

Mathematics-related self-beliefs: How important are they in predicting Achievement? Evidence from lower secondary school adolescents in Bahir Dar

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Abstract: *This study examines the degree to which cognitive and affective aspects of mathematics learning shape adolescents' interest and achievement in mathematics. It specifically investigates age-related patterns of interest and achievement in mathematics based on a randomly drawn sample of 137 (male = 54 and female = 83) grade 9 students in a large urban secondary school in Bahir Dar. The adapted Amharic versions of Mathematics Self-Efficacy (MSE), Mathematics Self-Concept (MSC), Mathematics Interest (Mathematics Interest), and Mathematics Anxiety (Mathematics-Anxiety) scales originally developed for Program for International Student Assessment (PISA) were employed to collect data. Mathematics Achievement (MAch) was measured based on composite mean class scores. The adapted Amharic measures yielded acceptable internal consistency reliabilities ranging from 0.67- 0.81 and statistically significant convergent and discriminant validity coefficients among the four sub-scales ($r = -.20, p < .05$ to $r = .67, p < .001$). Hierarchical and simultaneous Multiple Regression procedures were used to address the major research questions. The findings revealed that MSE and MSC are strong predictors of Mathematics interest and achievement. On the other hand, MAch is significantly predicted by Gender, Mathematics-Anxiety, and mathematics related self-beliefs (MSE and MSC). A declining trend in Mathematics-Interest and achievement is also evident with increasing age. Finally, the study outlines the implications of the findings.*

Key words: Mathematics self-efficacy, Mathematics self-concept, Mathematics interest, Mathematics anxiety, Mathematics achievement, adolescence, Ethiopia,

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Introduction

Since the past decades, there has been a growing shift towards Science, Technology, Engineering and Mathematics (STEM) oriented school curricula in many education systems globally. Particularly in the Western world, such type of curriculum has received considerable attention leading to the introduction of two major international student assessments: *Trends in International Mathematics and Science Study* (TIMSS) and *Program for International Student Assessment* (PISA) to ensure national competitiveness in the globalized economic order through gauging the performance of the young generation in STEM fields. For instance, the US National Academy of Science (NAS) is reported to have alarmed relevant authorities, professionals and practitioners that America needs more human resources trained in STEM fields in order to remain the leading economic power (NAS, 2007, 2010, in Riegle-Crumb, Moore, and Ramos-Wada, 2010). The growing desire for more competitive labor force in science, technology, engineering and mathematics in the West and East alike also triggered similar reforms in sub-Saharan African countries. The policy shift has thus fueled increased research to explain the cognitive and affective dimensions of science and mathematics learning (e.g., Semela and Zeleke, 2012). In Ethiopia, notwithstanding the policy favoring STEM, student performance particularly in science and mathematics has remained rather low as demonstrated in National Learning Assessments (ENLAs) in 2004, 2008, and 2012 (Joshi and Vaspoor, 2013; USAID and MoE, 2008). In view of the importance attached, it is critical to understand what underpins success in learning STEM related school subjects in general and mathematics in particular. Apart from the role of other contextual variables such as parental cultural capital, teacher characteristics, and school climate factors (OCED, 2005, 2012) the significance of affective and cognitive variables including adolescents' self-cognition and motivation (e.g., interest in mathematics) have been widely employed as key variables of empirical research in international assessments including the Program for International Student Assessment (PISA).

The present study is a modest attempt at addressing how Ethiopian grade 9 students measure in mathematics related self-cognition (i.e., Mathematics Self-efficacy and Mathematics self-concept), and mathematics related affect which includes intrinsic motivation (i.e., mathematics interest), and mathematics anxiety. Apparently, it is a subject in search of empirical attention. To date, little has been done in the field except scattered evidence related to gender differences in mathematics attitude and achievement among university students (e.g., Zeleke and Semela, in press), Mathematics performance at primary level (Seleshi, 2001, 2005; Tilaye, 2004), adaptation of Mathematics attitude scale (Semela and Zeleke, 2012). As such, it can be argued that the available empirical evidence is not only inadequate, but also highly fragmented. Thus, it is essential to assess how cognitive and affective aspects of mathematics learning shape adolescents' mathematics achievement; and their pattern with respect to age and gender. Besides, generating empirical data on the underlying motivational factors governing students' mathematics achievement provides scientific evidence to improve educational practice including how students should be taught, curricula and textbooks are prepared, teachers are trained, to mention a few. These are some of the implications of research studies focusing on cognitive and affective aspects of learning in different subject matter areas including those of STEM fields. However, the present study does not claim to address the range of STEM related subjects that young adolescents experience in secondary schools. Nor does it cover all secondary grade levels i.e., Grades 9 to 12. Instead, it is inspired by the results of PISA studies conducted in OECD (Organization for Economic Cooperation and Development) member countries over the past decade and half. PISA focuses on the group of 15 years old students which normally corresponds to grade 9 in the OECD sample. Nonetheless, it is important to note the fact that the situation in OECD countries is different from the reality in Ethiopia at least for two reasons. First, unlike in the OECD countries where grade level is interchangeably used to indicate age, there are indications that in Ethiopia the average age tends to be higher than that of their counterparts in OECD.

Secondly, there is a strong possibility that visible within grade-age differences may exist in any random sample of grade nine students in Ethiopian context. Hence, the present study takes grade level as its reference point.

This article is organized as follows: section two reviews pertinent literature to provide the analytical backdrop with particular reference to the relationships and effects of cognitive and motivational variables on mathematics interest and achievement, followed by section three which describes the target population, sampling methods, instrumentation, and data analyses procedures. Section four discusses the findings. Highlighting the key findings and limitation therein, section five, by highlighting the key findings and limitations, presents the conclusion and recommendations for policy makers.

Review of Literature

This part explores the theoretical, empirical, and methodological literature. It specifically reviews studies that establish systematic and empirical links between students' demographics and mathematics related affective and cognitive factors. Of special interest is finding tentative explanations to the questions: how age and gender influence the development of interest and achievement in mathematics in adolescence. The sections that follow explore relevant literature by way of providing tentative explanations to the above stated research questions.

Adolescent identity development and expectation of academic success

The target group of the study is between the age of 14 and 20 years - characterized as "adolescence" which according to Erick Erikson is a period of *storm and stress*. This is precisely because adolescents undergo rapid physical, socio-emotional, and cognitive changes. As such, the period of adolescence characterizes the time when the issue of individual identity takes a central place. To emerge from the ashes of

“identity crisis”, adolescents would like to find answers to several questions including: *Who am I? ...What is my place in my social group? What do I value? What do I want to do with my life* (Eccels, 2009:78)? Eccels (2009) classifies the precursors of adolescent’s identity formation in two major categories: (a) perception of self with respect to skills, characteristics, and competencies, and (b) perceptions related to personal values and goals. Eccels argues that the two sets of self-perception inform a young person’s expectation of success and the importance he/she attaches to actively engage in a range of academic tasks. In other words, motivated action in academic tasks is fueled by students’ positive self-evaluations of own skills and competencies regarding a given task or domain on the one hand, and the extent enjoyment in that particular academic task or domain consistent with adolescents’ personal values and future goals. For instance, an adolescent’s decision to seriously engage in learning and achieve higher in mathematics depends both on his/her self-perception (self-evaluation) of mathematics skills and abilities as well as becoming a mathematics is consistent with his/her personal values and future goals. These personal values and goals, according to Eccels (2009), are the ones that define adolescents’ collective identities (with respect to adolescent’s gender, religion, ethnicity, race, social class etc). Accordingly, if becoming a mathematics is inconsistent with personal values, the student will not engage as seriously as one would have to. This, in turn, leads to a decline in the level of the adolescent’s engagement in learning and engaging in mathematics tasks which results in a corresponding decline in achievement; and this would, in turn, negatively impinge on intrinsic motivation (or interest) as well as mathematics-related self-beliefs. In this vein, Eccles, Wigfield, and colleagues conducted studies regarding the development of mathematics values during the 1980s and 1990s. They consistently found a decline in intrinsic mathematics values in among adolescents across the transition to junior high school and into the high school years (Eccles et al., 1983, 1989; Eccles, Adler, and Meece, 1984; Wigfield, Eccles, Mac Iver, Reuman, and Midgley, 1991, in Eccels, 2009). Thus, this study suggests the decline in mathematics interest,

and mathematics related self-beliefs among adolescents could be attributed to identity development.

Self-Beliefs and Cognition and Mathematics Learning

Though self-beliefs are applicable in a wide range of areas, ability-related self-beliefs have received considerable empirical attention in scholarly literature. However, the terms self-cognition or self-beliefs are interchangeably used to refer to individual's own perceptions of self. More often than not, the available literature on academic/ability-related self-beliefs focuses on self-concept and self-efficacy (Bong and Clark, 1999). Thus, it should be noted that the two constructs - *self-efficacy* and *self-concept* - though considered to fall under a single, broader conceptual category of "self-beliefs", they are not one and the same. Accordingly, Bong and Clark (1999:139) delineate the boundaries between the two as follows:

From the conceptual perspective, self-concept emerges as a more complex construct incorporating both cognitive and affective responses toward the self and is heavily influenced by social comparison. Self-efficacy, in contrast, concerns primarily cognitive judgments of one's capabilities based on mastery criteria. Despite these differences, the 2 [sic] constructs demonstrate similar internal structures that are multifaceted and hierarchical.

The above distinction is consistent with Bandura's (1986:391) earlier definition of *self-efficacy* as *people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances*. This implies that students' self-efficacy in specific academic domain, for instance mathematics, affects their choice of activities, effort, and persistence in learning the same subject (Bandura, 1977). However, self-efficacy is not the same as self-concept because the latter, apart from being conceptually complex than the former, is shaped by social comparison (Bong and Clark,

1999). In other words, a student's mathematics self-concept is determined by the social context (i.e., ability of students with which he is learning). Therefore, it is not only student's individual judgment of his/her mathematics ability that shapes his/her mathematics self-concept, but also how good he/she is in relation to his/her classmates. On the other hand, since self-efficacy primarily capitalizes on individual's judgments of her/his abilities, it mainly constitutes the cognitive dimension as a construct. As such, the individual does not make reference to social context as in the case of self-concept.

Mathematics-related self-beliefs: Conceptualization and correlates

As discussed above, mathematics self-efficacy refers to the degree to which students believe that they can successfully perform given academic tasks at the desired level of proficiency (Schunk, 1991). It follows that better performance in mathematics leads to higher levels of self-efficacy while low performance likewise results in lower level of self-efficacy. In other words, other things being constant, students who have low levels of mathematics self-efficacy are very likely to perform poorly in mathematics (Bandura, 1997; Schunk and Pajares, 2009). Moreover, if students do not believe in their ability to accomplish particular tasks, they will not exert the effort needed to successfully complete the tasks (Schunk, 1991). On the other hand, unlike self-efficacy, self-concept is a generalized construct which constitutes both cognitive and affective dimensions (Bong and Clark, 1999). What is more, it is theoretically argued that self-concept is highly influenced by social comparison (i.e. comparing oneself with peers or a student compares her performance with that of her class average) which results in the student's judgment of self-worth, which is referred to as *self-esteem* (Bong and Clark, 1999; Marsh, 1990). At empirical level, however, studies show that students' mathematics self-concept or belief in their own mathematics abilities is an important outcome of education and strongly related to successful learning (Marsh, 1986; Marsh and O'Mara, 2008). Longitudinal studies that examined the existence of relationship between mathematics self-concept and

achievement further confirm that they are reciprocally related over time (Marsh and Martin, 2011; Marsh, Xu, and Martin, 2012).

Developmental Trends in Learning Mathematics: Gender and Age-related Changes

In the following, research studies focusing on gender and age-related developmental trajectories in mathematics related self-beliefs and cognition, interest and anxiety as relates to mathematics achievement are explored.

Gender Effects on Mathematics-related Cognitive and Motivational Factors

There has been substantial body of research devoted to unpacking gender differences in mathematics achievement and mathematics-related affective and cognitive factors. In this field there are two strands of research results that represent contrasting pattern. The first and the dominant strand is the one that is exclusively tuned to searching *differences* without attempting to explain what accounts for the variations (e.g., Jacobs et al., 2002; Marsh, 1990). The second strand of research on gender differences in mathematics seeks to unravel those factors rather actively be including environmental variables such as differential socialization practices, gender stereotypes (e.g., Spencer, Steele, and Quinn, 1999), and macro-level analysis of gender gaps (e.g., Else-Quest, Hyde, and Linn, 2010). In this vein, Else-Quest, Hyde, and Linn (2010) and Hyde and Mertz (2009) claim to confirm what Hyde (2005) characterized as “*Gender similarity hypothesis*” - revealing no differences in mathematics achievement and attitude between boys and girls in countries where there was no gender gap was evident while the opposite was true in countries where gender gap prevailed.

Taken together, there has been consistent findings that demonstrate gender differences in mathematics related cognitive and affective

factors expected to disfavor girls in the study context as found earlier among first year university students (e.g., Zeleke and Semela, in press) due to the apparent gender gap in all walks of life—in the professions, higher education, traditionally masculine careers like engineering, even as secondary school teachers where women are seriously under-represented.

Age-related Trajectories in Mathematics-related Self-beliefs, and Mathematics Interest

Below, the theoretical and empirical literature on age-related developmental trends of mathematics self-concept, interest, and achievement are explored with specific reference to middle-school age children and adolescents.

Changes in Self-concept over Time

Research has provided significant evidence about how self-concept changes over time. Many studies find that children (especially girls) have a declining academic self-concept through their adolescence (de Fraigne et. al., 2007; Eccles et al., 1993). But, as children grow older, academic self-concept may also become more stable and reliable (Guay, Mars, and Boivin, 2003). On the question of the relationship between self-concept and achievement, specifically on the strength of the association over time, the results appear mixed. Although Guay, Mars, and Boivin (2003) argue that self-concept becomes more strongly associated with academic achievement outcomes over time, their assertion contrasts with de Fraigne et. al. (2007), who found that the association between academic self-concept and language achievement becomes weaker with age. In this study, the association between academic self-concept and achievement at the individual level is rather strong at the start of high school. By the end of high school, however, this relation is much weaker, especially for girls. These findings suggest that academic self-concept changes over time and this can be taken up for future research.

Mathematics Interest in Developmental Perspective

Scholars in the area of interest development (e.g. Hidi, 2000; Krapp, 2000; Schiefele, 2001) seem to agree that interest declines from childhood through adolescence to adulthood. Lose of interest, according to Hidi (2000), may be explained by factors inherent in age-related changes, such as increased task complexity, demands for effort, and a resultant lack of the intrinsic attractiveness of academic contents as well as changes in social relationships during adolescence.

Regarding the empirical evidence for developmental trends in mathematics interest, the available literature is limited at best. Particularly, reliable data on African adolescents is almost non-existent. Thus, studies reviewed here depend largely on Australian, European, or North American sample. Accordingly, Köller et. al. (2001) longitudinally analyzed mathematics interest in students from German high-ability track schools (Gymnasium) at three time points (end of grade 7, end of grade 10, and middle of grade 12). Based on repeated measures of ANOVA, they reported consistent downward trends of interest in mathematics during that period.

Furthermore, large-scale longitudinal studies in Australia and the US provided important empirical data regarding the development of adolescents' mathematics related values (Fredricks and Eccles, 2002; Jacobs et al., 2002; Watt, 2004). Using latent growth curve modeling, the studies reported curvilinear declines of intrinsic mathematics values, which were more pronounced in earlier years and then plateaued in senior years (cited in Frenzel et. al., 2010). As it turned out, smooth quadratic growth trajectories fitted these declines well, even in the U.S. data set, which involved two school transitions during the observed time period, suggesting that those transitions did not dramatically affect the development of values. Nevertheless, Jacobs, Lanza, Osgood, Eccles, and Wigfield (2002) attributed some of the declines to transition-related changes in school environments.

Statement of the Problem

One may wonder why research, more than anything else, should focus on mathematics education. The reason is not only apparent, but more pressing than many people outside the educational practice might think. Today, more than ever, more engineering majors fail to pass introductory calculus courses. Mathematics, which is widely believed to be the language of science and engineering, seems to be less understood and not favored by students who receive F's and are forced to repeat courses (MoE, 2015; personal communication with Mathematics instructors at Bahir Dar and Hawassa Universities, 2015). This is also confirmed by the disappointing Mathematics performance in Ethiopian National Learning Assessment (ENLA) in Grades 10 and 12 (Eshetu et al., 2009; Joshi and Vaspoor, 2013; MoE, 2011; USAID and MoE, 2008). In view of these, it is important that sufficient empirical attention be given to understand the state of mathematics learning and achievement starting from early grades. The present study represents just an iota in the huge empirical effort needed to understand the problem under question. Yet, it can still serve as a point of departure for much larger scholarly endeavor.

Research questions

In view of the above, the present article addresses the following:

- the level of mathematics related self beliefs (MSE and MSC) of adolescents;
- the level of interest of grade 9 students to learn mathematics;
- the level of mathematics anxiety among grade nine students in the target population;
- whether the interest and achievement of boys and girls are connected to the same kind of background (i.e., age), mathematics-related cognitive and motivational variables (mathematics anxiety, self-efficacy, and self-concept), and

- how important mathematics related self-beliefs are in predicting mathematics interest and achievement when the effects of other covariates (age, gender and anxiety) are controlled.

Methodology

The study design, target population and sampling techniques, development and adaptation of the data gathering tools, and the methods of data analyses employed are discussed below.

Study Design, Population, and Sampling Techniques

Based on correlational survey design, the study specifically focuses on grade 9 students in a purposively selected urban secondary and preparatory school, in Bahir Dar City, the capital of the Amhara Regional State. The sample was randomly drawn from a total population of 902 grade 9 students (male= 438, female = 464) in Tana Haiq Secondary and Preparatory School. Of the 197 respondents randomly selected to participate in the study, 190 returned completed questionnaires. However, only 137 (83 females and 54 males) were considered in the final data analysis due to missing data on 53 cases.

Instruments of Data Gathering

The study employed adapted Amharic measures of Mathematics Self-Efficacy (MSE), Mathematics Self-Concept (MSC), Mathematics interest (Mathematics Interest), and Mathematics anxiety (Mathematics Anxiety). Biographical information on the respondents was obtained with the help of a questionnaire administered along with the adapted scales. Data on students' mathematics achievement were obtained from students' individual self-report. Below is given the details on the instrument adaptation and validation process.

Adapting the PISA (2003, 2012) scales

For the purpose of the present study, the PISA 2003 mathematics self-efficacy, mathematics self-concept, mathematics interest, and mathematics anxiety measures were adapted and translated into Amharic by the present researchers. PISA instruments are used because the measures are applicable world-wide including African OECD member countries. Besides, render the comparison of scores we obtain in this study with international standards (see OECD, 2005 for more).

- *Mathematics Self-Efficacy (MSE)*: The Adapted MSE measure consisted of eight items measured in a five-point Likert-type scale rated from “Highly confident” to “Not at all confident.” The response set begins with the general question: *How confident do you feel about having to do the following Mathematics tasks?* Sample question in this sub-scale include: “Calculating how much cheaper a TV would be after a 30% discount.” and “Solving an equation like $3x+5= 17$.” The MSE measure was then further scrutinized in terms of content. In particular, since MSE is conceptually based on what students should have mastered at that level from the school curriculum, the contents of the original MSE items were assessed against mathematics syllabi of grades: 7-9 (see: Mathematics Textbooks, Grades 7-9, MoE for details).
- *Mathematics Self-Concept (MSC)*: MSC was measured using the adapted Amharic MSC scale which was also used in PISA (2003, 2012). The adapted Amharic MSC measure included items like: “*I get good marks in Mathematics*” and “*I learn Mathematics quickly*”. The total number of items of the adapted Amharic MSC scale was four since one of the items was discarded owing to very low total-item correlation ($r = .12$). Of the remaining four items, one negatively phrased item (Item 1) was inverted for scaling. Thus, high score in the Amharic MSC scale is interpreted as high mathematics self-concept. Thus, the final

four-item MSC-Amharic measure yielded moderate internal consistency reliability ($\alpha = .67$) which was less than that of the original English version (see: Table 1 for details).

- *Mathematics Interest (M_Interest)*: The adapted four-item Amharic M_Interest measure was originally developed following Wigfield et al. (1997) dimensions tapping the “enjoyment” aspect of task interest (as opposed to the usefulness/importance aspect). The scale includes items like: “*I look forward to my Mathematics lessons*” and “*I am interested in the things I learn in Mathematics*”. No items were inverted for scaling because they were positively phrased. Positive scores indicate higher levels of interest in and enjoyment of Mathematics. The internal consistency reliability of the adapted, four-item Amharic M_Interest scale was found to be high ($\alpha = .81$), though slightly lower than that of the original English version ($\alpha = .88$).
- *Mathematics Anxiety (M_Anxiety)*: The original PISA Mathematics Anxiety measure was made up of five items ($n = 5$; $\alpha = .81$) developed in line with Wigfield and Meece (1988). According to the authors, the scale taps the “worry” component of mathematics anxiety (as opposed to the affective component). Sample items in this measure consisted of items like: “*I feel helpless when doing a Mathematics problem*” and “*I worry that I will get poor marks in Mathematics.*” All items were reverse-coded for scaling and ease of interpretation. Hence, higher scores indicate higher levels of mathematics anxiety. The internal consistency reliability of the Amharic M_Anxiety measure is high ($\alpha = .79$) though it is marginally lower than the original instrument as depicted in Table 1.

Validity Evidence

Both convergent and discriminant validity evidences were established using bivariate correlations among the four adapted Amharic measures of MSE, MSC, M_Interest, and M-Anxiety. As shown in Table 1,

statistically significant correlation was obtained between MSE and MSC, constructs believed to capture mathematics-related self-beliefs which, according to Bong and Clark (1999), constitute similar internal structure. Moreover, the measures constitute two scales of related constructs as both MSE ($r = .49, p < .01$) and MSC ($r = .62, p < .01$) showed significant positive correlations with M_Interest which taps “individual interest” (or enjoyment) dimension of mathematics learning. In contrast, mathematics-related self-belief measures i.e., MSE ($r = -.20, p < .05$) and MSC ($r = -.36, p < .01$) showed significant negative correlations with M_Anxiety. These suggest that students with positive mathematics related self-beliefs tend to experience less mathematics anxiety than those with negative mathematics related self-beliefs (Ma, 1999). On the other hand, the correlation of M_Anxiety with M-Interest ($r = -.14, ns$) was negative but not statistically significant. As such, M_Interest and M_Anxiety are inversely related, yet relatively independent from each other.

Table 1: Internal consistency reliabilities of original and adapted scales

Scale	English version		Amharic Version			Inter-correlations			
	<i>k</i>	α	Mean (SD)	<i>k</i>	α	1	2	3	4
1.MSE	8	0.816	3.72(.74)	8	0.811	-	.46**	.49**	-.20*
2.MSC	5	.886	3.45(.84)	4(1) ^a	0.665		-	.62**	-.36**
3.M_Interest	4	0.881	3.37(1.0)	4	0.808			-	-0.14
4.M_Anxiety	5	0.812	2.56(.95)	5	0.791				-

* $p < .05$, ** $p < .01$; *** $p < .001$

Note: ^aItem 5 had been removed from the Amharic MSC Scale due to low item-total correlation (< 0.30)

The inter-correlation results based on the four adapted Amharic measures (see: Table 1) provide empirical support regarding the cross-cultural validity of the constructs (i.e., Construct validity) and are also consistent with the findings of PISA (2003, 2012). Besides, similar to

the reliability and validity coefficients obtained on internationally representative sample, the indices of the adapted Amharic measures revealed significant and high correlations among mathematics self-efficacy, mathematics self-concept, and Mathematics anxiety. Likewise, the PISA study similarly found inverse relationship between MSE and M_Anxiety while the former (i.e., MSE) positively correlated with MSC. Besides, M-anxiety and MSC showed high negative correlation of about -0.80 (OECD, 2005). Overall, the adapted Amharic MSE, MSC, M_Interest, and M_Anxiety measures were found to be valid instruments to capture the constructs they purport to measure.

- *Mathematics Achievement (MAch)*: MAch was captured based on their first semester average scores of the 2014/15 academic year. The data were obtained from student self-reports included in the questionnaire. The raw scores were then transformed into standard scores (Z-score), and later to T-Scores to achieve the same mean and standard deviations. The bases for that was that **though** the mid-term and final examinations were the same for all the respondents, **though** the students' were taught by different teachers.

Data Analysis

Before running the final statistical analyses, preliminary cross-tabulations and frequency analysis were carried out for all variables in the questionnaire. Accordingly, variables with incorrect data, and cases with missing values were identified. Errors during data entry were corrected while cases with missing values were excluded from the final analysis. The remaining sample size following the removal of cases with missing values was sufficiently large ($n = 137$) to run the analyses. Then, data interpretation was made using descriptive statistics, line graphs, one-sample t-test, standard (simultaneous) and hierarchical multiple regression analyses.

Findings

This part attempts to answer the research issues mentioned above. In so doing, first answering the question: What is the level of adolescents' mathematics related self-cognition (i.e., mathematics self-efficacy and mathematics self-concept), mathematics-interest and mathematics-anxiety? The analysis a typical grade 9 as a reference.

Adolescents' Mathematics-related Self-cognition

As reported earlier, randomly selected grade 9 adolescents from the target population were asked about their mathematics related self-beliefs, i.e., their mathematics self-efficacy beliefs and mathematics self-concept. Table 2 presents summary of the results.

By employing the Amharic version of the Mathematics Self-Efficacy (MSE) scale, the researcher asked respondents to rate their level of confidence to do eight different mathematics tasks. The questions in the MSE measure are grade appropriate and included in Ethiopian mathematics syllabi. To answer the key research question: "How confident are grade 9 students in solving mathematics tasks?" students' observed mean scores on each MSE item was compared against set criteria (set as "confident" = 4). In SPSS language it is called "test value", but in statistical literature it is known as population mean: $\mu = 4$ (meaning, "I am confident"). As can be evident, the observed mean scores of all the MSE items were found to be less than four (which was set as criteria for comparison). This is evident from the negative t values. However, of the eight items, students' mean scores are particularly low for five out of the eight MSE items. These were: "Using a train timetable to work out how long it would take to get from one place to another" ($M = 3.57$; $SD = 1.07$, $t = -4.71$, $p < .001$), "Calculating how many square meters of tiles you need to cover a floor" ($M = 3.61$; $SD = 1.16$, $t = -3.91$, $p < .001$), "Finding the actual distance between two places on a map with a 1:10,000 scale" ($M = 3.49$; $SD = 1.20$, $t = -4.98$, $p < .001$), "Solving an equation like $2(x+3) = (x+3)(x-3)$ "

($M = 3.76$; $SD = 1.23$, $t = -3.82$, $p < .05$), and “*Calculating the petrol consumption rate of a car*” ($M = 3.58$; $SD = 1.28$, $t = -3.82$, $p < .001$).

On the other hand, on the remaining three items: “*Calculating how much cheaper a TV would be after a 30% discount*” ($M = 3.94$, $SD = 0.97$, $t = -0.71$, *ns*), “*Understanding graphs presented in newspapers*” ($M = 3.88$; $SD = 1.03$, $t = -1.41$, *ns*), and “*Solving an equation like $3x+5= 17$.*” ($M = 3.93$, $SD = 1.13$, $t = -0.68$, *ns*) the observed means did not differ from the criterion score (i.e., 4 or “confident”). This generally suggests that the average grade nine student is more or less confident to successfully solve three out of eight mathematics tasks. As such, it can safely be concluded that the average (or typical) grade nine student has low MSE in the target population.

Table 2: Mathematics self-efficacy among Grade 9 young adolescents (Test Value = 4: I am confident), N = 137

<i>Mathematics Self-Efficacy (MSE)</i>				
No.	<i>How confident do you feel about having to do the following Mathematicsematics tasks?</i>	Mean ^a	SD	t
1	Using a train timetable to work out how long it would take to get from one place to another.	3.57	1.07	-4.71***
2	Calculating how much cheaper a TV would be after a 30% discount.	3.94	0.97	-0.71(ns)
3	Calculating how many square meters of tiles you need to cover a floor.	3.61	1.16	-3.91***
4	Understanding graphs presented in newspapers.	3.88	1.03	-1.41(ns)
5	Solving an equation like $3x+5= 17$.	3.93	1.13	-0.68(ns)
6	Finding the actual distance between two places on a map with a 1:10,000 scale.	3.49	1.20	-4.98***
7	Solving an equation like $2(x+3) =(x+3)(x-3)$.	3.76	1.13	-2.49*
8	Calculating the petrol consumption rate of a car.	3.58	1.28	-3.82***
<i>Mathematics Self-Concept^b (MSC)</i>				
No.	<i>Thinking about studying Mathematics: To what extent do you agree with the following statements</i>	Mean	SD	t
1	I am just not good at mathematics ^c .	3.49	1.18	5.06***
2	I get good marks in mathematics.	3.46	1.04	-6.06***
3	I learn Mathematics quickly.	3.25	1.11	-7.93***
4	I have always believed that mathematics is one of my best subjects.	3.59	1.39	-3.45**

*p< .05, ***p < .001

Notes: -^aThe observed means of Mathematics Self-Efficacy (MSE) items were compared against a specified mean (or test value) =4 ("I am confident"),^bThe observed mean of Mathematics self-concept (MSC) items were compared against a specified mean (Test value) = 4 ("Agreement"); ^c The item is reverse coded.

Similar analyses on the four-item *Amharic* mathematics self-concept (MSC) (see Table 2, lower part) confirmed the findings reported above in case of MSE. In this study MSC is defined as students' own self-evaluation about their mathematics ability. As it turned out, all the t-values bear negative coefficients indicating that an average ninth grader in the target population, regardless of age, gender, and other background differences, hold negative self-concept of ability in mathematics. Accordingly, with the exception of the first item ("*I am just not good at mathematics*") [$M = 3.49$, $SD = 1.18$, $t = 5.06$, $p < .001$] which is a negatively phrased item (re-inverted scaling for this analysis) the t-values for the remaining three items: "*I get good marks in mathematics*" ($M = 3.46$, $SD = 1.04$, $t = -6.06$, $p < .001$), "*I learn mathematics quickly*" ($M = 3.25$, $SD = 1.11$, $t = -7.93$, $p < .001$), and "*I have always believed that mathematics is one of my best subjects*" ($M = 3.69$, $SD = 1.39$, $t = -3.45$, $p < .01$) are all negative and statistically significant beyond .01 level. This will lead us to conclude that other things kept constant, a typical grade 9 student has negative mathematics self-concept.

Table 3: Mean, SDs and One-Sample t-values of Mathematics Interest and Mathematics Anxiety

<i>Mathematics Interest^a</i>				
No.	<i>Thinking about your views on mathematics: To what extent do you agree with the following statements?</i>	Mean	SD	t
1	I enjoy reading about mathematics.	3.28	1.25	-6.71***
2	I look forward to my mathematics lessons.	3.34	1.27	-6.03***
3	I do mathematics because I enjoy it.	3.30	1.34	-6.11***
4	I am interested in the things I learn in mathematics.	3.56	1.17	-4.39***
<i>Mathematics Anxiety^b</i>				
S.No	<i>Thinking about studying mathematics: To what extent do you agree with the following statements?</i>	Mean	SD	t
1	I often worry that it will be difficult for me in mathematics classes.	3.10	1.25	10.32***
2	I get very tense when I have to do mathematics homework.	3.53	1.28	13.91***
3	I get very nervous doing mathematics problems.	3.50	1.31	13.40***
4	I feel helpless when doing a mathematics problem.	3.55	1.31	13.88***
5	I worry that I will get poor marks in mathematics.	3.51	1.28	13.77***

***p < .001, ^aTest value = 4 ("Agree"); ^bTest value = 2 ("Disagree")

Developing interest for a certain school subject such as mathematics may be due to either its intrinsic value (enjoyment) or extrinsic value such as possible future job opportunity (perceived usefulness; Wigfield et al., 1997). The data in Table 4 (upper), however, only captures the enjoyment aspect of doing or learning mathematics (also referred to as "*individual interest*"). As can be evident, all the observed mean scores are below 4 (which refer to average mean rating equivalent to "Agreement"). Besides, all the t-values are negative and significant (p < .001) indicating that the average grade nine student in the target population has low mathematics interest. As such, while the lowest observed mean score was found on the statement: "*I enjoy*

reading about mathematics” (Item 1: Mean = 3.28, SD = 1.25, $t = -6.71$, $p < .001$) while the highest was on: *“I am interested in the things I learn in mathematics”* (Item 4: Mean = 3.28, SD = 1.25, $t = -4.39$, $p < .001$).

In case of mathematics anxiety (M_Anxiety), the observed mean scores for all items exceeded the “Test value” = 2 (which represents “Disagreement”) with positive and significant t-values ($p < .001$) (see Table 4, lower). Meaning, other things being the same, the average grade 9 student in the target population generally experiences higher level of M_Anxiety. Specifically, the higher mean scores on all items suggest that a typical student: worries that mathematics classes would be difficult for him/her (Item 1: Mean = 3.10, SD = 1.25, $t = 10.32$, $p < .001$); experience tension when he/she has to do mathematics homework (Item 2: Mean = 3.53, SD = 1.28, $t = 13.91$, $p < .001$); get nervous when doing mathematics problems (Item 3: Mean = 3.50, SD = 1.31, $t = 13.40$, $p < .001$); feel helpless when doing a mathematics problem (Item 4: Mean = 3.55, SD = 1.31, $t = 13.88$, $p < .001$); and, worries that he/she will get poor marks in mathematics (Item 5: Mean = 3.51, SD = 1.28, $t = 13.77$, $p < .001$).

Taken together, based on the results, the average grade 9 student in the target population showed higher level of mathematics anxiety (M_Anxiety), lower levels of self-efficacy (MSE), self-concept (MSC) and interest (M_Interest) in mathematics. This does not mean that there were no adolescents in grade nine with low mathematics anxiety, high MSE and MSC and interested in learning and doing mathematics. What the findings demonstrate, however, is that the majority of the students in the target population performed very low in most important motivational aspects of mathematics learning. This would strongly influence students’ performance and future success in mathematics, and in turn, in other STEM related subjects.

Likewise, the following issues will be addressed below; (a) to what extent these four variables (MSE, MSC, M_Interest, and M_Anxiety) are empirically related with students’ age, gender, and mathematics

achievement (MAch), (b) How strongly mathematics related self-beliefs (i.e., MSE and MSC) predict MAch and M_Interest in the same domain, (c) whether there is age-related, developmental (coupling) pattern of mathematics interest and MAch?

Table 4: Mean, SD, and Inter-correlations of the study variables

Variables	1	2	3	4	5	6	7	M	SD
1 Age	-	-.09	-.15 ⁺	-.23 ^{**}	-.28 ^{**}	.03	-.01	16.52	1.77
2 Gender		-	-.04	-.12	.00	.22 [*]	-.28 ^{**}	0.61	0.49
3 MSE			-	.46 ^{**}	.49 ^{**}	-.20 [*]	.40 ^{**}	3.72	0.74
4 MSC				-	.62 ^{**}	-.36 ^{**}	.45 ^{**}	3.45	0.84
5 M_Interest					-	-.14	.23 ^{**}	3.37	1.00
6 M_Anxiety						-	-.36 ^{**}	2.56	0.95
7 MAch							-	50.00	10.00

+p < .10, *p < .05, **p < .01, ***p < .001

Notes: MSE = Mathematics Self-Efficacy, MSC = Mathematics Self-Concept, M_Interest = Mathematics Interest, M_Anxiety = Mathematics Anxiety, and MAch = Mathematics Achievement

Bivariate Relationship among the Variables

The inter-correlation results (see Table 4) show the bivariate linear relationships among the key variables of interest for which there exists some empirical or theoretical backing. The results suggest that students' age and gender represent distinct patterns of relationships with mathematics related self-cognition (i.e., MSE and MSC), mathematics interest, and mathematics anxiety. Specifically, age correlated significantly negatively with MSC ($r = -.28$, $p < .01$) and Mathematics Interest ($r = -.28$, $p < .01$) with a similar yet less strong linear relationship with MSE ($r = -.15$, $p < .10$), and very weak negative correlation with Mathematics achievement (MAch) ($r = -.01$, *ns*). On the other hand, gender seems to have no relationship with Mathematics Interest ($r = .00$, *ns*), though it has strong inverse relationship with MAch ($r = -.28$, $p < .01$). Moreover, MAch correlated positively and

significantly with Mathematics-related self-beliefs, namely, MSE ($r = .40$, $p < .01$) and MSC ($r = .23$, $p < .01$), while in contrast, strong inverse relationship was observed between MAch and M_Anxiety ($r = -.36$, $p < .01$). These findings not only confirm expectations, but they are also in agreement with the existing literature in the field (e.g., Beilock and Maloney, 2015; Parker et al., 2014; Preston, 1986).

Overall, from the bivariate correlations, it is possible to indicate which predictors may be selected for the further multivariate analysis with the help of simultaneous and hierarchical procedures of multiple regression analyses. In particular, the preference for hierarchical multiple regression analysis was based on its inherent advantage of controlling the effect of other independent variables except the variables of interest (Tabachnick and Fidell, 2013).

Predictors of Mathematics Interest

As shown in Table 5, the effect of “Age” is inverse, and statistically significant in Model I (Age: $\beta = -.28$, $p < .01$) in predicting mathematics interest while “Gender” ($\beta = -.02$, *ns*) played no role in the predictive relationship with overall percentage of shared variance that accounted for only 7.9% ($R^2 = .079$, $p < .01$). However, with the introduction of mathematics Achievement (MAch: $\beta = .24$, $p < .01$) in *Model II* apart from yielding significant predictive relationship with M_Interest, it has substantially increased the overall percentage of variance ($R^2 = .131$, $adjR^2 = .111$) contributing about 5.2% ($\Delta R^2 = .052$, $p < .01$) additional variance to the overall prediction. The inclusion of Mathematics Self-Efficacy (MSE: $\beta = .44$, $p < .001$) in *Model III*, however, caused a dramatic loss of effect of MAch ($\beta = .05$, $r^2 = .05$, *ns*) on interest (M_Interest) though the proportion of variance explained by the model moved up with an additional variance of 16% ($\Delta R^2 = .016$, $p < .001$).

Table 5: Hierarchical multiple regression models for Mathematics Interest

Model	Variables	B	SE	β	R^2	$adj R^2$	ΔR^2	F	ΔF	r	Pr^2	Sr^2
1	Age	-2.92	0.86	-.28**						-.28	-.28	-.28
	Gender	-.04	0.17	-.02	.079	.065	.079	5.76**	5.76**	.00	-.02	-.02
2	Age	-2.80	0.84	-.27**						-.28	-.28	-.27
	Gender	.09	0.17	.05	.131	.111	.052	6.68***	7.92**	.00	.05	.04
	Mach	.02	0.01	.24**						.23	.24	.23
3	Age	-2.21	0.77	-.21**						-.28	-.24	-.21
	Gender	.03	0.16	.02						.00	.02	.01
	Mach	.01	0.01	.05	.29	.27	.16***	13.5***	29.64***	.23	.05	.05
	MSE	.60	0.11	.44***						.49	.43	.40
4	Age	-1.23	0.68	-.12+						-.28	-.16	-.11
	Gender	.07	0.14	.04						.00	.05	.03
	Mach	-.01	0.01	-.11						.23	-.13	-.09
	MSE	.39	0.10	.28**	.472	.452	.18***	23.44***	45.13***	.49	.32	.24
	MSC	.62	0.09	.52***						.62	.51	.43
5	Age	-1.22	0.68	-.12+						-.28	-.16	-.11
	Gender	.05	0.14	.03						.00	.03	.02
	Mach	-.01	0.01	-.09						.23	-.11	-.08
	MSE	.38	0.10	.28***						.49	.32	.24
	MSC	.65	0.10	.54***	.477	.453	.005	19.75***	1.16(ns)	.62	.51	.43
	M_Anxiety	.08	0.07	.08						-.14	.09	.07

+ $p < .10$; * $p < .05$, ** $p < .01$, *** $p < .001$; *ns = not significantNote:

(a) The multiple regression analysis is free of multicollinearity problem since "Tolerance" statistics (.64 to .99) considerably larger than .10 while the VIF (Variance Inflation Factor) in all cases are below 10, which will be a cause for concern (Pallant, 2010, p. 158)

(b) In the far left columns the symbols: Pr^2 represents the partial correlation while Sr^2 represent the Semi-partial correlation of individual predictors

This suggest that MSE plays a role of a mediator since it correlates significantly with both Mach ($r = .40$, $p < .01$) and M_Interest ($r = .49$, $p < .01$) providing partial empirical support that MSE strongly affects both skill development and the development of interest in the same domain (Schunk and Pajares, 2002). Besides, the strength of "Age" as a predictor also lost its statistical significance following reduction in magnitude of the standardized regression coefficient. The introduction

of MSC in *Model IV* behaved more or less in the same way adding about 18% ($\Delta R^2 = .18$, $p < .001$) to the overall variance shared in M_Interest which climbed to from as low as 29% (in *Model III*) to as high as 47% ($adjR^2 = .452$) in *Model IV* apart from strong positive effect (MSC: $\beta = .52$, $sr^2 = .43$, $p < .001$). In contrast, the inclusion of M_Anxiety ($\beta = .07$, $sr^2 = .07$, ns) neither generated significant effect nor added meaningful amount of variance ($\Delta R^2 = .005$, ns) to the overall prediction.

Predictors of Mathematics Achievement

According to the existing empirical and theoretical literature, students' mathematics achievement is influenced by domain-specific affective motivational factors as well as demographic variables such as age and gender also found to meaningfully relate with mathematics achievement among young adolescents (e.g., Denissen et al., 2007; Jacobs et al., 2002; Marsh et al., 2005). In view of these, two key questions need to be addressed: of the selected variables, which ones do meaningfully predict mathematics achievement among grade 9 students? To answer this, a simultaneous multiple regression analysis needs to be computed. On the other hand, to find out which variable among the set of variables assessing affective and motivational components of learning mathematics (i.e., Mathematics self-concept, Mathematics self-efficacy, and Mathematics anxiety) and personal characteristics (i.e., age and gender) when the effect of others are statistically controlled, hierarchical multiple regression in four steps would need to be fitted to the data as illustrated below.

Moderating Effect of Mathematics related Self-beliefs

To examine which group of variables: classified as adolescents' background demographics (i.e., age and gender), mathematics self-beliefs (i.e., MSE and MSC), and intrinsic motivation (i.e., M_Interest), and mathematics-related affect (M_Anxiety) predict mathematics

achievement (MAch) among grade 9 adolescents? To answer this research question, hierarchical multiple regression was employed in four steps as depicted in Table 6. Accordingly, hierarchical multiple regression procedure was employed to fit the five models. In Model 1, the effects of “Age” and “Gender” on MAch were evaluated controlling for the effects of other covariates (or IV): M_Interest, MSE, MSC, and M_Anxiety.

As it is evident, “Gender” ($\beta = -.28$, $p < .01$; $\Delta R^2 = .28$) emerged as a statistically significant predictor of MAch. However, the negative regression coefficient shows that girls as a group tend to score lower than boys though “Age” has no meaningful effect. *Model 1*, which constituted the two variables contributes about 9.1% ($R^2 = .091$; $\Delta R^2 = .077$) of the variance in MAch.

Table 6: Hierarchical regression for mathematics achievement

Model	Variables	B	SE	β	R^2	$adj R^2$	ΔR^2	F	ΔF^b	r	Pr^2	Sr^2
1	Age	-1.07	.67	-.13						-.11	-.14	-.13
	Gender	-5.68	1.69	-.28**	.091	.077	.091**	6.62**	6.62**	-.27	-.28	-.28
2	Age	-0.58	.69	-.07						-.11	-.07	-.07
	Gender ^a	-5.65	1.66	-.28**						-.27	-.28	-.28
	M_Interest	2.07	.85	.21*	.130	.110	.039	6.56***	5.96*	.22	.21	.20
3	Age	-.64	.65	-0.08						-.11	-.09	-.08
	Gender	-5.4	1.56	-.26**						-.27	-.29	-.26
	M_Interest	.26	.91	.03(ns)	.233	.209	.103	9.95***	17.6***	.22	.02	.02
	MSE	5.01	1.19	.37***						.40	.34	.32
4	Age	-.65	0.61	-.08						-.11	-.09	-.08
	Gender	-4.43	1.5	-.22**						-.27	-.25	-.21
	M_Interest	-1.84	1	-.18 ⁺	.321	.294	.088	12.28***	16.77**	.22	-.16	-.13
	MSE	3.94	1.16	.29**						.40	.29	.25
	MSC	4.69	1.15	.39***						.45	.34	.30
5	Age	-.52	.61	-0.06						-.11	-.08	-.06
	Gender	-3.82	1.5	-.19*						-.27	-.22	-.18
	M_Interest	-1.56	.99	-0.16						.22	-.14	-.11
	MSE	3.73	1.15	.27**	.344	.313	.023	11.26***	4.53*	.40	.28	0.23
	MSC	3.93	1.19	.33***						.45	.28	0.24
	M_Anxiety	-1.76	.83	-.17*						.37	-.18	-0.15

+ $p < .10$, * $p < .05$; ** $p < .01$, *** $p < .001$, ^aGender = Female (Reference category); ^bdf (1, 124)

Notes: MSE = Mathematics Self-Efficacy, MSC = Mathematics Self-Concept, M_Interest = Mathematics Interest, M_Anxiety = Mathematics Anxiety, and MAch = Mathematics Achievement

In *Model II* M_Interest was included in the equation to assess its independent effect as well as its overall effect on the model's variance. It turned out that M_Interest ($\beta = .21$, $p < .05$; $Sr^2 = .21$) has a positive and significant predictive relationship with MAch adding a variance of about 3.9% ($\Delta R^2 = .039$, $p < .05$) boosting the overall variance explained by the model to 13% ($R^2 = .13$; $adj R^2 = .11$). However, the strength of the "Gender" variable did not change due to the inclusion of M_Interest. Nonetheless, in *Model III*, M_Interest ($\beta = .03$, ns ; $Sr^2 = .02$) not only lost its statistical significance, but also brought down its semi-partial correlation close to zero with the inclusion of MSE ($\beta =$

.377, $p < .001$; $Sr^2 = .30$) in the equation. This supposedly occurs as a result of the mediating effect of MSE, which is strongly correlated with both the criterion (MAch) and the independent (M_Interest) variables. However, the inclusion of Mathematics Self-Concept (MSC: $\beta = .39$, $p < .001$; $Sr^2 = .34$) in *Model IV* slightly reduced MSE's effect size ($\beta = .29$, $p < .001$; $Sr^2 = .25$) while increasing the overall shared variance to as high as 32.1% ($R^2 = .321$; $adjR^2 = .294$) adding 8.8% ($\Delta R^2 = .088$, $p < .01$) compared to *Model III*. At this juncture, it is interesting to note that M_Interest has re-emerged with increased, yet non-significant negative coefficient ($\beta = -.18$, $p < .10$; $Sr^2 = -.13$) with the inclusion of MSC. This is probably because; the effect of M_Interest on MAch seems to signal slight moderation effect by MSC. The inclusion of Mathematics anxiety (M_Anxiety) in *Model V* added a negligible 2.3% to the total variance in *Model IV* ($R^2 = .344$, $adjR^2 = .313$, $\Delta R^2 = .023$). Moreover, M_Anxiety ($\beta = -.17$, $p < .05$; $Sr^2 = -.15$) found to be inversely and significantly related to MAch. In sum, mathematics achievement among grade 9 students is strongly predicted by student gender, MSE, MSC and M_Anxiety contributing about 34.4% ($adjR^2 = .313$) of the variance. In other words, low achievement in mathematics among grade 9 adolescents is associated more with girls than boys, and students with low mathematics self-beliefs (i.e., MSE and MSC), and high mathematics anxiety.

Gender Differences in Mathematics Achievement and Interest

Research in mathematics education and educational psychology adequately established significant gender differences between boys and girls in mathematics achievement, mathematics-related self-beliefs and interest in mathematics in Western cultures. However, there has not been sufficient empirical evidence in the Ethiopian context. In particular, little or no research has so far been conducted to examine what underpins boys' and girls' mathematics achievement and interest. Are boys and girls influenced by the same cognitive and affective/motivational factors?

Mathematics Achievement: Do boys and girls behave in the same way?

As it is evident from the present findings, grade 9 girls are found to achieve significantly lower in mathematics compared to boys. However, despite the apparent difference, it is not clear how mathematics-related self-beliefs, interest, and anxiety in the same domain play out for the two sexes. To assess this, two separate multiple regression models (See Table 7) were fitted for boys and girls to find out how the predictors of mathematics achievement behave in the same way for the two sexes.

Table 7: Separate regression models fitted for boys and girls on determinants of mathematics achievement

<i>Variables</i>	<i>Model I: Girls</i>			<i>Model II: Boys</i>		
	<i>B</i>	<i>SE</i>	<i>β</i>	<i>B</i>	<i>SE</i>	<i>β</i>
(Constant)	106.74	31.56		-53.69	31.91	
Age	-25.61	10.52	-.24*	29.76	10.84	.32**
MSE	2.23	1.31	.18+	4.97	2.02	.35*
MSC	3.72	1.47	.32*	4.23	1.84	.37*
M_Interest	-.901	1.26	-.09	-1.67	1.42	-.18
M_Anxiety	-1.89	.918	-.20*	-2.01	1.51	-.16
<i>F</i>		7.41***			7.05***	
<i>df</i>		(5,77)			(5,48)	
<i>R</i> ²		.33			.42	
<i>adjR</i> ²		.28			.38	

+p < .10; *p < .05; **p < .01, ***p < .001

Notes: MSE = Mathematics Self-Efficacy, MSC = Mathematics Self-Concept, M_Interest =Mathematics Interest, M_Anxiety =Mathematics Anxiety, and MAch= Mathematics Achievement

To find out to what extent the predictors of mathematics achievement for female and male students vary, two separate regressions models were fitted. As shown in Table 7, distinct results are evident except for MSC which performed similarly for boys and girls. Accordingly, for girls “Age” ($\beta = -.24$, $p < .05$), and MSC ($\beta = .32$, $p < .05$), and M_Anxiety ($\beta = -.20$, $p < .05$) were significant predictors. In the case of boys, however, “Age” ($\beta = .32$, $p < .01$) and both mathematics related self-beliefs: MSE ($\beta = .35$, $p < .05$), and MSC ($\beta = .37$, $p < .05$). Nonetheless, unlike for girls, M_Anxiety ($\beta = -.16$, $p > .05$) played no meaningful role in predicting mathematics achievement in the case of boys. Interestingly though, while age emerges as important predictor

for both gender groups, the direction of prediction is not the same. In other words, for girls with increasing age, mathematics achievement steadily declines while for boys the reverse is true as shown in *Figure 1*. Nonetheless, as can be seen from *Figure 1* (Left) the age-achievement graph depicts the pattern of MAch as a function of age shows a declining trend for both sexes. When the data are disaggregated by gender, the line graph generated the contrasting differences between the sexes. Specifically, as shown in *Figure 1* (right), for boys increase in age is associated with a corresponding increase in achievement while, in contrast, increase in age in case of girls is associated with decrease in achievement.

Moreover, MSE did not emerge as an important predictor of girls' mathematics achievement while it was an important factor in case of boys. Similarly, though the direction of prediction is the same for both sexes, M_Anxiety was a statistically significant predictor of Mach for girls ($\beta = -.20, p < .05$) but not for boys ($\beta = -.16, ns$). This suggests that girls tend to be affected more negatively in mathematics achievement than boys.

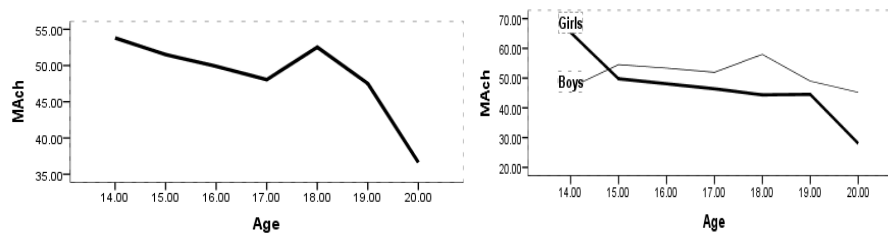


Figure1: Age-Mathematics achievement for both sexes (left) and pattern of MAch trends as a function of age disaggregated by gender (right),

Boys and girls and Mathematics Interest

In order to investigate whether or not mathematics interest is underpinned by the motivational and cognitive variables, two separate multiple regression models were fitted with Age, Mathematics self-efficacy (MSE), Mathematics self-concept (MSC), Mathematics anxiety (M_Anxiety), and Mathematics achievement (MAch) taken as predictors. The results are presented in Table 8.

At this juncture, it is important to note that “Age” is still a critical variable when it comes to developing mathematics interest. As shown in Figure 2 (Left), a declining pattern in mathematics interest is evident for both sexes. However, the graph in the right does not show discernable differences between boys and girls though both lines show a general decline in interest with increasing age. Instead, the significant predictors of mathematics interest for both boys and girls are the same. Namely, mathematics related self-beliefs i.e., MSE (Boys: $\beta = .34$, $p < .05$; Girls: $\beta = .25$, $p < .001$) and MSC (Boys: $\beta = .53$, $p < .001$; Girls: $\beta = .54$, $p < .001$) while other predictors, including MAch was not found to be significant. This finding is consistent with Denissen et al. (2007) who reported high degree of coupling among self-concept of ability, interest and achievement.

Table 8: Models of Mathematics Interest for Boys and Girls

Variables	Model I: Girls			Model II: Boys		
	<i>B</i>	<i>SE</i>	β	<i>B</i>	<i>SE</i>	β
(Constant)	4.67	3.00		1.94	3.28	
Age	-1.60	.97	-.15	-.76	1.17	-.08
MSE	.31	.12	.25***	.53	.20	.34*
MSC	.64	.12	.54***	.65	.17	.53***
M_Anxiety	.08	.09	.09	.07	.15	.06
Mach	-.01	.01	-.07	-.02	.01	-.16
F		13.48***			9.54***	
df		(5,77)			(5,48)	
R²		.47			.50	
adjR²		.43			.45	

+p < .10, *p < .05; **p < .01, ***p < .001

Notes: MSE = Mathematics Self-Efficacy, MSC = Mathematics Self-Concept, M_Interest = Mathematics Interest, M_Anxiety = Mathematics Anxiety, and MAch = Mathematics Achievement

Likewise, the present finding receives partial empirical support from similar other studies in Western culture. Accordingly, Köller et. al. (2001) also found age-related decline in mathematics interest among German students at all ability tracks. A subsequent study among German sample by Frenzel et. al. (2010) also found a consistent downward trajectory in mathematics interest for both sexes. A number of other related studies (e.g., Jacobs et al., 2002; Watt, 2004; Wigfield and Cambera, 2010) reported consistent findings in several non-African cultures and contexts. The substantive and theoretical explanation for the age-related decline in mathematics interest, according to Hidi (2000), is that with increasing age, there is an increase in the complexity of academic tasks, decrease in the attractiveness of academic content, and change in pattern of social relationships.

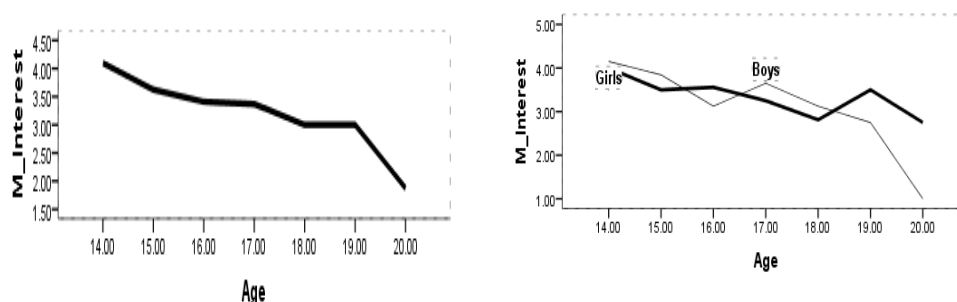


Figure 2: Age – Mathematics interest for box sexes (left), and disaggregated mathematics-interest development trends by gender (right),

Discussion and Conclusion

This study was carried out on five sections randomly selected from among 16 sections of grade 9 students. The total number of participants from which usable data were obtained was 137. The data gathering tools used for the study were the adapted *Amharic* versions of the Mathematics self-efficacy (MSE), Mathematics self-concept (MSC), Mathematics interest (M_Interest), and Mathematics anxiety (M_Anxiety) scales used in international assessment, namely Program for International Student Assessment (PISA). In addition, students' Mathematics achievement (MAch) was measured based on first semester average scores of grade 9 Mathematics of 2014/15 academic year. Internal consistency reliability coefficients of the four scales were found to be satisfactory, ranging from .67 - .82 (Nunnally, 1978). Besides, validity evidences were obtained by computing bivariate correlations among the four measured constructs. Accordingly, the results yielded convergent validity evidences. Convergent and discriminant validity evidences for adapted measures were also obtained by computing inter-correlations among the four scales. Accordingly, convergent validity evidence was established based on the positive and significant correlations obtained between three pairs, including: MSC and M_Interest ($r = .67$, $p < .01$), MSE and M_Interest

($r = .49$, $p < .01$), and MSE and MSC ($r = .46$, $p < .01$). Similarly, discriminant validity evidences were obtained from the negative correlations of M_Anxiety with MSC ($r = -.36$, $p < .01$), MSE ($r = -.20$, $p < .05$) and M_Interest ($r = -.14$, $p < .10$). This offers empirical support for the proposed inverse relationship of high anxiety with motivational and cognitive constructs like interest, self-efficacy and self-concept.

Profile of Students in Mathematics related Self-beliefs and other Motivational Variables

The findings generally show that the average ninth grader has low motivation in learning mathematics as measured by the Mathematics-related self-belief scales. In other words, the majority of the students reported low mathematics self-efficacy (MSE), negative mathematics self-concept (MSC), and low mathematics interest (M_Interest), and high mathematics anxiety (M_Anxiety). Surprisingly, the trends as a function of gender depict a declining pattern for mathematics-related motivational variables (i.e., MSE, MSC, and M_Interest); and increasing trend for M_Anxiety for girls. Besides, the growth trends of motivational variables and Mathematics achievement (MAch) as a function of student age further reveals contrasting results for the two sexes where increase in age among girls is associated with a decline in MAch while the opposite is true for boys. This suggests the possible negative effects on girls' future career opportunities and success in engineering and science. Similar trends were reported in several earlier studies (e.g., Riegle-Crumb et al., 2010; Su and Rounds, 2015) yet with unique situation of convergence in national contexts where gender equity is believed to have taken root (e.g., Else-Quest et al., 2010; Hyde, 2005; Hyde and Mertz, 2009) which leads to Hyde's (2005) "*Gender similarities hypothesis*".

In order to answer our research question that attempts to assess the degree to which mathematics related self-beliefs affect students' mathematics achievement and mathematics interest, two hierarchical multiple regression analyses in five steps were computed. With respect

to the effect of the two mathematics related self-beliefs/self-cognition on achievement, the influences of students' MSE and MSC on MAch were targeted by controlling the effects of other covariates: the effects of Age, Gender, M-Interest, and M_Anxiety. However, since MSE and MSC are distinct, yet related constructs, each of them was separately added respectively in steps 3 (*Model III*) and 4 (*Model IV*) with Age and Gender entered in *Model I*, and M_Interest, which is empirically related with MSE entered in step 2 (*Model II*).

The results show that both MSE and MSC have emerged as important predictors of MAch, each contributing between 9 -10% of the variance to the total prediction. However, comparing MSC and MSE in terms of relative strength, the former found to impact more on achievement than MSE. On the other hand, the entry of MSE in *Model III* resulted in the undermining effect of M_Interest on achievement (bringing it close to zero) which partially confirms the validity of reciprocal effects model, which argues, high self-efficacy causes an increase in mathematics interest, which in turn, results in an increase in achievement (MAch). In other words, M_interest is related to MAch through MSE. In contrast, the entry of MSC reversed the direction of the predictive relationships between M_Interest and MAch though it narrowly failed to achieve statistical significance ($\beta = -.18$, $p < .10$). This is probably because, unlike MSE which is only based on mastery of the subject mathematics, MSC is also influenced by social comparison in addition to individual's self-cognition of ability, which is basically context-dependent. In other words, a student whose average score is 80 in high achieving school where the school average is 81, will have low MSC compared to a student whose average mathematics score is 70 in a low achieving school with a school average score of, say 65. Paradoxically, however, the student with average mathematics score of 70 reports higher MSC than her counterpart. This phenomenon, which is conceived to result from social comparison (in this case, a student's self-comparison with his/her classmates), is referred to as the "Big Fish Little-Pond Effect" (Marsh, 1986, 1990).

The other possible explanation may be the predictive relationship between M_{Ach} and M_{Interest} is reversed due to the inclusion of M_{SC} since the latter is a measure of self-control (self-regulation) which calls for self-monitoring and evaluation of one's learning which may lead to high academic achievement even without being interested in a particular school subject (See: Trautwein et. al., 2015). In this relation, there is evidence to suggest that personality traits such as *conscientiousness* influence achievement behavior even when students are less interested (Trautwein et. al., 2015). Earlier, Trautwein and Lüdtke (2007, in Trautwein et al., 2015) also found that students high in conscientiousness tend to work hard across a wide range of subjects including mathematics. Moreover, controlling for the effects of background variables, M_{Interest}, and mathematics related self-beliefs (M_{SE} and M_{SC}), and M_{Anxiety} showed significant inverse predictive relationship with M_{Ach}. This is consistent both with the existing theoretical and empirical literature (e.g., Beilock and Maloney, 2015; Preston, 1986). However, it is important to note that one would not expect to find significant negative predictive relationship had simultaneous regression method been employed which does not allow statistically control on the effects of other covariates or independent variables; mainly M_{SE} and M_{SC}.

Policy Implications

Overall, mathematics interest and achievement among grade 9 adolescents by and large, are strongly predicted by mathematics related self-beliefs, namely mathematics self-efficacy and mathematics self-concept - both of which are believed to develop based on students' prior achievement in the same domain (i.e., mathematics), which in turn, influence subsequent achievement as proposed by reciprocal-effects model. This would mean that education systems need to work very hard to put in place effective schools that enable young people to achieve adequate mastery of the subject to bolster M_{SE}; which subsequently impinge on mathematics interest. On the other hand, high M_{SE} would mean high self-concept of ability which relates to low

mathematics anxiety. Specifically speaking, young adolescents should be taught mathematics to be able to acquire sufficient mastery of the subject. To that effect, schools need to be staffed by motivated and qualified mathematics teachers who are not only limited to content knowledge (CK), but most importantly, equipped with relevant and adequate pedagogical and pedagogical content knowledge (PCK) (Shulman, 1986). Apart from that, students should have sufficient opportunities to take part in mathematics-related extra-curricular engagements such as mathematics clubs and similar activities which relate mathematics to students' daily life experiences. These would help students to develop interest in learning and doing mathematics.

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