

Using Multi-Group Invariance Analysis in Exploring Cross-Cultural Differences in Mathematics Anxiety: A Comparison of Australia and Russia

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Abstract: Mathematics anxiety is well known and studied concept. Most of the studies have been focused on the effects of mathematical anxiety on students' academic achievement, especially from the viewpoint of analysing large national and international data sets. We aim to bring a different perspective to the existing research on mathematics anxiety and resilience by considering the measurement equivalence across cultures, so they can be compared fairly. We used Multi Group Invariance analysis with this purpose. Our findings suggested that full metric and partial scalar model invariance were confirmed which advise that the mathematics anxiety scale can be compared across two countries. We also ran multiple regression using Fisher's Z to understand the reciprocal relationship among the variables across two samples. Preliminary results revealed that the perceived mathematics anxiety and perceived mathematics ability predict the measured mathematics anxiety equally well for both Australia and Russia.

Keywords: cross cultural comparison, mathematics anxiety, multi-group invariance analysis.

In mathematics education “non-cognitive” attributes have become a widely studied subject, especially to develop cognitive aspects of mathematics' success. The term “non-cognitive” refers to a wide-ranging concept of personal attributes and skills based on one's emotional and other psychological dispositions (Lee & Stankov, 2018). Mathematics anxiety and resilience concepts are some of the important “non-cognitive” dispositions towards mathematics. Researchers who study affective aspects of mathematics learning acknowledge that those affective dispositions influence people's learning of mathematics (Ashcraft, 2002; Bicer et al., 2020; Brewster & Miller, 2020; DeBellis & Goldin, 2006; Hembree, 1990; Lim & Chapman, 2012; Ma, 2011; Ma et al., 2014; Seah, 2016; Segarra, Julià, & Valls, 2021; Villavicencio & Bernardo, 2016; Valentine et al., 2004).

Various researchers further emphasise the need to maximise research in mathematics education through the integration of affective issues into the study of cognition and instruction (Chaman et al., 2014; Hattie, 2009; McLeod, 1992; Stankov et al., 2012; Opstad, 2021). There is a wide range of research which investigates the effects of mathematical anxiety on to students' academic achievement, especially analysing large national and international data sets;

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however, mathematics anxiety, like many other attributes, can be affected by cultural, language and educational setting in different samples from different countries. For example, in the Trends in International Mathematics and Science Studies ([TIMSS], 2015), the Year 8 mathematics scale showed that Russia's score was significantly higher than Australia's score in mathematics. Australia was at 505 and Russia was at 538 (in TIMMS) (TIMMS, 2015) and Australia's score was identical to Russia's score as 494 in the Programme for International Students Assessment (PISA) (Organisation for Economic Co-operation and Development [OECD], 2017). On average across OECD countries, 55% of students reported "even if I am well prepared for a test, I feel very anxious" (Australia was at 67%, and Russia was at 51%); 36% reported, "I get very tense when I study" (Australia was at 47%, and Russia was at 39%) (OECD, 2017). Australia and Russia had identical mathematics scores in the 2015 PISA, but their students' anxiety and well-being levels differ from each other.

Chan (2011) indicates that "we cannot assume the same construct is being assessed across groups by the same measure" without tests of measurement invariance (p. 108). Therefore, in cross-cultural comparisons, analysing group equivalence to understand how different groups of people respond to the measurement structure is needed to improve the validity and reliability of our research.

We aim to bring a different perspective to the existing research on mathematics anxiety and resilience by considering the measurement equivalence across cultures, so they can be compared fairly. The majority of studies on mathematics anxiety focused on mathematics scale adoption into one sample, or in each sample individually, to compare the samples mostly using exploratory and confirmatory factor analysis methods (Cipora et al., 2018; Vahedi, 2011). Our research aims to fill this gap by measuring invariance across different cultural groups utilising the multigroup invariance testing method which is not widely used in the literature. To date, multi-group invariance testing has most commonly been used with the purpose of gender comparisons (Caviola et al., 2017; Pletzer, 2016; Roick & Henschel, 2018; Szczygiel, 2021; Wigfield & Meece, 1988) and some small number of studies with cultural comparisons (Bakan-Kalaycioğlu, 2015; Ho et al., 2000).

We aim to explore the reciprocal relationships between mathematics anxiety, reasons for mathematics anxiety and perceived mathematical ability that the preservice teachers (PSTs) have. We also aim to investigate to what extent the reasons for their anxiety sources differ and resembles each other. The research questions that guided the study are as follows:

1. What is the cross-cultural validity of the Australian and Russian versions of the mathematics anxiety scale?
2. What is the reciprocal relationship between the reasons for mathematical anxiety mathematics anxiety and perceived mathematics ability in Russia and Australia?
3. Do PSTs' mathematics anxiety levels in Australia and Russia significantly vary by gender?

Background

Mathematics anxiety is defined as a condition in which students experience negative reactions to mathematical concepts and testing procedures (Richardson & Woolfolk, 1980). Richardson & Suinn (1972) define Mathematics anxiety as "involving feelings of tension and anxiety that interfere with the manipulating of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Mathematics anxiety is also associated with decreased motivation and self-confidence in mathematics (Ashcraft, 2002; Li et al., 2021).

Mathematical resilience, which is a relatively new approach, is defined as a positive academic mindset that allows students to grow a positive viewpoint regarding mathematics (Lee & Johnston-Wilder, 2014, Rivera & Waxman, 2011, Yeager & Dweck, 2012). High-level mathematics resilience is associated with low-level mathematics anxiety (Duggan et al., 2017). Lee & Johnston-Wilder (2014) has found the four aspects based on those attributes:

- having a growth mindset, such that learners believe their mathematical capabilities can be developed through dedication and hard work
- knowing that mathematics can be of personal value is of value in the world and that the learner is valued within the community of learners
- knowing how to work at learning mathematics
- knowing how to find the appropriate support to stay in the ‘growth zone’

Various researchers (Chaman et al., 2014; Hattie, 2009; McLeod, 1992; Stankov et al., 2012) further emphasise the need to maximise research in mathematics education through the integration of affective issues into the study of cognition and instruction. Studies that emphasise the need for research on the non-cognitive, dispositional aspects of mathematics learning every day, are increasing (Chaman et al., 2014; Hattie, 2009; He et al., 2018; Jamieson et al, 2021; Stankov, 2013).

Hattie’s (2009) meta-analytic research revealed that there are four “best” student-level constructs related to academic success; attitude towards mathematics (Cohen’s $d=.36$), anxiety (Cohen’s $d=.40$), self-concept (Cohen’s $d=.43$) and engagement and motivation (Cohen’s $d=.48$). Stankov’s (2013) study on “non-cognitive constructs” reveals that domain-specific self-concepts correlates with student’s achievement around mid ($r=.20s$) and mathematics or test anxiety has moderately strong correlations with academic achievement.

The increasing number of studies is showing that “non-cognitive constructs” such as anxiety are a fundamental part of mathematics learning. The “non-cognitive” assessment has been given importance in international exams which compare large data from international samples such as the TIMMS administered by the International Association for Evaluation of Educational Achievement (IEA) and the PISA administered by the OECD. In the 2015 TIMMS exam, the “non-cognitive” aspects were addressed by “Liking Learning Mathematics”, “Self-Confidence in Mathematics” and “Valuing of Mathematics” under the category of “Attitudes, Engagement and Aspirations” (TIMMS, 2015).

The results of TIMMS 2015 suggested that;

“More than one-quarter of Australian Year 4 students reported that they *do not like learning mathematics*, and this was significantly higher than the international average of 19 per cent of students; Just 13 per cent of Australian Year 8 students said that they *very much like learning mathematics*, with a further 36 per cent in the middle category and 50 per cent saying that they *do not like learning mathematics* over the four years between Year 4 and Year 8, attitudes deteriorated” (OECD 2017, p. 207).

According to TIMMS 2015 results year 4 students were reasonably confident about learning mathematics, although not as confident as on average internationally; according to just 15 per cent of Australian Year 8 students said that they were *very confident in mathematics*, with a further 42 per cent in the middle category and 43 per cent reporting that they *were not confident in mathematics* over the four years between Year 4 and Year 8, confidence declined (OECD 2017, p. 214). Forty-three per cent of Australian students reported that they strongly

value mathematics, twelve per cent of Australian Year 8 students reported that *they do not value mathematics* (OECD 2017, p. 214).

The TIMSS (2015) mathematics results as average scores and distributions on the TIMSS Year 4 mathematics scale showed that Russia's score was significantly higher than Australia's score in mathematics (Australia was at 517 and Russia was at 564). The TIMSS 2015 mathematics results as average scores and distributions on the TIMSS Year 8 mathematics scale showed that Russia's score was significantly higher than Australia's score in mathematics (Australia was at 505 and Russia was at 538).

TIMSS 2015 results on "self-confidence in mathematics" showed that year four students *not confident* in mathematics had very similar scores in both countries (27% of students in Australia with an average achievement score of 473 and 28% of students in Russia with an average achievement score of 522). For year eight students the results were not very different; in Australia, 43% of students *not confident in* mathematics had an average achievement score of 465 while in 46% of Russia students *not confident in* mathematics had an average achievement score of 503. These results are very interesting because when we compare the achievement scores in mathematics, Russia was significantly higher than Australia. However, regarding self-confidence in mathematics, both countries had very similar percentages of students who reported themselves as *not confident in mathematics*.

In the 2015 PISA exam, the "non-cognitive" aspects were addressed by "self-related beliefs and attitudes towards school" under the category of "domain-general student attitudes and behaviours (OECD, 2017). PISA 2015 used a test anxiety scale to predict mathematics achievement. The results have been reported in PISA based on the test anxiety scale. On average across OECD countries, 55% of students reported "*even if I am well prepared for a test, I feel very anxious*" (Australia was at 67%, and Russia was at 51%); 36% reported, "*I get very tense when I study*" (Australia was at 47%, and Russia was at 39%) (OECD, 2017).

A comparison of academic performance in mathematics in PISA showed that the OECD average was 490 and Australia's score was identical to Russia's score at 494. Australia and Russia had identical mathematics scores in the 2015 PISA, but their students' anxiety and well-being levels differ from each other. There are also studies focussing on the relationship between mathematics performance and mathematics anxiety mostly based on deficit theory. These suggest that mathematics anxiety and mathematics ability follow each other negatively in a way that while mathematics ability reduces, mathematics anxiety grows, and in return mathematics anxiety would also have a negative effect on mathematical performance (Carey et al, 2016; Guzmán et al, 2021).

Methodology

This research was derived from a pilot study based on an international research project supported by two public universities in Australia and Russia where the research occurred. In this paper, we adopted a quantitative methodological approach which allows us to compare the data from culturally different backgrounds of preservice teachers (Creswell & Plano Clark, 2011). To examine the reciprocal relationships between the reasons of mathematical anxiety, levels of mathematics anxiety and perceived mathematical competence, we used multi-group invariance testing with AMOS 7.0 (Arbuckle, 2006) using the maximum likelihood estimation. Based on existing evidence, we expected mathematics anxiety to be reciprocally associated with mathematics resilience, and they would negatively predict each other (Duggan et al., 2017). To further our understanding on if there was any significant difference between preservice teachers with two cultural backgrounds in terms of their level of Mathematics Anxiety, the Perceived Mathematics Anxiety and Perceived Mathematical Competence, we utilized a hierarchical regression analysis using enter method along with Fisher's Z estimates.

Samples

Participants were preservice teachers (PSTs) who were enrolled in various teacher programs in schools or faculties of education. The Australian sample included 41 PSTs (27%) which had 17% males and 75 % females enrolled in an Australian State of Victoria based university whilst the Russian sample included 114 (74%) which had 75% males and 25% females who enrolled in a Federal university in Russia. 75 % of the respondents' age in the Russian university were between 18-23 and 21% of them were between 24-29 and only 3% were between 30-35 years old. The 27 % of the respondents' age in Australian University were between 24-29 and 12 % for the ages ranging from 18-23, 30-35, 36-40 years old and lastly 20 % of them were over 46 years old. In the Russian sample, 75% of PSTs intended to teach after graduation, 27% of the undecided and 1% was not interested in teaching at all. In the Australian sample, 80% of PSTs intended to teach after graduation whilst 12% of them undecided about it and 2% of them were not interested in teaching after graduation. The ethics process had been completed in each country before the data collection and the participation was voluntary based.

Data Tools and Measures

We followed Geisinger's (1994) steps for translating and adapting the scales into Russian which was as follows: (a) translations from English to Russian and back - translations were done by the same translator fluent in both languages. The reverse translation to the English version was compared with the original one to ensure accuracy. (b) The Russian translated version was reviewed by a panel of bilingual experts to check the quality of translations. Upon the panel individual's opinion on the translation quality and cultural adaptation consistency, the translation and adaptation process were finalized. After translations were completed, we started to collect data in the first trimester of 2020 at both universities.

To make sure the invariance between the scales in two languages, we tested if the structures in the translated scales were understood the same between two cultures using a multiple group invariance analysis.

The Mathematics Anxiety scale has ten items with responses obtained on a 5-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree" (Betz, 1978). Betz revised the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) which is one of the most used scales to measure the mathematics-related attitudes and anxiety originally developed as 108 item scale with nine domain-specific components by Fennema and Sherman in 1976. In 1998 it was revised by Mulhern & Rae to become a 51-item scale with six domain-specific components.

The Russian adaptation of Mulhern & Rae's version of the FSMAS consists of 51 items made by Sapazhanov and his colleagues in 2020. Since this version has six sub-components and one of them includes mathematics anxiety with confidence component together, it did not fit in our purpose for this study. Also, Betz's revision takes less time than both Fennema and Sherman's and Mulhern and Rae's versions because of the number of items. Therefore, we decided to use Betz's version with ten items in this study.

The perceived level of mathematics anxiety scale consists of one closed question "What level do you feel mathematics anxiety?" using a 0 to 10 scale where 0 means "no anxiety at all" and 10 means "high level of anxiety". Perceived mathematics ability scale uses a 0 to 10 scale where 0 means "no content knowledge at all" and 10 means "high level of content knowledge," following the question "How much content knowledge do you think you have in relation to teaching mathematics as a subject?"

Analysis Procedures

We used three main approaches to analyze the data. Before we started using the main analysis methods, we reverse coded some items (items 6-10) in the mathematics anxiety scale to prepare them for the analysis. Following the data preparation, we used a series of descriptive analyses to understand the data and its distribution, we used mean, standard deviation, skewness, kurtosis, and correlation analysis for this purpose.

Firstly, we ran an exploratory factor analysis for each sample separately to better see how the factor structure is distributed without any restrictions. Cronbach alpha coefficient was used as an indicator of the internal consistency.

Secondly, we employed a multi-group confirmatory factor analysis (MGCFA) since it is one of the best approaches in cross-cultural comparisons and appropriate for sample sizes smaller than 500 (Billiet, 2002; Stark et al., 2006). MGCFA is also a useful approach in testing invariance based on cross-group constraints from a more restricted model to a less restricted one (Baumgartner & Steenkamp, 1998). A series of nested models was tested using MGCFA across two samples. We followed Vandenberg and Lance (2000) to fit the mathematics anxiety data using MGCFA models (being configural invariance, metric invariance, scalar invariance).

Measurement invariance testing reveals how the items in a scale show similar psychometric structures across different samples (Little, 1997). Therefore, to interpret the results from cross-cultural research, the measurement invariance should be used to generalize the measurement tool (Baumgartner & Steenkamp, 1998; Vandenberg & Lance, 2000). We utilized a series of rules to assess how the nested model fitted following Hu and Bentler's (1999) suggestions which include TLI, and CFI should be larger than .95 and SRMR should be smaller than .09. In this case, we also avoided the larger Type 1 and Type 2 error coefficients (Hu & Bentler, 1999). To assess chi-square differences, we utilized the most used ones for an acceptable model fit if χ^2/df is <3.80 , RMSEA is $< .08$, SRMR is $\approx .06$, CFI/TLI is equal or larger than $\geq .90$ (Cheung & Rensvold, 2002; Hu & Bentler, 1998; Tabachnick & Fidell, 2007).

Finally, we used a hierarchical regression model to further understand if the PSTs' reasons for anxiety, level of anxiety and their perceived mathematics ability differs between two different cultures and languages. In addition to this analysis, we also further investigated how gender impacts on mathematics anxiety cross culturally. We used a two-way factorial Anova to explore the difference in mathematics anxiety by cultural background and gender. A series of descriptive analyses were also employed such as mean, standard deviation, correlation analysis etc.

Results

The cross-cultural validity of the Australian and Russian version of mathematics anxiety scale, among preservice teachers from different cultural and language backgrounds. To explore the cross-validity of the Australian and Russian version of mathematics anxiety scale we used measurement invariance testing (MGCFA) to see psychometric structures across two samples. Firstly, we investigated the relationship among the variables summarized in the below table 1.

The perceived level of anxiety and the sub-factors of the mathematics anxiety scale were negatively correlated with perceived mathematics ability. In other words, whilst mathematics anxiety levels were going down, the perceived mathematics ability levels were going up, so they were negatively correlated. deviation, correlation analysis etc.

Table 1
Correlation Matrix and Descriptive Statistics for the Variables

Variable Name	Perceived level of anxiety	Perceived mathematics ability	F1	F2
Perceived level of anxiety		-.394**	-.508**	-.616**
Perceived mathematics ability	-.394**		.597**	.293**
F1	-.508**	.497**		.517**
F2	-.616**	.293**	.517**	

Note. Correlations were calculated based on combined data from both countries. $p < .001$

Table 2
Descriptive Statistics for the Variables – Mathematics Anxiety Scale, Level of Math Anxiety and Perceived Mathematical Ability

Samples	Australian (N=41)				Russian (N=114)			
	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
F1	16.60	5.78	-.090	-1.292	15.52	4.11	-.143	.008
F2	18.20	7.37	-.591	-1.270	17.61	4.22	-.975	1.404
LA1	3.82	3.23	.538	-1.12	3.84	2.80	.523	-.507
PMA1	6.28	2.24	-.548	.137	5.60	2.30	-.659	-.128

Note. Math anxiety scale sub factors (F1, F2), level of math anxiety (LA1), perceived math ability (PMA1)

Table 2 summaries the intercorrelations among the main factors individually from each sample. Mean range of the items between two countries were very similar to each other (ranging from 2.78 to 6.28). The skewness (ranging from -.090 to -.659) and kurtosis (ranging from .008 to 1.404) coefficients indicated that both Australian and Russian data are normally distributed (Bryne, 2010; George & Mallery, 2010).

Exploratory Factor Analysis

The preliminary analysis of the math anxiety factor structure yielded reliability and validity results. There was also a positive and high correlation between Factor 1 and Factor 2 as .660 (see table 2). Kaiser-Meyer-Olkin (KMO) was found to be .855 and Bartlett's test was significant (566.591, $p < 0.000$) for the Russian sample and KMO was .893 and Bartlett's test was significant (438.852, $p < 0.000$) for the Australian sample which shows math anxiety scale can be factorable with these samples. We used principal components analysis, Kaiser normalization, and varimax rotation to identify the factor structure of the math anxiety scale. The factor analysis results revealed the two-factor solution in both samples. In the Russian sample, the two-factor solution explained 62.553% of the total variance, whilst in the Australian sample, it explained 85.322 of the total variances. Cronbach alpha coefficients were very high in both samples (see Table 3).

Table 3

Factor Loadings and Dimensions of Mathematics Anxiety Scale in Australian and Russian Samples

Factors	Items	Factor Loadings (Australia ($\alpha=.961$)	Factor Loadings (Russia) ($\alpha=.875$)
Factor 1	Item 1-It would not bother me at all to take more math courses.	.807	.658
	Item 2- I have usually been at ease during math tests.	.748	.704
	Item 3- I have usually been at ease in math courses.	.748	.831
	Item 4- I usually don't worry about my ability to solve math problems.	.636	.644
	Item 5- I almost never get uptight while taking math tests.	.713	.683
Factor 2	Item 6- I get really uptight during math tests.	.718	.656
	Item 7- I get a sinking feeling when I think of trying hard math problems.	.882	.712
	Item 8- My mind goes blank, and I am unable to think clearly when working mathematics.	.898	.787
	Item 9- Mathematics makes me feel uncomfortable and nervous.	.937	.825
	Item 10- Mathematics makes me feel uneasy and confused.	.917	.851

Multiple Group Invariance Testing

We used the common guidelines to decide the acceptable model fit (e.g., Hu & Bentler, 1998; Tabachnick & Fidell, 2007), for CFI/TLI should be equal or larger than $\geq .90$ and RMSEA should be equal or smaller than $\leq .06$.

As summarised in table 4, firstly, we run the configural invariance testing which involved no constrained parameters to find the baseline model and the fit indices suggested that the baseline model is acceptable (χ^2 (df)= 132.359 (68), $p < .000$; TLI=.92, CFI=.94, RMSEA=.079, SRMR=0.69). Since the chi-square coefficient was significant, we decided to extend the investigation further and test the metric model in comparison with the configural model. Secondly, we ran the configural model where we constrained the factor loadings across two groups (M1-M2) and this less constrained model in the sequence yielded a series of acceptable parameters in both groups ($\Delta\chi^2$ (Δdf) = 10.611, $p > .000$, TLI=.93, $\Delta CFI = .003$, $\Delta RMSEA = .04$, $\Delta SRMR = .04$) there was a very minimal and nonsignificant change among these parameters which shows the model is acceptable. Since this model was holding well, we continued with the third level which was the scalar model where we constrained the intercepts in each parameter in comparison to models M2-M3. The scalar invariance model suggested that the difference between chi-square and degree of freedom levels were significant. For the nested models, the difference between CFIs should be less than .01 to support invariance between the groups (Cheung & Rensvold, 2002) and the and a change in RMSEA should be less than .015 (Chen, 2007) ($\Delta\chi^2$ (Δdf) = 40.127 (10), $p < .000$; $\Delta CFI = .027$; $\Delta RMSEA = .12$; $\Delta SRMR = .601$). After relaxing each intercept individually, we tested each intercept's contribution to chi-square and checked whether there is a significant difference (see table 5). We detected the items which were significant in terms of the difference between their chi-square (df) value in comparing to the scalar model. According to results, items 5 and 10 were found to be significant and after releasing the constraint of these items from the model, the partial scalar model revealed acceptable fit indices across two groups ($\Delta\chi^2$ (Δdf) = 26.09 (2), $p < .000$; TLI=.92; $\Delta CFI = .021$, $\Delta RMSEA = .01$, $\Delta SRMR = .518$) in comparison to full scalar model (M3-M3a). The result yielded from the partial model suggested that there is a significant decrease in the chi-square (df) as a result of constraining the intercepts to equality. The CFI change was not significant based on Cheung and Rensvold's (2002) criterion, but the change in RMSEA was significant according to Chen's criterion.

Table 4
 Goodness of Fits Statistics for Nested Measurement Invariance Tests

Model	χ^2 (df)	CFI	RMSEA (90%CI)	SRMR	Model comparis on	$\Delta\chi^2$ (Δdf)	TLI	ΔCFI	$\Delta RMSEA$	$\Delta SRMR$	Result
M1: configural Invariance	132.359 (68)	.94 0	.079 (.058- .099)	.06 9	-----	-----	.92	----	-----	-----	-----
M2: Metric Invariance	142.970 (76)	.93 7	.077 (.056- .095)	.07 3	M1	10.611 (8)	.93	.00 3	.04	.04	Accept
M3: Scalar Invariance	183.097 (86)	.91 0	.089 (.069- .103)	.12 9	M2	40.127*(10)	.90	.02 7	.12	.601	Reject
M3a: Partial Scalar Invariance	154.926 (82)	.93 1	.076 (.058- .094)	.06 47	M3	26.09** (2)	.92	.02 1	.01	.518	Accept
M4: Residual Invariance	213.839 (92)	.88 4	.093 (.077- .109)	.09 08	M3a	58.913** (10)	.88 7	.04 7	.017	.0261	Accept

* $p \leq .05$, Note. Items 5 and 10 were removed from the scalar model to provide equality constraints in the final partial scalar invariance model.
 ** $p \leq .01$

Lastly, we ran the residual model in comparison to the partial scalar invariance model by releasing each residual individually. It was found that there were no significant differences in chi-square (df) coefficients, therefore we finalised the analysis with no constrained residual

scores since they were invariant across two groups. Our result supported full configural, full metric, partial scalar invariance, and full residual invariance, in other words, both Australian and Russian preservice teachers understood and responded to the mathematics anxiety scale in a conceptually similar way. This result also suggests that both the Australian and Russian version of the mathematics anxiety scale with two dimensions is a valid and reliable tool to measure mathematics anxiety across two cultures.

Table 5*Parameters (Intercepts) Being Tested in Partial Invariance Model*

Parameters	chi-square	df	$\Delta\chi^2$ (Δdf)	p value
p1	180.812	83	.204 (1)	.651511
p2	176.293	83	4.723 (1)	.029762
p3	172.844	83	8.172 (1)	.005254
p4	181.013	83	.003 (1)	.95632
p5	165.372	83	15.644* (1)	.000076
p6	176.410	83	4.606 (1)	.03186
p7	173.309	83	7.707 (1)	.005501
p8	180.927	83	.089 (1)	.765452
p9	180.961	83	.055 (1)	.814581
p10	170.573	83	10.443* (1)	.001231
Scalar model invariance	181.016	84		

p<.001

The reciprocal relationship between the reasons of mathematical anxiety mathematics anxiety and perceived mathematics ability in Russia and Australia.

In order to examine the reciprocal relationship between the perceived mathematics anxiety and measured mathematics anxiety and perceived mathematics ability, a series of regression analyses was carried out for each of the variables. A Pearson correlation analysis first was run to the level of corresponding between variables. The result of the correlation analysis revealed that there was a negative correlation ($r = -.394$, $p < .000$) between perceived level of mathematics anxiety and perceived mathematical ability. There was also a moderate-level negative correlation ($r = -.508$, $p < .000$) between perceived level of anxiety and the first factor of maths anxiety scale while this relationship remained negative for the second factor ($r = -.616$, $p < .000$). As we expected, there was a positive correlation between perceived mathematics ability and the first factor ($r = .497$, $p < .000$) and it was with the second factor ($r = .293$, $p < .000$).

Secondly, a multiple linear regression analysis was run to explore the reciprocal relationships among the measured mathematics anxiety, perceived mathematics anxiety, and perceived mathematics ability, and to see if they work equally well for Australian and Russian samples. We compared how well the perceived mathematic ability and perceived mathematics anxiety levels predict the measured mathematics anxiety across two samples. First, we ran the multiple regression using the split file function to find the results for each country, then we compared if the difference in the regression coefficients, (R values) is significantly changing between two samples using Fisher's Z-test. The result of this calculation we found $r_{y_{\text{Australia}}} = .617$ & $N=41$ and $r_{y_{\text{Russia}}} = .716$ & $N=114$ gives $Z = -.095$ with the two tailed significance= 0.3421 $p > .05$). Based on this result we can conclude that the perceived mathematics anxiety and perceived mathematics ability predict the measured mathematics anxiety equally well for both samples. However, as we mentioned before, this is a preliminary

analysis because of the sample size and the Fisher's Z-test is not as powerful as a multiple group SEM analysis. We would like to re analyse this relationship using multiple group SEM analysis with a larger sample for future research.

Do PSTs' mathematics anxiety levels in Australia and Russia significantly vary by gender?

Based on the demographics there is an apparent difference between the number of males and females in both groups (Australian sample: 17% males and 75 % females; Russian sample: 75% males and 25% females). To determine if there is a significant difference in between Australian and Russian PSTs' mathematics anxiety by gender, we used a two-way factorial Anova. We also used Levene's test of homogeneity to determine to explore if the group variances are unequal.

Table 5

Means and Standard Deviations for Mathematics Anxiety by Gender and Country

Country	Female		Male		Total	
	M	SD	M	SD	M	SD
Australia	35.613	1.491	35.857	3.137	35.38	10.604
Russia	35.034	1.541	32.494	.900	33.14	7.392

Note. Gender [F (2, 148) =.887, p>.05], Country [F (1, 148) =.264, p>.05]

A Two-Way Factorial Anova, the Levene's test of homogeneity revealed that there was an equal variance among the groups meaning by gender and country [Gender [F (2, 148) =.887, p>.05], Country [F (1, 148) =.264, p>.05]. Therefore, this finding can be interpreted as: there was no significant difference in mathematics anxiety levels in two countries in terms of being male or female.

Discussion

With this current research, we aimed to explore the reciprocal relationships between mathematics anxiety, perceived level mathematics anxiety and perceived mathematical ability that the preservice teachers have. We also aimed to investigate to what extent the reasons for their anxiety sources differ from and resemble each other. Since this was a pilot study, mainly aimed to establish the measurement invariance between two countries, the reciprocal investigations were made using hierarchal regression. For a future study, we aim to use a larger data set with various antecedents and outcomes of mathematics anxiety to explore the reciprocal relationships between these two countries using multi-group structural equation modelling.

The results of this study contribute to research regarding mathematics anxiety by providing evidence of cross-cultural generalizability of mathematics anxiety scale originally developed by Fennema and Sherman in 1976 and updated by Betz in 1978. The 10-items short version of this scale was consistent between the two countries except for items 5 and item 10 as we expected (item #5: I almost never get uptight while taking math tests; item #10: Mathematics makes me feel uneasy and confused). The intercept estimation for item 5 was higher in the Australian sample than in the Russian sample. In contrast, the intercept estimation for item 10 was lower in the Australian sample than in the Russian sample. This means Australian preservice teachers' response to item 5 which was related to situational anxiety during a test-taking with a higher rating than Russian preservice teachers and Australian PSTs' response to item 10 which was related to general anxiety towards mathematics with a lower rating than Russian PSTs.

One way of looking at this is from a cultural point of view. Australian education philosophy adopts Plato's and Pythagoras' views in their educational system, so social justice-

respect for everyone and a holistic approach to education are the main concepts in Australian education (Shahidzade et al., 2019). In the Melbourne Declaration (Ministerial Council on Education, Employment, Training and Youth Affairs, 2008), it is stated that schools play a vital role in promoting the intellectual, physical, social, emotional, moral, spiritual, and aesthetic development and wellbeing of young Australians” as well as promoting “national values of democracy, equity and justice, and personal values and attributes such as honesty, resilience and respect for others” (Ministerial Council on Education, Employment, Training and Youth Affairs, 2008, p. 4). Therefore, Australian education focuses on improving one’s abilities and moral behaviours rather than strictly focusing on teaching subject knowledge in a specific area of study. The Tests in the Australian education system are not commonly used, hence the students from primary to higher education do not have the practice skills of taking tests other than a few opportunities required by various assessment authorities (e.g. NAPLAN, LANTITE, ATAR). On the other hand, the Russian education system and philosophy adopt a traditional education approach to learning, teaching, and testing even though they were recently shifted to child-centred education. However, there were difficulties on how the child-centred approach can be carried out (Krylova, 1998). Krylova (1998) also suggested that testing was an important tool to improve the education system. The Russian education system is still heavily dependent on testing and teachers. The only change is the name of the exams, for example, the old, unified university exams are now administered by a central body to each high school graduate (Bolotov, 2018; Evlalia & Ostaptschuk, 2012). Based on our findings, test-taking anxiety in mathematics can be relatively higher in Australian students than Russian students since the tests are not a common approach in Australia when it comes to quality assessment. Another important finding was related to item 10 which is addressing general mathematics anxiety. The Russian education system is heavily and traditionally teaching mathematics at Russian education levels especially in higher education (Kuzenkov & Zakharova, 2018). Australian mathematics education mostly focuses on improving students’ conceptual understanding; therefore, it is more important to improve students’ mathematic abilities through different approaches such as problem-solving rather than a high level of mathematical content acquisition. One result of this can yield less general mathematics anxiety in the Australian sample than it is in the Russian sample.

Swars et al. (2006), Gresham (2007) and Finlayson (2014), among many others, indicate low anxiety and high content knowledge leads to higher efficacy in teaching mathematics, (and vice versa) so there is nothing new here. It has been shown that PSTs’ engagement in mathematics increases Mathematics Pedagogical Content Knowledge (PCK) and decreases mathematics anxiety and anxiety about teaching mathematics (Brown et al., 2012; Gresham, 2007).

Another important finding was regarding gender. We found that there was no significant difference between males and females in terms of the level of maths anxiety in both countries. There are many studies that show that gender has an impact on students’ mathematics anxiety. However, our findings are parallel to some studies which have also found that there was no significant difference of mathematics anxiety in terms of gender (Brown et al., 2020; Devine et al., 2012). Sarfo and his colleagues investigated if mathematics anxiety differs by gender (2020) in 12 countries with 4342 students. They have found that in nine countries (Ghana, India, Iran, Mexico, Pakistan, Romania, Thailand, Ukraine, United Arab Emirates), gender has a significant effect on mathematics anxiety in a way that females have more anxiety cores than males. However, they have also found that in three countries (Egypt, Malaysia, Nigeria) gender has no significant impact on students’ mathematics anxiety levels. There are also some debates about economically developed and underdeveloped countries in terms of the gender differences in mathematics anxiety suggesting that students from economically developed countries have lower level of mathematics anxiety than less developed economies regardless of their gender (Stoet et al., 2016). There might be other currently unknown factors effecting mathematics

anxiety, therefore more research on this topic would support and improve our understanding of the structure and nature of mathematics anxiety further.

Conclusion

The results of this study are expected to bring a different point of view to the existing literature so that we can understand the causes of mathematics anxiety and how those related to students' perceived competencies by adding new and beneficial information into our knowledge in this area. The current finding suggests that full metric and partial scalar model invariance were confirmed which advise that the mathematics anxiety scale is comparable across two cultures. There were also limitations regarding the sample size and the number of related concepts to mathematics anxiety. Future research should integrate more related concepts in a multi-group SEM analysis to see the different levels of mathematics anxiety and its antecedents or outcomes further in a larger sample.

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