

Examining the Relationship Between Learning Style Preferences and Attitudes Toward Mathematics Among Students in Higher Education

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Abstract

The current study examines whether a difference exists between learning style and attitudes toward mathematics relative to gender and race. The sample comprised 384 undergraduate and graduate students enrolled in institutions of higher education within the United States who completed the Index of Learning Styles and Attitudes Toward Mathematics Inventory. The results suggest that science, technology, engineering, or mathematics (STEM) majors have more positive attitudes toward mathematics and that gender and race do influence both learning style preference and attitudes toward mathematics.

Introduction

According to the U.S. Census Bureau (Shrestha & Heisler, 2011), the United States is changing demographically in many areas, including in the workforce. Due to the increased diversification of the country, researchers and other stakeholders have begun to focus on the recruitment of racial and gender minorities in the science, technology, engineering, and mathematics (STEM) fields. Despite these efforts, there remains a discrepancy in college enrollment in STEM fields among minorities, which directly relates to employment, as most occupations in STEM fields require at least a 4-year degree. According to Gates and Vistro-Yu (2003), mathematics “acts as a ‘gatekeeper’ to social progress” (p. 32) because mathematics provides a way to communicate across cultures, genders, and other boundaries to solve real-world problems. Because mathematics can be such a powerful tool, it is important to study students’ attitudes toward mathematics, as this has been shown to affect mathematics performance (Bramlett & Herron, 2009; Middleton & Spanias, 1999) and could potentially affect who chooses mathematics as a college major. Furthermore, “Students whose learning styles are compatible with the teaching style of a course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches,” (Felder, 1993, p. 286). Thus, the study of student

learning styles is imperative to ensuring instructional match and subsequent student success.

The current study centers on the notion that a student's attitude affects his/her performance, interest, and pursuit of a major and/or career in mathematics (Bramlett & Herron, 2009). Researchers have long found that a relationship exists between attitudes toward mathematics and mathematics achievement (Aiken, 1976; Ma & Kishor, 1997). Learning styles can also be related to attitude, especially if course instruction is being conducted in a manner that is opposite a student's learning style. This could make the student uncomfortable and disinterested in the subject. In a study by Peker and Mirasyedioğlu (2008), there were differences found between learning styles and mathematics attitudes among undergraduate college students who were training to become mathematics educators. A thorough search of the literature indicates a void in the literature with respect to students who are not studying to become educators in mathematics. This study provides additional research in an area that has not been studied much at all in the United States – postsecondary students' attitudes toward mathematics among non- pre-service educators and their learning styles, as well as the relationship that exists between the two variables.

Theoretical Orientation

The expectancy-value theory of achievement motivation suggests that student expectancies for success and the values that they place on achieving in school contribute to positive achievement behaviors and learning trajectories. Eccles and colleagues (1983) developed a model of expectancies and values for success to understand motivation and achievement in children and adolescents. This model suggests that an individual's expectancy for success and his/her valuing of academic tasks have a direct effect on their choices, persistence, and performance (Eccles et al., 1983; Wigfield & Eccles, 2000; Eccles & Wigfield, 2002). Conceptually, these constructs represent an individual's overall attitude towards learning through his/her expectations for success and the value they place on achievement. The expectancy component examines the extent to which the learner believes he or she is capable of achieving well on the task (Wigfield & Eccles, 1992). The task value component consists of four different areas of task values: (1) intrinsic value indicates the extent to which the learner is inherently interested in completing the task, (2) utility value represents the extent to which the task is relative to future plans, (3) attainment value represents the extent to which the task is central to the learner's identity, and (4) cost value represents what the learner will have to relinquish to successfully complete the task. All of these components represent the task value component of expectancy-value theory (Eccles & Wigfield, 2002). These varying components of task value are related to task choice, persistence, effort, performance, and cognitive engagement.

Much of the research examining the relationships between students' expectancy and values in particular academic domains has focused on children and adolescents. This research suggests that children and adolescents distinguish between expectancy of success or failure on a given task and the value they place on success in the particular domain (Wigfield & Eccles, 2002). In addition, males have higher expectancies for success in mathematics compared to females (Wigfield & Eccles, 1992). Researchers have suggested that future research examining expectancy-value related constructs should focus on the salience of expectancies and values within a particular learning context (Wigfield & Cambria, 2010). Understanding relationships between learning styles and attitudes toward mathematics will discern contextual factors that contribute to positive achievement outcomes. For example, understanding how individuals prefer to receive information and how this preference relates to attitudes towards mathematics can provide a complete picture of instructional strategies and classroom context that relates to positive achievement behaviors and learning trajectories.

Literature Review

According to several reports, for the first time in 15 years, enrollment in higher education has declined over the past few years in community colleges, colleges, and for-profit programs (Knapp, Kelly-Reid, & Ginder, 2012). In addition to a decline in enrollment rates at 4-year colleges and universities, graduation rates have also declined (Brainard & Fuller, 2010; Knapp, Kelly-Reid, & Ginder, 2012). Although the cost of higher education is the most cited reason for students dropping out of college, academic disqualification, or the inability to handle coursework, is also a highly cited reason for students dropping out of higher education (Johnson, Rochkind, Ott, & DuPont; 2009). How a student learns, or his/her learning style, has been found to be related to academic performance (Felder, 1993). As such, the topic of how a student learns has become a considerably relevant pedagogical focus (Hawk & Shah, 2007).

Mathematics Learning Styles

Students' learning styles can be described as students' preference on how they "receive and process information" (Felder & Silverman, 1988, p. 674). Although there are a number of models related to learning styles (Canfield, 1988; Gregorc, 1979; Kolb, 1984;), this study uses the learning style model of Felder and Silverman (1988). This model was originally developed to assess the various learning styles of engineering students and is now used with students across majors. This model identifies the following four dimensions of learning preferences. (1) The sensing to intuitive dimension moves from concrete thinkers to those who are more abstract thinkers. (2) The visual to verbal dimension moves from thinkers who prefer learning through visual representation to those who prefer verbal explanations. (3) The active to reflective dimension moves from active learners who prefer learning through performing an activity to reflective learners who prefer to learn by thinking and working alone. Lastly,

(4) the sequential to global dimension moves from thinkers who prefer a linear thinking process to global thinkers who prefer more of a holistic thinking process.

Although learning styles are specific to an individual, there are patterns that emerge when learning styles are investigated through group categorizations, such as gender and race. Researchers have consistently found that there are significant differences in learning styles between males and females. For example, Matthews (1994) found that, although males and females prefer learning in ways that are more applied, females are more independent in their learning styles than males. Results from Philbin, Meier, Huffman, and Boverie, (1995) found that, on average, females score higher on the dimension related to concrete or sensing learning styles, whereas males tended to prefer abstract conceptualization or intuitive approaches to learning. Several researchers who have found the same pattern have echoed these results (Litzinger, Lee, & Wise, 2005; Severiens & Ten Dam, 1994). Additional research confirms that females tend to prefer accommodating or diverging learning, which focuses on concrete methods of knowledge acquisition, whereas males prefer traditional and analytical learning, which focuses on the use of abstraction (Matthews, 1996; Orhun, 2007).

Other research has suggested that there are racial differences in learning styles between Caucasian and African-American college students in various disciplines, including mathematics, science, business, and social science. Specifically, with regard to mathematics and science, African Americans have demonstrated a more conceptual style of learning, whereas Caucasians preferred more applied learning (Matthews, 1994). Additional research that investigates racial differences in learning styles in high school students finds that, in general, African Americans tend to use concrete application and reflective observation and are significantly less likely than Caucasians to use active experimentation (Matthews, 1996).

Attitudes Toward Mathematics

Students' attitude towards mathematics has been cited as a contributing variable to their success in the subject (Mata, Monteiro, & Peixoto, 2012). Kulm (1980) suggests that "it is probably not possible to offer a definition of attitude toward mathematics that would be suitable for all situations, and even if one were agreed on, it would probably be too general to be useful" (p. 358). According to Daskalogianni and Simpson (2000), the definition of attitude assumes the role of a working definition. The working definition of attitude for this study is related to intrinsic motivation, self-confidence, enjoyment, and values (Tapia & Marsh, 2004).

For many years, gender differences have been a reoccurring theme throughout mathematics literature (Mata, Monteiro, & Peixoto, 2012). Traditionally, Mata et al. (2012) suggested that mathematics is a domain in which males have been considered higher achievers than females; and evidence suggests that significant differences exist

between males and females with respect to their attitudes toward mathematics (p.2). Although this is true, other research shows that attitude and motivation are unique to the individual and may not be necessarily influenced by gender alone. When looking at gender specifically, it has been found that attitudes and motivation are factors that are considered highly correlated (Daskalogianni & Simpson, 2000).

Research has consistently shown that females have lower mathematics self-concept than males. According to Odell and Schumacher (1998), differences between gender and previous mathematics experience, perceived ability, and attitudes toward mathematics have all been suggested as explanations for male superiority on standardized tests of mathematics. Moreover, results from this study support the hypothesis that females prefer rote versus autonomous learning; that they choose familiar over novel situations; and that they are less confident than males about their ability to solve math problems. Consistent with these findings, Saunders (2005) conducted a study examining confidence and perception related to mathematics and learning. It was reported that even when male and female students were doing equally well as evinced through their grades, female students' reported feelings of being less comfortable (Saunders, 2005).

The literature on racial differences in attitudes toward mathematics is scant, but in a study by Stanic and Hart (1995), differences were found between African-American and white students on perceived usefulness of mathematics as well as in confidence in mathematics. African-American students scored higher overall on both subscales in relation to their White counterparts. More specifically, African-American females scored significantly higher on confidence than any other subgroup. In another report by the National Science Foundation (1994), in both 1988 and 1992, African-American students were more likely to look forward to and to like mathematics than their White peers.

Relationship Between Learning Styles and Attitudes Towards Mathematics

Research has also consistently found positive relationships between learning styles and mathematics achievement as well as a positive relationship between attitudes towards mathematics and achievement (Bramlett & Herron, 2009; Middleton & Spanias, 1999). Although research has found these significant findings, there is a dearth of research that investigates the relationship between learning styles and attitudes towards mathematics. The investigation of these characteristics is critical to understanding the function of the relationship between learning styles, attitudes towards mathematics, and mathematics achievement. The few studies that have been conducted on this relationship correlation have provided mixed findings. Research on pre-service teachers, by Peker and Mirasyedioğlu (2008), shows that there are significant differences in attitudes toward mathematics according to learning styles. These findings suggested that convergent learners have the highest attitudes toward mathematics, and this is

significantly higher than the attitudes toward mathematics held by assimilators. Peker and Mirasyedioğlu (2008) hypothesized that this might be due to the natural fit of convergent learners in the traditional classrooms teaching styles. They also find that this relationship correlation persists even with 10th grade students. Specifically, Peker and Mirasyedioğlu (2008) found that assimilator and convergent learners have significantly better attitudes towards mathematics than those learners who employ divergent learning styles. However, other research conducted by Orhun (2007) found that, in general there is no relationship between learning styles and attitudes towards learning. The mixed results found with regard to the relationship between learning styles and attitudes toward mathematics warrants additional investigations of this research question.

Methods

The current study was conducted to assess whether there are differences in learning styles and attitudes toward mathematics relative to race and gender as well as whether a relationship exists between attitude toward mathematics and mathematics learning styles among students enrolled in institutions of higher education in the United States. The data used in this study were collected during an exploratory study that examined the relationship between attitudes toward mathematics, learning styles, and mathematics performance. Mathematics performance, however, was not included as a variable in this study.

Studies on the relationship between learning styles and attitudes toward mathematics, specifically among students enrolled in higher education institutions from various programs of study, are limited. The current study will add to the literature by providing a more representative sample and, hence, more generalizable results. The following research questions guided this study:

1. After controlling for major (STEM/non-STEM), are there differences in learning styles and attitudes toward mathematics relative to race and gender?
2. Is there a relationship between learning style preference and attitudes toward mathematics relative to race and gender?

Study Participants

In total, 384 undergraduate and graduate students from higher education institutions (technical schools/community colleges and colleges and universities) across the United States and U.S. territories participated in the study. However, there were some variables that had missing observations. How many participants were included in each analysis are reported in the tables that follow. A note for the current study is that the term Black is used instead of African-American because no distinction was made between those who were born in the U.S. and those Black persons who were born in countries outside of the U.S.

Study Instruments

Two surveys were administered for this study: (1) the Index of Learning Styles (ILS) (Felder & Soloman, 1996) survey and (2) the Attitudes Toward Mathematics Inventory (ATMI) (Tapia & Marsh, 2004). The mathematics assessment was followed by several demographic questions. The entire survey took approximately 15-30 minutes to complete.

The ILS is a 44-item forced-choice instrument that requires respondents to select one of two statements that is more like them. The instrument is divided into four subscales

(active/reflective, sensing/intuitive, visual/verbal, and sequential/global), with 11 items per subscale that were used to assess learning styles. Cronbach's alpha for the overall ILS scale was .74. The four subscales had internal consistency reliabilities ranging from .48 to .66 which according to Tuckman (1999), is sufficient with the exception of the .48 reliability. Tuckman states that internal consistency reliability for attitude measures should be .50 or higher.

The ATMI is a 40-item survey that contains likert-type items that gauge how students feel about mathematics. The scale is divided into four subscales (value, enjoyment, satisfaction, and motivation with 10, 10, 15, and 5 items respectively), with reliabilities ranging from .60 to .93 and an overall Cronbach's alpha of .89. The following section presents the findings based on an analysis of participants' survey responses.

Results

Learning Style Preferences

Tables 1 and 2 below, present the percentages from the ILS survey, which measured participants' learning style preferences by gender and race. As shown in Table 1, most females have a reflective learning style, while most males have an active learning style. The majority of both males and females indicated a preference for sensing over intuitive, visual over verbal, and sequential over global.

Table 1

Percentages of Learning Style Preferences by Gender

Learning Style	Female <i>n</i> = 190	Male <i>n</i> = 163
Active	45.3	52.1
Reflective	54.7	47.9
Sensing	69.5	68.7
Intuitive	30.5	31.3
Visual	66.3	83.4
Verbal	33.7	16.6
Sequential	77.4	65.0
Global	22.6	35.0

As can be seen in Table 2 below, Black and White students preferred the reflective learning style over active; and American Indian, Asian, and Hispanic students preferred an active learning style. The remaining learning style preferences were the same for all races; they preferred sensing, visual, and sequential learning styles.

Table 2

Percentages of Learning Style Preference by Race

	American Indian (<i>n</i> = 16)	Asian (<i>n</i> = 99)	Black (<i>n</i> = 58)	Hispanic (<i>n</i> = 51)	White (<i>n</i> = 126)
Active	62.5	55.6	39.7	58.8	42.1
Reflective	37.5	44.4	60.3	41.2	57.9
Sensing	75.0	61.6	75.9	70.6	71.4
Intuitive	25.0	38.4	24.1	29.4	28.6
Visual	100.0	78.8	69.0	78.4	67.5
Verbal	0.0	21.2	31.0	21.6	32.5
Sequential	75.0	66.7	67.2	70.6	78.6
Global	25.0	33.3	32.8	29.4	21.4

A χ^2 analysis was conducted on each subscale of the ILS to determine whether there was a between learning style preference and gender and between learning style

preference and race. A significant difference between races was found on the visual/verbal subscale, $\chi^2(4) = 10.89, p = .028$. For gender, significance was found on the visual/verbal subscale $\chi^2(1) = 13.44, p < .001$ as well as the sequential/global subscale, $\chi^2(1) = 6.58, p = .01$. The odds of males preferring visual learning over verbal learning were 2.55 times that of females. Additionally, the odds of females preferring sequential learning over global learning were 1.84 times that of males.

Attitudes Toward Mathematics

Tables 3 through 5 summarize the data from the ATMI survey, which measured participants' attitude toward mathematics. The attitudes are presented by gender, race, and type of major. The tables indicate that males have more positive attitudes toward mathematics than females; they also had less variability in their scores on the attitude assessment. The same held true for those students who were majoring in STEM fields. American Indians had the most positive attitudes toward mathematics and the least variability in scores. They were followed by Asians, Hispanics, Blacks, and Whites.

Table 3

Scores on ATMI by Gender

Gender	<i>n</i>	<i>M</i>	<i>SD</i>
Female	144	130.76	19.09
Male	112	135.63	17.88

Table 4

Scores on ATMI by Race

Race	<i>n</i>	<i>M</i>	<i>SD</i>
American Indian	12	141.75	10.80
Asian	64	138.28	18.64
Black	43	135.05	17.50
Hispanic	32	136.97	19.95
White	105	126.48	17.78

Table 5

Scores on ATMI by Major

Major	<i>n</i>	<i>M</i>	<i>SD</i>
STEM	109	137.53	14.89
Non-STEM	150	129.55	20.30

At $\alpha = .05$, there was a significant effect of major on attitudes toward mathematics, $F(1, 245) = 6.78, p = .01, r = .16$. Students who were enrolled in STEM fields had a significantly more positive attitude toward mathematics and they were less variable in their attitude. To determine if there were differences in mathematics attitudes based on race and gender, an ANCOVA was conducted with major as the covariate. After controlling for major, there was a non-significant effect of gender, $F(1, 245) = .453, p = .50, r = .04$ but a significant effect of race was found, $F(4, 245) = 3.81, p = .005, r = .16$. The subscales were also examined individually to see whether there was an effect of gender or race on value, satisfaction, enjoyment, or motivation. Just as with overall motivation, there was a significant effect for major across each of the four subscales of the ATMI, with STEM majors having a significantly more positive attitude toward mathematics than non-STEM majors. Additionally, on the enjoyment subscale, there was a significant effect of race, $F(4, 267) = 4.962, p = .001$. The descriptives for each group were as follows: American Indians ($M = 38.28, SE = 1.99$); Asians ($M = 35.08, SE = .90$); Blacks ($M = 35.38, SE = 1.07$); Hispanics ($M = 33.89, SE = 1.22$); and Whites ($M = 31.43, SE = .72$).

To determine whether there is a relationship exists between learning style preference and attitude toward mathematics, a correlational analysis was performed using Pearson's r . Because learning style preference is measured using a dichotomy (e.g., visual/verbal), visual was dummy coded as 0; and verbal was coded as 1. The data were then divided into groups based on gender and race. Significant relationships were found with respect to females' visual/verbal learning style preference and motivation; with those females with a visual learning style being more motivated about mathematics, $r = -.17, p = .02$. Another significant finding was found among Black students' visual/verbal learning style preference and the enjoyment of mathematics. Blacks who were more visual learners enjoyed mathematics more, $r = -.29, p = .03$. The final significant finding relates to Hispanic students' active/reflective learning style preference and value: Hispanics who were more reflective learners valued mathematics more, $r = .29, p = .04$.

Discussion

The visual/verbal learning continuum displayed the most divergent results with regard to both gender and race. The odds of males preferring visual learning were much higher than their female counterparts, and the odds of females preferring sequential learning were quite a bit higher than their male counterparts. Females do not need to see the big picture as much when it comes to learning; they can complete problems within a vacuum, whereas their male counterparts need to see how what they are doing relates to the overall grand scheme. One interesting finding was that each of the 16 American Indian students had a visual learning style preference, and this may have contributed to the significant χ^2 result as a consequence. A larger sample that includes more American Indian students would aid in determining if, in fact, there is an overwhelmingly larger preference for visual over verbal learning style preference among this subgroup. Although not statistically significant, it is worth noting that Black students were much more reflective learners than the other races. Although this is consistent with the literature, the Black students in this sample chose reflective learning more than 1.5 times their choice of active learning. This suggests that collaborative learning may not be best for this group of students.

As expected, students whose majors were STEM-related had more positive attitudes toward mathematics. This finding supports the major tenets of expectancy-value theory, which states that students with a high expectancy for success and valuing of academic tasks towards learning will more than likely show positive achievement behaviors. STEM majors believe that they are capable of achieving success in mathematics and value mathematics, thus adopting an overall positive attitudes toward mathematics learning. Additionally, just as prior research has shown, White students scored the lowest on the enjoyment subscale meaning their enjoyment of mathematics is lower than any of the other races.

The current study included students from technical schools and community colleges, as well as from colleges and universities. Most studies in this area focus on university students solely. Additionally, few studies investigate learning styles among postsecondary students; and even fewer studies examine the relationship correlation between learning styles and attitudes toward mathematics among U.S. samples. The majority of prior studies examine this topic among non-U.S. students and U.S. students enrolled in K-12 education. As education does not stop at secondary school, it is important to continue to look for patterns that may exist, or help explain the discrepancy in minorities (lack of) advancement in the STEM fields among those enrolled in post-secondary education and in pursuit of career. The results indicate that further research should be conducted to determine whether these differences hold true in larger samples of the U.S. college population, especially because some small yet statistically significant relationships were found among subgroups with regard to the relationship between learning styles and attitudes toward mathematics, as attitude has

been shown to be directly related to achievement in past studies (Ma, 1997; Ma & Kishor, 1997). As the U.S. looks to increase the number of minorities majoring in STEM fields and pursuing STEM careers, learning styles is an area that needs to be studied further in relation to teaching styles and the college curriculum.

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