Exploring the Relationship among Mathematics Attitude, Gender, and Achievement of Undergraduate Health Science Students

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Abstract: The purpose of this study was to investigate the gender differences in students' attitude toward mathematics and how attitude impacts achievement in the course. The sample consisted of 172 undergraduate health science students (123 women, 49 men) enrolled in mathematics courses at a University in the Midwestern United States. Data were collected using a 20-item self-report survey adapted from the TIMSS 2011 context questionnaire. Independent sample t-test, Pearson correlation analysis and Path analysis were performed on the data. We found that there is a positive relationship between mathematics attitude and achievement. There is also a statistically significant gender difference for students liking of mathematics, with men reporting higher scores than women.

INTRODUCTION

In recent times, studies of learning mathematics have expanded to include conceptions and beliefs of mathematics (Andrews & Hatch, 2000; Cai & Wang, 2010), motivation and self-regulation (Cleary & Chen, 2009; Meyer & Turner, 2002; Schmitz & Perels, 2011), self-concept, self-esteem and self-efficacy (Bong & Skaalvik, 2003; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014; Skaalvik & Skaalvik, 2006). The general view is that people are not only cognitive individuals but also social persons with emotions and beliefs that influence their development as learners. People's behavior and choices, when confronted with a task, are

determined more by their attitudes, emotions, beliefs and personal theories, rather than by their knowledge of the specifics of the task. As such, efforts to improve mathematics education must take these attitudes into account.

The term *attitude* generally refers to an individual's learned tendency to respond either positively or negatively to a situation or concept, or in this case, towards mathematics (McLeod, 1994). Hart (1989) characterized attitude towards mathematics as consisting of three components: an emotional response to mathematics, a conception about mathematics, and a behavioral tendency toward mathematics. Ma and Kishor (1997) defined attitudes towards mathematics as "an aggregated measure of a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (p. 27).

Mathematics Attitude and Achievement

Many scholars have observed that students' attitudes are associated with their performance in mathematics. Pajares and Graham (1999) observed that mathematics self-efficacy was significantly related to the performance of middle school students. House (1993) observed that students who had higher academic self-concept earned higher grades in mathematics. Additionally, House (1995) found that several aspects of academic self-concept and achievement expectancies were significantly associated with mathematics achievement. These findings emerge across cultures and ages. In a study of high school students in Hong Kong, Rao, Moely, and Sachs (2000) observed that self-concept was a significant predictor of mathematics performance. Results of a study of elementary and middle school students showed that initial mathematics achievement was significantly related to mathematics self-concept (Skaalvik & Valas, 1999).

Though students' mathematics achievement is linked to their attitudes toward mathematics, the direction of this relationship is not agreed upon. Some studies claim that students' mathematics

attitude is formed and influenced by achievement in mathematics (Pajares & Graham, 1999; House, 2003). Conversely, other studies suggest that mathematics achievement occurs as a result of students' attitude toward the subject (Di Martino & Zan, 2011; Goldin, 2002). Marsh and Young (1997) also observed that adolescent students' academic self-concept had a significant causal effect on their mathematics achievement. Trautwein, Lüdtke, Marsh, Köller, & Baumert (2006) observed that once students gain interest in the mathematics course, they may be likely to surpass initial achievement expectations. Hence, a student's attitude can affect their achievement in mathematics. Another school of thought is that the effect one has on the other is cyclical. Abu-Hilal (2000) observed that the views of students regarding the importance of mathematics had a significant effect on their mathematics performance, and that mathematics performance results in an increase in self-concept. That is, mathematics attitude is influencing achievement and achievement is influencing mathematics attitude simultaneously. Other studies (Ma & Xu, 2004; Michelli, 2013) did not find any relationship between attitudes and achievement.

In sum, this body of research confirms the importance of attitudes on students' performance. Further, we operate under the assumption that attitudes are not innate but result from experiences that can be changed. Students' attitudes toward mathematics are critical to understand because they affect how invested students will be in their approach to learning mathematics, and how much enjoyment they derive from it (Moenikia, M., & Zahed-Babelan, 2010). Therefore, even moderate attitude changes could ultimately impact cognitive processing and achievement.

Mathematics Attitude and Gender

Earlier studies on mathematics attitudes reported significant gender differences in favor of men (Fennema & Sherman, 1976). However, with time, the trends became more complex and tenuous. While some studies emphasized that males showed more positive attitudes towards mathematics than females (Michelli, 2013; Tasdemir, 2009); other studies found just the opposite

(Savas & Duru, 2005). Ma and Xu (2004) stated that both males' and females' attitude scores decrease in the same manner across grade levels indicating no gender difference regarding mathematics attitude among secondary school students.

Schoenfeld (1989) conducted a study with high school students and found that gender differences were consistently negligible. Pajares and Graham (1999) did not find gender differences in mathematics attitudes in their study with gifted middle school students. A study conducted by Kenney-Benson, Pomerantz, Ryan and Patrick (2008) using students in 5th and 7th grades found significant differences in mathematics attitudes by gender in favor of girls. Hall (2012) found that gender gaps in mathematics attitudes and achievement at the elementary and secondary level were statistically insignificant, with boys scoring higher than girls. Research shows that gender gaps in mathematics carry on after high school. For instance, males in the United States regularly score higher on the mathematics section of the Scholastic Aptitude Test (SAT) than their female counterparts (Chubbuck et al., 2016). Also, in Turkey, males in college outperformed females in mathematics (Saygin, 2020).

A meta-analysis by Hyde et al. (1990) showed that there are gender-based inconsistencies in attitudes towards mathematics. Emotions are typically discussed in the literature on gender differences in mathematics. For example, Brush (1985) noted a feelings factor in mathematics learning, and observed that this feelings factor was highly predictive of the level of students' course preferences.

Stipek and Gralinsky's (1991) noted that females attributed failure to low ability, while attributing success to luck. Girls were further found to report less pride after success and a stronger desire to hide their paper after failure, a behavior interpreted as representing feelings of shame.

Aim of the Study

The aim of this study is to investigate the gender differences in students' attitudes toward mathematics and how attitudes impacts achievement in the course. The specific research questions for this study are:

1. What differences exist between the way women and men characterize their attitudes toward mathematics in a health science institution?
2. How are undergraduate health science students' attitude toward mathematics (liking, value, and confidence in mathematics) related to their mathematics achievement (measured by their final grade in the course)?

METHOD

Participants

The participants of this study were 172 undergraduate health science students (49 men, 123 women) enrolled in mathematics courses at a research university in the Midwest. The mathematics classes were College Algebra, Precalculus, and Calculus. Students were asked to complete the survey, which was provided through a link to a google form during the first week of classes. Participation was voluntary. Ethical approval for this study was granted by the University's Institutional Review Board.

Instrumentation

A 20-item survey instrument, adapted from the TIMSS 2011 contextual questionnaire (House & Telese, 2014; Khine, Al-Mutawah, & Afari, 2015) was used to measure students' attitudes toward mathematics. We used a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3= agree, 4= strongly agree) which consists of three 3 subscales: *liking*, *value*, and *confidence*. *Liking* measures the extent to which student report how much they like mathematics (e.g. 'I enjoy learning mathematics'). It comprises five items. *Value* measures students' perception of the value

they place in mathematics and its importance to their personal and professional goals (e.g. 'I need to do well in mathematics to get the job I want'). It has six items. *Confidence* measures students' perception of how confident they feel when working on mathematics problems (e.g. 'I usually do well in mathematics'). It is measured by nine items.

Statistical analysis

In order to answer our first research question, an independent sample *t*-test was performed to compare the mean scores of men's and women's attitude toward mathematics using IBM SPSS version 23. The second research question was addressed by means of a Pearson Correlation analysis and a Path analysis using AMOS version 23 (Arbuckle, 2015).

RESULTS

Table 1 summarizes means, standard deviations, and mean differences of the TIMSS 2011 constructs. The mean scores range from 2.45 to 3.61 for men, and 2.37 to 3.57 for women on a 4-point Likert scale. This shows that the sample in this study held mostly positive attitudes toward mathematics. Also, in all but three of the items (items 5, 18 and 19), men had higher scores than women.

Table 1: Mean and Standard Deviation of Survey Items (0= strongly disagree; 4 = strongly agree)

	All (n=172)		Men (n=49)		Women (n=123)		
Item	Mean	SD	Mean	SD	Mean	SD	Mean Difference

							(Men - Women)
Liking							
1. I enjoy learning mathematics.	3.06	0.79	3.18	0.76	3.02	0.80	0.16
2. I wish I did not have to study mathematics.	2.96	0.92	3.04	0.87	2.92	0.95	0.12
3. Mathematics is boring.	3.10	0.71	3.16	0.66	3.08	0.73	0.08
4. I learn many interesting things about mathematics.	2.94	0.77	2.98	0.88	2.92	0.73	0.06
5. I like mathematics.	2.92	0.85	2.90	0.77	2.93	0.88	-0.03
Value							
6. I think learning mathematics will help me in my daily life.	3.03	0.81	3.16	0.92	2.98	0.75	0.19
7. I need mathematics to learn other subjects.	3.37	0.70	3.43	0.71	3.34	0.70	0.09
8. I need to do well in mathematics to get into my desired program.	3.53	0.62	3.65	0.56	3.48	0.63	0.17
9. I need to do well in mathematics to get the job I want.	3.33	0.77	3.45	0.79	3.28	0.75	0.16
10. I would like a job that involves using mathematics.	2.45	0.85	2.65	0.90	2.37	0.82	0.29

11. It is important to do well in mathematics.	3.61	0.52	3.71	0.54	3.57	0.51	0.15
Confidence							
12. I usually do well in mathematics.	3.10	0.72	3.29	0.74	3.02	0.71	0.26
13. Mathematics is more difficult for me than for many of my colleagues.	2.77	0.94	2.88	0.93	2.72	0.94	0.15
14. Mathematics is not one of my strengths.	2.73	1.01	2.94	0.97	2.65	1.02	0.29
15. I learn things quickly in mathematics.	2.58	0.83	2.73	0.79	2.51	0.84	0.22
16. Mathematics makes me confused and nervous.	2.69	0.96	2.88	0.81	2.61	1.01	0.27
17. I am good at working out difficult mathematics problems.	2.47	0.80	2.73	0.73	2.37	0.80	0.37
18. My colleagues think I can do well in mathematics.	2.96	0.70	2.94	0.75	2.97	0.68	-0.03
19. My colleagues tell me I am good at mathematics.	2.82	0.79	2.82	0.81	2.82	0.78	-0.01
20. Mathematics is harder for me than any other subject.	2.95	1.00	3.06	0.99	2.91	1.01	0.15

The results of an independent sample *t*-test showed that there were no statistically significant differences for liking, $t(170) = 0.79$, $p = 0.432$ and confidence, $t(170) = 1.74$, $p = 0.084$. Although men's mean scores were slightly higher ($M_{Liking} = 3.55$ and $M_{Confidence} = 2.92$) than those

for women (M_{Liking} = 2.97 and $M_{Confidence}$ = 2.73), these differences were not statistically significant (see Table 2). In contrast, a statistically significant difference was found for value, $t(170) = 2.07$, $p < 0.05$, with men scoring higher (M_{Value} = 3.34) than women (M_{Value} = 3.17). Cohen's effect size of $d = 0.34$ implies a small effect.

Table 2: Mean and standard deviation of men's and women's perception of their attitude toward mathematics and effect size estimates for differences between samples

	Men(49)		Women(123)				Effect Size
	Mean	SD	Mean	SD	*t*-value	*p*-value	(Cohen's *d*)
Liking	3.05	.57	2.97	.62	.79	.432	0.13
Value	3.34	.51	3.17	.50	2.07	.040*	0.34
Confidence	2.92	.55	2.73	.66	1.74	.084	0.31
Overall	3.08	.42	2.92	.47	2.01	.046*	0.36

Table 3 shows the associations between students' attitudes toward mathematics and their mathematics achievement. The correlation coefficients range from 0.02 and 0.58. There is a positive, albeit small correlation between *Confidence* and Grade (r = 0.257, $p < 0.01$). The correlations between the attitude factors of *Liking* and *Value*, and Grade are not significant.

Table 3: Pearson correlations among the affective scales and grade for all participants

Variable	Grade	Liking	Value	Confidence
Grade	1			

Liking	.121	1		
Value	.020	.367**	1	
Confidence	.257**	.583**	.223**	1

Note: **. Correlation is significant at the 0.01 level (2-tailed).

The Path diagram is shown in Figure 1, and the fit indices for the Path analysis are shown in Table 4. The chi square value of 1.337 was not significant ($p = 0.248$), and the GFI (0.996), NFI (0.998), TLI (0.980), CFI (0.997), SRMR (0.021), and RMSEA (0.044) showed values that, taken together, suggest that the model was an excellent fit to the data.

Gender was a statistically significant predictor of both the hypothesized mediator variables of *confidence* (standardized regression coefficient = 0.595, unstandardized regression coefficient = 0.640 with a standard error of 0.178, $p < 0.001$) and *value* (standardized regression coefficient = 0.375, unstandardized regression coefficient = 0.318 with a standard error of 0.102, $p < 0.01$). Also, *confidence* was a statistically significant predictor of *grade* (standardized regression coefficient = 0.224, unstandardized regression coefficient 2.748 with a standard error of 0.929, $p < 0.01$). However, value did not influence grade in that it did not yield a statistically significant path to grade (standardized regression coefficient = -0.059, unstandardized regression coefficient = -0.912 with a standard error of 10178, $p = 0.439$).

Figure 1: Path diagram for the model

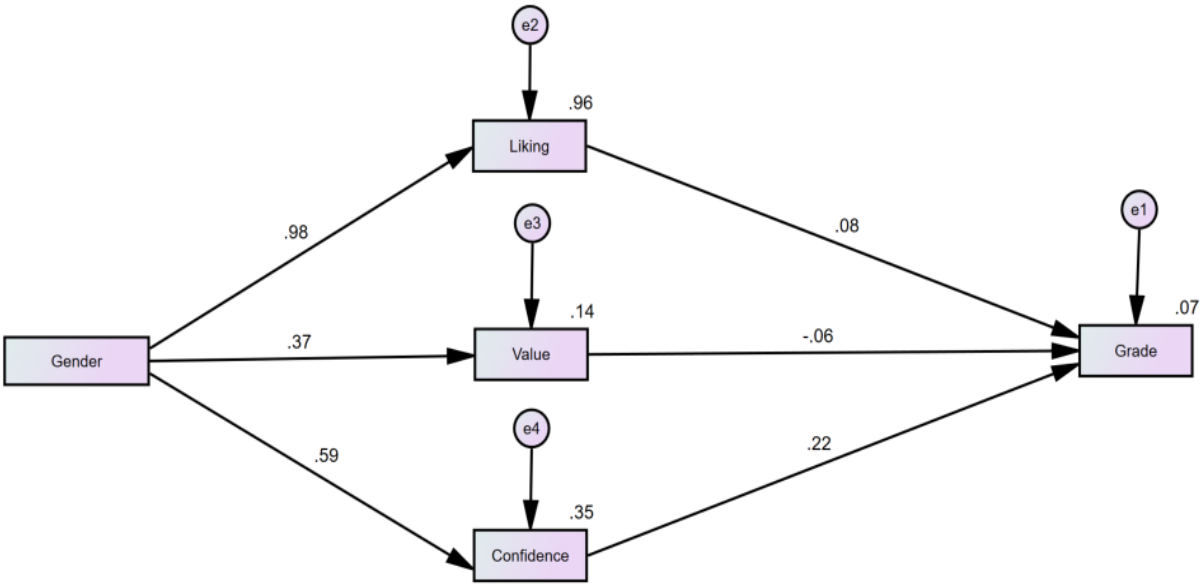

Table 4: Fit indices for the model

Model fit indices	Values	Recommended guidelines
χ^2	1.337, $p = 0.248$	Nonsignificant
χ^2 / df	1.337	< 5.00
TLI	0.980	≥ 0.90
CFI	0.997	≥ 0.90
GFI	0.996	≥ 0.90
RMSEA	0.044	≤ 0.08
SRMR	0.021	≤ 0.05

DISCUSSION

This study investigated gender differences in students' attitude toward mathematics as well as the effect of mathematics attitude on students' grade at an undergraduate health science institution in the Midwestern United States. The results of both the descriptive statistics and correlation analysis show that overall, students' attitudes toward mathematics had a positive relationship with their mathematics achievement. Students who reported that they usually did well in mathematics also tended to earn higher grades. Similarly, students who felt they learned things quickly in mathematics also earned higher grades. Conversely, students who reported negative comparisons of themselves to their classmates tended to earn low grades. Students who showed high achievement levels were also more likely to feel that they were good at working out difficult problems.

These findings are consistent with recent research results (Ethington, 1992; Ethington & Wolfle, 1984; Ganley & Vasilyeva, 2011; Lloyd, Walsh, & Yailagh, 2005; Nosek & Smyth, 2011). The *confidence* scale was found to significantly predict students' achievement. This is consistent with the findings of Khine, Al-Mutawah, & Afari (2015). It is also important for mathematics instructors to take the necessary measures to ensure that we not only focus on the mathematics content, but also attend to the affective needs of students. In particular, teachers must ensure that they instill confidence in students who have no confidence in themselves.

We also found that there was no statistically significant difference between men and women for the mathematics attitude scales, except for *liking*, where men reported higher scores than women. Thus, mathematics educators need to examine practices and policies to try to understand the reason behind the existence of the gender imbalance. There may be instructional practices that unintentionally contribute to the gender difference.

Limitations and Future Studies

One limitation of this study is that a convenience sample of undergraduate students enrolled in a health science program were recruited as research participants; thus, due to the nature of the population there was a disproportionate number of females and Caucasian students in the sample. Therefore the sample was not as diverse as one would expect. Another limitation is that the study was based on self-reported data which can promote bias. Therefore, caution should be taken in generalizing this study to other samples with different demographics.

The findings from this study provide several directions for further studies. For example, additional studies are needed to determine if findings observed in this study would be apparent for students from other institutions whose settings are different from the one in this study. In addition, further research is needed to assess the relationship between students' math attitude and achievement outcomes in other academic disciplines.

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