therefore, *Social Class* was only used as a covariate in the Logistic Regressions and not used a covariate in some of the other analysis. However, given the significant differences found with respect to the other three variables, *University type, race*, and *age of respondent* and the pursuit of *STEM without nursing* and non-*STEM with nursing* majors, were initially used as covariates in the subsequent_analysis, and subsequently, removed from certain analysis where they were found not to have any significant predictive variances.

The *Early Feminine Intensification Scale* (EFIS) was developed for the purpose of this study. Data collected from this study was used for the purposes of validating this newly designed measure through the establishment of its psychometric properties. Given that the EFIS was a newly created measure for the current study, the psychometric properties were evaluated. First, the measure's factor structure was determined through an exploratory factor analyses, using an orthogonal rotated solution with varimax-rotated solutions with Kaiser Normalization. Once the factor structures were identified, they were used to represent subscales of the measure. Accordingly, internal consistency was determined using Cronbach's α for each individual subscale as well as for the total measure. This measure consisted of 20 statements relating to stereotypically feminine behaviors and attitudes in middle school. A five-point likert scale with the following rating scale of "1" (never), "2" (rarely), "3" (sometimes), "4" (often), and "5" (almost always) was used to assess how much they agreed with the statements.

Questions number 2, 9, 12, 15 and 19 described less stereotypically feminine behaviors and were reverse scored. In the exploratory factor analysis, four factors emerged from the original 20-item index, based on Eigen values equal to or greater than one, and accounted for 49.17% of the cumulative variance. The emerging themes included *Flirty*, *Popular*, *Not-Nerdy*, and *Trendy*. Factor loadings for each item were rounded to one decimal, and a cut-off for factor loading of .5 was used for an item to be included in a scale. Two items did not reach this level and were not included in any of the scales. Items and reliability information can be seen in Table 4. This newly developed scale possessed good internal reliability as demonstrated by a high Cronbach alpha (α = .786) for the entire measure. After excluding the two items the internal reliability as demonstrated by Cronbach alpha for the remaining items in the four scales improved to α = .801.

Table 4. EFIS Factor Analysis

Component	Factor Loading	% of Variance	Cumulative %	Chronbach's Alpha	Eigen Value
EFIS Flirty		23.403	23.403	.787	4.681
1. I would wear make-up to school	.52				
4. I wore tight form-fitting clothing to school	.62				
5. Parents and teachers complained about my clothes being too revealing	.64				
6. I liked getting boys attention	.63				
10. I wore heals or dressier shoes to school	.62				

11. I got into conflicts with other girls over boys or rivalries	.70				
16. I knew how to get boy's attention	.56				
18. I dated	.51				
EFIS Popular		10.791	34.194	.728	2.158
3. I was popular	.75				
7. I went to most school dances and functions	.59				
12. I felt like I did not fit in with friends and classmates (reversed)	.66				
17. I engaged in a lot of social activities	.82				

EFIS Not Nerdy		7.728	41.923	.538	1.546
2. I would wear clothes that were comfortable rather than trendy (reversed)	.62				
9. My first priority was dong well in school (reversed)	.73				
20. I would rather spend time with friends instead of homework	.71				
EFIS Trendy		7.247	49.170	.464	1.449
8. I followed or tried to follow fashion trends	.46				
13. I carried a purse	.71				
14. I did not use a backpack and instead I carried my books	.58				

Excluded Items					
My parents told me I slouched when I walked (reversed)	.30				
I thought girls who wore makeup were self-absorbed (reversed)	.34				

Good internal reliability was additionally found for two of the factors with a high Cronbach alpha for *EFIS Flirty* (α = .78) *and EFIS Popular* (α = .73). Moderate internal reliability was found for the other two factors, with a Cronbach alpha for *EFIS Not-Nerdy* (α = .54)*,* and for *EFIS Fashion Trendy* (α = .46). Significant correlations were found between the EFIS's favorability factors. The *Flirty* factor was positively correlated with *Popular* ($r = .36$, $p < .001$), *Not-Nerdy* ($r = .32$, $p < .001$), and *Fashion Trendy* ($r = .33$, $p < .001$). The *Popularity* factor was also positively correlated with *Fashion Trendy* ($r = .19$, $p = .01$), and with *Not-Nerdy,* but not at a significant level ($r = .13$, $p < .07$). Lastly, *Not-Nerdy* was also positively correlated with *Fashion Trendy* ($r = .33$, $p < .001$).

Construct validity for the EFIS subscales was determined by comparing the EFIS subscales with the *BEM feminine* scores and the *BEM masculine scores*. In addition, self-report data relating to the age of the participant when they had their *first kiss*, their age at the time of their *first romantic relationship*, and their age when they had their *first sexual encounter* was used for further cross-validation in which it was expected that participants with high early feminine intensification scores would also report earlier ages of having their *first kiss*, their *first romantic* *encounter*, and first *sexual encounter*. However, in the current sample not all participants had yet experienced these activities. So subsequent cross-validation was first correlated with whether participants with elevated EFIS scores were more likely to have had those experiences, versus not having had those experiences.

The EFIS *Popular* subscale was significantly positively correlated with both total *Feminine BEM* score ($r=.23$, $p<.01$) and the total *Masculine BEM* score ($r=.18$, $p<.05$). The EFIS *Popular* subscale was also significantly positively correlated with *having ever had a first kiss* ($r=.21$, $p<.01$), but not with having had a *romantic relationship*, or with having had a *sexual encounter*. However, none of the other EFIS subscales were significantly correlated with either of the total BEM scores (table 4). The EFIS *Flirty* subscale was significantly positively correlated with *having had a first kiss* ($r=.23$, $p<.01$), and *having ever had a sexual encounter* ($r=.29$, $p<.05$), but not with *having ever had a romantic relationship*. EFIS *Not-Nerdy* subscale was significantly positively correlated with *having ever had a fist kiss* ($r=.19$, $p<.01$), and *having had a romantic relationship* ($r=.18$, $p<.05$), but not with having ever *had a sexual encounter*. The EFIS *Fashion Trendy* subscale was not significantly correlated with any of the three romantic activities (table 5).

Table 5. Cross Validation of *EFIS subscales* and *BEM Feminine* and *BEM Masculine.*

Variable	*M*	*SD*	1	2	3	4	5
1. *BEM Feminine*	53.73	8.84	_				
2. *BEM Masculine*	47.65	8.33	.10	_			
3. *EFIS Popular*	3.32	.84	.23**	.18*	_		
4. *EFIS Flirty*	2.10	.65	.01	.03	.19*	_	
5. *EFIS Not-Nerdy*	2.54	.73	-.12	-.10	-.13	.32**	_
6. *EFIS Fashion Trendy*	2.45	.88	.07	-.05	.19*	.33**	.21**

** Correlation is significant at the .01 level. * Correlation is significant at the .05 level (2-tailed).

Among participants who endorsed experiencing their first kiss, the *mean age* (N=213) was 14.25 years of age. The *mean age for having their first romantic relationship* was 15.9 years (N=204); and 17.18 years (N=190) for *having their first sexual encounter*. EFIS *Flirty* subscale was negatively correlated with the *age of the participants' first kiss* (r= -.19, p<.05), the *age of the first romantic relationship* (r= -.22, p<.01), and *age of the first sexual encounter* (r= -.19, p<.05). Thereby indicating that the flirtier the participant was, the more likely they were to have endorsed having their *first kiss*, *relationship*, and *sexual encounter* at an earlier age. The EFIS *Popular* subscale was also inversely correlated with the *age of the participants' first kiss* (r= -.20, p<.01), and the *age of the first romantic relationship* (r= -.21, p<.01), but not with the *age of the first sexual encounter*. The EFIS *Not-Nerdy* subscale was negatively correlated with the *age of the participants' first kiss* (r= -.21, p<.01) but not with the other two romantic activities. The EFIS *Fashion Trendy* subscale was not significantly correlated with the age of any of the romantic activities.

Table 6. Cross Validation of *EFIS subscales* and *Age of Romantic Activities*.

Variable	*M*	*SD*	1	2	3	4	5	6
1. *First Kiss*	14.25	2.51	_					
2. *First romantic rel.*	15.90	2.05	.55**	_				
3. *First sexual encounter*	17.18	2.24	.45**	.50**	_			
4. *EFIS Popular*	3.32	.84	-.20**	-.21**	-.12	_		
5. *EFIS Flirty*	2.10	.65	-.19*	-.27*	-.18*	.36**	_	
6. *EFIS Not-Nerdy*	2.54	.73	-.21*	-.09	-.15	.13	.32**	_
7. *EFIS Fashion Trendy*	2.45	.88	-.06	-.10	-.02	.19*	.33**	.21**

** Correlation is significant at the .01 level. * Correlation is significant at the .05 level (2-tailed).

Main Analyses

Initially correlational analyses were performed to test the first three hypotheses: a positive relationship between the two biological variables, *age at menarche* and *digit ratio,* a positive relationship between both *age at menarche* and *2D:4D ratio,* and *mental rotation ability* and *performance on the quantitative section on* standardized tests, and finally a negative relationship with *age at menarche* and *2D:4D ratio* on *perceived femininity* and *feminine gender intensification*.

Two by four MANOVAs were performed to test hypothesis four and five where the independent variable *Age at Menarche (early vs. late)* was expected to have a significant main effect on the following dependent variables: *Mental Rotation ability*, *Quantitative section, Sex Role Identity* and *Sex Intensification*. Participants who enter menarche late were expected to have higher rotation ability, higher quantitative scores, more masculine sex role identity and less gender intensification. Additionally, the independent variable *digit ratio (masculine vs.*

femine) was expected to have a significant main effect on the following dependent variables: *Mental Rotation ability*, *Quantitative section, Gender Role Identity* and *Gender Intensification*. Participants with more masculine *digit ratio* are expected to have higher rotation ability, higher quantitative scores, more masculine gender role identity and less gender intensification.

Finally, a logistic regression was completed in order to test the final hypothesis and find the extent each of the above mentioned variables were able to predict the choice of *STEM without nursing* major in college. The predictor variables were entered into the regression model in a stepwise approach, allowing us to assess the change in model fit between the model including the covariates and the addition of the predictor variables. First all four of the covariates were entered into the model, followed by the two biological variables, *Age at menarche in full years* and *Digit ratio*, the two cognitive outcome variables, *scores on the quantitative sections of the standardized college entrance exams relative to reading section* and *mental rotation ability* on the PSVT-R, and the two psychosocial criterion variables *BEM ratio* and *gender intensification during middle school*.

Hypothesis 1:

A Pearson *r* bivariate correlation was performed to investigate the hypothesis that there would be a positive relationship between *age of menarche* and *digit ratio* (with higher scores being more masculine) in that participants with a longer ring finger would have a higher age of menarche. However, this hypothesis was not supported. No significant correlation was found with respect to age of menarche and digit ratio (*n*=194, *r*= -0.006, *p*=.93), and the mean *age of menarche* for the two groups was essentially the same: 12.48 years of age (*SD*=1.41, *n*=91) for the participants with a longer index finger or equal length of the index and ring finger, and 12.47 years of age (*SD*=1.48, *n*=103) for the participants with a longer ring finger.

Hypothesis 2:

A Pearson *r* bivariate correlational matrix was performed to investigate the hypothesis that there would be a positive relationship between *age of menarche* and the cognitive variables consisting of *mental rotation* (i.e. *adjusted scores on the Revised PSVT:R)* and relative better performance on the quantitative versus verbal *standardized scores.* This hypothesis was not supported and partially contradicted. While there was a minute positive correlation between *age of menarche in total years* and *mental rotation adjusted score*, (*r* = .01, *n*=167), this was not significant (*p*=.86). Furthermore, not only was no significant relationship found with respect to *age of menarche* and *relatively higher quantitative standardized scores,* the correlation was negative (*r*= -.07, n=183). And when using the categorical variable of *Early vs. Late Menarche* (before the age of 12 vs. on time or later), this same negative correlation persisted, now marginally significant (*r*=-.14, *p*=.059). This finding contradicts the hypothesis of a positive correlation between age at menarche and a better relative performance on the quantitative section of standardized tests, and instead indicates an association between early menarche and a better relative performance on the quantitative section of standardized tests.

Another Pearson *r* bivariate correlational matrix was performed to investigate the hypothesis that *digit ratio* would be positively correlated with *mental rotation* and *relatively higher quantitative scores*. This hypothesis was not supported. While the correlations were positive, the correlation was not significant between the masculine profile of a *longer ring finger* and higher *mental rotation adjusted score* (r=.08, p=.32, n=166). A minute positive correlation was found with respect to *digit ratio* and relatively higher *quantitative standardized scores (*r=.01, p=.86, n=174*)*, but having a more masculine profile of a *longer ring finger* was not associated with significantly higher *quantitative standardize scores* (table 7).

Table 7. Correlations between Biological variables and Cognitive variables.

Variable	*M*	*SD*	1	2	3	4
1. *Mental Rotation Adjusted Score*	-3.02	5.77	_			
2. *Relative Quant. standard scores*	0.37	0.48	-.02	_		
3. *Age at Menarche*	12.46	0.50	.01	-.07	_	
4. *Early vs. Late Menarche*	.75	0.43	.06	-.14	.72**	_
5. *Masculine Digit ratio*	0.53	0.50	.08	.01	-.01	.04

** Correlation is significant at the .01 level (2-tailed). *Marginally significant (p=.059)

Hypothesis 3:

A Pearson *r* bivariate correlational matrix was performed to investigate the hypothesis that there would be a negative relationship between *age of menarche* and the psychosocial variables of the *BEM ratio* as well as the *EFIS subscales*, suggesting participants with higher age of menarche would have higher scores on the *BEM ratio* and lower scores on the *EFIS subscales*. This hypothesis was only partially supported. That is as hypothesized, *age of menarche* was negatively correlated with three of the EFIS scales, but not *EFIS Fashion Trendy*, and the correlations reached significant levels for *EFIS Flirty* (r= -.23, p<.01) and *EFIS Not-Nerdy* (r= -.16, p<.05), indicating that participants who had a lower age of menarche had a higher mean score on *EFIS Flirty* and *EFIS Not-Nerdy* (*n*=184). However, *age of menarche in full years* was not correlated with the *BEM ratio* (*n*=186), and the directionality of the correlation was in fact negative, rather than positive indicating that the score on the *BEM ratio scale* decreased with *age of menarche* (r=.11, p=.15, NS). In other words, participants who entered menarche later had less masculine BEM scores relative to feminine BEM scores.

Another Pearson *r* bivariate correlational matrix was performed to investigate the hypothesis that there would be a negative relationship between *digit ratio* (*n*=181) and the psychosocial variables of *BEM ratio scale* as well as the *EFIS scales,* suggesting participants with a higher *digit ratio* (longer ring finger than index finger) would have higher scores on the *BEM ratio scale* and lower scores on the *EFIS scales*. While the correlation between *digit ratio* and *BEM ratio* was indeed positive, suggesting a longer ring finger was positively correlated with higher total scores on the *BEM ratio*, (r=.03, p=.71, n=181) it was minute and did not reach a significant level. No significant correlations were found between the psychosocial variables of any of the *EFIS scales*, and *digit ratio* (table 8).

Table 8. Correlations between Biological variables and Psycho-social variables.

Variable	*M*	*SD*	1	2	3	4	5	6
1. *BEM ratio*	.91	.23	_					
2. *EFIS Popular*	3.32	.85	-.02	_				
3. *EFIS Flirty*	2.10	.67	-.01	.36**	_			
4. *EFIS Not-Nerdy*	2.54	.73	.00	.13	.32**	_		
5. *EFIS Fashion Trendy*	2.45	.88	-.09	.19*	.33**	.21**	_	
6. *Age at Menarche*	12.46	1.49	-.10	-.01	-.23*	-.16*	.02	_
7. *Digit ratio*	0.53	.50	.03	-.01	-.09	.03	.00	-.01

** Correlation is significant at the .01 level , * Correlation is significant at the .05 level (2-tailed).

Hypothesis 4:

Participants who enter *menarche on time or later* (on or after the age of 12) are expected to have higher *mental rotation ability*, higher *quantitative scores* compared to reading scores on the standardized tests, more *masculine gender role identity* and less *gender intensificati*on. *Age at Menarche (early vs. on time or late)* is expected to have a significant main effect on *Mental Rotation ability (PSVT:R adjusted score)*, *standard score ratio, BEM ratio (BEM masculine relative to BEM feminine)* and *EFIS scales*.

In preliminary analysis, where all identified covariates, *University type, Race, Age or participant,* and *SES*, were entered it was evident that *Race* and *SES* did not significantly contribute to the model [Race: p =.47; SES: p =.31], but *Age of respondent* and *University type* reached significant levels [Age of respondent: p =.002; University type: p =.032]. Performing the MANOVA without Race and SES as covariates, improved the model so that the MANOVA for *Early menarche* (before the age of 12) *vs. On time or Late* improved from a non-significant p=.16, to approaching significance, p =. 078.

The analysis commenced with a test of the assumption of independence of the covariates, University type and *age of participant*, and the independent variable, *Early Menarche*. The main effect of *University type* on *Early Menarche* was not significant [F (1, 227) = .009, p = .926]. The average *University type* is similar across the two groups. Our assumption of independence of covariate *University type* with *Early Menarche* was supported. The main effect of *age of participant* on *Early Menarche* is not significant [F (1, 228) = .514, p = .474]. The average *age of the participants* is similar across the two groups. Our assumption of independence of covariate *age of the participants* with *Early Menarche* was supported.

Then the assumptions of homogeneous regression slopes were tested for both of the covariates and the independent variable, *Early Menarche* (before the age of 12), for each of the dependent variables. The interaction between *Early Menarche* and *University type* for the *EFIS scales* were not significant [*EFIS Popular*: F(1,180) = .686, p = .41; *EFIS Flirty*: F(1,180) = .037, p = .85; *EFIS Not-Nerdy*: F(1,180) = .083, p = .77; *EFIS Trendy*: F(1,180) = 1.085, p = .30]. The interaction between *Early Menarche* and *University type* for the *BEM ratio* was not significant, [F (1,182) = 1.036, p = .31], nor was the interaction between *Early Menarche* and *University type* for *PSVT:R adjusted score*, [F(1,163)=1.41, p=.24]. The regression slopes of *University type* predicting *Early Menarche* across the *dependent variables* were the same. The assumption of homogeneity of the regression is supported, suggesting we could use *University type* as a covariate for this analysis.

The interaction between *Early Menarche* and *Age of Participant* for the *EFIS scales* were not significant [*EFIS Popular*: $F(1,180) = .081$, $p = .78$; *EFIS Flirty*: $F(1,180) = .315$, $p = .78$; *EFIS Not-Nerdy*: $F(1,180) = 1.088$, $p = .30$; *EFIS Trendy*: F(1,180) = .863, p = .35]. The interaction between *Early Menarche* on or after the age of 12 and *Age of Participant* for the *BEM ratio* was not significant, [F (1,182) = .000, $p = .99$]. The interaction between *Early Menarche* and *Age of Participant* for the *PSVT:R adjusted score* was not significant, [F (1,163) = .031, $p = .861$]. The assumption of homogeneity of the regression is supported, suggesting we could use *Age of Participant* as a covariate for this analysis.

In the main analysis the main effect of the covariates was first assessed and found both *University type* [$F(1,158)=2.85$, $p<.05$] and *Age of participant* [$F(1,158)=3.56$, $p<.01$] to be significant, indicating they adjusted the values of the outcome. We then assessed the main effect of the categorical predictor variable *Early vs. Late Menarche* on participants' *BEM ratio*, *PSVT:R adjusted* scores, and *early feminine intensification*; *EFIS popular, EFIS Flirty, EFIS Not-Nerdy*, and *EFIS Trendy*, while controlling the effects of *University type* and *age of the participants*. The main effect of *Early vs. Late Menarche* approached a significant level, [$F(1, 158) = 1.94$, $p=.078$].

When testing the between subject effects, a significant main effect was found among the independent levels of the covariate *University type* on *EFIS Trendy* [$F(1, 158)=6.65$, $p<.05$], and among the independent levels of the covariate *University type* on *EFIS Popular* [$F(1, 158)=8.40$, $p<.01$]. A significant main effect was also found among the independent levels of the covariate *Age of respondent* on *EFIS Not-Nerdy* [$F(1, 158)=8.85$, $p<.01$] and among the independent levels of the covariate *Age of respondent* on *EFIS Popular* [$F(1, 158)=6.59$, $p<.05$].

Even though the main effect of *Early Menarche* reached a marginally significant level, its effect was assessed on each individual outcome variable and a significant main effect was found among the independent groups of the outcome variable *EFIS Flirty* [$F(1, 158)=4.54$, $p<.05$], where the mean *EFIS Flirty* scores for the participants who entered menarche early (before the age of 12) ($M=2.27$, $SD=0.1$) were significantly higher compared to the mean *EFIS Flirty* scores for the participants who entered menarche later (at or after the age of 12) ($M=2.02$, $SD=0.06$).

Because *Standard scores* was a nominal variable, it was not included in the MANOVA, instead a Chi squared analysis was performed to assess the effect of *On Time or Late Menarche* on the dependent variable of *Standard scores*. First a correlational matrix was performed to assess the correlations between the four covariates and relative performance on Quantitative section of standardized tests. Relative performance on Quantitative section of standardized tests was significantly negatively correlated with three of the covariates, Race of participant

(r=-.18, p<05), University type (r=-.19, p<05), and Age of the participant (r=-.18, p<05). Therefore the Chi squared analysis included these three covariates, Race, Age of Participant, and University type, together and separately. Marginally significant effects were found when the covariates were included regarding *On time or Late Menarche* and *Standardized scores* [$x^2(1)=3.05$, p=.08], suggesting participants who entered menarche at or after the age of 12 were significantly different from participants who entered menarche before the age of 12 . Among those who entered menarche early, their *Standardized scores* were fairly equally distributed between the reading and quantitative sections of the standardized tests, (53.2% did better or equally well on the reading section compared to the quantitative section, and 46.8% did better on the quantitative section) compared to the participants who entered menarche later (67.4% reported they did better or equally well on the reading section, and 32.6% did better on the quantitative section). This finding was the opposite of the hypothesized direction where later age of menarche was predicted to be associated with higher scores on the quantitative section compared to the reading section.

Hypothesis 5:

Participants with a higher *Digit ratio* (longer ring finger) are expected to have higher *mental rotation ability*, higher *relative quantitative scores*, more *relative masculine gender role identity* and less *gender intensification*. *Digit ratio* *(low vs. high)* is expected to have a significant main effect on *PSVT:R adjusted scores*, *Relative Quantitative scores, BEM ratio* and *the EFIS scales*.

First the assumptions of the covariates independence with the Independent Variable were tested. The main effect of *University type* on *Digit ratio* is not significant [F (1, 194) = .004, p = .949]. The average *University type* is similar across the two groups. Our assumption of independence of covariate *University type* with *Digit ratio* was supported. The main effect of age of participant on *Digit ratio* is not significant F (1, 194) = .651, p = .421. The average *age of the participants* is similar across the two groups. Our assumption of independence of covariate *age of the participants* with *Digit ratio* was supported.

Then the assumptions of homogeneous regression slopes were tested for both of the covariates and the independent variable, *Digit ratio*, for each of the dependent variables. The interaction between *Digit ratio* and *University type* for three of the *EFIS scales* were not significant [*EFIS Popular*: F(1,177) = 1.12, p = .29; *EFIS Flirty*: F(1,177) = .499, p = .48; *EFIS Not-Nerdy*: F(1,177) = .337, p = .56]. The interaction between *Early Menarche* and *University type* for the *BEM ratio* was not significant, [F (1,177) = .190, p = .66], nor was the interaction between *Early Menarche* and *University type* for *PSVT:R adjusted score*, [F(1,162)=.852, p=.36]. But the interaction between *Digit ratio* and *University type* for *EFIS Trendy* was significant [F(1,177) = 5.387, p = .02]. The regression slopes of *University type* predicting *Early Menarche* across the *dependent variables* are not the same. The assumption of homogeneity of the regression is not supported, suggesting we should not use *University type* as a covariate for this analysis.

The interaction between *Digit ratio* and *Age of Participant* for the *EFIS scales* were not significant [*EFIS Popular*: $F(1,177) = .097$, $p = .76$; *EFIS Flirty*: $F(1,177) = .000$, $p = .98$; *EFIS Not-Nerdy*: $F(1,177) = .003$, $p = .95$; *EFIS Trendy*: F(1,177) = 1.309, p = .25]. The interaction between *Digit ratio* and *Age of Participant* for the *BEM ratio* was not significant, [$F\ (1,177) = .072$, $p = .79$]. The interaction between *Digit ratio* and *Age of Participant* for the *PSVT:R adjusted score* was not significant, [$F\ (1,162) = 1.284$, $p = .26$]. The assumption of homogeneity of the regression is supported, suggesting we could use *Age of Participant* as a covariate for this analysis.

In the main analysis the main effect of the covariate *Age of participant* on the model was assessed and found to be significant [$F(1,161)=3.07$, $p<.01$], indicating it adjusted the values of the outcome. We then assessed the main effect of the categorical predictor variable *Digit ratio* on participants' *BEM ratio*, *PSVT:R adjusted* score, and early feminine intensification; *EFIS popular, EFIS Flirty, EFIS Not-Nerdy*, and *EFIS Trendy*, while controlling the effects of *age of participants*. The main effect of *Digit ratio* did not reach a significant level [$F(1, 161) = .68$, $p=.667$].

According to Levene's Test of Equality of Error Variance, the assumption of homogeneity was not violated. When testing the between subject effects, a significant main effect was found among the independent levels of the covariate

Age of respondent on *EFIS Not-Nerdy* [$F(1, 161)=9.207$, $p<.01$], and an effect approaching significance for *EFIS Trendy* [$F(1, 161)=3.500$, $p=.063$].

Because *Standard scores* was a nominal variable, it was not included in the MANOVA, instead a Chi squared analysis was performed to assess the effect of *Digit ratio* on the dependent variable of *Standard scores*. The Chi squared analysis included *Race, Age of Participant,* and *University type*, together and separately. Non-significant effects were found when the covariates were included regarding *Digit ratio* and *Standardized scores* [$x^2(1)=.01$, $p=.923$], suggesting there was no difference between participants based on their *Digit ratio* on their relative performance on the reading and quantitative sections of the *standardized tests*.

Hypothesis 6:

The following variables were expected to predict an increased likelihood of a choice of *STEM major without nursing* in college: a higher *age at menarche*, higher *digit ratio*, higher *mental rotation ability*, higher *relative quantitative SAT scores*, higher *perceived relative masculine gender role* and less *early feminine gender-intensification* scores.

A logistic regression was performed including all four covariates of *University type, Race, Age of participant*, and *Social class* in step one (table 9). The logistic regression model was statistically significant, X^2 (7) = 32.098, p <.01. The model with only the covariates explained 25% of the variance of selecting a *STEM degree excluding nursing*. The model correctly predicted 69.9% of *STEM degree* *excluding nursing* degree selection. The four covariates together predicted the pursuit of STEM degree. Holding other covariates constant, the odds for participants who were Asian to select a *STEM degree excluding nursing* was 6.37 times higher than participants who were White with a 95% confidence interval of (1.96, 20.69). Holding all other covariates constant, the odds for participants who were Black to select a *STEM degree excluding nursing* was 2.8 times higher than

participants who were White with a 95% confidence interval of (.73, 10.72). However, these odds were not significant. Nor were the odds significant for participants who identified as Hispanic or Native American/Pacific Islanders. Holding other covariates constant, when *age of participants* increased by one year the odds of selecting a *STEM degree excluding nursing* was .88 times lower with a 95% confidence interval of (.78, .98) (p<.05). Holding all other covariates constant, the odds for participants who were from a Liberal Arts University to select a *STEM degree excluding nursing* was .65 times lower than participants who were from a Technology university, with a 95% confidence interval of (.27, 1.56). However, these odds were not significant. Finally, holding all other covariates constant, the odds for participants who were from a higher social class to select a *STEM degree excluding nursing* was 1.01 times higher than participants who were from a lower social class, with a 95% confidence interval of (.96, 1.01). Again, these odds were not significant.

Table 9. Logistic Regression Model 1

	X^2	R^2	**Hosmer and Lemeshaw Test**	*Sig.*	*B*	**Wald**	**Odds**
Model 1, Control Variables Only							
Goodness of fit test	32.10(7) **	.25	9.41(8) *NS*				
Lib. Arts vs. Tech University				.34	-.43	.92	.65
Race				.03			
Asian vs. White				.002	1.85	9.50	6.37**
Black vs. White				.13	1.03	2.26	2.8
Hispanic vs. White				1.0	-20.8	.00	.00
Other vs. White				.72	-.45	.13	.64
Age of participants				.02	-.13	5.60	.88*
Social Class				.37	-.01	.81	.99

** Significant at the .01 level, * Significant at the .05 level

In step 2 when introducing the predictive variables the logistic regression model was also statistically significant, X^2 (16) = 58.82, p <.05 (table 10). And the Hosmer-Lemeshow test for goodness-of-fit, was not significant in this model. The model with the predictive variables explained 42% of the variance of selecting a *STEM degree excluding nursing*, and correctly predicted 75.0% of *STEM degree excluding nursing* degree selection. However, only two predictive variables reached a significant level, *Relative Quantitative scores* and *BEM ratio*. Holding all other covariates constant, the odds for participants who performed better on the quantitative section of the Standardized tests to select a *STEM degree excluding* *nursing* was 3.10 times higher than participants who performed better or equally well on the reading section of Standardized tests, with a 95% confidence interval of (1.31, 7.34). Holding all other covariates constant, when *BEM ratio* increased by one unit the odds of selecting a *STEM degree excluding nursing* was 6.01 times higher ($p<.05$) with a 95% confidence interval of (1.01, 35.58). Mental rotation scores were marginally significant in predicting a STEM degree excluding nursing ($p=.056$). Holding all other covariates constant, when *PSVT:R adjusted score* increases by one unit the odds of selecting a *STEM degree excluding nursing* was 1.07 times higher with a 95% confidence interval of (1.00, 1.15).

The biological predictor variables increased the odds for selecting a *STEM degree excluding nursing,* but they did not reach a significant level. Holding all other covariates constant, when *Age at Menarche* increased by one year the odds of selecting *STEM degree excluding nursing* was 1.12 times higher ($p=.23$) with a 95% confidence interval of (.54, 3.08). When *Digit Ratio* was in the masculine direction instead of the feminine direction the odds of selecting *STEM degree excluding nursing* was 1.29 times higher ($p=.56$) with a 95% confidence interval of (.54, 3.08).

While *BEM ratio* had proven to be a significant predictor of selecting *STEM degree excluding nursing,* the other Psycho-Social variables, *Early Feminine Intensification Scales*, did not reach significant levels. Two of them reduced the odds of participants selecting a *STEM degree excluding nursing*. Holding all other covariates constant, when *EFIS Flirty* score increased by one year the odds of selecting *STEM degree excluding nursing* was .56 times lower (*p*=.13) with a 95% confidence interval of (.32, 1.16). Holding all other covariates constant, when *EFIS Not-Nerdy* score increased by one unit the odds of selecting *STEM degree* was .60 times lower (*p*=.13 with a 95% confidence interval of (.68, 1.83). Two of the EFIS increased the odds of participants selecting a *STEM degree excluding nursing*. When *EFIS Popular* score increased by one unit the odds of selecting *STEM degree excluding nursing* was 1.11 times higher (*p*=.72) with a 95% confidence interval of (.64, 1.89). When *EFIS Fashion Trendy* score increased by one unit the odds of selecting *STEM degree excluding nursing* was 1.12 times higher (*p*=.65) with a 95% confidence interval of (.68, 1.83). (See table 10.)

Table 10. Logistic Regression Model 2.

	X^2	R^2	**Hosmer and Lemeshaw Test**	*Sig.*	*B*	**Wald**	**Odds**
Model 2, Predictor Variables Included							
Goodness of fit test	58.82(16) **	.42	13.47(8) *NS*				
Lib. Arts vs. Tech University				.46	-.39	.54	.68
Race							
Asian vs. White				.02	1.53	5.44	4.62*
Black vs. White				.36	.78	.83	2.18
Hispanic vs. White				1.0	-20.87	.00	.00
Other vs. White				.73	-.46	.12	.63
Age of participants				.14	-.10	2.22	.91
Social Class				.30	-.02	1.07	.98
Age at menarche				.43	.12	.63	1.12
Digit Ratio				.56	.26	.34	1.29
EFIS Popular				.72	0.10	.13	1.10
EFIS Flirty				.13	-.59	2.26	.56
EFIS Not-Nerdy				.13	-.50	2.30	.60
EFIS Trendy				.65	.11	.20	1.12
BEM Ratio				.05	1.79	3.91	6.01*
Standard test scores				.01	1.13	6.64	3.10**
PSVT:R total score				.07	3.64	.62	1.07

** Significant at the .01 level, * Significant at the .05 level

Additional logistic regressions excluding non-significant covariates were also performed. While these logistic regression models were all statistically significant, the elimination of covariates did not improve the ability of the model to predict or explain the variance of selecting a *STEM degree excluding nursing*. And when *University type* was not included as a covariate, the Hosmer-Lemeshow test for goodness-of-fit, became significant, indicating there may have been some interactions or non-linearity without *University type* as a covariate.

Discussion

The results of the present study showed that the cognitive variables were the most predictive of pursuit of STEM majors among college females, particularly a *higher relative performance on the quantitative section of standardized tests*. The odds for participants who performed better on the quantitative section of the Standardized tests to select a *STEM degree* was 3.10 times higher than participants who performed better or equally well on the reading section of *Standardized tests*. *Mental rotation* ability as measured by the PSVT:R adjusted score reached a marginally significant level in predicting a *STEM degree*, but the odds ratio was not very large, only increasing the odds for those with higher adjusted scores on mental rotation by 1.07 times to select a *STEM degree*. One of the psychosocial variables was also significantly predictive of the pursuit of STEM majors among college females, *sex role orientation* as indicated by BSRI showed significance in predicting a selection of STEM excluding nursing, where participants who were relatively higher on their *masculine sex role identity*, compared to their *feminine sex role identity*, were 6 times more likely to pursue a *STEM degree*.

It is also noteworthy that there were trends that suggested that *early feminine intensification* might have had some influence in the *STEM major* selection. While these findings did not reach a significant level, females who possessed a more *intensified feminine gender role* orientation during middle school, were less likely to pursue a *STEM major*. This would include females who described themselves as being less *Nerdy*, and more *Flirty*.

Although the biological variables, *age at menarche* and *digit ratio*, did not prove to have predictive variance with respect to *STEM major* selection, it is noteworthy that *age at menarche* had trends for an inverse relationship for predicting *STEM majors* among females, such as the *early feminine intensification scales*. Females who entered menarche before the age of 12, reported they were on average more "*flirty*" and less "*nerdy*" during middle school, and participant who were more "*flirty*" and less "*nerdy*" were approximately half as likely to pursue a *STEM degree*. It is also noteworthy that the ANOVA's with *EFIS flirty* and *EFIS Not-Nerdy* were significant even though *age at menarche* at the multivariate level was marginally significant. This was suggestive of insufficient power as we did not reach the projected sample size of 214 for many of the variables.

A surprising finding was how *early vs. late menarche* reached a marginally significant effect on *Standardized scores*, but in the opposite direction of what was hypothesized. A larger percentage of participants who entered *menarche early* reported they did better on the *quantitative section* 48%, compared to those who entered *menarche later* (33%). However, relative performance on the two sections is not the same as actual scores. The different standardized tests taken by the participants made it difficult to compare scores between different tests, and the use of the relative performance variable limited the ability to investigate the association between standardized test scores effectively.

Digit ratio across the board did not reveal any significant findings regarding female's pursuit of a *STEM major*. While there have been some studies that have found *digit ratio* associated with athleticism and *mental rotation* tasks, it is important to consider that those studies required exceptionally large sample sizes to detect moderate associations. And even when significant association was found, effect size was modest (Peters, Manning & Reimers, 2007; Falter, Arroyo & Davis, 2006; Beaton, Magowan and Rudling, 2012). With the same token there have been many studies that did not find similar effects with respect to *digit ratio* and onset of puberty. While some studies have found an association between digit ratio and puberty onset, other studies have not been able to replicate these results (Matchock, 2008; Helle, 2010). In addition, this fairly precarious biological determinant is somewhat of an enigma in terms of its speculated connection with androgen exposure. The research so far on digit ratio and androgen exposure is correlational and speculative in the sense that no causational association has been found. Therefore, it is questionable if this is indeed an accurate measurement of the constructs that would predict STEM selection in males or females.

Major contribution to the literature is the newly created measure *Early Feminine Intensification Scale* (EFIS) where there is no such previous measure for assessing gender intensification with middle school girls. The strong correlations between the scales of this measure, with romantic activities, and the age of menarche speaks to the literature that emphasize the social challenges associated with early puberty in girls and how early puberty may affect their self-perception and academic pursuits (Hill & Lynch, 1983; Cavanaugh, Riegle-Crumb & Crosnoe, 2007). The results of this study indicate the importance of relative performance on the quantitative section of standardized tests in predicting the pursuit of a STEM degree. It also highlights the predictive power of having a more masculine sex role identity relative to a feminine sex role identity in selecting a STEM degree. While this study answered some questions as to variables that influence female students pursuit of STEM, it not only failed to answer some questions, it raised new questions and highlighted the complicated combination of factors that influence female students' academic pursuits and outcome.

Additionally, there is a preponderance of cross-cultural research that suggests that the propensity for women to pursue STEM fields may be complicated by a variety of ethnic cultural factors. For example, the presence of "gender equality" demonstrated in Sweden, was found to be associated with women out performing men in mathematics (Reilly, 2012). Further more, in countries with large power distance the gender gap in mathematics was smaller (Reilly, 2012). It is possible women in cultures that have greater tolerance for inequality in power have increased motivation to learn math and science to pursue higher status occupations as a way of overcoming social inequity (Reilly, 2012). In line with the findings that have found women to be more likely to pursue a STEM degree in countries with inequality, due to the possibility of improving their social status, we found Asian and Black participants in this study to be more likely to pursue STEM compared to the white and Hispanic participants.

Limitations of Present Study and Future Research

Despite the contributions of the present study, there are several potential limitations. First, there were several limitations that potentially explain some of the non-significant findings. A concern regarding the current study was the length of the survey, and differential methodology in recruitment and incentives as indicated by the relatively higher rate of attrition and uncompleted surveys among the general population, as compared to participants who were recruited via University Sona systems, and received academic incentives for their participation. The incentives for participating in the study differed between groups depending on sampling method. The participants that were reached by Social Media were not offered any incentive, those who participated through the university SONA system received class credit for participation, and students enrolled in Humanities classes were encouraged by their professors to participate and were eligible to enter into a lottery to win one of three $30 Amazon gift cards. The large number of participants who failed to complete the entire survey reduced the sample size for several of the variables of interest, especially for mental rotation. The anticipated sample size of 250 was not reached, which affected the power in many of the analyses, contributing to the lack or only marginally significant findings.

Additionally, the present study relied on retrospective data for almost all of its variables. Age of menarche, standardized test scores, demographic information, academic performance, sports involvement and father's involvement were susceptible to response bias and error. While mental rotation was directly measured in the survey, it was the one measure many participants failed to complete as it was challenging and preceded by a long survey. The survey did not measure actual prenatal androgen exposure. Instead the *digit ratio* was used as an inferential measure of prenatal testosterone exposure. There were several limitations associated with this inferential measure. It is very possible that *digit ratio* was not associated with prenatal testosterone exposure in the selected sample given that it was impossible in retrospect to receive actual measures of prenatal testosterone levels from in utero amniotic fluid at the time of gestation. Also, the *digit ratio* was self reported and it was not measured independently, making it susceptible to response bias and error.

There are many avenues for future directions in the research. First, after securing a larger sample size many of the analyses of this study will be repeated and with a better power hopefully provide more significant findings. Additionally, further cross validation of the EFIS scales with the age group for which it was intended, females in middle school, is recommended. Given that is was first standardized on an adult population providing retrospective data, the data may be slightly faulty in relying on recreated memories of one's middle school years.

Preliminary analysis indicated there are significant interaction effects between age at menarche and the selection of STEM degree on the psychosocial outcome variables, *EFIS Popular, EFIS Not Nerdy, EFIS Trendy,* and *BEM ratio*. These analyses were not included in this study as it was outside of the initial hypothesis. These interactions will be investigated in future research with a larger sample size.

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Appendix A – Informed Consent

We are interested in examining how biological, social and personality variables relate to female students' choice of STEM (Science, Technology, Engineering and Mathematics) majors or non-STEM majors in college. As part of your participation in this study you may find some therapeutic value in considering certain aspects of your life. Your participation will not subject you to any physical pain or risk, but because some of the interview questions seek to solicit some personal information, no identifying information (such as your name) will be asked. Initially, you will be asked to complete a preliminary screening survey that asks a couple of questions to determine your eligibility for participating in this study. If you meet criteria, you will be prompted to complete a series of surveys regarding biological and social factors from when you were growing up, and personality variables. We are interested to see how these variables relate to female students' self-reported scores on standardized tests, as well as spatial ability. Certain questions may be repeated to determine if and how these aspects changed from when you were in elementary school to when you were in high school. These surveys will take approximately 50 minutes to an hour to complete. If for any reason you are uncomfortable completing the survey, you are free to stop at any time.

If you have any concerns please feel free to contact the researchers:
Primary Investigator: Anna Brenner-Shuman, M.S., ashuman2013@my.fit.edu, Address: 150 West University Blvd., Melbourne, FL 32901
Co-Investigator: Felipa Chavez, Ph.D., chavezf@fit.edu, T: 321.674.8104. Address: 150 West University Blvd., Melbourne, FL 32901
Chair of the International Review Board: Lisa Steelman, Ph.D., lsteelma@fit.edu, T: 321.674.8104. Address: 150 West University Blvd., Melbourne, FL 32901
We assure you that any reports about this research will contain only data of an anonymous or statistical nature.

Continuing with this survey indicates that you agree to participate in this research and that:
1. You have read and understand the information provided above.
2. You understand that participation is voluntary and that refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled; and,
3. You understand that you are free to discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.
4. You are 18 years of age or older.
I have read the preceding information and understand its meaning. By choosing "YES": I acknowledge I am 18 years old or older, and I am agreeing to proceed with the survey and participate in the study.
However, by choosing "NO": I am signifying that I am under the age of 18 and/or do not want to proceed with the survey nor participate in the study.

Appendix B – Demographics

Q104 There will be some questions in this survey asking for your scores on standardized tests such as the SAT and ACT or other entrance exams. If possible, it would be advisable for you to look up those scores at this time so that you have them handy when answering the questions. If this is not possible, you can still take the survey and please provide your best estimate.

Q105 Which college or university are you attending or did you attend?
- ❑ Florida Institute of Technology (1)
- ❑ University of Central Florida (2)
- ❑ Texas A&M (3)
- ❑ Other, please enter name of institution (4) ____________________

Q18 What is your race/ethnicity?
- ❍ White/Caucasian (1)
- ❍ African American (several generations in the U.S.) (2)
- ❍ African (first or second generation from Africa) (3)
- ❍ African Caribbean (4)
- ❍ Bi- or multi-racial. (5)
- ❍ Hispanic (6)
- ❍ Asian (7)
- ❍ Pacific Islander (8)
- ❍ Native American (9)
- ❍ Other. If so please describe. (10) ____________________

Q113 Please describe you mother's race/ethnicity.
- ❍ White/Caucasian (1)
- ❍ African American (several generations in the U.S.) (2)
- ❍ African (first or second generation from Africa) (3)
- ❍ African Caribbean (4)
- ❍ Bi- or multi-racial. (5)
- ❍ Hispanic (6)
- ❍ Asian (7)
- ❍ Pacific Islander (8)
- ❍ Native American (9)
- ❍ Other. If so please describe. (10) ____________________

Q114 Please describe you father's race/ethnicity.
- White/Caucasian (1)
- African American (several generations in the U.S.) (2)
- African (first or second generation from Africa) (3)
- African Caribbean (4)
- Bi- or multi-racial. (5)
- Hispanic (6)
- Asian (7)
- Pacific Islander (8)
- Native American (9)
- Other. If so please describe. (10) ____________________

Q86 Please indicate with whom you resided during most of your childhood?
- I resided mostly with my mother, or mother's side of the family. (1)
- I resided mostly with my father, or father's side of the family. (2)
- I resided with both, or spent equal amount of time with my parents or their families. (3)

Q119 Please indicate the educational level for your FATHER or paternal caregiver.
- Professionals (Master's degree, doctorate or professional degree) (1)
- College graduate (2)
- 1-3 years college or business school (3)
- High school graduate (4)
- 10-11 years of schooling (5)
- 7-9 years of schooling (6)
- Under 7 years of schooling (7)
- I did not have a paternal caregiver (8)

Q122 Please indicate the educational level of your MOTHER or maternal caregiver.
- Professionals (Master's degree, doctorate or professional degree) (1)
- College graduate (2)
- 1-3 years college or business school (3)
- High school graduate (4)
- 10-11 years of schooling (5)
- 7-9 years of schooling (6)
- Under 7 years of schooling (7)
- I did not have a maternal caregiver (8)

Q121 Please indicate the occupational status of your FATHER or paternal caregiver.
- ❍ Major Executives of large companies, major professionals, and proprietors (1)
- ❍ Lesser professionals and proprietors, and business managers (2)
- ❍ Administrative personnel, owners of small business and minor professionals (3)
- ❍ Clerical and sales workers, and technicians (4)
- ❍ Skilled trades (5)
- ❍ Machine operators and semiskilled workers (6)
- ❍ Unskilled employees (7)
- ❍ Homemaker (8)
- ❍ Student (9)
- ❍ Other (10)
- ❍ I did not have a paternal caregiver (11)

Q123 Please indicate the occupational status of of your MOTHER or maternal caregiver.
- ❍ Major Executives of large companies, major professionals, and proprietors (1)
- ❍ Lesser professionals and proprietors, and business managers (2)
- ❍ Administrative personnel, owners of small business and minor professionals (3)
- ❍ Clerical and sales workers, and technicians (4)
- ❍ Skilled trades (5)
- ❍ Machine operators and semiskilled workers (6)
- ❍ Unskilled employees (7)
- ❍ Homemaker (8)
- ❍ Student (9)
- ❍ Other (10)
- ❍ I did not have a maternal caregiver (11)

Q121 What is the current combined approximate yearly income of your parents' household?
- ❍ $0 - $25,000 (1)
- ❍ $25,000 - $50,000 (2)
- ❍ $50,000 - $75,000 (3)
- ❍ $75,000 - $100,000 (4)
- ❍ $100,000 - $250,000 (5)
- ❍ Over $250,000 (6)

- ❍ Q2 What year were your mother or maternal caregiver born to the best of your knowledge?
- ❍ Q305 What year were your father or paternal caregiver born to the best of your knowledge?

Q2 What year were you born?

Q3 In which month were you born?

	January (1)	February (2)	March (3)	April (4)	May (5)	June (6)	July (7)	August (8)	September (9)	October (10)	November (11)	December (12)
Month (1)												

Q112 Which type of climate did you live in for the most part during the ages of 10 and 15?

- A state or country that had distinct differences between summers and winters, often with snow during the winter.
- A state of country that had some differences between seasons, but winter did not usually involve snow fall, and if it did it did not stay for long.
- A state or country that had very slight differences between seasons. In winter there may occasionally be a night time frost but never or hardly ever snow fall.

Q124 Did you have any brothers or sisters (biological, half or step) who lived in your home with you when you were growing up? Please select all that apply.

- ❑ No brothers or sisters
- ❑ Older brother/s
- ❑ Older sister/s
- ❑ Younger brother/s
- ❑ Younger sister/s
- ❑ Identical twin
- ❑ Fraternal twin/triplet/multiple

Answer If Did you have any brothers or sisters (biological, half or step) who lived in your home with you when you were growing up? Older brother/s Is Selected

Q106 How much older than you are/were your older brother/s? (if more than 18 years slide to 18)

_______ Oldest brother

_______ Second oldest brother

_______ Third oldest brother

_______ Fourth oldest brother

Answer If Did you have any brothers or sisters (biological, half or step) who lived in your home with you when you were growing up? Older sister/s Is Selected

Q107 How much older than you are/were your older sister/s? (if more than 18 years slide to 18)

_______ Oldest sister
_______ Second oldest sister
_______ Third oldest sister
_______ Fourth oldest sister

Answer If Did you have any brothers or sisters (biological, half or step) who lived in your home with you when you were growing up? Younger brother/s Is Selected

Q108 How much younger than you are/were your younger brother/s? (if more than 18 years slide to 18)

_______ Youngest brother
_______ Second youngest brother
_______ Third youngest brother
_______ Fourth youngest brother

Answer If Did you have any brothers or sisters (biological, half or step) who lived in your home with you when you were growing up? Younger sister/s Is Selected

Q109 How much younger than you are/were your younger sister/s? (if more than 18 years slide to 18)

_______ Youngest sister
_______ Second youngest sister
_______ Third youngest sister
_______ Fourth youngest sister

Answer If Did you have any brothers or sisters (biological, half or step) who lived in your home with you when you were growing up? Fraternal twin/triplet/multiple Is Selected

Q110 Was your fraternal twin/triplet/s a brother/s or a sister/s?

❑ Brother/s
❑ Sister/s

Q165 When you were in MIDDLE SCHOOL or JUNIOR HIGH SCHOOL, did you have a father or father figure in your life ?

❍ Yes (1)
❍ No (2)

Q167 Please indicate how often your father or father figure engaged in the following activities with you during your MIDDLE SCHOOL or JUNIOR HIGH SCHOOL years:

	Not at all (1)	Occasionally (2)	Frequently (3)
Eating meals together. (1)	❍	❍	❍
Personal care activities, such as grooming and hygiene. (2)	❍	❍	❍
Play and companionship activities, including sports, games and other leisure activities. (3)	❍	❍	❍
Helped with mathematics and science homework. (4)	❍	❍	❍
Helped with reading, writing and social studies homework. (5)	❍	❍	❍
Household activities, such as housework, shopping and caring for other children. (6)	❍	❍	❍
Social activities, like conversations, participation in social events and religious activities. (7)	❍	❍	❍
Achievement related activities, such as learning new skills. (8)	❍	❍	❍
Other activities. (9)	❍	❍	❍

Q109 How many different sports have you actively played before entering college?

	None (1)	1 (2)	2 (3)	3 (4)	4 (5)	5 (6)	6 (7)	7 (8)	8 (9)	9 (10)	10 or more (11)
Click to select number of sports (1)											

Q163 When you were in ELEMENTARY SCHOOL, did you participate in any organized sports or other athletic activities during your free time? (In addition to scheduled physical education classes during school hours.)

- ❍ Yes (1)
- ❍ No (2)
- ❍ I cannot remember (3)

Q171 Please write in the sport or sports you participated in during your ELEMENTARY SCHOOL years. Please also indicate for how many seasons (or years) you participated in that sport during your ELEMENTARY SCHOOL years.

	One season/ year (1)	Two seasons/ years (2)	Three seasons/ years (3)	Four seasons/ years (4)	Five seasons/ years (5)	Six or more seasons/ years (6)
Sport number 1: (1)	❍	❍	❍	❍	❍	❍
Sport number 2: (2)	❍	❍	❍	❍	❍	❍
Sport number 3: (3)	❍	❍	❍	❍	❍	❍
Sport number 4: (4)	❍	❍	❍	❍	❍	❍
Sport number 5: (5)	❍	❍	❍	❍	❍	❍
Sport number 6: (6)	❍	❍	❍	❍	❍	❍

Q174 For each sport or sports you participated in during your ELEMENTARY SCHOOL years, please also indicate your degree of psychological investment in the sport (i.e. how important the sport was to you).

	Little investment (1)	Medium investment (2)	High investment (3)	Extremely high investment (4)
Sport number 1: (1)	❍	❍	❍	❍
Sport number 2: (2)	❍	❍	❍	❍
Sport number 3: (3)	❍	❍	❍	❍
Sport number 4: (4)	❍	❍	❍	❍
Sport number 5: (5)	❍	❍	❍	❍
Sport number 6: (6)	❍	❍	❍	❍

Q169 When you were in MIDDLE SCHOOL, did you participate in any organized sports or other athletic activities ? (In addition to scheduled physical education classes during school hours.)

❍ Yes (1)
❍ No (2)
❍ I cannot remember (3)

Q172 Please write in the sport or sports you participated in during your MIDDLE SCHOOL years. Please also indicate for how many seasons (or years) you participated in that sport during your MIDDLE SCHOOL years.

	One season/year (1)	Two seasons/years (2)	Three seasons/years (3)
Sport number 1: (1)	❍	❍	❍
Sport number 2: (2)	❍	❍	❍
Sport number 3: (3)	❍	❍	❍
Sport number 4: (4)	❍	❍	❍
Sport number 5: (5)	❍	❍	❍
Sport number 6: (6)	❍	❍	❍

Q175 For each sport or sports you participated in during your MIDDLE SCHOOL years, please also indicate your degree of psychological investment in the sport (i.e. how important the sport was to you).

	Little investment (1)	Medium investment (2)	High investment (3)	Extremely high investment (4)
Sport number 1: (1)	❍	❍	❍	❍
Sport number 2: (2)	❍	❍	❍	❍
Sport number 3: (3)	❍	❍	❍	❍
Sport number 4: (4)	❍	❍	❍	❍
Sport number 5: (5)	❍	❍	❍	❍
Sport number 6: (6)	❍	❍	❍	❍

Q170 When you were in HIGH SCHOOL, did you participate in any organized sports or other athletic activities ? (In addition to scheduled physical education classes during school hours.)

❍ Yes (1)
❍ No (2)
❍ I cannot remember (3)

Q173 Please write in the sport or sports you participated in during your HIGH SCHOOL years. Please also indicate for how many seasons (or years) you participated in that sport during your HIGH SCHOOL years.

	One season/year (1)	Two seasons/years (2)	Three seasons/years (3)	Four seasons/years (4)	Five seasons/years (5)
Sport number 1: (1)	❍	❍	❍	❍	❍
Sport number 2: (2)	❍	❍	❍	❍	❍
Sport number 3: (3)	❍	❍	❍	❍	❍
Sport number 4: (4)	❍	❍	❍	❍	❍
Sport number 5: (5)	❍	❍	❍	❍	❍
Sport number 6: (6)	❍	❍	❍	❍	❍

Q176 For each sport or sports you participated in during your HIGH SCHOOL years, please also indicate your degree of psychological investment in the sport (i.e. how important the sport was to you).

	Little investment (1)	Medium investment (2)	High investment (3)	Extremely high investment (4)
Sport number 1: (1)	❍	❍	❍	❍
Sport number 2: (2)	❍	❍	❍	❍
Sport number 3: (3)	❍	❍	❍	❍
Sport number 4: (4)	❍	❍	❍	❍
Sport number 5: (5)	❍	❍	❍	❍
Sport number 6: (6)	❍	❍	❍	❍

Appendix C – Example of Standardized Test Score Measure

Q65 Which one of the following standardized tests have you taken and can best remember the scores you achieved?

- ❍ SAT (Scholastic Assessment Test) (1)
- ❍ ACT (American College Test) (2)
- ❍ CLAST (College Level Academics test) (3)
- ❍ CPT (College Placement Exam) (4)
- ❍ I can't remember or never took any of the above mentioned standardized tests. (5)

What were your approximate scores on each section of the SAT? (The scores range between 200-800 on each section, and the composite score is the sum of all three sections so a perfect score would be 2400, but some people only consider the reading and math sections when they talk about their composite score so then a perfect score would be 1600.)

	Below 400 (1)	401 - 450 (2)	451 - 500 (3)	501 - 550 (4)	551 - 600 (5)	601 - 650 (6)	651 - 700 (7)	701 - 750 (8)	751 - 800 (9)	Do not remember (10)	I took the SAT before 2005 (11)
Critical Reading Section (1)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Writing Section (2)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Mathematical Section (3)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q111 Do you have a suspected or diagnosed learning disability?

- ❍ If yes, please describe ____________________
- ❍ Maybe (please describe) ____________________
- ❍ No

Q101 What grades did you receive in most of your classes in 4th grade?

- ❍ Mostly A's and B's
- ❍ Mostly B's and C's
- ❍ Mostly C's and some D's

Q102 What grades did you receive in most of your classes in 8th grade?

- Mostly A's and B's
- Mostly B's and C's
- Mostly C's and some D's

Appendix D – Bem Sex Role Inventory – Short Form

Q90 Please indicate how often the following descriptions apply to you.

	Never (1)	Hardly ever (2)	Every now and then (3)	Sometimes (4)	Often (5)	Very Often (6)	Almost always (7)
Defends own beliefs (1)	❍	❍	❍	❍	❍	❍	❍
Independent (2)	❍	❍	❍	❍	❍	❍	❍
Affectionate (3)	❍	❍	❍	❍	❍	❍	❍
Assertive (4)	❍	❍	❍	❍	❍	❍	❍
Strong personality (5)	❍	❍	❍	❍	❍	❍	❍
Forceful (6)	❍	❍	❍	❍	❍	❍	❍
Sympathetic (7)	❍	❍	❍	❍	❍	❍	❍
Has leadership abilities (8)	❍	❍	❍	❍	❍	❍	❍
Sensitive to the needs of others (9)	❍	❍	❍	❍	❍	❍	❍
Willing to take risks (10)	❍	❍	❍	❍	❍	❍	❍
Understandi ng (11)	❍	❍	❍	❍	❍	❍	❍
Compassion ate (12)	❍	❍	❍	❍	❍	❍	❍
Eager to soothe hurt feelings (13)	❍	❍	❍	❍	❍	❍	❍
Dominant (14)	❍	❍	❍	❍	❍	❍	❍
Warm (15)	❍	❍	❍	❍	❍	❍	❍
Willing to take a stand (16)	❍	❍	❍	❍	❍	❍	❍
Tender (17)	❍	❍	❍	❍	❍	❍	❍
Aggressive (18)	❍	❍	❍	❍	❍	❍	❍
Loves children (19)	❍	❍	❍	❍	❍	❍	❍
Gentle (20)	❍	❍	❍	❍	❍	❍	❍

Appendix E – Early Feminine Identification Scale

Q89 Please indicate your level of agreement with the following statements for when you were in JUNIOR HIGH SCHOOL or MIDDLE SCHOOL (7th and 8th grade).

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Almost always (5)
I would wear make-up to school. (1)	❍	❍	❍	❍	❍
I would wear clothes that were comfortable rather than trendy. (2)	❍	❍	❍	❍	❍
I was popular. (3)	❍	❍	❍	❍	❍
I wore tight form-fitting clothing to school. (4)	❍	❍	❍	❍	❍
Parents or teachers complained about my clothes being too revealing. (5)	❍	❍	❍	❍	❍
I liked getting boys' attention. (6)	❍	❍	❍	❍	❍
I went to most school dances and functions. (7)	❍	❍	❍	❍	❍
I followed or tried to follow fashion trends. (8)	❍	❍	❍	❍	❍
My first priority was doing well in school. (9)	❍	❍	❍	❍	❍
I wore heals or dressier shoes to school. (10)	❍	❍	❍	❍	❍
I got into conflicts with other girls over boys or rivalries. (11)	❍	❍	❍	❍	❍
I felt like I did not fit in with friends or classmates. (12)	❍	❍	❍	❍	❍
I carried a purse. (13)	❍	❍	❍	❍	❍
I did not use a backpack and instead I carried my books. (14)	❍	❍	❍	❍	❍
My parents told me I slouched when I walked. (15)	❍	❍	❍	❍	❍
I knew how to get boys' attention. (16)	❍	❍	❍	❍	❍
I did not engage in a lot of social activities. (17)	❍	❍	❍	❍	❍
I dated. (18)	❍	❍	❍	❍	❍
I thought girls who wore makeup were self-absorbed. (19)	❍	❍	❍	❍	❍

Appendix F - Debriefing

Q112 The goal of the proposed study is to investigate variables that may impact female students educational preferences, performance and choice of a STEM or non-STEM major in college. We seek to better understand the factors that affect female students' academic pursuits and choices. This will enable us to better address the needs of female students as they go from elementary school to higher education. Any questions you have regarding this research may be directed to the researchers or the chair of the International Review Board (IRB), Dr. Lisa Steelman. Please find the necessary contact information below. Thank you for your participation in this research study. If you wish, a summary of the results will be provided to you, at a later time, by contacting the researchers at the following address.

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