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Relations among Engagement, Self-Efficacy, and Anxiety in Mathematics among Omani Students

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Abstract

Introduction. Mathematics is one of the most important academic subjects in school. However, it is one of the most difficult subjects, and both students and teachers face difficulties in this subject. Teachers have difficulty engaging students in learning the subject. Rarely has the concept of engagement been researched in the Middle East region, in general, and in Oman in particular. Similarly, the concept of self-efficacy has been minimally investigated. The purpose of this study is to test the construct validity of: self-efficacy, engagement, and anxiety in mathematics.

Method A multi stage cluster sample (n=900: 420 females; 480 males) was selected from two Omani school directorates. The sample was selected from grades 6, 8 and 10 in Muscat and Aldhahira. Three measures were administered to intact classes. Models of relations among the constructs were developed and tested.

Results. The results revealed reasonable construct validity for each construct. Structural equation models indicated that self-efficacy significantly predicted engagement. Neither self-efficacy nor engagement was able to predict anxiety. The results of correlations, SEM as well as dis-criminant analysis, with math anxiety is included, are inconsistent with most previous re-search.

Discussion and Conclusion. For programs and initiatives to promote engagement in mathematics, students should devel-op confidence in learning mathematics. In addition, any program should assess students' math anxiety and focus more on students with low to medium math anxiety. The nature of math anxiety in Oman raises many questions.

Keywords: Self-efficacy; engagement; anxiety; mathematics; Oman

Resumen

Introducción. Las matemáticas son uno de los temas más difíciles, y tanto los estudiantes como los maestros enfrentan dificultades en esta materia. Los maestros tienen dificultades para involucrar a los estudiantes en el aprendizaje de la materia. Rara vez se ha investigado el concepto de compromiso en la región de Medio Oriente, en general, y en Omán en particular. Del mismo modo, el concepto de autoeficacia ha sido mínimamente investigado. El propósito de este estudio es probar la validez de constructo de: autoeficacia, compromiso y ansiedad en las matemáticas.

Método. Se seleccionó una muestra de grupo de múltiples etapas (n = 900: 420 mujeres; 480 hombres) de dos direcciones escolares de Omán. La muestra fue seleccionada de los grados 6, 8 y 10 en Mascate y Aldhahira. Se administraron tres medidas a las clases intactas. Se desarrollaron y probaron modelos de relaciones entre los constructos.

Resultados. Los resultados revelaron una validez de construcción razonable para cada construcción. Los modelos de ecuaciones estructurales indicaron que la autoeficacia predijo significativamente el compromiso. Ni la autoeficacia ni el compromiso fueron capaces de predecir la ansiedad. Los resultados de las correlaciones, SEM y análisis discriminantes, con ansiedad matemática incluida, son inconsistentes con la mayoría de las investigaciones anteriores.

Discusión y **Conclusion.** Para programas e iniciativas que promuevan la participación en las matemáticas, los estudiantes deben desarrollar confianza en el aprendizaje de las matemáticas. Además, cualquier programa debe evaluar la ansiedad matemática de los alumnos y centrarse más en los alumnos con ansiedad matemática baja a media. La naturaleza de la ansiedad ante las matemáticas en Omán plantea muchas preguntas.

Palabras clave: autoeficacia; compromiso; ansiedad; matemáticas; Omán

Introduction

This study is a cross-sectional one that intends to explore the relationships among self-efficacy, engagement, and anxiety in mathematics. Learning, specifically, learning mathematics, can't be understood if the conditions of this learning are not known or understood. Engagement is one such condition where mathematics requires focus, interest, and engagement. Also, students should believe in their abilities to learn. If they have little confidence in their abilities to learn and they are not engaged in the learning process, they will probably develop unpleasant emotions in the subject such as helplessness and anxiety. Mathematics is one of the subjects in which students clearly develop annoyances and anxiety. Anxiety, in turn is one of the emotional states that may hinder learning. Therefore, it is important to know how and to what extent engagement and self-efficacy operate to reduce anxiety in mathematics. Yet, more important is that we know exactly what we mean when we talk about self-efficacy, engagement, and anxiety in mathematics. It is important to validate these constructs before they can be used in research and programs.

Curriculum developers, as well as teachers would benefit from knowing the logical relations among self-efficacy, engagement, and anxiety when they plan the curriculum and plan their lessons. Such knowledge is important to every subject matter, yet, it is most important to the subject of mathematics.

Thus, there is need to investigate the constructs of self-efficacy, engagement and anxiety in the context of mathematics learning and establish their validity. The specified relations among these constructs fall within the construct validation. This is precisely the purpose of the present research. Once a construct's validity is established, it is possible to proceed with various kinds of meaningful research such as possible causal relationships. Thus, the establishment of a validated instrument is, in fact, a prerequisite to future development in the field of student learning of mathematics. In the following lines we discuss the conceptualization of each construct and the theoretical inter-relations among them as evidenced in the relevant literature.

Self-efficacy

Self-efficacy is considered as one important component of motivation. It has been defined as the beliefs about the capabilities to produce a specific performance and influence events that will affect different aspects of individuals' lives (Ashcraft & Rudig, 2012). As such, people's levels of motivation, thinking and behavior are determined by their self-efficacy beliefs. It has been considered as a key motivational construct (Linnenbrink & Pintrich, 2003) and an emotional ingredient (Martin & Rimm-Kaufman, 2015) that can predict effort expenditure and performance.

Self-efficacy beliefs are strongly related to cognitive engagement, in the form of using cognitive and metacognitive or regulatory strategies, that lead to better performance (Metallidou, & Vlachou, 2007). Bandura (1986) claims that cognition, such as self-efficacy, exerts an influence on human behavior, particularly in achievement settings. Some researchers argue that self-efficacy influences the types of learning strategies and other affective variables such as anxiety, choice and persistence (e.g., Pajares and Graham, 1999). Research within the social cognitive theory of learning has shown that self-regulated learners approach academic tasks more strategically. Self-regulated learners have more confidence, more positive attitudes and achieve more. They are more likely to use self-regulated strategies when they believe they have higher self-efficacy and interest (Zimmerman, Bandura, & Martinez-Pons, 1992). Some studies in Arabic also found relations between self-efficacy and achievement, either directly, or indirectly through mediating variables such as metacognition (e.g., Author, 2011).

Additionally, self-efficacy, expectation, and interest have been found related to affective engagement (Cleary & Chen, 2009; Martin & Rimm-Kaufman, 2015). Pintrich and Schunk (1996) argued that the feelings and beliefs about interest and value lead to more student engagement and learning. Researchers have increasingly employed self-efficacy theory in recent years to study motivation as well as to explore the role of self-efficacy in the formation of engagement. As self-efficacy refers to the speculation and judgment of whether an individual is capable of completing an action (Kamen, Flores, Etter, Lazar, Patrick, Lee, … & Gore-Felton, 2013), self-efficacy can play a corrective action on math anxiety.

Nevertheless, researchers caution against the "conceptual mess" among the self-belief constructs (e.g., Bong, 1996; Bong & Skaalvik, 2003). They recommend that these construct be clearly defined; and they advise that confirmatory factor analysis (CFA) and structural equation models (SEMs) be applied to evaluate the structural, predictive, convergent, and discriminant validity of the different motivational constructs. This particularly applies to self-efficacy and other self-perception constructs. Again, this is precisely the aim of this study.

Engagement in mathematics

The constructs of engagement and motivation are closely related; however, they are different (Kong, Wong & Lam, 2003). Motivation refers to the ways in which students choose to behave and show confidence in their ability to overcome obstacles and challenges as well as their capacity to recover from academic setbacks (Kim, Park, Cozart, & Lee 2015). Student engagement, on the other hand, is a new and slowly evolving construct that has been perceived essential for math-learning (Martin & Rimm-Kaufman, 2015). It has been defined as the “psychological investment in and effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (Newmann, Wehlage, & Lamborn, 1992, p.12).

Student engagement is an important aspect of motivation (Linnenbrink, & Pintrich, 2003). Everingham et al. (2017, p. 1154) stated, “… evidence for the effectiveness of student engagement for learning and subject mastery is overwhelming”. Everingham et al. (2017) pointed that few studies that have investigated the effect of engagement on mathematics anxiety. Everingham et al. (2017) used some strategies to engage students in mathematics and science and found those strategies overcome mathematical anxieties. They found that reduced math anxiety enhanced subject mastery (Everingham et al., 2017).

Math engagement has been conceived as a multidimensional construct (Kahu, 2013). Behavioral, affective and cognitive dimensions represent the the major components of engagement. Although behavioral engagement can be observed, cognitive and emotional engagement are not. Therefore, self-report measures of the constructs have been developed. Some researchers indicated that measures of engagement have been with weak conceptualization and unclear psychometric properties (e.g., Fredricks, Wang, Linn, Hofkens, Sung, Parr & Allerton, 2016; Kahu, 2013; Wang, Fredricks, Ye, Hofkens, & Linn, 2016). Kahu, (2013) and Everingham, Gyuris, & Connolly (2017) commented that engagement has a poor definition and a lack of distinction from the factors that influence it and those that are caused by it. Wang et al. (2016) suggested that developing measures for engagement is urgently needed. Despite the criticism that has been directed to the conceptualization and measurement of engagement, several measures have been developed (e.g., Kong et al., 2003; Veiga, 2016; Wang et al., 2016) that have sound theoretical frameworks and reasonable psychometric characteristics. These measures were validated with Western and Asian samples. Both of the measures relied on the conceptualization that engagement is a multidimensional construct with three or four factors: Cognitive, emotional/affect, and behavioral (Kong et al., 2003). Wang et al. (2016) added a fourth dimension, social engagement. The present research is using an adapted, yet, brief measure of engagement that was developed by Wang et al. (2016) as we will describe in the method section.

Math anxiety

Math anxiety has been defined as a feeling of "tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551, quoted from Jameson & Fusco, 2014). Research on math anxiety indicates that individuals in particular domains have higher levels of anxiety than others do, although it is not clear how and why some individuals develop math anxiety. Akin and Kurbanoglu (2011, p. 264) stated: "Some researchers sustain that this structure is multi-dimensional while others argue that math anxiety is a form of test anxiety particular to the field".

It is believed that self-efficacy as well as other personal factors play a role in the development of anxiety. Individuals low in self-efficacy tend to be high in math anxiety. Self-efficacy has consistently been shown to be low in highly math-anxious individuals (Akin & Kurbanoglu, 2011; Cooper & Robinson, 1991; Meece, Wigfield, & Eccles, 1990). The negative relationship between the two constructs is quite sensical, as it is difficult to have confidence in one's abilities when anxiety results in self-doubt. Previous research have found that self-efficacy is predictive of an individual's level of math anxiety and performance, particularly in mathematics (Akin & Kurbanoglu, 2011; Jameson, 2013a; Pietsch, Walker, & Chapman, 2003; Usher & Pajares, 2008). Author (2000) and Ya'aqoub (1996) found negative correlations between math anxiety and each of attitudes toward math and effort exerted in math. Similarly, Author and Author (in press) found that math anxiety correlated negatively with math self-concept and general motivation. Also, Metallidou and Vlachou (2007) and Akin & Kurbanoglu, (2011) found a negative correlation between self-efficacy and math test anxiety. Hence, math anxiety seems to be negatively correlated with most other motivational constructs such as self-efficacy, self-concept, mastery orientation, performance orientation, and general motivation.

Research that deals with self-efficacy, engagement and math anxiety, together in one model, in Middle Eastern educational settings, is scarce. No published study has been found that used the three constructs together with Arab or Omani samples. Probably, this is what makes this research a novel one. Although research published in English is much more than that in Arabic, most of the previous studies have found relations between engagement and achievement. Previous research has found association between engagement and math anxiety (e.g., Everingham et al., 2017; Kahu, 2013). Nevertheless, a review of research conducted by Dowker, Sarker, and Looi (2016) concluded that there was no clear association between math anxiety and its predictors. Dowker et al. attributed the no clear association to: a) none pure construct and confounding factors such test anxiety, general anxiety and other social factors; b) complex constructs such as engagement.

This research assumes that logical relationships exist among the three constructs. Self-efficacy is assumed the precedent in the relationships, whereas engagement is the antecedent. We also assume that if a student has high self-efficacy in learning mathematics he/she becomes more engaged. Together self-efficacy and engagement are assumed to reduce anxiety of mathematics, or at least students who have high confidence in learning math and those who are engaged in learning math would be less subjected to math anxiety symptoms. The purpose of this study is to test the structure of each of the constructs and evaluate their relations. Specifically, this study will test several hypotheses as explained next.

Hypotheses

Based on the relevant literature and theoretical frameworks, the study tested the following hypotheses:

1. Math self-efficacy would positively correlate with each of the engagement constructs: cognitive, emotional and behavioral.
2. Math self-efficacy would negatively correlate with math anxiety.
3. Each of the math engagement constructs would correlate negatively with math anxiety.
4. Self-efficacy in mathematics would positively predict the cognitive, emotional and behavioral engagement in mathematics.
5. Each of self-efficacy, cognitive, emotional and behavioral engagement would negatively predict math anxiety.

It should be noted, however, that hypotheses 4 and 5 were modified, as we will explain in the results section. This modification was made based on the results of testing hypotheses 3 and 4, as only self-efficacy and the engagement constructs were used in the structural equation model during advanced stages of the analysis.

Method

Sample

This study followed a multi-stage cluster sampling strategy. First, two directorates were selected from the eleven educational directorates of Oman. The two selected directorates were Muscat and Al Dahirah. The selection of the two directorates was because the first represents the urban population of Oman, while the second represents the rural population. In addition, the two directorates are accessible to the researchers. It should be noted also, that all 11 directorates share the same rules and regulations as well as budgeting and infrastructure in schools. Second, from each directorate, two schools were randomly drawn, one for boys and one for girls. Third, from each of selected schools, three sections (first, second and last) of each of grades 6, 8 and 10 were selected.

The bases of this selection was that if schools distribute students to section based on any criteria such as ability, such a method of selection would rule out any bias in selecting sections. Certainly, if students were distributed randomly to sections, no bias would be involved in any case. The estimated number of students in each section would have approximately 20 to 30. Thus, approximately 450 students were selected from each directorate with 900 students from the two directorates. Table 1 shows the distribution of the sample.

Table1. Distribution of Sample in Two Directorates by Grade and Gender (actual sample)

			Grade			
Directorate			6	8	10	Total
Al Dhahira	Sex	F	80	80	80	240
		M	83	72	87	242
	Total		163	152	167	482
Muscat	Sex	F	62	57	61	180
		M	68	92	78	238
	Total		130	149	139	418
Total	Sex	F	142	137	141	420
		M	151	164	165	480
	Total		293	301	306	900

Instruments

In this study, we used three instruments to collect data from the respondents. The first instrument measures student's self-efficacy in learning mathematics, which refers to the belief one has that he/she can perform successfully. This instrument comprised 8 items with alpha Cronbach was .88. The students responded to each item on a 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Factor analysis of the eight items produced one factor. Example of items is '*I can solve most problems in mathematics'*. Therefore, the higher the score the higher the self-efficacy.

The second instrument measured students' engagement in learning mathematics, which refers to observable and unobservable qualities of students' interaction with learning activities. This instrument comprised 11 items and Cronbach alpha was .80. The students responded to each item on 4-point scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Examples of items are '*I abandon the problems of mathematics that I don't understand (reversed)'* and '*I keep trying when the math problems are difficult'*. Therefore, the higher the score the more engaged the student is. Table 2 shows alphas of the sub-constructs of the engagement scale. Compared to the full scale, alphas are low. They ranged from .54 to 0.69.

Table 2. Sample Items and Scale Reliability (alpha Cronbach)

Measure	Scale Sample item	Number of items	(α Cronbach)
Self-efficacy	I can solve most math questions.	8	.88
Engagement		11	.80
cognitive	I try to connect what I am learning to things I have learned before.	3	.56
Emotional	I feel good when I am in math class.	4	.69
Behavioral	I keep trying even if something is hard.	4	.54
Anxiety	I am annoyed: when I start a new subject in mathematics.	8	.93

The third instrument measured students' feelings of anxiety in learning mathematics. The instrument comprised 8 items and alpha Cronbach was .93. This measure used a 4-point scale ranging from 1 '*does not bother me'* to 4 *'bothers me a lot'*. The eight items have one stem as a question: '*To what extent each of the following bothers you*?' Examples of items are '*when we start a new topic in mathematics' and 'when the teacher asks me to solve a problem on the board'*. The three instruments used the self-report method. The instruments were administered in classes after the objectives of the project were explained to students and their teachers.

Models and analysis

To address the hypotheses of the present study, confirmatory factor analysis was utilized applying the Amos program version 23. Within the confirmatory factor analysis (CFA) approach, we can test simple as well as complex models. We tested models when items of each construct are assumed to measure their relative factor. Next, we integrated constructs and allowed them to correlate. Finally, we tested models were some constructs were assumed to predictive other constructs. In all of these models, we used the maximum likelihood estimation. To ascertain model fit, we used the chi-square test statistic, the comparative fit index (CFI), and root-mean square error of approximation (RMSEA). A non-significant chi-square indicates that the model adequately represents sample data. Nevertheless, chi-square is known to be sensitive to sample size. Fit indices like CFI and RMSEA are known to be less sensitive to sample size. Values of more than 0.95 of CFI indicate a good fit, and values greater than 0.90 indicate a reasonable fit. As for RMSEA, values less than 0.06 indicate a close fit, and values up to 0.08 represent reasonable errors of approximation (Hu & Bentler, 1998; Hu & Bentler, 1999).

Invariance analysis is an important component of construct validation and a prerequisite to any variance-covariance (including correlations and predictive paths) and mean-level comparisons across subpopulations (i.e. gender). In testing invariance across gender we were interested in whether there is support for the invariance of factor loadings (weak invariance), item intercepts (strong invariance), path coefficients, and factor means.

The most commonly used goodness-of-fit index for invariance tests has been the difference in chi square ($\Delta\chi^2$). However, this test is known to be sensitive to sample size (Cheung & Rensvold, 2002; Dimitrov, 2010). Therefore, it has been proposed that ΔCFI or ΔTLI are robust statistics for testing between-group invariance models when the sample size is large. Dimitrov (2010) suggests that a value of ΔCFI (TLI) smaller than or equal to .01 indicate that the null hypothesis of invariance should be retained. As the sample size of this study is large (n = 900), $\Delta\chi^2$ might be a biased indicator to examine between-group invariance. Therefore, Cheung and Rensvold’s, and Dimitrov's suggestions were used as the statistics indicator for the invariance tests.

Results

Structure of scales

Mathematics self-efficacy. The findings of the internal structure of math self-efficacy in Table 4 (model 4), implicate the validity of the one-dimensional nature of self-efficacy ($\chi2_{(18)}$ = 28.843, CFI = 0.996, RMSEA = 0.026). It can be noted in Table 3 that all items load substantially on one factor ranging from 0.57 to 0.76 ($p < 0.01$). The goodness of fit statistics indicate a good fit between the data and the model of one factor. These results provide support to our first hypothesis.

Engagement in mathematics scale. The results in Table 4 show that the fit statistics for model 2 is superior to model 1 ($\chi2_{(42)}$ = 108.376, CFI = 0.966, RMSEA = 0.042). These findings implicate the internal structure of engagement in mathematics validity of the three-fold multidimensional nature of engagement. As Table 3 shows, all items load substantially on their respective factors and range from 0.32 to 0.68 ($p < 0.01$). The correlations among factors ranged from 0.72 to 0.79 ($p < 0.01$).

Table 3. Factor Loadings of the items on their respective factors

	Self-efficacy	Behavioral	Emotional	Cognitive	Anxiety
1	0.565	0.650	0.607	0.607	0.772
2	0.741	0.332	0.607	0.521	0.874
3	0.638	0.647	0.607	0.619	0.713
4	0.583	0.324	0.607		0.915
5	0.762				0.501
6	0.725				0.877
7	0.697				0.676
8	0.618				0.834

All loadings are significant, $p < .01$.

Mathematics Anxiety. As can be seen in Table 4, the fit statistics of model 3 implicate the validity of one-dimensional construct of mathematics anxiety ($\chi2_{(20)}$ = 70.092, *CFI* = 0.990, *RMSEA* = 0.053). Table 3 demonstrate that all items load substantially on one factor as the loadings range from 0.50 to 0.92 ($p < 0.01$). Invariance across gender for each of these constructs was evaluated and the fit statistics indicated a good model fit. The results of these tests are not presented here, but available and can be obtained from the first author.

Table 4. Summary of Goodness of Fit Statistics for Various Models

Model	χ^2	*DF*	*CFI*	*RMSEA*	χ^2/DF
1. Self-efficacy (1 factor, 8 items)	24.843*	18	0.996	0.026	1.602
2. Engagement model (1 factor)	202.120**	45	0.919	0.062	4.492
3. Engagement model (3 factors)	108.376**	42	0.966	0.042	2.580
4. Anxiety model (1 factor, 8 items)	70.092**	20	0.990	0.053	3.505
5. SE, Anxiety (1 factor each), Engagement (3 factors) Correlated	944.153**	314	0.940	0.047	3.007
6. SE and engagement factors (3 factors) Revised path model	396.977**	138	0.952	0.046	2.877

Note. CFI: Comparative fit index; RMSEA: Root mean square error of approximation; SE: Self-efficacy.

* $p < .05$. ** $p < .01$.

Relations among self-efficacy, engagement and anxiety. After the structure of each scale was established, the next wave of analyses involves combining the five constructs: Math self-efficacy, cognitive engagement, emotional engagement, behavioral engagement, and math anxiety, in one correlational model (model 5, Table 4). The Indices of model fit attested a good fit to model 5 ($\chi^2_{(314)} = 944.153$, $p < .001$, $CFI = 0.940$, and $RMSEA = 0.047$). All of the loadings were significant ranging from 0.34 to 0.92 ($p < 0.01$).

Table 5 shows the correlations among the constructs. The correlations among the latent constructs were all substantial ranging from .17 (between cognitive engagement and math anxiety) to .96 (between self-efficacy and cognitive engagement). As can be seen in Table 4, math self-efficacy was more highly correlated with cognitive engagement in mathematics than with behavioral and emotional engagement. The constructs of engagement were strongly inter-related ($p < 0.01$). These results confirm that self-efficacy, engagement constructs provide support to the construct validity, and provide support to hypothesis 2.

Table 5. Correlations among the Latent Factors

	1	2	3	4	5
1. Self-Efficacy	1.00				
2. Behavioral Engagement	.70**	1.00			
3. Cognitive Engagement	.96**	.85**	1.00		
4. Emotional Engagement	.76**	.81**	.78**	1.00	
5. Math Anxiety	.21**	.18**	.17**	.19**	1.00

** $p < .01$.

Contrary to most previous studies, the correlation between mathematics anxiety and self-efficacy was positive. In addition, the correlations of each of the engagement constructs with math anxiety were surprisingly positive. These results prompted us to look more closely to the nature of these correlations. What we found was that the shapes of scatter plots were curvilinear taking a 'u' shape. We found two correlations rather than one. Low to medium anxiety scores correlated negatively with engagement (r = -.23, p < .01). A similar pattern existed in the relation between self-efficacy and low to medium math anxiety (r = -0.28, p < .01). However, medium to high anxiety scores correlated positively with engagement (r = .33, p < 0.01). A similar pattern existed in the relation between self-efficacy and medium to high math anxiety (r = .41, p < .01). The latter –positive- correlations were a little stronger than the negative correlations. Hence, the overall correlations were positive though small (p < .01). Therefore, the correlations between anxiety and the other constructs did not provide support to hypotheses 3 and 4. As for hypotheses 5, we analyzed the data and found that self-efficacy was able to predict each of the engagement constructs; but neither self-efficacy nor any of the engagement constructs were able to predict math anxiety. Hence, we modified this hypothesis and used another approach to study the relations of anxiety with self-efficacy and the engagement constructs.

Because of this unusual pattern of relation between mathematics anxiety and each of the engagement constructs and with self-efficacy, we opted to modify hypothesis 5 and we dropped anxiety from the structural equation model (SEM). We transformed anxiety into a dichotomous variable: low anxiety (from lowest score to below median) and high anxiety (from above median to highest anxiety score). The distribution of anxiety scores supported such procedure, as the distribution was bi-modal with two distributions rather than one. More than one third of the sample was highly anxious and more than one third was with low math anxiety. Usually, the normal distribution has about 68% that fall between -1.0 and +1.0 standard deviations around the mean. In the current study, only 42% fall in this area and more than 52% fall beyond -1.0 and +1.0 standard deviations. Thus, normality is violated. Furthermore, we checked the distribution of responses to each item of the scale. We found that about an average of 70% of the responses were marked as '*doesn't bother me'* (1)' and '*bothers me a lot'* (4). The average responses of '*bothers me a little*' (2) and '*bothers me'* (3) was a little less than 30%. Due to non-normality of the anxiety scores, we revised the path model and dropped hypotheses 5. Hence, we revised the model and considered only self-efficacy and the engagement constructs in the structural equation model. The anxiety variable was treated as a grouping variable; and we ran a multi-sample invariance model with anxiety as a grouping variable.

The aim of this analysis was to test if the two types of anxiety would produce equal – invariant- parameters. If loadings, intercepts, variances, co-variances, and path coefficients are invariant across the two groups of anxiety, then one can test the model with the specification that self-efficacy predicts the engagement constructs across low and high math anxiety. Hierarchical nested models were tested beginning with a model of no constraints on the equality of parameters; then we proceeded with constraints of equality on loadings, then intercepts, path coefficients, and finally measurement residuals. Of particular importance for the current study are the invariance of loadings and path coefficients.

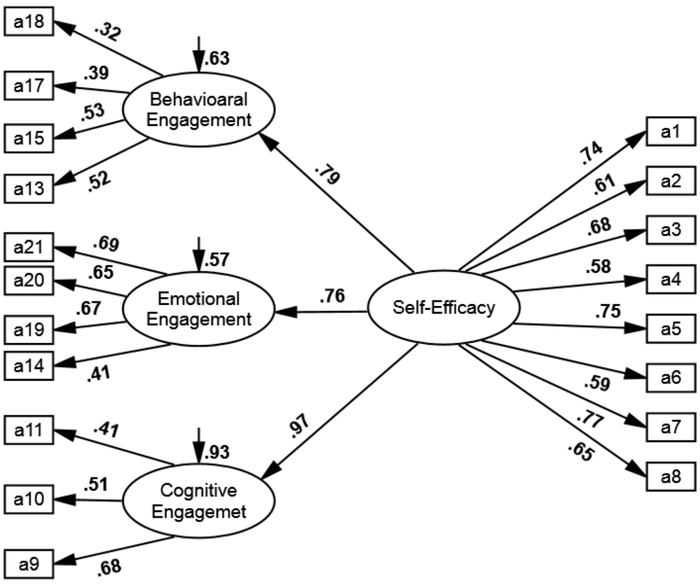

Figure 1. Revised model of relation among self-efficacy and engagement components (complete invariance and standardized parameters of model 6, Table 3).
Note. Rectangles are observed variables, ovals are latent constructs. All path coefficients are significant, p <.001.

Invariance across anxiety groups.

The abovementioned specification was tested using SEM. The results of this analysis revealed a model fit to the data, and the parameters were invariant across the two types of anxiety ($\chi^2_{(138)}$ = 396.977, *CFI* = 0.952, *RMSEA* = 0.046). In other words, loadings, intercepts, variances and co-variances as well as path coefficients were equal among low and high anxiety students. These results allow for mean comparisons or classification of individuals into low and high using the constructs for this classification. That is, the two groups of individuals (low and high anxiety) had similar structure and relations among the constructs among self-efficacy and engagement.

In addition, the results of this analysis provide evidence of the predictive validity of self-efficacy equally for low and high anxiety students. Students with higher self-efficacy in math were more likely to report higher cognitive engagement (β = 0.96, p < .001). Similarly, students with higher self-efficacy in math were more likely to express higher emotional (β = 0.76, p < .001) and higher behavioral engagement (β = 0.79, p < .001). A large proportion of variance was explained in each of the predicted constructs (see Figure 1).

To maintain anxiety as dependent on the self-efficacy and engagement constructs we used discriminant analysis. In this analysis, we used self-efficacy and global engagement as discriminating factors and anxiety as two classes. When participants were classified according to the level of math anxiety, discriminant analysis revealed a significant mean difference in self-efficacy between low (*mean* = 22.19) and high (*mean* = 24.45) math anxiety ($Lambda_{(1, 743)}$ = 0.949. p < 0.01), with high anxiety students having higher self-efficacy. Also, high anxiety students (*mean* = 32.69) had more engagement than low anxiety students did (*mean* = 30.66), ($Lambda_{(1, 743)}$ = 0.960, p < 0.01). With these results, the question remains open: what is the nature of relation between math anxiety and self-efficacy and between math anxiety and engagement? The ability of self-efficacy and engagement to correctly classify individuals into low and high was still acceptable. Using self-efficacy and engagement as discriminating factors, only 57% were correctly classified as low anxiety, and 61% were correctly classified as high anxiety. The overall correct classification was about 59%, which means that more than 40% were incorrectly classified. These results shed more doubts on the negative relation between math anxiety and each of self-efficacy and engagement.

Invariance across gender

To test the construct validity of self-efficacy and engagement constructs, we tested the structural model with multi-samples invariance across gender. We tested models where none of the parameters was constrained to be equal ($\chi^2_{(276)}$ = 604.153, 0.940, *RMSEA* = 0.036). Then, we added constraints on each model of the hierarchy (six models overall). The results of the analysis confirmed the construct validity of the structural model. The fit statistics for all six models including the most restricted model of invariant measurement residuals ($\chi^2_{(347)}$ = 814.384, *CFI* = 0.914, *RMSEA* = 0.039) imply reasonable fit to data. The results suggest that the measurement model and the path coefficients were invariant across gender. Self-efficacy was able to predict each of the engagement constructs significantly ($p < .01$). Self-efficacy explained substantial variance in each of the engagement constructs (0.93, 0.57, and 0.67, $p < .01$, for cognitive, emotional and behavioral constructs, respectively).

Discussion and conclusion

Construct validity involves the internal validity of the constructs and their convergent and discriminant validity. Convergent validity assumes that constructs are strongly related to similar constructs, whilst discriminant validity assumes weak relation with dissimilar constructs. The results confirm largely the first hypothesis. The results of CFA and reliability analyses provide support to the validity and reliability of the measures used in this study. Of particular importance is the construct validity of the three subscales of engagement. Compared to Wang et al. (2016), the current study used an adapted brief version of the measure (Wang et al., 2016) and still produce reasonable psychometric properties. On the average, the loadings of items on their relative factors in this study were similar to those reported for the long measure used by Wang et al. (2016). The correlations among the three subscales of engagement provide support to the convergent validity of the constructs.

In addition, as motivational constructs, self-efficacy and the engagement constructs show reasonable convergent validity in that self-efficacy was able to predict each of the engagement constructs and in the expected direction. The results confirm largely the second hypothesis of the study as well as previous research evidence stressing the key motivational role of self-efficacy. Self-efficacy proved to be significantly related to cognitive, emotional, and behavioral engagement in mathematics, and a significant predictor of these constructs.

This finding is consistent previous research describing self-efficacy as a significant component of student's motivation to learn mathematics (Linnenbrink & Pintrich, 2003; Martin & Rimm-Kaufman, 2015; Pintrich & De Groot, 1990; Wang et al., 2016; Wolters & Pintrich, 1998).

If teachers and educators want their students to be engaged in learning mathematics, they should equip them with high confidence expectations. Programs and interventions planned to engage students in learning mathematics would not do well if students lack confidence in learning mathematics. Stated more succinctly, "Teachers can design and organize their instruction to have a positive impact on student self-efficacy and, in turn, on student engagement and learning in the classroom." (Linnenbrink & Pintrich, 2003, p. 136). Additionally, Martin and Rimm-Kaufman (2015) argued that self-efficacy and engagement are cyclical in that higher levels of engagement may produce feelings of self-efficacy. Other researchers (e.g., Kahu, 2013; Linnenbrink & Pintrich, 2003) argued that the relation between self-efficacy and engagement is reciprocal.

The relation of math anxiety with each of self-efficacy, cognitive engagement, emotional engagement, and behavioral engagement did not support our hypotheses. The relation of math anxiety with self-efficacy and engagement proved to be problematic. Although individuals with low levels of math self-efficacy –or self-concept- would traditionally have high levels of math anxiety (Author, 2000; Akin & Kurbanoglu, 2011; Ashcraft & Kirk, 2001; Hembree, 1990; Jameson, 2013b; Ya'aqoub, 1996), the results of the current study did not find such pattern of relation. With a newly researched environment, it is hard to provide conclusive explanation as to why an inverse relation was not evident. Students who reported higher levels of efficacy and engagement were more likely to report higher levels of math anxiety. Nevertheless, this finding is consistent with some of previous work in a social cognitive framework (Pintrich & De Groot, 1990; Wolters & Pintrich, 1998). Wolters and Pintrich (1998) argued that students who are anxious might use more cognitive strategies in an attempt to do better. This is only true, in current study, when high math anxiety students were isolated from students who reported low math anxiety. As for low math anxiety -as a separate group-, student who were high on self-efficacy and engagement were low on math anxiety, whilst students who were low on self-efficacy and engagement were high on math anxiety. This particular part of the results seems to support previous research.

The results of correlations, structural equation modeling as well as discriminant analysis, with math anxiety is included, are inconsistent with most previous research. This is not only with regard to the relations between anxiety and self-efficacy, and between anxiety and engagement, but even the nature of anxiety raises many questions. For example, majority of Omani students in grades 6, 8, and 10 were equally distributed into low and high anxiety, but few of the students had medium math anxiety. This in itself is an important finding implying that we have two populations, as far as math anxiety is concerned. This was true for male and female students as well. As such, the assumption of normality for one construct may be violated and statistics based on the normality assumption may not be valid. The results of the study suggest that the relations between self-efficacy and anxiety and between engagement and anxiety may be more complex than was anticipated. The results of the current study suggest that there is a need to know more about the nature of math anxiety among Omani students. It could be that math anxiety is a trait among Omani students and they have either a high or a low math anxiety. This may suggest that math anxiety is a dichotomous trait and not a continuum trait.

Another interpretation of the peculiar relations of math anxiety with engagement and self-efficacy can draw on Dowker et al. (2016) interpretation of the inconsistent relation between math anxiety and math achievement. Dowker and her colleagues argued that the relation between math achievement and math anxiety is inconsistent between high achieving counties and less achieving countries. Students in high achieving countries –especially -Asian countries- could be high in math anxiety because students in those countries attach high importance to achievement in mathematics making failure more threatening. Probably, the same logic can be used to explain the unexpected positive relation of math anxiety with engagement and self-efficacy. Students who are more efficacious and more engaged in mathematics may place more importance to mathematics and compare themselves with other similar students, which results in higher math anxiety. However, this interpretation remains possible but can’t be taken as a conclusive one.

Moreover, there is a need to know if students in Oman who are low in math anxiety are low or high math achievers, and students who are high in math anxiety are low or high math achievers. Unfortunately, math achievement was not part of the design of this study. Therefore, future research needs to address this issue.

The generalizability of the results of this study, however, is limited by investigating self-efficacy, engagement and anxiety in mathematics using the self-report survey method, which has known limitations. Kahu (2013) pointed to some of those limitations, especially in evaluating behavioral engagement. Therefore, future research will have to examine the relations of self-efficacy, engagement, and math anxiety with triangulated methods including observation and interview methods as well as teacher ratings of their students to evaluate math anxiety and its relation with self-efficacy, engagement and performance. In addition, future research will have to examine relations among these constructs in other subject areas and among more samples that represent Omani students in other grades to provide better understanding of anxiety in various academic subjects.

Until that is done, we can only conclude that self-efficacy is an important predictor of students' engagement in mathematics. However, conclusions or implications cannot be drawn from the relation of math anxiety with self-efficacy and engagement. The implication of our results is that for programs and initiatives to promote engagement in mathematics, students should develop confidence in learning mathematics. In addition, any program should assess student's math anxiety and focus more on students with low to medium math anxiety. This is because students in this category of math anxiety produced negative correlations between math anxiety and self-efficacy and between math anxiety and engagement in mathematics. As for students who expressed medium to high math anxiety there is still a need for future research to find out why they expressed more math anxiety although they were more self-efficacious and more engaged. In other words, we need to know why Omani students who were more efficacious and more engaged were also more bothered and annoyed by mathematics activities.

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Appendix

	Math Self-Efficacy
1.	I feel myself sufficient in solving mathematical problems.
2.	I can solve all kinds of mathematical problems, if I strive sufficiently.
3.	Compared to others I have sufficient knowledge in math.
4.	I have sufficient confidence to ask and discuss in math class.
5.	I can easily answer the questions in math.
6.	I have the ability to finish all assignments in math.
7.	I believe I am among the gifted in math.
8.	I finish my math assignments more easily than others do in my class.
	Cognitive Engagement
1.	I try to connect what I am learning to things I have learned before.
2.	I try to understand my mistakes when I get something wrong.
3.	I do just enough to get by (rev).
	Emotional Engagement
4.	I enjoy learning new things about math.
5.	I feel good when I am in math class.
6.	I like to understand what I learn in math class.
7.	I do not care about learning math (rev).
	Behavioral Engagement
8.	I often feel frustrated in math class (rev).
9.	I do not work with classmates in math class (rev).
10.	If I do not understand, I give up right away (rev).
11.	I keep trying even if something is hard.
	Math Anxiety Scale
To what extent does each of the following bother you?	
1.	To listen to a student explaining a math problem.
2.	To start a new topic in math.
3.	To grab the math book to do a homework.
4.	To listen to the math teacher in class.
5.	To think about the math test a day before.
6.	To raise my hand to ask a question in math class.
7.	To solve a word problem.
8.	To be asked to solve a math problem on the board in front of the class.

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