International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:14, No:2, 2020

# The Influence of Interest, Beliefs, and Identity with Mathematics on Achievement

Asma Alzahrani, Elizabeth Stojanovski

***Abstract*—**This study investigated factors that influence mathematics achievement based on a sample of ninth-grade students (N = 21,444) from the High School Longitudinal Study of 2009 (HSLS09). Key aspects studied included efficacy in mathematics, interest and enjoyment of mathematics, identity with mathematics and future utility beliefs and how these influence mathematics achievement. The predictability of mathematics achievement based on these factors was assessed using correlation coefficients and multiple linear regression. Spearman rank correlations and multiple regression analyses indicated positive and statistically significant relationships between the explanatory variables: mathematics efficacy, identity with mathematics, interest in and future utility beliefs with the response variable, achievement in mathematics.

***Keywords*—**Mathematics achievement, math efficacy, mathematics interest, identity.

## I. Introduction

THERE is an increased interest in strengthening science, technology, engineering and mathematics (STEM) in learning institutions, arising particularly from modern economic trends whereby qualifications in STEM subjects are considered vital to gain employment [1]. Hence there is an increased need to investigate factors that influence academic performance and interest in this field [2]. It is believed that learners are likely to perform better in subjects towards which they hold positive attitudes [3]. Negative attitudes in subject areas can result from performing poorly in tasks, and when not addressed, negative attitude disposition can become permanent in learners and consequently affect their performance in mathematics [3]. Further research is thus required to assist mathematics educators to identify opportunities to enhance the learning experience of students.

Academic performance has additionally been found to be closely related to the efficacy of students [4]. The contribution of efficacy and mathematics identity towards performance in mathematics was illustrated in a study conducted by Marshall which found that performance must be supported by a strong foundation in mathematics, a positive attitude towards the subject, and an identification with the subject [5]. Efficacy is a personal quality referring to one's confidence to perform a certain task competently and describes a learner's beliefs of their performance of a particular task [4], [6]. This quality is what determines how people cope with challenges they face and the amount of effort they apply to achieve personal targets [4]. Some researchers [7]-[9] argue that one's ability to combine qualities of efficacy determines their performance in mathematics [10], [11]. Success expectation can be regarded as a component of efficacy [12]. A study conducted on university students where prior knowledge combined with personal confidence in success made them excel in their studies by demonstrating that positive self-belief increased academic performance [6]. Furthermore, there are several studies that have attempted to explain the gender disparity in the update of STEM courses [13]-[15]. Over time, the number of females entering into STEM fields has reduced when compared to the number of their male counterparts entering these fields [13]. Some have attributed the disparity to the difficulty in attracting females to STEM as their initial career interests tend to not be in STEM areas while female students who demonstrate some interest in areas such as physics, for example, from the beginning of high school, have a higher probability of remaining within STEM [13], although these numbers tend to be quite low relative to males. Another factor postulated to contribute to this difference is that female students tend to be more anxious about mathematics compared to males [14].

In another study the issue of how mathematics ability and beliefs of male and female students influence choices of computer and science career fields was investigated [15]. The results indicated that male students performed much better in mathematical ability compared to their female counterparts. It has been proposed that the trajectory into STEM has to be initiated earlier enough in students for them to develop a strong interest in the field. Wang and Degol emphasized that in order to reduce the gender gap in STEM, attention must be directed towards addressing the cognitive, motivational and social-cultural factors which contribute to the observed gap [16].

Currently, there is a need to enhance research to enable policy agencies and educators to provide appropriate advice on how enrolment in STEM courses can be increased. The key focus of the present paper is to investigate the relationship between mathematics efficacy, mathematics identity, interest and enjoyment of mathematics and future utility beliefs with mathematics achievement, and we will further assess the extent to which there is a difference in these measures between male and female students. This will contribute to the existing literature in the field with the intention to help to identify aspects that can be focused on to enhance enrolment into mathematics related courses and hence careers requiring these skills.

Asma Alzahrani is with the University of Newcastle, Australia (e-mail: asma.alzahrani@uon.edu.au).

## II. Methods

### A. Study Sample

In order to monitor the performance of students as they transit from high school to post-secondary years, a series of studies were conducted by the National Center for Education Statistics (NCES). One such study was the HSLS09, which seeks insights into, and highlights students' understanding of the available workforce [17]. Some issues addressed by the HSLS09 study include: insight into the integration into and out of STEM fields in addition to the impacts of such shifts which may either be of educational or social in nature [17].

In achieving the objectives of the study, a two-step sampling process was implemented using stratified sampling and school recruitment [17]. Stratified sampling involves the researcher first dividing the population into small sub-groups called strata, based on a chosen criteria (such as age), and a random sample is then acquired from the subgroups [18]. The target population included both public and private schools inclusive of public charter schools across all States of the United States (US) and the District of Columbia, offering at least from the 9th to 11th grades. A total of 944 private and public schools throughout the 50 States of the US and the District of Columbia during 2009 were recruited [18] with students given instructions by their respective institutions. A total of 21,444 ninth grade students were selected in the HSLS09 study from these schools [17].

The survey was implemented using questionnaires which were administered to target subjects. A questionnaire for: students, parents, teachers (mathematics and science) and one for school administrators and counselors were administered. A student assessment was also implemented on simple algebraic reasoning which was conducted through a computer-assisted telephone interview (CATI) [17]. Through these study surveys, the stakeholders (students, parents, teachers' school heads, and lead counselors) completed the surveys which were delivered through an online platform [17].

The HSLS09 student's mathematics assessment of algebraic reasoning, together with student questionnaires in ninth grade, were the primary sources of data used for the present study. This provided information regarding the independent variables considered for the present study (mathematics efficacy, mathematics identity, mathematics enjoyment, interest and future utility belief) and the dependent variable (mathematics achievement).

### B. Student Questionnaire

The information contained in the students' questionnaire included demographic information and information on school experiences. The questionnaire also covered other aspects such as information concerning high school, student's career plans, post-secondary plans, concepts in mathematics, how well student understands them, among other items [17]. There were ten scales used to assess student responses. The scales considered for the present study included: mathematics identity scale, mathematics utility-scale, mathematics self-efficacy scale, interest in mathematics course scale. Ability of students in mathematics was also collected from this questionnaire [17]. Students who were not enrolled in a mathematics course at the time of the questionnaire were assigned a missing value.

### C. Measures

#### 1. Mathematic Achievement

The dependent variable was mathematics assessment of algebraic reasoning and was acquired from respondents in the HSLS09 study. There are six algebraic content domains that define mathematics assessment: language algebra, proportion relationships and change, linear equations, inequalities, and functions, system of linear equations, sequence and recursive relations and four algebraic processes (algebraic skills, representation of algebraic ideas and performing algebraic reasoning) [17]. Each item on the mathematics assessment of algebraic reasoning was coded to one of the algebraic domains above. There were 40 items tested for the mathematics assessment, which was administered to the students through a two-stage computer interface linked to a scientific calculator.

Knowledge in algebraic reasoning on the mathematics assessment of the HSLS09 was measured on a scale with five response options ranging from fair to excellent performance and scored on a scale from 1 to 5 respectively. The five response options were selected using quintiles that were created based on the approximate number of correct scores [17]. For example, lowest achieving students from the (HSLS09) in mathematics assessment of Algebraic reasoning scores scored in the Quantile 1 range (bottom scoring), while highest achieving students scored in Quantile 5, representing the top scoring students.

#### 2. Mathematics Identity

This is a measure of the extent to which the students in ninth grade felt about how much they liked mathematics and how other people viewed them as likers of mathematics [17]. The measure of 'identification as a mathematics person' for the ninth-grader respondents in the HSLS09 study was based on responses to the statements "You see yourself as a math person" and "Others see me as a math person". Students were asked to rate these on a 4-point scale ranging from 1 (strongly disagree) to 4 (strongly agree) [17]. These measures are considered to be a composition of students' perceptions about their mathematics performance in their academic journey and include personal performance in mathematics, challenges and opportunities one has faced, knowledge students have acquired over the years, among other aspects that form one's experience with mathematics [19].

#### 3. Mathematics Efficacy

Efficacy is the personal self-confidence regarding a learner's ability to excel in certain areas and is considered a measure of academic self-belief [4], [20]. Students completed response to a set of items measuring efficacy (How often do you think you really understand the assignment?, You are confident that you can do an excellent job on math tests, You are certain that you can understand the most difficult material

International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:14, No:2, 2020

presented in the textbook used in a math course, You are certain that you can master the skills in a math course and You are confident that you can do an excellent job on assignments in a math course) and were asked to assign a response from a scale from 1 to 4, representing a scale from strongly disagree to strongly agree, in terms of how much they agreed with each statement.

4. Mathematics Enjoyment

Mathematics enjoyment scale is a composite of four individual variables concerning mathematics course: enjoying this class very much, this class is a waste of time, think this class is boring and really enjoy mathematics. Each item was measured on a scale from 1 to 4, with this item representing the level of agreement with each item (from strongly disagree to strongly agree respectively), except item (you really enjoy math) was coded as Yes (1) and No (0).

5. Interest in Mathematics

Interest of mathematics was measured by the survey question: "what is your favorite school subject". Survey respondents indicating that mathematics or a related area science and computer education or computer science was their favorite subject were coded as Yes (1), indicating an interest in mathematics, while a response indicating that their favorite subject did not include a mathematics related subject was coded as No (0), indicating a lack of interest in mathematics.

6. Future Utility Beliefs in Mathematics

The Future Utility Beliefs scale was assessed by three items ("Math courses are useful for everyday life," "Math courses will be useful for college," and "Math courses are useful for future careers) with four response options for each of these items ranging from 1 (strongly disagree), 2 (disagree), 3 (agree) to 4 (strongly agree).

*D. Statistical Analyses*

The average was calculated for each set of items for each of the considered measures and the average score was consequently used in the analyses to measure mathematical identity, mathematical efficacy, mathematics enjoyment, interest, future utility beliefs and mathematical assessment score in algebraic reasoning. The relationship between each explanatory variable with mathematics performance was examined using Spearman's rho correlation coefficients using a 0.05 significance level. Multiple linear regression analysis was used to predict the mathematics achievement outcomes as a function of all of the potential predictor variables, enabling adjustment for the other predictor variables in the model. Gender differences on each measure were examined using Pearson's chi-square test of independence for the categorical independent variable, interest, and the non-parametric Mann-Whitney U test for the other variables. IBM SPSS statistics 25 was used for the data analysis in this study.

## III. Results

Table I displays descriptive statistics and the gender differences for each of the variables considered in this study. The non-parametric Mann-Whitney U test was conducted to reveal differences between males and females for all measures except interest, which was assessed using the Chi-Square test of independence as interest was a categorical variable, to determine if there is a significant statistical relationship between males and females on mathematics interest. The average mathematics achievement score, based on the assessment of algebraic reasoning, the average score among males was 3.23 (SD = 1.4) compared with 3.22 for females (SD = 1.37) for females which was not statistically significant different ($p$ = 0.86). However, males and females scored significantly different on average mathematics efficacy ($\bar{X}$ = 3.1, SD = 0.62 and $\bar{X}$ = 2.99, SD = 0.62 respectively for males and females) ($p$ < 0.01), mathematics identity ($\bar{X}$ = 2.61, SD = .87 and $\bar{X}$ = 2.49, SD = .86) for males and females respectively) ($p$ < 0.01). Females also scored significantly lower than males on mathematics identification and future utility beliefs (Table I) ($p$ < 0.01), while both males and females had the same median and interquartile range for enjoyment, with females appearing to score slightly higher on mean enjoyment.

TABLE I
SUMMARY STATISTICS OF VARIABLES BY GENDER

| Model | Male | | Female | | *p*-value |
|---|---|---|---|---|---|
| | Mean(SD) | Median (IQR) | Mean (SD) | Median (IQR) | |
| Mathematics Achievement | 3.23 (1.411) | 3.00 (3.00 ) | 3.22 (1.376) | 3.00 (2.00) | .86+ |
| Efficacy | 3.10 (.62) | 3.20 (.80) | 2.99 (.618) | 3.00 (.80) | < 0.01 + |
| Identification | 2.61 (.872) | 2.50 (1.00) | 2.49 (.859) | 2.50 (1.00) | < 0.01 + |
| Enjoyment | 2.18 (.588) | 2.25 (.75) | 2.21 (.555) | 2.25 (.75) | < 0.01 + |
| Interest | | | | | |
| Yes | N = 3101(16.1%) | | N = 2714(14.1%) | | < 0.01 ++ |
| No | N = 6519(33.9%) | | N = 6881 (35.8%) | | |
| Future Utility Beliefs | 3.18 (.64) | 3.00(1.00) | 3.13 (.606) | 3.00(1.00) | < 0.01 + |

+*p*-value from Mann-Whitney U Test.
++ *p*-value from Pearson's Chi-square Test.

The correlation analysis (Table II) was performed on the data to examine the relationships between predictors and mathematics achievement of ninth-grade students. Spearman's rho correlation analysis indicates a positive statistically significant relationship between mathematics achievement and both of mathematics efficacy and mathematics identity ($p$ <

0.01). In addition, there was a positive relationship between mathematics interest, mathematics enjoyment and future utility beliefs with achievement in mathematics.

Table III reports multiple regression coefficients for the model with mathematics efficacy scale, mathematics identity, mathematics enjoyment and interest treated as the independent variables and mathematics achievement score as the response variable. Results indicated that mathematics efficacy, mathematics identity and interest remained statistically significant predictors of mathematics achievement after adjusting for the other predictors in the model ($p < 0.01$).

## IV. Discussion and Conclusion

The aim of this research was to explore factors that influence mathematics achievement among males and females in the HSLS09. The results indicated that mathematics efficacy, mathematics identity, and interest remained positively and significantly related to mathematics achievement. The identified factors that impact student's achievement in mathematics can provide important links into where resources could focus to help improve performance with the intention to help to improve rates of STEM uptake. In order to improve mathematics achievement, a focus could be within schools to implement strategies to help to improve mathematics efficacy and mathematics identity via in-class tasks and assessments with a view to focus also on assisting students to understand the importance of STEM in the future careers.

TABLE II
CORRELATION ANALYSIS BETWEEN MATHEMATICS ACHIEVEMENT AND SEVERAL PREDICTORS IN NINTH-GRADERS FROM THE HIGH SCHOOL LONGITUDINAL HSLS09

| Model | | Mathematics achievement | Efficacy | Identification | Enjoyment | Interest | Future Utility Beliefs |
|---|---|---|---|---|---|---|---|
| Correlations | Efficacy | .325** | 1.000 | .593** | .486** | .236** | .334** |
| | Identification | .375** | .593** | 1.00 | .466** | .293** | .292** |
| | Enjoyment | .172** | .486** | .466** | 1.00 | .283** | .432** |
| | Interest | .151** | .236** | .293** | .283** | 1.00 | .162** |
| | Future Utility Beliefs | .002 | .334** | .292** | .432** | .162** | 1.00 |

**Spearman correlation ($P < 0.01$)

TABLE III
MULTIPLE REGRESSION COEFFICIENTS OF NINTH-GRADERS FROM THE HSLS09

| Model | Unstandardized Coefficients | | Standardizd Coefficients | t-value | p-value |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| Efficacy | .432 | .021 | .192 | 20.73 | .000 |
| Identification | .442 | .015 | .275 | 29.77 | .000 |
| Enjoyment | -.127 | .020 | -.052 | -6.20 | .000 |
| Interest | .105 | .022 | .035 | 4.68 | .000 |

## References

[1] National Council of Teachers of Mathematics. Focus in high school mathematics: Reasoning and sense making. Reston, VA (2009).

[2] M. Alexander, The New Jim Crow: Mass incarceration in the age of colorblindness. New York, London: The New Press. (2010).

[3] M. Nicolaidou, & G. Philippou, Attitudes towards mathematics, self-efficacy and achievement in problem-solving. European Research in Mathematics Education III. Pisa: University of Pisa, 1-11(2003).

[4] A. Bandura, Self-efficacy: Toward a unifying theory of behavioral change. Psycholocial Review, 84, 191-215(1977).

[5] A. Marshall, Black/African American students' perceptions of mathematical success and mathematical success factors at a community college (Doctoral dissertation, University of Maryland, College Park), (2007).

[6] T. Hailikari*, A. Nevgi, & E. Komulainen, Academic self-beliefs and prior knowledge as predictors of student achievement in mathematics: a structural model. Educational Psychology, 28(1), 59-71, (2008).

[7] M. Bong, & R. Clark, Comparison between self-concept and self-efficacy in academic motivation research. Educational Psychologist, 34(3), 139-153, (1999).

[8] K. D. Multon, S. D. Brown, & R. W. Lent, Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. Journal of counseling psychology, 38(1), 30, (1991).

[9] B. Zimmerman, Self-efficacy in changing societies. New York: Cambridge University Press, (1995).

[10] G. Hackett, & N. Betz, (December). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational Behavior, 23(3), 329-345, (1983).

[11] F. Pajares, & L. Graham, Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. Contemporary Educational Psychology, 24, 124-139, (1999).

[12] P. Pintrich, & P. Ruohotie, Conative constructs and self-regulated learning. Finland: Research Center for Vocational Education (RCVE) (2000).

[13] P. M. Sadler, G. Sonnert, Z. Hazari, & R. Tai, Stability and volatility of STEM career interest in high school: A gender study. Science education, 96(3), 411-427(2012).

[14] M. Kyttälä, and P. M. Björn, Prior mathematics achievement, cognitive appraisals and anxiety as predictors of Finnish students' later mathematics performance and career orientation. Educ. Psychol.30, 431–448 (2010).

[15] L. Perez-Felkner, S. Nix, and K. Thomas, Gendered pathways: How mathematics ability beliefs shape secondary and postsecondary course and degree field choices. Front. Psychol.8, 386(2017).

[16] M. T. Wang, and J. L. Degol, Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. Educ. Psychol. Rev.29, 119–140(2017).

[17] S. J.Ingels, D. J Pratt, D. R Herget, L. J., Burns, J. A Dever, R. Ottem, et al, High School Longitudinal Study of 2009 (HSLS: 09). Base-Year Data File Documentation (NCES 2011-328). National Center for Education Statistics. Washington, DC: National Center for Education Statistics, (2011).

[18] J. W. Creswell, Educational Research: Planning, conducting, and evaluating quantitative and qualitative research. Upper Saddle River, NJ: Pearson. (2008).

[19] D. B. Martin, Mathematics learning and participation as racialized forms of experience: African American parents speak on the struggle for mathematics literacy. Mathematical Thinking and Learning, 8(3), 197-229(2006).

[20] A. Bandura, Social foundations of thought and action: A social cognitive theory. Englewood, New Jersey: Prentice-Hall, (1986).