Mathematics Work Ethic Mediates Effects of Anxiety and Instrumental Motivation on Science Literacy

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Article Info	**Abstract**
	Previous research has examined instrumental motivation to learn mathematics (IM) and mathematics anxiety (MA) as predictors of students' scientific literacy. A major aim of this study was to examine mathematics work ethic (MWE) as a mediating factor. Structural equation modeling (SEM) was used to analyze the Programme for International Student Assessment (PISA), the year 2012 data of 4,500 high school students from Australia. We constructed three SEM models. The first model concerned the entire sample; the second and third models used multi-group SEM to examine gender and socioeconomic status (SES) as moderating factors. The results indicated a positive relationship between MWE and scientific literacy, which acted as a mediator between the negative impact of MA and the positive effect of IM on scientific literacy. Indirect effects were significant for females, not males. Work ethic was significant for females, not males. Instrumental motivation was significant for high SES, not low. Findings help integrate the construct of work ethics within theory and research on academic anxiety and motivation. We discuss the practical implications.

Introduction

The positive link between motivation to learn and performance in science, technology, engineering, and mathematics (STEM) has been examined extensively (Bol & Berry, 2005; Chang et al., 2016; Liu, Hau, & Zheng, 2018; Pitsia, Biggart, & Karakolidis, 2016; Tella, 2007). Motivation theory and research suggest that students' academic choices, level of effort, and persistence are influenced by a multitude of underlying motivational factors. These factors are: students' values, beliefs, goals, and emotions among others (Eccles & Wigfield, 2002). For example, students who identify meaningful instrumental (means-end) connections between academic tasks and the attainment of future goals are more likely to invest effort in learning (Husman et al., 2004) and perform better than their peers (Husman & Hilpert, 2007). Students who are instrumentally motivated strive to learn course contents in-depth because they anticipate to apply course concepts in the future (e.g., for future courses and careers) (Liu et al., 2018; Pitsia, Biggart, & Karakolidis, 2017; Sastre-Vazquez, D'Andrea, Villacampa, & Navarro-Gonzalez, 2013).

Academic emotions also influence motivation and performance (Pekrun et al., 2011). Anxiety is a powerful explanatory factor in STEM contexts. Mathematics anxiety, as well as general anxiety, have been negatively associated with performance in STEM courses (Kargar, Tarmizi, & Bayat, 2010a; Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016; Stuart, 2016). Anxiety can inhibit students' concentration (Fernandez-Castillo et al., 2015) and contribute to maladaptive patterns of motivational beliefs and the use of learning and self-regulatory strategies (Pekrun et al., 2011).

Previous research has looked at anxiety and instrumental motivation separately, studies that have looked at both together have found that each one affects math performance differently: math anxiety tends to lower performance, while motivation to learn math tends to improve performance (Jürgen Baumert et al., 2013; Dowker, Sarkar, & Looi, 2016; Garon-Carrier et al., 2016; R. Harari, Vukovic, & Bailey, 2013; Kargar et al., 2010a). However, less is known about potential mediators that could explain why anxiety and instrumental motivation influence performance. We propose that work ethic is a viable mediator. Work ethic has been defined as a belief that hard work, determination, and continuously striving for excellence are essential qualities to succeed in various endeavors (Areepattamannil et al., 2016a; Bol & Berry, 2005 & Meriac, Thomas, & Milunski, 2015). Furthermore, the work ethic construct encompasses the motivated behaviors that reflect this belief (McCortney & Engels, 2003), and it is the later behavioral facet of work ethic (i.e., students' perceptions of their behavior) that are emphasized in the current study.

Students with low instrumental motivation for learning mathematics may be less likely to exhibit a strong work ethic in mathematics contexts because they see little utility between mathematics learning and their future goals. Similarly, high mathematics anxiety may lead students to resist enacting a strong work ethic in mathematics contexts because of the debilitating and distracting role of anxiety. Mathematics work ethic may help to explain motivational routes through which anxiety and instrumental motivation influence performance outcomes in science. However, our review of the literature found no studies that examined mathematics work ethic as a mediator between these variables and scientific literacy. Furthermore, we found no studies that have investigated

how these relationships may vary for students based on gender and socioeconomic status (SES). The Program for International Student Assessment (PISA) dataset provides a unique opportunity to examine these relationships because all of the variables of interest in the current study were measured during the 2012 year in the Australian sample.

A major purpose of this study is to examine students' mathematics anxiety, instrumental motivation to learn mathematics, and mathematics work ethic as predictors of scientific literacy (as measured by PISA) and the extent to which these relationships vary by gender and socioeconomic status. Given the dearth of research on mathematics work ethic, the current study helps to integrate this construct within social-cognitive theory and research on anxiety and instrumental motivation.

Theoretical Framework

According to Ajzen's theory of planned behavior (TPB) (Ajzen, 1991; Ajzen, 2011), it is believed that a person's attitudes, perceived social norms, and perceptions of control, among other beliefs, influence their decision to intentionally engage in social behavior (Ajzen et al. (2019). That is to say a person's desire to act is the strongest indicator of how that action will play out in reality. Three things have a role in the development of a person's desire to act. A person's general opinion or attitude toward engaging in an action is thought to be positively or negatively impacted by their behavioral beliefs. Furthermore, it is believed that normative ideas would cause one to feel societal pressure, or a subjective norm, to participate in or abstain from the activity in question. Finally, Ajzen et al. (2019) posit that control beliefs influence the third concept, perceived behavioral control. They found that when real control is high, rather than low, the influence of intention on behavior is larger. The result suggests that actual control moderates the intention-behavior association. Keep in mind that there are many contextual elements, including cultural, individual, and situational aspects, that contribute to the diversity of these views.

Additionally, this model has some implicit basic assumptions (Ajzen et al., 2019). First, future intentions and behaviors may be shaped by feedback loops, whereby the execution of an action yields fresh insights about its probable results, the expectations of others, and matters of control. Secondly, prevailing attitudes might retroactively affect the development of new behavioral beliefs by distorting the perception and interpretation of novel information. Third, attitudes, subjective norms, and perceptions of control may correlate due to their partial reliance on the same information. Depending on the activity and the group of people under study, the importance of attitude, subjective norm, and perceived control in predicting someone's intention varies. TPB shows a chain of events that starts with forming beliefs about behavior, social norms, and control; these beliefs are thought to influence attitudes, social norms, and perceived control, which then lead to intentions and actions.

The theory of planned behavior (TPB) provides a way to understand and predict social behavior, suggesting that people's intentions to act are based on their beliefs about how to carry out the action (Ajzen et al., 2019). The current study adopts this framework to examine relationships among personal factors (i.e., mathematics anxiety and instrumental motivation) and behavioral factors (i.e., mathematics work ethic and scientific literacy). While recognizing possible reciprocal relationships among these factors, we propose a pattern of relationships where

mathematics anxiety and instrumental motivation predict mathematics work ethic behaviors, which in turn predict science performance on PISA.

Literature Review

Instrumental Motivation to Learn Mathematics

Motivation has been defined as the "…processes that instigate and sustain goal-directed activities" (Schunk & DeBeneditto, 2020, p. 1). It involves psycho-social factors such as students' values, beliefs, goals, and emotions (Eccles & Wigfield, 2002) and their behavioral choices and level of effort and persistence. Accordingly, motivation to learn has been described as the psychic energy that encourages students to persist or overcome challenges in their studies (Garon-Carrier et al., 2016; Middleton & Spanias, 1999; Pitsia et al., 2016). Students are motivated for various reasons; for example, a student may be motivated to learn mathematics because performing mathematics tasks is perceived as enjoyable or intriguing (Eccles & Wigfield, 2002). Liu, Hau, & Zheng (2018) assert that students' future goals correlate with their instrumental motivation to learn. More specifically, instrumental motivation refers to a perceived connection between current behavior and future objectives or expectations (Pitsia et al., 2017). For example, a student may be motivated to improve his or her competency in mathematics with the expectation of passing a test or increase his or her prospects of a career in STEM fields or gain entrance to a competitive university.

Institutions of learning play an important role in the formation of instrumental motivation among students (Pitsia et al., 2017). For example, guest speakers in STEM fields may serve as role models for students. Speakers tend encourage students to envision themselves in STEM positions and make connections between current learning activities and their future STEM identities. Additionally, cultural factors and students' socialization play an important role in the development of instrumental motivation. Teachers are essential in the formation of instrumental motivation among students. Linder, Smart, & Cribbs (2015) focused on the role of teachers in creating a learning environment that nurtured instrumental motivation. The study found that solving application problems regularly in STEM courses, instead of, solving for unknown values (i.e., finding x and y) instrumentally motivated students because they could see the application of the concepts they were learning in class. Asking students to read and reflect about possible uses of learning has also been found to increase perceptions of instrumentality (Federici) and the utility value of course learning tasks (Hulleman et al., 2010).

Jerrim (2015), study compared instrumental motivation among Australian-born students and their counterparts from East Asian countries (China, Hong-Kong, Singapore, South Korea, and Taiwan), found that students from East Asian countries had higher levels of instrumental motivation compared to their Australian peers. For example, students from East Asian countries had stronger beliefs that they would have a better life if they excelled in their studies. Several studies that have examined the relationship between instrumental motivation among students and their academic performance in languages and STEM courses based on students' gender found no differences among genders (Areepattamannil, 2014; Liu et al., 2018; Tella, 2007). The development of instrumental motivation in mathematics starts at a young age (Linder et al., 2015). Linder's study examined instrumental motivation in mathematics for students in elementary school and found that a significant number of

students could articulate the rewards of working hard in mathematics and how an excellent grade in mathematics would be beneficial to them in the future. Research has also shown positive relationships of perceived instrumentality with effort (Husman et al., 2004) and performance (Husman & Hilpert, 2007) among college students.

Mathematics Anxiety

According to Novak & Tassell (2017), mathematics anxiety is a feeling of nervousness, fear, or defeat experienced by a person when performing numerical tasks. Numerous factors contribute to the formation of mathematics anxiety. One such factor is the student's attitude toward learning mathematics. Stoet et al. (2016a) found that students who expressed negative attitudes toward mathematics tended to have higher levels of mathematics anxiety. Moreover, both negative attitudes toward mathematics and high levels of mathematics anxiety have been found to have negative relationships with students' STEM course performance (Kargar et al., 2010a; Novak & Tassell, 2017; Pitsia et al., 2017).

Another factor related to mathematics anxiety is a student's level of competency in executing numerical tasks. Students who experience higher levels of mathematics anxiety tend to underperform in mathematics (Dowker et al., 2016). Dowker et al. mentioned that students who are anxious tend to avoid tasks involving numerical manipulation. Additionally, the lack of practice hinders students' understanding of mathematics concepts. Although both men and women experience mathematics anxiety, women tend to report higher levels than men (Dowker et al., 2016; Kargar, Tarmizi, & Bayat, 2010b; Novak & Tassell, 2017; Stoet, Bailey, Moore, & Geary, 2016a). Studies that have investigated differences in mathematics anxieties between men and women have reached diverse conclusions. However, cultural factors and negative stereotypes against women partially explain why women report higher levels of mathematics anxiety (Stoet et al., 2016a). Research has shown that gender achievement gaps in mathematics tend to be narrower in developed countries with societies that have similarly high expectations for both boys and girls to excel academically (Bailey, Moore, & Geary). Mathematics anxiety levels are higher among girls in developing countries where girls have fewer educational opportunities than boys. Although mathematics anxiety has been suggested to be unrelated to the numbers of women working in STEM fields (Bailey, Moore, & Geary, 2016b), mathematics anxiety has detrimental effects on mathematics performance, and beliefs about performance influence course enrollment decisions and career paths in STEM (Eccles & Wigfield, 2002).

Mathematics Work Ethic

According to McCortney & Engels (2003) work ethic encompasses two distinct components (a) attitudes and values and (b) the behaviors that reflect those attitudes and values. As a construct, work ethic has theological roots in Scripture (e.g., the Book of Genesis), the Protestant Reformation, and Calvinism (McCortney & Engels, 2003). Work ethic has also been operationalized for research purposes in education (Fox & Gram, 2007), work (Blau & Ryan, 1997), and general psychology (Miller, Woehr, & Hudspeth, 2002) contexts. Work ethic has been described as a belief that hard work and perseverance pay off, are necessary for increasing a person's chances of succeeding

on a task (Kobylski et al., 2009), and are inherently valuable (Miller, Woehr, & Hudspeth, 2002). Emphasizing the behavioral component of work ethic, PISA (2015) described its self-report assessment of mathematics work ethic as measuring domain-related behaviors. Work ethic manifests in several ways. For instance, it can be demonstrated by a person's determination to persevere through challenging or uninteresting mathematics tasks. Additionally, a person's diligence in tackling a problem from various perspectives, with the aim of identifying the most effective solution or utilizing an alternative method to eliminate tedious approaches, is noteworthy.

Although students may internally activate work ethic to solve problems when studying independently (Areepattamannil et al., 2016 & Kobylski et al., 2009). Mathematics work ethic is an important predictor of academic resilience (Cheung et al., 2015). Mathematical resilience is a positive approach towards learning mathematics which enables people to overcome challenges (Johnston-wilder & Lee, 2010). Cheung (2015) investigated the effect of mathematics work ethic on mathematic literacy performance for students in China, South Korea, Singapore, and other East Asian countries. Cheung (2015) found that mathematics work ethic had low to medium effect on mathematic literacy performance among East Asian students. Mathematics work ethic has been found to be related to self-confidence in one's abilities to perform tasks involving arithmetic operations (OECD, 2014). Although the behavioral manifestation of mathematics work ethic is likely to improve mathematical resilience this construct has not been investigated adequately or examined in conjunction with instrumental motivation and mathematics anxiety to explain science performance on PISA (Johnston-wilder & Lee, 2010).

The Present Research

As described in our literature review, extensive research has been conducted on mathematics anxiety and instrumental motivation as predictors of mathematics performance. However, few studies have examined these factors as predictors of scientific literacy. Furthermore, we found no studies that have examined mathematics work ethic as a mediator. Mathematics work ethic construct was introduced by the Programme for International Student Assessment (PISA) in 2012.The construct emphasizes on students' perceptions of their work ethic behaviors, rather than attitudinal facets of work ethic. Social-cognitive theory (Schunk & DiBenedetto, 2020), research on academic anxiety (Pekrun et al, 2011) and instrumental motivation (Husman & Hilpert, 2007) predict behavioral effects of personal factors related to students' emotions (e.g., anxiety) and attitudes (e.g., instrumental motivation) towards learning.

Researchers (Schunk & DiBenedetto, 2020) have also called for more nuanced investigations that examine the robustness of findings for subpopulations of students, as relationships among variables and the salience of constructs may vary by culture, socioeconomic status, gender, and other factors. The purpose of our investigation is to examine mathematics anxiety, instrumental motivation to learn mathematics, and mathematics work ethic as predictors of scientific literacy, and mathematics work ethic as a mediator. In addition, we aim to examine these relationships by gender and socioeconomic status. Aligned with this purpose, we have three overarching research questions:

1. Do mathematics anxiety, instrumental motivation in mathematics, and mathematics work ethic have direct effects on scientific literacy?

2. Does mathematics work ethic mediate relationships between mathematics anxiety and scientific literacy and between instrumental motivation and scientific literacy?

3. Are the relationships among study variables invariant by gender and socioeconomic status?

For research question 1, we hypothesized that mathematics anxiety would be negatively related to scientific literacy and that instrumental motivation and mathematics work ethic would be positively related to scientific literacy. For research question 2, we hypothesized that mathematics work ethic would mediate relationships between mathematics anxiety and scientific literacy and between instrumental motivation and scientific literacy. For research question 3, we had no specific hypotheses about whether or not the relationships among study variables would be invariant by gender and socioeconomic status.

Methods

Data for this study were obtained from the Programme for international student assessment (PISA) from Austrialia in the 2012 survey. PISA data were obtained from the Organisation for Economic Co-operation and Development (OECD) website. A description of the survey and methodology are provided on the website.

Participants

A total of 4500 participants were randomly selected from a nationally representative sample of over 14,000 secondary school students who were surveyed by PISA in Australia (OECD, 2014). The study sample consisted of female ($n = 2,222$, 49%) and male ($n = 2,278$, 51%) students, and students who were identified as low SES ($n = 1,747$, 38%) and high SES ($n = 2,753$, 62%). The age of surveyed students ranged between 15 years and 3 months and 16 years and 2 months.

Research Design and Procedures

This secondary analysis of PISA 2012 data utilized a correlation research design. Participants included in the PISA 2012 Australian sample completed self-report questionnaires and performance assessments that yielded numerous variables (for a detailed description of PISA 2012 data and methods used to obtain these data see OECD, 2014). Variables selected for use in this study were self-report measures of instrumental motivation to learn mathematics (predictor), mathematics anxiety (predictor), mathematics work ethic (mediator), gender (moderator), and socioeconomic status (moderator) and a performance assessment of scientific literacy (outcome).

Measures

PISA 2012 measures (OECD, 2014) were used in the current study and internal-consistency reliability analyses were conducted for each self-report scale. Four statements were used to measure instrumental motivation to learn mathematics (e.g., "making an effort in mathematics is worth it because it will help me in the work that I want to do later on"; Cronbach's $\alpha = 0.91$), five statements were used to measure mathematics anxiety (e.g., "I get very

tense when I have to do mathematics homework"; Cronbach's $\propto = 0.85$) and nine statements were used to measure students' mathematics work ethic (e.g., "I work hard on my mathematics homework"; Cronbach's $\propto = 0.91$). Survey participants responded to each statement on a four-point Likert scale by choosing one of the following options: strongly agree; agree; disagree, and strongly disagree. To address issues with missing data, PISA used five plausible values to determine students' performance scores in scientific literacy (OECD, 2014). Performance in scientific literacy has been defined as:

> … scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues; their understanding of the characteristic features of science as a form of human knowledge and inquiry; their awareness of how science and technology shape our material, intellectual and cultural environments; and their willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen (Thomson De Bortoli, & Buckley, 2012, p. 127).

The PISA 2012 scientific literacy assessment has been divided into four categories (OECD, 2014). The first category assessed students' scientific knowledge about situations and content in which science was used in life situations that involve science and technology (i.e. rapid changes (earthquakes, severe weather), slow and progressive changes (coastal erosion, sedimentation, and risk assessment). The second category assessed students' scientific competencies (i.e. interpreting scientific evidence and communicating conclusions). The third category assessed students' scientific knowledge (i.e. role of science-based technology in solving problems and how technology is used to help humans meet their needs). Additionally, data on students' gender (female, male) and SES (low SES, high SES) were obtained from PISA 2012 (OECD, 2014). PISA determined the socioeconomic status of each student based on their parental level of education, occupations, and home possessions.

Data Analysis

Structural equation modeling (SEM) using Analysis of Moment Structures (AMOS) version 26 software was used for hypotheses testing. SEM was used to examine mathematics work ethic as a mediator between mathematics anxiety and scientific literacy and between instrumental motivation to learn mathematics and scientific literacy. Multi-group SEM was used to examine gender and socioeconomic status as moderators of these relationships. All SEM models included 18 survey items used to estimate the latent constructs instrumental motivation, mathematics anxiety, and mathematics work ethic, and five plausible values to estimate the latent construct scientific literacy. In addition, parameters were estimated for the following relationships among latent constructs: three direct effects of mathematics anxiety, instrumental motivation, and mathematics work ethic on scientific literacy, two direct effects of mathematics anxiety and instrumental motivation on mathematics work ethic, and two indirect effects of mathematics anxiety and instrumental motivation on scientific literacy through mathematics work ethic. Researchers have recommended large sample sizes for SEM analyses with at least several hundred cases (Tabachnick & Fidell, 2013) and with at least 10-20 cases per parameter estimate (Kline, 2015; Schreiber et al., 2006). Therefore, our sample of 4,500 participants was more than adequate for the proposed analyses involving 30 parameter estimates for the overall model and 60 parameter estimates for each multi-group SEM analysis. We used the following fit indices: chi-square, TLI (Tucker-Lewis Index), CFI (comparative fit index), SRMR

(standardized root-mean-square residual), and RMSEA (root mean squared error of approximation) to assess model fit (Kline, 2011). The following rule of thumb was used for determining models that fit the data well: CFI ≥.95, RMSEA ≤ .06, and SRMR ≤ .09 (Hu & Bentler, 1999 & Kline, 2011). Regression coefficients were tested for statistical significance at the $p < .05$ level. Standardized regression coefficients are reported as a measure of effect size. Bootstrapping in AMOS was used to test direct and indirect effects (Hu & Wang, 2010). The number of Bootstrap samples was 2000 and the bias-corrected confidence interval was 95%.

Results

Cronbach's alpha reliability coefficients were above 0.80 for each self-report scale, showing strong internal consistency reliability. Items for each construct were averaged to derive scale scores to compute descriptive statistics and bivariate correlations among variables (see Table 1). Continuous variables were all normally distributed and we found no violations of statistical assumptions. For our primary analyses, we constructed three SEM models to test the study hypotheses. In the first model, we regressed instrumental motivation, mathematics anxiety, and mathematics work ethic on scientific literacy and examined mathematics work ethic as a mediator between mathematics anxiety and scientific literacy and between instrumental motivation and scientific literacy. This model had the following fit indices: Chi-square (222, $N = 4500$) =2,580.856, TLI= 0.969, CFI = 0.973, SRMR = 0.078, RMSEA= 0.049 and RMSEA (0.047, 0.050). Following (Hu & Bentler, 1999), these model-fit indices indicated the hypothesized model fit the data well. Standardized regression coefficients and statistical significance levels are reported in Figure 1. As hypothesized, instrumental motivation to learn mathematics was positively related to mathematics work ethic ($\beta = 0.52$, $p = 0.001$), whereas mathematics anxiety was negatively related to mathematics work ethic ($\beta = -0.24$, $p = 0.001$). In addition, mathematics work ethic positively predicted scientific literacy ($\beta = 0.06$, $p = 0.01$) and mathematics anxiety negatively predicted scientific literacy ($\beta = -0.32$, $p = 0.001$). Examination of indirect effects (i.e., mediation) showed that mathematics work ethic fully mediated the relationship between instrumental motivation to learn mathematics and scientific literacy (indirect effect: $\beta = 0.029$, $p = 0.009$), while the direct relationship between instrumental motivation and scientific literacy ($\beta = 0.03$, $p = 0.12$) was not statistically significant. This type of mediation has been referred to as full or indirect-only mediation (Zhao et al., 2010). As hypothesized, higher scores on instrumental motivation were associated with higher scores on mathematics work ethic which in turn increased the likelihood of performing well in scientific literacy. The indirect effect of mathematics anxiety on scientific literacy through mathematics work ethic was also statistically significant (indirect effect: $\beta = -0.013$, $p = 0.008$). As hypothesized, this indirect effect showed that higher mathematics anxiety was associated with lower mathematics work ethic which in turn decreased the likelihood of performing well in scientific literacy. Because the direct effect of mathematics anxiety on scientific literacy was statistically significant, the indirect effect could be described as partial mediation; and, because the directional relationship of the indirect and direct effects involving anxiety on scientific literacy was congruent (i.e., anxiety detracted from scientific literacy directly and indirectly through work ethic), this mediational relationship could be described as complementary to the direct effect (Zhao et al., 2010). These results supported our hypotheses that work ethic would mediate relationships involving both mathematics anxiety and instrumental motivation.

We conducted a multi-group SEM analysis of the proposed model for females and males and found strong model fit indices for the unconstrained model that allowed regression coefficients to vary between females and males (χ^2 (444) = 2,861.405, TLI= 0.968, CFI = 0.972, SRMR = 0.077, RMSEA = 0.035 (0.034, 0.036). As an overall test of the differences in model parameters between females and males, we conducted a chi-square difference test between the unconstrained and constrained models (Schumacker & Lomax, 2010). The test was statistically significant (χ^2 (24) = 58.858, $p < 0.001$) and supported our decision to differentiate the results by gender. Coefficients for females and males are presented in Figure 2. For both males and females, the following links were statistically significant: mathematics anxiety to work ethic (Female: β = -0.282, $p = 0.001$; Male: β = -0.226, $p = 0.001$), instrumental motivation to work ethic (Female: β = 0.507, $p = 0.001$; Male: β = 0.537, $p = 0.001$) and anxiety to science (Female: β = -0.284, $p = 0.001$; Male: β = -0.348, $p = 0.001$). The pattern of results for males and females diverged with regards to relationships involving instrumental motivation and work ethic. For females, work ethic fully mediated the relationship between instrumental motivation and scientific literacy (indirect effect: β = 0.049, $p = 0.001$) and partially mediated the relationship between mathematics anxiety and scientific literacy (indirect effect: β = -0.027, $p = 0.001$). The pattern of indirect effects for females was the same as previously described for the first model that did not differentiate females and males. For males, neither indirect effect was statistically significant (indirect effects: β = 0.007, $p = 0.642$; β = -0.003, $p = 0.645$, respectively). However, the direct effect of instrumental motivation on scientific literacy was statistically significant (β = 0.062, $p = 0.030$). This showed that instrumental motivation in mathematics positively contributed to male students' scientific literacy, but not through an indirect effect on mathematic work ethic as it did for females.

We also conducted a multi-group SEM analysis of the proposed model for students of low and high socioeconomic status and found strong model fit indices for the unconstrained model that allowed regression coefficients to vary between groups (χ^2 (444) = 2,891.753, TLI= 0.967, CFI = 0.971, SRMR = 0.070, RMSEA = 0.035 and RMSEA (0.034, 0.036). The chi-square difference test between the unconstrained and constrained models was statistically significant (χ^2 (24) = 40.098, $p = .021$) and supported our decision to differentiate the results by socioeconomic status. Standardized regression coefficients and statistical significance levels for low and high SES are presented in Figure 3. For both low and high SES groups, the indirect effects involving mathematics anxiety through work ethic (Low SES: β = -0.008, $p = 0.239$; High SES: β = -0.003, $p = 0.647$) and instrumental motivation through work ethic (Low SES: β = 0.022, $p = 0.266$; High SES: β = 0.006, $p = 0.654$) were not statistically significant, nor was the relationship between work ethic and scientific literacy (Low SES: β = 0.039, $p = 0.270$; High SES: β = 0.012, $p = 0.667$). In addition, and as was true for the first two models, instrumental motivation was positively related to mathematics work ethic (Low SES: β = 0.555, $p = 0.001$; High SES: β = 0.493, $p = 0.001$) and mathematics anxiety was negatively related to both mathematics work ethic (Low SES: β = -0.200, $p = 0.001$; High SES: β = -0.242, $p = 0.001$) and scientific literacy (Low SES: β = -0.295, $p = 0.001$; High SES: β = -0.314, $p = 0.001$). The pattern of results for the low and high SES groups diverged with regards to relationships involving instrumental motivation. For the low SES group, instrumental motivation was not a statistically significant predictor of scientific literacy (β = 0.037, $p = 0.277$), whereas for the high SES group instrumental motivation had a statistically significant positive relationship with scientific literacy (β = 0.060, $p = 0.008$).

Table 1. Descriptive Statistics of Scale Scores for Each Study Variable

		1	2	3	4
1	Instrumental motivation to learn mathematics	1			
2	Mathematics Anxiety	-0.27***	1		
3	Mathematics work ethic	0.51***	-0.32***	1	
4	Performance in scientific literacy	0.14***	-0.31***	0.18***	1
5	M	2.99	2.44	2.76	517.05
6	SD	0.72	0.64	0.59	96.46

$N = 4500$, ***$p < 0.001$. Items for each construct were averaged to compute scale scores.
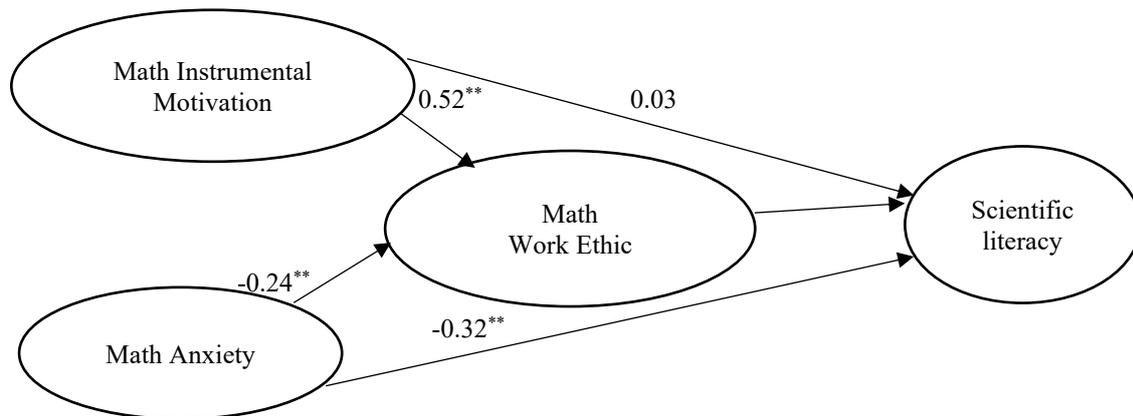

Figure 1. Standardized Estimates for Pathways between the Constructs for the Total Sample

*$p < .05$, **$p < .01$. ***$p < .001$. The 23 survey items and plausible values used to estimate the five latent constructs shown above were included in the SEM model but are not shown here. Math work ethic mediated effects of anxiety and instrumental motivation on scientific literacy.
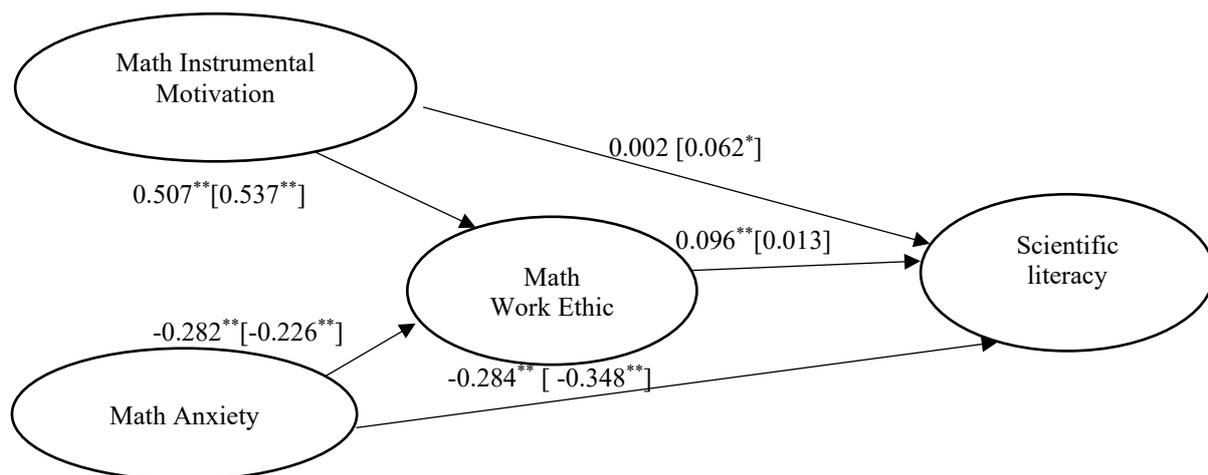

Figure 2. Standardized Coefficients for the Multi-Group Model Investigating Gender

Female [Male]. *$p < .05$, **$p < .01$, ***$p < .001$. The 23 survey items and plausible values used to estimate these four latent constructs were included in the SEM model but are not shown here. For females, math work ethic mediated effects of anxiety and instrumental motivation on scientific literacy. For males, no statistically
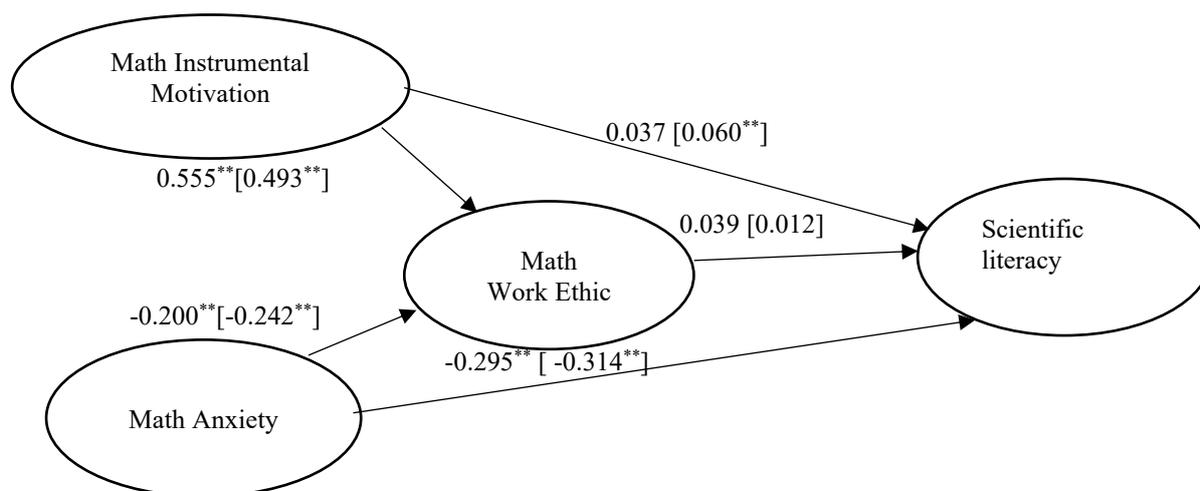
significant mediation effects were detected.

Figure 3. Standardized Coefficients for the Multi-Group Model Investigating Socioeconomic Status

Low SES [High SES]. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. The 23 survey items and plausible values used to estimate these four latent constructs were included in the SEM model but are not shown here. There were no statistically significant indirect effects through math work ethic for either group.

Discussion

Our study found support for the hypotheses that instrumental motivation to learn mathematics was positively associated with mathematics work ethic, and mathematics anxiety was negatively associated with both mathematics work ethic and performance in scientific literacy. These associations remained the same when gender and social-economic status of the participants were considered. The multi-group SEM analyses by gender showed that mathematics work ethic mediated relationships for females, but not for males. More specifically, for females, we found that mathematics anxiety detracted from their work ethic behaviors and affected their performance in scientific literacy. Furthermore, instrumental motivation positively contributed to female students' work ethic behaviors which in turn enhanced their scientific literacy. For males, neither of these indirect effects were statistically significant and work ethic did not have a direct effect on scientific literacy. This suggests that, females, work ethic behaviors may be a more pronounced mediational path through which anxiety and instrumental motivation influence science performance. The finding that work ethic mediates effects of anxiety and instrumental motivation on science performance for females but not males could provide new insights to research attempting to understand gender differences in science learning and motivation. Intervention research examined methods for increasing students' instrumental motivation (Rozek et al., 2015). Results vary between females and males. For example, Gaspard et al. (2015) found some evidence that females reaped stronger benefits than males from personal relevance interventions designed to strengthen instrumental connections between course learning and students' interests and goals. In addition, research has suggested that anxiety is a stronger interference to academic performance for females than males (Zhang et al., 2019). The findings from the current study give reason to question whether previously observed gender differences may be related to the different mediational

paths we observed between males and females involving their work ethic behaviors.

Given disparities faced by female students (Rosenthal, London, Levy, Lobel, & Herrera-Alcazar, 2011), work ethic may be a vital component to overcoming barriers and succeeding in science. Our results suggest that, mathematics anxiety among female students and instrumental motivation for mathematics contribute to science performance through their effects on work ethic. For males in our study, mathematics anxiety negatively predicted scientific literacy. However, instrumental motivation positively predicted scientific literacy. These effects were not mediated through work ethic. Theory and research suggest that anxiety and instrumental motivation may work through other mediators. For example, research has shown that anxiety can detract from task performance because of difficulty concentrating while anxious (Fernandez-Castillo et al, 2015). Instrumental motivation could facilitate students' science learning because it involves cognitive elaboration, making connections between the learning content and personal knowledge, experiences, and goals, and could aid memory and deep level processing (Schunk et al., 2008). Therefore, it is plausible that alternative mediational routes may be more pronounced for males that were not examined in this study.

Multi-group SEM results for students of low and high SES had the same pattern of results with one exception—the low SES group, instrumental motivation was not related to scientific literacy, whereas the high SES group this relationship was positive and statistically significant. Research has shown that students of low SES are more likely than students of high SES to experience financial, and social obstacles to attending college and pursuing careers in mathematics and science (McConney & Perry, 2010). Students of low SES are also less likely to have role models in their community who are familiar with these career pathways and could provide support (McConney & Perry, 2010). These environmental factors may overshadow the role of instrumental motivation in supporting scientific performance for students of low SES. Also, the reasons that motivate students of low SES may be different, on average, than the reasons that motivate high SES. For example, research has shown that students of first-generation status are more likely to report being motivated towards college success because they want to make their family proud and help trailblaze new pathways for their relatives to travel (Lundberg, Schreiner, Hovaguimian, & Slavin Miller, 2011). For students of high SES, on the other hand, instrumental connections between science learning and the attainment of individual goals may be a more salient reason for facilitating science performance.

The negative association between mathematics anxiety and performance in scientific literacy found in this study are supported by results from previous studies (Harari, Vukovic, & Bailey, 2013a, 2013b; Kargar et al., 2010b; Sherman & Wither, 2003). However, most studies in the past examined the link between mathematics anxiety and performance in mathematics. Numerous reasons have explained the more pronounced effects of mathematics anxiety on female compared to their male counterparts. In several self-reported surveys, a relatively larger percentage of female students than male students doubted their ability (e.g. mathematics self-concept, mathematics self-efficacy) to excel in mathematics as a subject or in performing daily tasks that require arithmetic skills (Dowker et al., 2016). Also, research has shown that female students are less likely to pursue a career in science, technology, engineering, and mathematics (STEM) (Zhang, Zhao, & Kong, 2019 & Ziegler et al., 2014). Cultural factors play a significant role in magnifying or reducing the effects of mathematics anxiety on students'

performance in a STEM subject (Zhang et al., 2019). In societies where both male and female students are encouraged and supported to pursue studies and/or careers in STEM, the availability of role models and positive feedback from teachers, parents, and guardians can reduce the negative effects of mathematics anxiety for both female and male students (Dowker et al., 2016; Harari et al., 2013b; Stoet et al., 2016b; Stuart, 2016).

We found that mathematics anxiety was negatively linked to mathematics work ethic. This observation is aligned with various studies on the subject (e.g. the study habits of students who experience mathematics anxieties) (Harari et al., 2013a; Pitsia et al., 2017; Sherman & Wither, 2003). The two variables (mathematics anxiety and mathematics work ethic) may be cyclically linked, for example, in general, ineffective study habits and low mathematics work ethic tend to increase mathematics anxiety because they indicate students' low mastery of the course content (Dowker et al., 2016). Reciprocally, high mathematics anxiety can contribute to behaviors that reflect a low mathematics work ethic when students avoid seeking help and engaging in activities that involve numerical manipulations. Therefore, students struggle when doing their assignments, are afraid of trying new or better methods of solving mathematics and/or science problems. Students anxious about mathematics may benefit from joining a study group (Ashcraft, 2002 & Passolunghi et al., 2016).

Instrumental motivation to learn mathematics was positively linked to mathematics work ethic. Instrumentally motivated students exhibit study habits that increase their chances to excel academically. For example, students instrumentally motivated to learn mathematics are more likely to seek help and/or feedback from teachers, work on their assignments on time with minimal supervision and, explore alternative ways of solving mathematics problems (Liu et al., 2018). Additionally, students who are instrumentally motivated are more likely to strive to understand the subject content in-depth because they intend to apply current course content in future courses or their careers (Pitsia et al., 2017).

Limitations and Future Directions

Several factors may limit the generalization of this study's findings. The scope of the data sample is narrow. Participants were Australian high school-aged students between 15 years and 3 months and 16 years and 2 months. Therefore, making generalization to students in other age brackets and countries or cultures may be challenging. For example, the negative effects of mathematics anxiety on students' academic performance tend to intensify with age (Harari et al., 2013). Although mediational pathways were tested involving work ethic, the correlational nature of this study limits any causal claims. Future longitudinal research should examine the relationships among study variables across different academic stages (e.g., elementary, middle, and high school). Similarly, replication of this study with data from other countries will enable comparisons and widen discussions on the present study's results. Examination of work ethic as a mediator yielded encouraging results for females, however, further studies are needed to identify mediators for males. Also, for females, the effect of instrumental motivation on scientific literacy was fully mediated by work ethic, whereas the relationship between anxiety and scientific literacy was partially mediated. This calls for future research to examine other potential mediators between anxiety and scientific literacy for females.

Conclusion

The results of this study contribute new evidence about the predictive roles of mathematics anxiety, instrumental motivation, and work ethic in explaining performance on PISA's scientific literacy test, and how some of these relationships vary by gender and socioeconomic status. Findings suggest that mathematics anxiety is negative predictor of students' work ethic behaviors and scientific literacy, implying the ongoing need for researchers, educators, and parents to help students mitigate the negative effects of mathematics anxiety. For females, mathematics work ethic positively predicted scientific literacy and mediated the effects of both anxiety and instrumental motivation, whereas these relationships were null for males. For students of high SES, instrumental motivation was a positive predictor of scientific literacy, but this was not the case for low SES. These different patterns of results by gender and SES suggest a need for more research to understand the root causes of these differences. They also offer insights that may help to explain why students of different genders and socioeconomic statuses may benefit differently from educational interventions targeting instrumental motivation, anxiety, and work ethic. Accordingly, researchers and practitioners conducting intervention work targeting these factors should examine the moderating roles of gender and SES and investigate the extent to which students are being served equitably. The results of this study also corroborated relationships between personal and behavioral factors proposed by social-cognitive research on anxiety and motivation and provide new avenues for research about how the patterns of relationships may vary by gender and socioeconomic status.

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