Mathematics Attitude among University Students: Implications for Science and Engineering Education

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Abstract: *The aim of this study is to examine the effects of gender, college stay, and previous achievement on attitudes towards mathematics among university students. The participants were 431 (of which 118 or 27.4% were female) randomly selected sophomore and junior undergraduates enrolled in applied science and engineering fields at Hawassa University. An adapted measure of Attitudes towards Mathematics Inventory (ATMI-Amharic) was used to determine attitude towards mathematics while prior mathematics achievement (PMA) was assessed using a self-reported measure. A multivariate factorial model (MANOA) fitted to the data revealed that students generally held positive attitude towards mathematics though significant group variations were evident as a function of gender and previous mathematics achievement (PMA) across all math-attitude dimensions. The implications of the findings for science and engineering education are discussed.*

Keywords: Math attitude, Gender, Math Achievement, University, Ethiopia

Introduction

In recent decades there has been a growing research endeavor to find more plausible ways to improve the affective and cognitive aspects of learning mathematics. The reason is apparent. Understanding the secret behind learning mathematics and the success in quantitative disciplines is central to developing cutting-edge human capital in

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science, technology and engineering. Thus, high proficiency in and positive attitude towards mathematics among young people is viewed as indispensable to guaranteeing the survival of nations in a rather fiercely competitive, knowledge-based global economy. This is why the last decade saw a resurgence of research on cognitive and affective aspects of mathematics education with a renewed vigor, fresh theoretical perspectives, and refined methodologies (e.g., Elen-Quest, Hyde, and Linn 2010; Hyde and Mertz 2009; Hyde 2005; Spelke 2005).

The importance attached to mathematics at global level has several manifestations. Among other things, the effort to periodically gauge young people's mathematics profiles, both cognitive and affective, which went to the extent of setting up a collective mechanism among OCED (Organization for Cooperation and Economic Development) member states (which does not include sub-Saharan African countries) suggests the level of importance attached. In fact, this does not include the barrage of criticisms that the media and the research community throw on policy makers, teachers, and educational leaders in the event of low achievement by a nation state in the aftermath of the announcement of the test results such as "Program for International Student Assessment" (PISA).

Contrary to what is going on in the developed world, however, empirical data on cognitive and affective aspects of mathematics in sub-Saharan Africa is scanty at best. And Ethiopia is not an exception to this rule. Thus, the slim volume of empirical data that is available is far from sufficient to understand the status of mathematics education in Ethiopia leave alone to regularly monitor the trends over the years at any level of the education system.

Notwithstanding the limited studies (e.g.; Seleshi 2001; 2005; Tilaye 2004; Mulu 2009; Ayalew, Dawit, Tesfaye and Yalew 2009; Tesfaye 2010) that could only scratch the surface, the results nevertheless came out with critical information sufficient to send a warning signal. Of interest, a study based on national examinations results show that mathematics achievement among primary school children (Grades 4 and 8) and adolescents (Grades 10 and 12 i.e. pre-university) was below the average passing score (i.e.50%) (e.g.; USAID and MoE 2008; Mulu 2009). Similar findings were reported in another survey study conducted in three public universities (Ayalew et al. 2009). Despite the paucity of data, three key trends could be discerned from the current landscape: (a) low mathematics achievement (e.g., Mulu 2009), (b) declining interest and willingness to study math and other quantitative fields, and (c) the near absence of females making young women rare species in fields like mathematics and physical sciences (e.g., Tesfaye 2010; Ayalew et al. 2009). Hence, there is sufficient reason to be anxious when young university students show little appetite to major in disciplines like mathematics and physics (e.g., Tesfaye 2010; Ayalew et al. 2009) despite the apparent policy attention to science and engineering (MoE 2008).

Regardless of the multiplicity of factors that may come into play, this study only attempts to figure out the extent to which previous mathematics achievement (PMA), college stay (year level), and gender shape students' attitude towards mathematics. Regardless of "college stay" that the present authors included on the assumption that doing more math courses (as a result of years of stay in college) might influence attitude, the rationale behind singling out past achievement and gender as units of analyses is that both variables are systematically associated with cognitive and affective aspects of mathematics (e.g., Marsh 1990; Pajaries 1995; Chipman 2005) and entry into, and success in science and engineering fields (Eccels 1982; Sell 1980).

In view of the above, this article closely examines the empirical link of mathematics attitude with the variables of interest based on data generated on undergraduate students of science and engineering at Hawassa University.

Accordingly, this study addresses the following:

- Whether college students vary in attitude towards mathematics as a function of gender, college stay and prior mathematics achievement (PMA)
- Whether previous mathematics achievement (PMA) is systematically related with attitude towards mathematics
- Whether there is significant gender effect on mathematics attitude

Literature Review

This section reviews the existing theoretical and empirical literature on the determinants of mathematics attitude with special emphasis on the explanations and systematic relationship between past and present mathematics achievement, gender, stay in college, and other cognitive and affective variables. However, first, a conceptual clarification of mathematics attitude will be in order.

Conceptualization of Mathematics Attitude

The conceptualization of mathematics attitude has never been uniform and the definitions given are as diverse as the number and perspectives of the researchers in the field. For instance, in a classic work, Neale (1969:623) defined mathematics attitude as an aggregated measure of “a liking or disliking of mathematics, a tendency to engage in or avoid mathematics activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless.” About a decade and half later, Haladyna, Shaughnessy, and Shaughnessy (1983: 20) offered a broader conceptualization of math attitude defining it as “a general emotional disposition toward the school subject of mathematics.” However, Haladyna et al. cautioned that their definition should not be confused with the notion of attitude toward the field of mathematics, toward one's ability to perform in the field of mathematics, or toward some specific area within mathematics (e.g., geometry, word problems). About three decades later, Ma and Kishor (1997) extended Neale's classical definition by including affective responses related to the easy/difficult dimension as well as the importance/unimportance dimension of mathematics attitude. Overall, even though the above stated math attitude measures are not exhaustive, it can be discerned that all of them share one common feature - the dimensionality of the construct. Similarly, the widely used instruments to capture the math attitude construct (e.g., Fennema and Sherman1976; Tapia and Marsh 2004), in spite of their diversity, have no confusion about its multidimensional conceptualization.

Mathematics Achievement and Attitude

Substantial body of empirical evidence suggests that math attitude predicts achievement in the same domain. Some of these studies, however, made no distinction between past and present achievement since both variables are robust correlates of each other. Accordingly, previous mathematics achievement is not only related to current performance and success/failure in mathematics, but also affects math attitude through psychological processes via mathematics self-efficacy beliefs (e.g., Bandura 1997), self-concept of ability (Marsh 1990), and expectations of success (Eccels 1994).

In agreement with earlier studies (e.g., Fennema and Sherman, 1977; Ma and Kishor 1997), recent findings (e.g., Hemmings, Grootenboer, and Kally 2010; Yee 2010; Ma and Xu 2004) found significant predictive relationship between math attitude and past and present achievement in mathematics. Ma and Kishor (1997: 273), for instance, found significant positive causal relationship between mathematics achievement and attitude. In another study, Ma and Xu (2004) reported consistent findings regarding the predictive relationships between math attitude and achievement and they concluded that the effects between attitude and achievement are the same for males and females with causal predominance (priority) of achievement over attitude for entire high school level (Grades 7-12). Similar findings endorsing the systematic association between math achievement and attitude are reported in recent studies. In this regard, drawing on a sample of Australian secondary school students, Hemmings et al.(2010) reported strong predictive capacity of past achievement and attitudes towards mathematics on current math achievement with a large percentage of shared variance (R^2 = .69) accounted for the two predictor variables.

Gender Differences in Cognitive and Affective Aspects of Mathematics

This section first examines the empirical literature regarding the effect of gender on math achievement and attitude, and other affective aspects of mathematics learning followed by the theoretical explanations offered to these relationships.

Empirical evidence on gender differences

Differences between boys and girls in math related affect and academic achievement were considered as established since mid-1970s (Maccoby and Jackline 1974). What is common to most of these studies, however, is that the difference between boys and girls does not normally occur at primary grades. Instead, it emerges at middle and upper secondary levels coinciding with the onset of puberty. In this regard, Wise’s (1985) study found marginal gender differences in favor of boys in mathematics among ninth graders that steadily increased during high school years. Later, in a large meta-analytic study of gender differences in mathematics achievement, Hyde, Fennema, and Lamon (1990) found marginal gender differences favoring females at elementary grades (*d* = -.005), while no difference was observed in middle school. However, the age-related trends show that gender differences in mathematical problem solving favoring males emerged in high school (*d* = .029) and college (*d* = .031) levels. Consistent with Hyde (1990), Seleshi (2005) found out no gender differences among grade five students in both mathematics achievement and attitude though he indicates that variations are evident in grade six. In agreement with Seleshi (2001; 2005), Tilaye (2004) also found gender differences at upper primary level disfavoring girls.

In his research on a large and representative sample of high school students in Western culture, Marsh (1989) observed a slightly different pattern. Accordingly, he found marginal gender differences in mathematics achievement and attitude while he found no differences in math course enrollment. Hence, he concluded that gender differences that existed before are diminishing among high school students which recent empirical literature seem to suggest. Specifically, current research on gender differences comes up with compelling evidences suggesting gender similarities rather than differences (e.g., Hyde 2005; Spelke 2005). Nonetheless, these findings are at variance with the pattern evident among Ethiopian university students since significant gender differences that favor males (Demewoz et al. 2005) is still apparent in math related attitude and self-perception of ability. These emerging developments are discussed below to explain why the differences are fading away, and what factors are behind this trend.

Theoretical explanations for emerging gender similarities

Investigating gender differences in cognitive and affective aspects of mathematics goes back to the 1960s. However, it is with the publication of the influential book *The Psychology of Sex Differences* that Maccoby and Jackline (1974) asserted the superiority boys over girls in mathematics problem solving and other mathematical abilities. Since then, a number of explanations have been forwarded regarding the factors that underpin gender differences in mathematics ranging from biological (e.g., hormones and prenatal brain differentiation), to sociological (traditional gender stereotypes, gender inequality) (e.g., Hyde 2005; Baker and Jones 1993), to macro-level political and economic (Else-Quest et al. 2010; Hyde and Mertz 2009; Chiu and Xihua 2008) variables. Notwithstanding the other factors, empirical evidence has been piling up in favor of the sociological perspective which Baker and Jones (1993) dubbed as: "*The Gender Stratification*

Hypothesis". The authors argued that girls' poorer math achievement and more negative math attitudes are the result of societal gender stratification. This perspective posits that in patriarchal cultures, male students associate their achievement to future opportunities and outcomes. Baker and Jones (1993:92) specifically argued that "...female students, who are faced with less opportunity, may see mathematics as less important for their future and are told so in a number of ways by teachers, parents, and friends. In short, opportunity structures can shape numerous socialization processes that shape performance."

In most recent cross-national meta-analytic study on gender differences in mathematics achievement, Else-Quest, Hyde, and Linn (2010) provided empirical support for the two complementary theoretical prepositions; namely, the *gender stratification* hypothesis (Baker and Jones 1993) and Hyde's (2005) g*ender similarities* hypothesis which is the byproduct of her recent meta-analytic study. Specifically, Else-Quest, et al. (2010) found out significant gender similarities (i.e. no gender differences in math achievement and affect) confirming Hyde's (2005) hypothesis in national contexts where gender gap does not exist. In contrast, the same study reported that gender differences in mathematics achievement and attitude in cultural contexts where there is gender inequity. Interestingly, Else-Quest et al (2010) confirmed the findings of an earlier study by Hyde and Mertz (2009). Further, Hyde and Mertz (2009:8806) attributed achievement differences favoring boys: "…mathematics achievement correlates well with measures of a country's gender equity, strongly indicating that the gap is due, in large part, to socio-cultural and other environmental factors, not biology or gender *per se."*

In short, based on the existing empirical and theoretical literature, it can be argued that mathematics attitude is strongly affected by past achievement and gender. Nevertheless, it should also be recognized that socio-economic, political, and other environmental factors also come into play particularly in moderating the relationship between math achievement and gender.

Methodology

Sample

The participants of the study were 445 randomly selected undergraduate students enrolled for mathematics courses in the faculties of Applied Sciences and Engineering at Hawassa University. Of these, 431 (118 or 27.4% female and 313 or 72.6% male) respondents returned completed questionnaires. The distribution of the final sample in terms of “Year” (i.e. College Stay) is 45.5% (n= 196) sophomore and 55.5% (n= 235) junior years respectively. In terms of field of study, the sample constituted students from departments of Chemistry (6.5%; n = 28), Computer Science (8.4%; n = 36), Mathematics (21.1%; n = 91), Physics, (8.8%; n = 38), Statistics (18.6%; n = 80), Civil Engineering (20.2%; n = 87), Electrical Engineering (13.2%; n = 57), and Soil and Water Engineering (3.2%; n = 14) respectively. The mean age of the respondents was 21.6 (*SD = 3.2*) years. Stratified random sampling procedure is employed to ensure the proportional representation of all academic departments. Nevertheless, the selection of actual participants was based on a systematic random sampling using the name list received from the respective departments.

Instruments

Three data gathering tools employed included (a) The Attitude towards Mathematics Inventory (ATMI)- *Amharic* (b) a self-reported measure of previous mathematics achievement (PMA), and (c) a questionnaire to secure respondents bio-data.

The ATMI-Amharic

The Attitudes towards Mathematics Inventory (ATMI) (Amharic version) consisting of 40 items originally designed by Tapia (1999) and later revised by Tapia and Marsh (2004) to measure students' attitudes towards mathematics adapted by Tesfaye and Getachew (2012) to fit the Ethiopian context was employed for the study. ATMI (*Amharic)* consisted of four dimensions: self-confidence, value, enjoyment and motivation. *Self-confidence* taps students' confidence and self-concept of their performance in mathematics. The Self-confidence dimension consisted of 15 items as in the original. Sample items include:"Mathematics does not scare me at all" and "Studying mathematics makes me feel nervous". The *Value* dimension consisted of 10 items assessing students' beliefs about the usefulness, relevance and worth of mathematics in their lives now and in the future. It included phrases like "Mathematics courses will be very helpful no matter what I decide to study." The *Enjoyment* dimension was made up of 10 items and designed to assess the degree to which students enjoy learning math and the mathematics classes. It included items: "I really like mathematics" and "I usually enjoy studying mathematics in school". The fourth dimension is *Motivation.* It is meant to measure interest in mathematics and the desire to pursue studies in mathematics. This dimension made up of five items represented by statements like "I am willing to take more than the required amount of mathematics" and "The challenge of mathematics appeals to me".

The equivalence of the adapted ATMI-*Amharic* and the original ATMI-*English* had been established in an earlier study (Tesfaye and Getachew, 2012). Accordingly, the similarity of the ATMI-*Amharic* with the original English equivalent was determined by using internal consistency reliability and factorial validity analyses. Thus, the results of Confirmatory Factor Analysis (CFA) of the ATMI-*Amharic* yielded strong construct validity evidence for the full scale as well as the part measures (i.e. self-confidence, value of math, enjoyment of math, and motivation) found in Tesfaye and Getachew (2012, pp. 72-75) are consistent with Tapia (1996) and Tapia and Marsh (2004). Furthermore, like the original measure, ATMI-*Amharic* yielded high internal consistency for the full scale (α = 0.94) and for the four sub-scales (i.e. Self-Confidence = .89, Value = 0.83, Enjoyment = 0.87, and Motivation = 0.79*),* that warrant further analyses (Nunnally, 1978).

Mathematics Achievement

Students' previous mathematics achievement (PMA)was measured using self-reported questions composed of five items. The first, the second, and the third Likert-scaled items required the respondents to rate the degree to which their previous math achievement influenced their (a) Grade Point Average (GPA) in the Ethiopian General Secondary Education Certificate Examination (EGSECE), (2) their achievement in Ethiopian Higher Education Entrance Examination (EHEEE), and; (3) their grades earned at university in the courses they took in the previous semesters, respectively. Sample item included: *"How do you express the influence of the math grade earned in General Secondary Education Certificate Examination (EGSECE) on your overall EGSECE GPA?"* Assessed on a five-point Likert-type scale, the ratings range from "Severely decreased my GPA" to "Significantly increased my GPA." The fourth and fifth items asked respondents to select the letter grades (A, B^+, B, C^+, C, D^+ and D) they frequently scored in math courses and the courses that needed mathematical knowledge and skills respectively.

The mean of the aggregate scores on the five items measuring Previous Mathematics Achievement (PMA) were used to tap students' own ratings of their achievement in Math in high school and university. Based on their average scores on the five PMA items the respondents were grouped as *low*, *medium*, and *high* groups. The minimum and maximum mean scores on the five PMA items ranged between 1.25 and 5.00 respectively while the overall mean score was 2.75. Students who scored below the mean (*Mean* = 2.75) on PMA were categorized as *low* achievers, those whose scores ranging between 2.75 and 3.25

were categorized as *medium*, while those whose scores exceeded 3.25 were classified as *high* achievers. Thus, of the total, 163 (38%) cases were found to fall under *low* achieving group, 135 (31%) as *medium*, and the remaining 133(31%) as *high* achievers. The internal consistency of the five-item PMA measure was found to be 0.74 (Cronbach α = 0.74) which, according to Nunnally (1978:245), represents a sufficiently high internal consistency reliability for research purposes.

Questionnaire

As indicated above, a questionnaire assessing respondents' demographic characteristics is in the adapted ATMI-*Amharic* instrument. The purpose is to solicit information on respondents' background characteristics including their age, gender, field of study, and year at university.

Procedure of Data Gathering

The adapted ATMI-*Amharic* was administered to the participants during their regular class time with the permission from the Faculty of Applied Science and Engineering academic departments at Hawassa University in mid-May, 2007. The lecturers who assisted in the data collection were given verbal and written instructions on the procedures for administering the instrument. All the participants requested to volunteer were willing to take part in the survey.

Data Analysis

The data generated using the above mentioned instruments were entered using SPSS for Windows Version 13. Data were interpreted based on the results of the univariate, bivariate and multivariate statistical analyses computed to test the statistical hypotheses.

Results

In this study, the independent variables are gender, "Year" level (years in university study), and the levels of students previous mathematics achievement (PMA). The year level is designed to have two groups: junior and senior groups. The PMA measure, as indicated in the methodology, was used to categorize the sample into three groups (i.e. low, medium, and high) based on their composite mean scores.

Preliminary findings

As shown in Table 1, for each attitude dimension, a composite score was calculated by averaging all the responses to the items belonging to that category. The means, *SD*s and zero-order correlations among the key variables of the study were computed to provide an overview of the data.

Table 1: *Means*, *SD*s, and Correlations of the Study Variables

Math attitude Dimensions	***Mean***	***SD***	**Correlations**						
			Gender	Year	PMA	1	2	3	4
1 Self-confidence	3.95	.73	.22[b]	.07[a]	.52	-	.58	.81	.87
2 Value	4.28	.52	.25	.03	.26		-	.68	.64
3 Enjoyment	3.97	.66	.25	.03	.46			-	.82
4 Motivation	3.78	.79	.31	.01	.39				-

[a] Correlations below .07 are not significant (Sig. > 0.05);
[b] Correlations above 0.22 are significant at $p < .01$ level (2-tailed)

The descriptive findings based on respondents scores on ATMI-*Amharic* measure reveals that generally students have positive attitude towards mathematics since the mean scores on all math attitude dimensions are closer to "agreement" (or a mean score of 4). A closer inspection of the math attitude dimensions further indicate that the students enjoyed mathematics (*Mean*= 3.97; *SD* = .66), confident in the ability to do mathematics (*Mean* = 3.95; *SD* = .73), saw the value in mathematics (*Mean* = 4.28; *SD* = .52), and motivated (*Mean* = 3.78; *SD* = .79) to learn math. Regarding their prior achievement in mathematics (PMA), however, students assessed themselves as moderate (*Mean* = 2.97; *SD* = .87).

Regarding bivariate relationships of the dependent and explanatory variables, the four math attitude dimensions (i.e. self-confidence, value, enjoyment, and motivation) correlated positively and significantly with gender (coefficients ranging between: 0.22-0.31, $p < .05$) and PMA (coefficients ranging between: 0.26-0.51, $p < .05$) while no statistically significant linear relationship was observed between math attitude and college stay (Year).

Multivariate Analysis

A multivariate factorial model (MANOVA) was used to determine the presence of main and interaction effects with the four math-attitude dimensions taken as criterion variables: (a) self-confidence, (b) value, (c) enjoyment, and (d) motivation; while gender, year in college, and previous math achievement (PMA) are taken as explanatory variables. Though the absence of linear association between PMA and stay in college (Year in college) contradicts our expectation, its inclusion in the model was justified in the hope that it might provide some information through interaction effects.

The findings of the full factorial MANOVA yielded significant main effects for gender and PMA whilst no “Year” main effect was found. The results further disclosed that the main effects of ‘Gender’ (Pilla’s Trace = .097, F= 11.18, $p< .0001$, $\eta^2 = 0.1$), and PMA (Pilla’s Trace = .211, F = 12.27, $p< .0001$, , $\eta^2 = .105$) were statistically significant. Thus, it can be concluded that gender and previous mathematics achievement are significantly related with students’ math attitude dimensions: self-confidence, value, enjoyment, and motivation. In order to further examine the between subject effects on each of the math attitude dimension separate analyses were conducted for gender and PMA.

In contrast, the analysis indicated that the'Year" main effect was not significant (Pilla's Trace = 0.008, F= .838, p> .50, η^2< .01) indicating that stay in college did not produce meaningful difference in math attitude among college students. And each of the interaction effects of the three independent variables on the four dependent variables was found to be non-significant effect as it depicts small effect size: Gender x Year(Pilla's Trace= 0.003,F = 0.294, p> 0.88, eta^2< .005),Gender x PMA(Pilla's Trace = 0.016, F = 0.829, *ns*), Year xPMA (Pilla's Trace = 0.015, F = 0.803, *ns*), and Gender x Year xPMA (Pilla's Trace = 0.032, F = 1.70, p< .10, η^2= .016).

Table 2**:** Multivariate tests for the four math attitude factors

Variables	**Pillai's Trace**	**F**	*df*	*Error df*	η^2
Intercept	0.984	6359**	4	416	0.984
Year (A)	0.008	0.84	4	416	0.008
Gender (B)	0.097	11.18**	4	416	0.097
PMA (C)	0.211	12.27**	8	834	0.105
AxB	0.003	0.29	4	416	0.003
AxC	0.015	0.80	4	416	0.008
BxC	0.016	0.83	8	834	0.008
AxBxC	0.032	1.70*	8	834	0.016

*p < .10; **p < .0001

A further analysis of between-subject effects (see Table 3) was carried out to determine how the main effect of gender separately related to each of the four attitude dimensions. Accordingly, gender has a statistically significant effect on self-confidence (F (1,419) = 16.64, p< .0001, η^2 = .04), enjoyment (F (1,419) = 22.36, p< .0001, η^2= .05), motivation (F(1,419) = 42.08, p< .0001, η^2 = .09) and value (F(1,419) = 23.28, p< .001, η^2 = .05).

The same test of between-subject effects of PMA (see Table 4) on the four math-attitude dimensions also turned out to be statistically significant. Specifically, PMA is found to have statistically significant effect on math self-confidence (F (2,419) = 51.04, p< .0001, , η^2 = .20), enjoyment (F (2,419) = 39.76, p< .0001, , η^2 = .16), and motivation to do math (F (2,419) = 34.94, p< .0001η^2 = .14) and seeing value in math (F (2,419) = 13.35, p< .001, η^2 = .06). The tests of between subject effects for Gender and PMA showed the existence of statistically significant effect on all the four dimensions of math attitude. Nevertheless, it is not yet clear how big the differences are between the sexes (in case of gender) and achievement groups (in case of PMA).

Table 3: Test between subject effects for gender

Source	Dep. Variable	Type IIISS	*df*	MS	F	Partial η^2
Year (A)	Value	0.015	1	0.015	0.064	0
	Enjoyment	0.054	1	0.054	0.162	0
	Motivation	0.706	1	0.706	1.495	.004
	Self-Confidence	0.006	1	0.006	0.015	0
Gender (B)	Value	5.48	1	5.48	23.281**	0.053
	Enjoyment	7.435	1	7.435	22.36**	0.051
	Motivation	19.868	1	19.868	42.076**	0.091
	Self-Confidence	6.52	1	6.52	16.641**	0.038
PMA (C)	Value	6.285	2	3.143	13.35**	0.06
	Enjoyment	26.444	2	13.222	39.764**	0.16
	Motivation	33	2	16.5	34.944**	0.143
	Self-Confidence	39.994	2	19.997	51.037**	0.196
A*B	Value	0.111	1	0.111	0.472	0.001
	Enjoyment	0.001	1	0.001	0.003	0
	Motivation	0.024	1	0.024	0.051	0
	Self-Confidence	0.023	1	0.023	0.058	0
A*C	Value	0.179	2	0.089	0.38	0.002
	Enjoyment	0.132	2	0.066	0.198	0.001
	Motivation	0.135	2	0.067	0.143	0.001
	Self-Confidence	0.971	2	0.486	1.24	0.006
B*C	Value	0.719	2	0.36	1.528	0.007
	Enjoyment	0.744	2	0.372	1.119	0.005
	Motivation	1.897	2	0.949	2.009	0.009
	Self-Confidence	0.205	2	0.102	0.261	0.001
A*B*C	Value	1.933	2	0.966	4.105*	0.019
	Enjoyment	1.61	2	0.805	2.421	0.011
	Motivation	2.262	2	1.131	2.395	0.11
	Self-Confidence	0.877	2	0.439	1.119	0.005

*p < .05, ** p < .0001

To determine these, in each case, pair-wise comparisons are made based on the marginal means. The following section discusses the findings summarized in Tables 4 and 5 below.

4.3. Gender differences in math attitude

In order to determine the magnitude of gender differences **(**see Table 4**)** and among PMA categories **(**see Table 5**),** pair-wise comparisons were made based on estimated marginal means**.** Accordingly, the estimated marginal means showed that males scored significantly higher in the four attitude factors than females. A closer look at the data reveal that on self-confidence males scored higher estimated marginal mean (Mean = 4.06; SE = .04) compared to females (Mean = 3.77; SE = .06). Hence, the magnitude of gender difference in *self-confidence* is statistically significant (F (1,419) = 16.64, p< .0001, η^2= .04). Similar degree of significance variation emerged between the sexes on *value* (F (1,419) = 23.28, p< .0001,η^2 = .05), *enjoyment* (F (1,419) = 22.36, p< .001, η^2 = .05), and *motivation* to do math (F (1,419) = 42.08, p< .0001, η^2= .09) disfavoring females. In other words, compared to females, males feel higher self-confidence and motivation and enjoy in doing math.

Prior-achievement and math attitude

As in the case of gender, pair-wise comparisons were made across the three PMA categories: *high*, *medium*, and *low*. Accordingly, the finding shows that the differences among the PMA groups were statistically significant in all of the math attitude dimensions.

Table 4 Gender differences in estimated marginal means of the math-attitude dimensions

Dependent Variables	Gender	M(SE)	95% C.I.		Pair-wise Comparison				
			Lower B	Upper B	Mean Differences			95% C.I.	
					(F-M)[a](SE)	F	*eta*^{2}	Lower B	Upper B
Self-Confidence	F	3.79(.07)	3.60	3.97	-0.29 (.07)	16.64**	0.05	-0.485	-0.098
	M	4.07(.04)	3.95	4.20					
	Total	**3.93 (.04)**	**3.81**	**4.05**					
Enjoyment	F	3.77(.06)	3.60	3.94	-0.32(.06)	22.36**	0.05	-0.497	-0.134
	M	4.09(.04)	3.95	4.20					
	Total	**3.93 (.04)**	**3.81**	**4.05**					
Motivation	F	3.44(.07)	3.24	3.64	-0.51(.076)	42.08**	0.09	-0.722	-0.290
	M	3.95(.05)	3.81	4.08					
	Total	**3.70(.05)**	**3.57**	**3.83**					
Value	F	4.10(.05)	3.96	4.26	-0.27(.05)	23.28**	0.05	-0.416	-0.113
	M	4.37(.03)	4.27	4.46					
	Total	**4.24(.03)**	**4.14**	**4.33**					

**p <. 0001;[a]F-M = the difference between female and male marginal mean scores

As can be seen from Table 5, the magnitude of differences was the highest in case of self-confidence (*Mean* = .88; *SE* = .09, p. < .001, 95% C.I.:0.71-1.05) and smallest in case of the *value* dimension (*Mean* = .35; *SE* = .06, p < .001, 95% C.I.: 0.22 - 0.49). A closer inspection of the group differences on self-confidence suggest that students in the *high* group scored higher estimated marginal mean (*Mean* = 4.34; *SE* = .07) compared to the *low* group (*Mean* =3.47; *SE* = .06) although variations on the factor is still statistically significant across the three PMA levels (F (2,419) = 51.04, p< .00, η^2 = .20). Similar findings are evident in case of *enjoyment* with the largest variation observed between *high* and *low* groups though the score differences on enjoyment was statistically significant across the three PMA categories (F (2,419) = 39.76, p< .001, η^2= .16). Likewise, the mean score differences on *motivation* (F (2,419) = 34.94, p< .00, η^2 = .14) and *value* (F (2,419) = 13.35, p< .0001, η^2= .06) dimensions were significant for all possible paired comparisons of PMA.

It is evident that students generally saw high value in math with their PMA scores making relatively lower impact vis-à-vis enjoyment, motivation, and self-confidence. This partly demonstrates that students who achieved low in math still tend to believe that learning math is valuable despite their low level of confidence, motivation, and enjoyment in doing math.

Table 5 Estimated marginal means and mean comparisons across the levels of previous math achievement (PMA)

Dependent Variable	PMA	Mean (SE)	95% C.I.		Pair-wise Comparison					
			Lower B	Upper B	Mean Differences				95% C.I.	
					Between levels	SE	F	*eta*^{2}	Lower B	Upper B
Self-Confidence	Low	3.465(.06)	3.281	3.649	L1-L2 = -0.474***	0.081			-0.743	-0.206
	Medium	3.94(.06)	3.744	4.135	L1-L3 = -0.878***	0.088	51.04**	0.20	-1.171	-0.586
	High	4.34(.07)	4.116	4.571	L2-L3 = -0.404***	0.090			-0.704	-0.104
	Total	**3.93(.04)**	**3.81**	**4.05**						
Enjoyment	Low	3.29(.05)	3.40	3.74	L1-L2 = -0.358***	0.075			-0.605	-0.111
	Medium	3.57(.06)	3.74	4.10	L1-L3 = -0.720***	0.081	39.76**	0.16	-0.989	-0.450
	High	4.29(.06)	4.08	4.49	L2-L3 = -0.361***	0.083			-0.637	-0.085
	Total	**3.93(.04)**	**3.81**	**4.05**						
Motivation	Low	3.29(.06)	3.09	3.49	L1-L2= -0.400***	0.089			-0.694	-0.105
	Medium	3.69(.06)	3.48	3.91	L1-L3= -0.804***	0.097	34.94***	0.14	-1.125	-0.483
	High	4.10(.08)	3.85	4.35	L2-L3= -0.404***	0.099			-0.733	-0.075
	Total	**3.70(.05)**	**3.57**	**3.83**						
Value	Low	4.07(.04)	3.93	4.21	L1-L2= -0.131*	0.063			-0.339	0.077
	Medium	4.20(.05)	4.05	4.35	L1-L3= -0.353***	0.068	13.35**	0.06	-0.580	-0.127
	High	4.23(.05)	4.25	4.60	L2-L3= -0.223**	0.070			-0.455	0.010
	Total	**4.24(.03)**	**4.14**	**4.33**						

*p <.05; ** p < .001; *** p < .0001

L_1 = Low achievers = Group of students with lower Mathematics performance than the average; L_2 =Medium = Group of students with equal Mathematics performance to the average; L3 = High achievers = Group of students with better mathematics performance than the average

Discussion

This study was initiated owning to the unfolding macro-level circumstances and global events shaping research agenda in the field of mathematics education. At macro level, at least three outstanding issues could be identified: (a) the growing significance of mathematics resulting from the policy focus on science, technology and engineering education, (b) poor performance in mathematics at all levels coupled with lack of interest and willingness to choose mathematics as a college major, and;(c) the near absence of women math majors in HEIs.

In view of the above, the present study attempted to find out to what extent gender, prior math achievement, and stay in college shape math attitude among Ethiopian university students. Only students' gender and prior math achievement (PMA) are systematically related to attitude towards mathematics. Specifically, females scored significantly lower in math attitude (i.e. in all the four dimensions) than their male counterparts suggesting the latter's superiority not only in the level of confidence, enjoyment, and motivation, but also with respect to attaching high value to doing mathematics. These findings are consistent with the results of similar studies in other cultures (e.g., Tapia and Marsh 2000; Yee 2010) though recent studies show that gender differences are disappearing (e.g., Marsh 1989; Hyde 2005; Spleke 2005) particularly in cultural contexts where gender gap is not apparent (Hyde and Mertz 2009; Else-Quest et al. 2010).

The existing data in Ethiopian context, however, suggest no evidence of "Gender similarities." On the contrary, the variations reported to emerge as early as elementary school age (e.g., Seleshi 2000; 2001; 2005; Tilaye 2004). In the absence of empirical evidence why gender differences in math attitude emerged so early among Ethiopian children (i.e. since the differences between boys and girls do not normally emerge before the onset of puberty or junior school) may be due to the gender stratification hypothesis. Most importantly, one would concur with the sociological theory which claims that the social and economic disadvantage that females experience in collectivist patriarchal societies as they have unequal opportunities to available resources including access to education and gainful employment. The low math achievement among girls at primary level can therefore be partly attributed to what Baker and Johns (1993) refers to as *gender stratification* that demonstrates why traditional cultural contexts deprive girls of equal opportunities which draw empirical backing from the findings of Else-Quest et al. (2010) and Hyde and Mertz (2009) which unveils a systematic link between gender equity/inequity and math achievement and attitude.

The present study also found evidence suggesting that previous mathematics achievement is related to students' math attitude formation. Specifically, the data revealed that high achievers tend to score higher in math self-confidence, enjoyment, motivation, and value compared to their counterparts who were in the "*Medium*" or "*Low*" groups. Interestingly, however, males and females are found to differ significantly (in favor of the former) in all math attitude dimensions including 'value'. This seems to suggest that a gender difference in math achievement may not basically emanate from how females view the value of doing math *per se*. This may persuade us to endorse that gender differences in math related constructs that emerge in adolescent years (e.g., Hyde et al. 1990) are informed by differential treatment accorded to girls to make gender appropriate choice of profession which is also in agreement with the gender stratification hypothesis so that a formation of solid feminine identity can be achieved. This is particularly true in patriarchal societies such as Ethiopia whereby female college students are more likely to undergo the process of traditional sex-role socialization (e.g., Tesfaye, 1997; 2008) partly exacerbated by the absence of women role models in stereotypically masculine careers such as mathematics (Nixon and Robinson 1999) which in turn, thwarts the desire to create sufficient human capital in the fields of science, technology, and engineering education in Ethiopia.

Conclusion

In view of the findings of the study, the following suggestions are worth the attention of policy makers and practitioners:

- Prior mathematics achievement impinges on students' future aspiration to major in mathematics, technology or engineering fields via shaping their math attitude. Thus, boosting students' mathematical skills from early primary grades is the necessary condition to build self-confidence and increase motivation. This requires qualified and motivated mathematics teachers and appropriate curriculum.
- On the other hand, addressing the extant challenges of mathematics education, however, seems to require large scale, nation-wide research on cognitive and affective aspects of mathematics. Such research endeavor should also include ways of improving teacher preparation programs (including content and pedagogical content knowledge), and curriculum development to be complete and meaningful.
- Though closer empirical attention is essential to arrive at conclusive result, it appears that pursuing quick-fix policies (by assigning young undergraduate women, as observed in the study context, exclusively to non-quantitative fields like biology, social science and humanities, languages, and the like in higher education institutions) to maintain more females in the system would have more damaging consequences in the long term than their benefits.

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