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A Multigroup Invariance Analysis and Gender Difference of Students' Self-efficacy and Attitude Concerning Mathematics

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Abstract. *This article aimed to examine multigroup invariance of Mathematics Self-efficacy and Attitude Scales (MSAS) and examine the differences of MSAS in term of gender. 1135 (630 female and 505 male) Year 9 students in Aceh, Indonesia were involved in the study. The invariance analysis was performed to investigate whether the items in the MSAS are behaving identically for Year 9 female and male students in the province of Aceh, Indonesia. The results reported the indication of multigroup equivalence of the MSAS between gender (p-value is not statistically significant or $\Delta CFI \leq 0.01$). An independent t-test indentified that students' attitude concerning mathematics is significantly different between gender of students. Female students' positive attitude concerning mathematics is higher compared to male students'. This study may be used as one of the evidences as for the needs to enhance male students attitude toward mathematics.*

Keywords: *Attitude toward mathematics, gender different, multigroup invariance*

Introduction

Self-efficacy and attitude toward mathematics have been widely studied and long recognized as important aspects in mathematics education (Finney & Schraw, 2003; Hackett & Betz, 1989; Hall & Ponton, 2005; Hoffman, 2010; Pajares & Miller, 1994). Both self-efficacy and attitude are believed to have an interaction in contributing to the academic performance (Nicolaidou & Philippou, 2003; Zimmerman, 2000). While many studies have found no differences between female and male mathematics self-efficacy (Chen, 2002; Hall & Ponton, 2005; F. Pajares & L. Graham, 1999; Pajares & Kranzler, 1995), gender disparities have been identified in other studies (Hackett, 1985). It has been observed that males tend to have higher mathematics self-efficacy than female (Hackett, 1985) and that the males' attitudes toward mathematics is also more positive than the females' (Else-Quest, Hyde, & Linn, 2010; Fennema & Sherman, 1978; Frenzel, Pekrun, & Goetz, 2007; Skaalvik & Skaalvik, 2004). Lloyd, Walsh, and Yailagh (2005) discovered that females are inclined to be under-confident while males are inclined to be over-confident, despite no significant disparities found in self-efficacy. Thus, some studies still find a gender gap relating to self-efficacy and attitude concerning mathematics indicating the need for investigation.

Self-efficacy has been, and continues to be, an important area of study in research in mathematics education. It has the power to change individual behavior both directly and indirectly (Bandura, 2006). Self-efficacy is defined as 'people's judgement about their capabilities' (Bandura, 1986, p. 94). 'Performance accomplishment' is the main trigger of self-efficacy, with high self-efficacy being correlated to highly successful performance while low self-efficacy is related to failure (Bandura, 1977, p. 195). Despite the main core of self-efficacy being an individual judgement of one's performance, one's confidence to execute a particular task is also involved (Pintrich, 1999). Thus, in an educational setting, self-efficacy could be described as what students think of their skills and how confident of success they are in a particular subject.

Many studies reported that self-efficacy has a high correlation to students' mathematics achievement (Hackett & Betz, 1989; Nicolaidou & Philippou, 2003; M. F. Pajares & L. Graham, 1999). Self-efficacy is a subject-specific matter, with no single self-efficacy scale being applicable across all subjects. Bandura (2006) advised that a generic form of self-efficacy scale will result in a poor fit of the measurement for a particular subject. Thus, a specific scale for mathematics self-efficacy should be designed.

Students' attitudes towards a particular subject have also been seen to serve as a good predictor for academic performance. Students' attitude toward mathematics is believed to be related to their self-efficacy in mathematics. Attitude is defined as the 'evaluation', involving liking or disliking, or providing a 'positive or negative ' response to a particular subject (Aiken, 1970, p. 551; Shrigley, Koballa, & Simpson, 1988, p. 675). Students' attitudes toward mathematics has a corresponding relationship to their performance (Aiken, 1970). When students have a positive attitude toward mathematics then they have high performance or they perform well in mathematics; positive performance then reinforces positive attitude. One of the attitudinal variables is motivation which includes both intrinsic and extrinsic motivation. Intrinsic motivation comprises interest in learning and liking mathematics while extrinsic motivation involves the utility values of whether mathematics is perceived as important and useful (Guay et al., 2010; Pintrich, 1999; Ryan & Deci, 2000).

Based on the review mentioned earlier, in this study, self-efficacy and attitude toward mathematics is measured by four correlated subscales, as shown in the Figure 1.

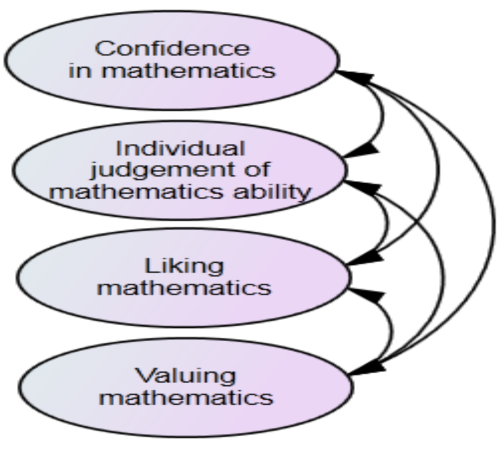

Figure 1. Mathematics Self-efficacy and Attitude Scales (MSAS): a four correlated subscales model

Various factors have been seen as contributing to gender differences in self-efficacy and attitude toward mathematics. Cultural background and upbringing (Else-Quest et al., 2010) and the perceived stereotyping of mathematics as being a male-oriented domain (Fennema & Sherman, 1978; Nosek, Banaji, & Greenwald, 2002) are among these factors. Another important factor regarding gender is the quality of the test used to measure the scales. Bias in the design and administration of tests should be avoided to enable more accurate assessment (Choi & Pak, 2005). Tests should be design to be gender-neutral, not to favour either male or female. In order to accurately compare differing populations it is essential to eliminate any subtle biases in the assessment tool (Reise, Widaman, & Pugh, 1993). The result of the assessment can only be comparable across groups if the measurement invariance is achieved (Doll, Deng, Raghunathan, Torkzadeh, & Xia, 2004). Therefore, statistical tests are required to investigate the measurement invariance.

This paper presents the results of multigroup analyses of invariance of Mathematics Self-efficacy and Attitude Scales (MSAS) across gender in Year 9 students in the state of Aceh, Indonesia and also to investigate any differences in self-efficacy and attitudes concerning mathematics between female and male students. The research questions of this study are (1) Whether components of the measurement model of MSAS are equivalent across gender? and (2) Whether there is any significant difference of the MSAS across gender?

Method

The Mathematics Self-efficacy and Attitude Scales (MSAS) comprises 18 items. The population sample is 1135 (630 female and 505 male) Year 9 students in Indonesia. The 18 items in MSAS are adopted from the Trends in International Mathematics and Science Study (TIMSS) student questionnaire. MSAS consists of four subscales: Liking Mathematics (LM), Valuing Mathematics (VM), Confidence in Mathematics (CM) and Individual Judgement of Mathematics ability (IJM). The description of each item of the scale is presented in Table 1 below. A four Likert scale is used in the questionnaire, with the responses are Strongly disagree, Disagree, Agree and Strongly disagree. Six items which have negative meaning were recoded to adjust the coding into the homogeneous direction with other items.

The data was analyzed using AMOS and SPSS 21. The multigroup analysis of invariance was undertaken using AMOS 21 to answer the first research question; the independent t-test was undertaking using SPSS 21, addressing the second research question. Multigroup analysis is conducted to test the factorial equivalence of the measuring instrument across different groups (Byrne, 2013). In this study, it is testing whether the MSAS items are equivalent across the female and male groups. An independent t-test is used to seek group differences (Field, 2013). In this case, it was administered to examine if the mathematics self-efficacy and attitudes of females and males are significantly different.

Table 1. The description of MSAS items

Item		Description	Subscale
1.	CM_a	I usually do well in mathematics	Confidence in mathematics
2.	CM_b	I learn things quickly in mathematics	
3.	CM_c	I am good at working out difficult mathematics problem	
4.	CM_d	My teachers think I can do well in mathematics classes with difficult materials	
5.	CM_e	My teacher tells me I am good at mathematics	
6.	IJM_a	Mathematics is not one of my strengths*	Individual judgement of mathematics ability
7.	IJM_b	Mathematics is more difficult for me than for many of my classmates*	
8.	IJM_c	Mathematics makes me confused and nervous*	
9.	IJM_d	Mathematics is harder for me than any other subject*	
10.	LM_a	I enjoy learning mathematics	Liking mathematics
11.	LM_b	I learn many interesting things in mathematics	
12.	LM_c	I like mathematics	
13.	LM_d	I wish I would not have to study mathematics*	
14.	LM_e	Mathematics is boring*	
15.	VM_a	I think learning mathematics will help me in my daily life	Valuing mathematics
16.	VM_b	I need mathematics to learn other school subjects	
17.	VM_c	I need to do well in mathematics to get into the university or college of my choice	
18.	VM_d	I need to do well in mathematics to get the job I want	

*item is recoded

Results and Discussion

Multigroup Analysis of Invariance

Confirmatory Factor Analysis (CFA) was conducted using AMOS 21 before proceeding to the multigroup analysis. The model used is presented in Figure 2.

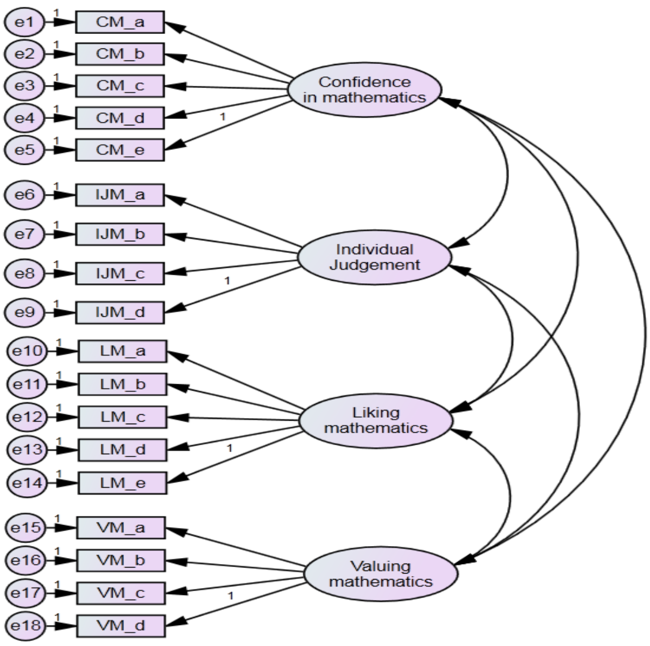

Figure 2. Initially hypothesised model of 18 items MSAS structure for female and male student

Large error covariances were found to be consistent across groups in investigating the validity of scores related to the proposed 18-item MSAS model for each female and male student group. Large error covariances were found between items 13 and 14, between items 4 and 5, and between items 3 and 4. All items with large error covariances were checked and then correlated. The errors were correlated and the change to the model shows that the new model has a better fit. As the multigroup analyses of invariance involve hierarchical order, none of the further models will fit the data if the baseline model is not able to do so (Marsh, 1994 in Doll, Hendrickson, & Deng, 1998). With RMSEA below 0.05, GFI and CFI above 0.9 is considered as a good fit (Byrne, 2013), our four model of female and male satisfies the requirement. The summary of goodness-of-fit statistics for determining the baseline model for multigroup analysis is provided in Table 2. The model seems to fit the male group better than the female. The female model is modestly good at best. Model 4 which fits the data best for both groups, is used as the hypothesised multigroup baseline model and is presented in Figure 3.

Table 2. Summary of goodness-of-fit statistics in determination of baseline models

Model	χ^2	df	GFI	CFI	RMSEA	RMSEA 90% CI	ECVI
			Male				
1. Hypothesised four-factor model	315.771	129	0.934	0.926	0.054	0.046; 0.061	0.793
2. Model 1 with one error covariance (item 13 and 14)	284.491	128	0.941	0.938	0.049	0.042; 0.057	0.735
3. Model 2 with two error covariances (item 13 and 14; 4 and 5)	263.830	127	0.946	0.946	0.046	0.038; 0.054	0.698
4. Model 3 with three error covariances (item 13 and 14;4 and 5; 3 and 4)	243.440	126	0.950	0.954	0.043	0.035; 0.051	0.662
			Female				
1. Hypothesised four-factor model	498.343	129	0.915	0.882	0.067	0.061; 0.074	0.926
2. Model 1 with one error covariance (item 13 and 14)	467.295	128	0.920	0.891	0.065	0.059; 0.071	0.880
3. Model 2 with two error covariances (item 13 and 14; 4 and 5)	404.291	127	0.930	0.911	0.059	0.053; 0.065	0.783
4. Model 3 with three error covariances (item 13 and 14;4 and 5; 3 and 4)	364.295	126	0.937	0.924	0.055	0.048; 0.061	0.772

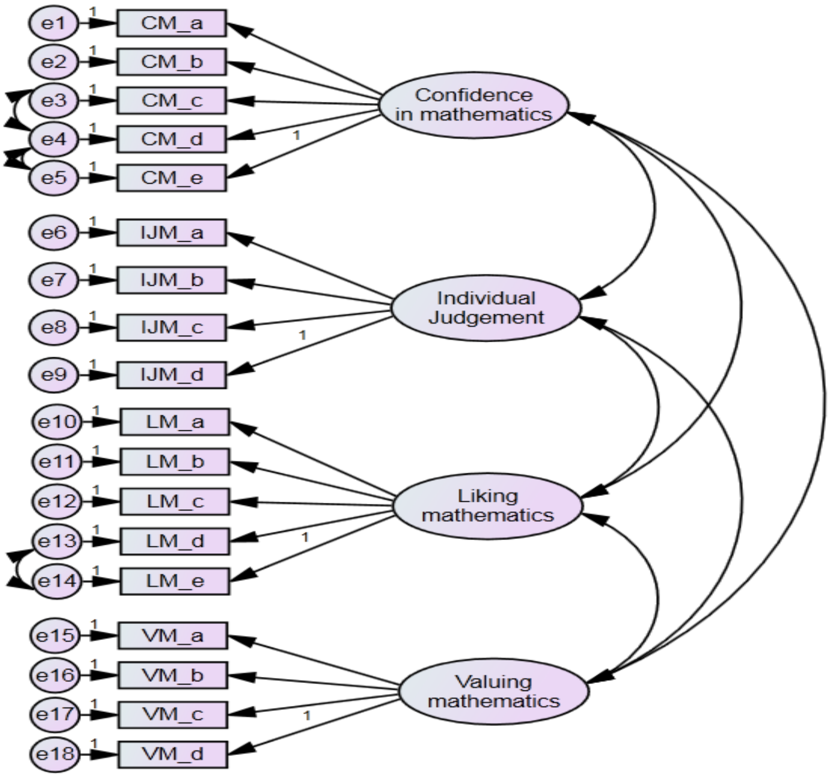

Figure 3. Hypothesised multigroup baseline model of MSAS structure

The hypothesised multigroup baseline model is also commonly labelled as the 'configural model' and this term will now be applied. Although the factor structure of both groups is much the same in the configural model, that does not mean that it is exactly the same, as there are no constraints yet applied to any parameters (Byrne, 2013). The configural model (Model 1) will be used as the foundation for comparison for any further model of testing invariance. The result of the configural model testing shows that the model fits both groups acceptably well (χ^2 = 607.735, df = 252, CFI = 0.937). A further test is the multigroup invariance test was begun by imposing equal constraints for all factor loading (Model 2). This was followed by imposing equal constraints for all factor loadings, variances and covariances among all four factors (Model 3), and, finally, by imposing equal constraints to all factors loadings, as well as to variances and covariances between factors and also all errors (Model 4).

The test revealed that Model 2 ($\Delta\chi^2$ = 25.705, and df = 14) and Model 3 ($\Delta\chi^2$ = 47.915, and df = 24), are not statistically different from Model 1 ($p < 0.01$). Based on that finding, it is indicated that there is no evidence of noninvariance. This means that all items designed to measure MSAS have an equivalent function across female and male student groups at both the measurement model and structural model. An indication of noninvariance is detected in Model 3: when the loading of errors is fixed to be the same for both groups, the measurement residual model ($\Delta\chi^2$ = 116.339, and df = 45, p = 0.000). However the ΔCFI in model is still falling within the range of less than or equal to 0.01 (ΔCFI = 0.008), according to Cheung and Rensvold (2002), indicating invariance. The summary of goodness-of-fit statistics for all models is presented in Table 3.

Table 3. Summary of goodness-of-fit statistics for tests of multigroup invariance

Model Description	Comparative model	χ^2	Df	$\Delta\chi^2$	Δdf	Statistical significance	CFI	ΔCFI
1. Configural model; no equality constraint imposed	-	607.735	252	-	-	-	0.937	-
2. Measurement model; all factor loadings constraint equal	2-1	633.440	266	25.705	14	0.028 (NS)	0.935	0.002
3. Structural model; measurement model with covariances among CM, IJM, LM and VM constrained equal	3-1	655.649	276	47.915	24	0.003 (NS)	0.933	0.002
4. Measurement residual models; structural model with all errors constrained equal	4-1	724.074	297	116.339	45	0.000 (p <0.001)	0.925	0.008

Independent t-test

Having found that the items and subscales are operating equivalently across gender, an independent t-test was performed to investigate the differences in self-efficacy and attitude towards mathematics between females and males. There was a significance differences between female and male students in two out of the four subscales in MSAS. The significant differences are found in liking mathematics and valuing mathematics ($p \leq 0.01$). Even though both groups show that they have a high positive attitude towards mathematics, generally female students have a more positive attitude. There are no significant differences between female and male students for confidence and individual judgement. However, on average, female students have higher self-efficacy towards mathematics. The summary of t-test is presented in Table 4.

Table 4. Summary of independent t-test

	Lavene's test for equality of variances		t-test for equality of means			
	F	Sig.	t	df	Sig.	Means differences
Confidence in mathematics	2.360	0.125	0.035	1057	0.972	0.00528*
Individual judgement	0.103	0.749	1.220	1067	0.223	0.172772*
Liking mathematics	10.362	0.001	3.104	933.288	0.002	0.46253**
Valuing mathematics	3.546	0.060	4.033	1103	0.000	0.46454*

Note: *equal variances assumed, **equal variances not assume

Conclusion

The multigroup analysis of invariances shows no evidence of noninvariance which testifies that the test operates equivalently across the female and male groups of students. The independent t-test advises that there are significant differences across gender for liking mathematics and valuing mathematics, with the interesting fact that females have a more positive attitude toward mathematics than the males. Although, no significant differences are discovered for confidence in mathematics and individual judgement of mathematics ability, females also show a higher mean for these two subscales, which means that females' self-efficacy concerning mathematics is more positive. These finding contradicts the notion of mathematics being a male-oriented subject, where males tend to have the more positive toward mathematics as reported in Lloyd et al. (2005) and the finding of PISA 2012 which reported that female students have both a less positive attitude and self-efficacy toward mathematics than male students (OECD, 2013). The finding provides a positive insight related to mathematics for female students, specifically for Year 9 female students in Aceh, Indonesia. Having said that the test for invariance is not significant, we could also conclude that the differences across gender for the attitude toward mathematics are not the result of a misleading test. Further research is required to investigate possible related factors contributing to the gender differences in attitude toward mathematics to discover how female students in Aceh have a more positive attitude toward mathematics than male students.

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