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TIMSS 2003: RELATING DIMENSIONS OF MATHEMATICS ATTITUDE TO MATHEMATICS ACHIEVEMENT

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Abstract. This study, which used a sample of 137,346 students from thirty three countries that participated in the TIMSS 2003 project in the eighth grade, examined the features of the individual and collective relations of three dimensions of mathematics attitude to mathematics achievement (MA), searching for the dimension mostly related to that achievement. The three dimensions of mathematics attitude were self-confidence in learning mathematics (SCLM), liking mathematics (LM) and usefulness of mathematics (UM). By utilizing psychometrically valid and reliable measures of the three dimensions, it was found that: (1) each dimension of mathematics attitude alone was positively related to MA for almost all thirty three countries; (2) SCLM was primarily related to MA for thirty one countries; (3) when the two other dimensions were held constant, SCLM was positively related to MA for thirty three countries, LM was negatively related to MA for thirty countries, whereas UM was not related to MA for twenty one countries; (4) positive collective relationships of SCLM, LM and UM to MA considerably varied from country to country. Implications for research and practice are included.
Key words: TIMSS, mathematics attitude, self-confidence in learning mathematics, liking mathematics, usefulness of mathematics, mathematics achievement.

INTRODUCTION

Relating mathematics attitude and its dimensions to mathematics achievement

According to Ma and Kishor (1997a), there is a positive interaction between mathematics attitude and mathematics achievement. There is also a positive relationship between self-concept about mathematics and achievement in mathematics (Ma & Kishor, 1997b).

Positive relations between mathematics attitude and mathematics achievement in general and self-confidence in mathematics and mathematics achievement in particular, have been documented for a problem solving context

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(e.g. Hembree, 1992). As regards the TIMSS context, a positive association has been found not only between mathematics attitude and mathematics achievement (Mullis *et al*., 2001), but also between self-perceived competence in mathematics and mathematics achievement in particular (e.g. Shen, 2002; Wilkins, 2004).

Although Reyes (1984) finds that causal attribution, confidence in learning mathematics and usefulness of mathematics are primarily related to mathematics achievement, research has not focused on the features of the individual and collective relations of dimensions of mathematics attitude to mathematics achievement, searching for the dimension mostly related to that achievement. Previous research only suggests that the dimension in question may be self-confidence in learning mathematics (extrapolated from Hembree, 1992; Shen, 2002; Simpkins, Davis-Kean & Eccles, 2006). This study searched for a theoretical framework supporting this kind of research in the TIMSS 2003 study, and main attitudinal patterns within that framework that apply for most TIMSS 2003 countries. Uncovering, if any, stable patterns across countries regarding the issue in question would help us develop better mathematics instruction (cf. Seidel & Prenzel, 2006).

Identifying possible problems in analyzing TIMSS background data

TIMSS questions regarding background (context) variables primarily reflect a consensus among the representatives of the participating countries what data to collect from their students, teachers and school principals. As a consequence, these questions have not been explicitly based on some theoretical frameworks to be tested and refined. Because of such a state, researchers who wish to utilize the TIMSS data on background variables usually face the following two problems: (1) finding out suitable theoretical grounds that support the desired secondary analysis; and (2) making use of measures that can be considered reliable and valid. Of course, in order to resolve the second problem, researchers are to utilize not only good-quality data, but also adequate computations applying adjustments for clustering and dependency due to multiple stratifications in data collection.

Searching for suitable theoretical grounds of mathematics attitude

Mathematics attitude has been frequently assessed by FSMAS, Fennema-Sherman Mathematics Attitude Scales (Fennama & Sherman, 1976), dealing with nine attitudinal dimensions including attitude towards success in mathematics, confidence in learning mathematics, mathematics usefulness, mathematics anxiety, and mathematics as a male domain. Although less than nine dimensions might be covered by the original 108 FSMAS statements (e.g. Melancon, Thompson & Becnel, 1994, identified eight, whereas Mulhern & Rae, 1998, found six), recent adaptations of the FSMAS instrument, comprising about fifty statements, have demonstrated the original nine-factor structure (see, for example, Vezeau *et al*, 1998, and Alkhateeb, 2004). Aiming at a short mathematics attitude scale with a straightforward factor structure, Tapia and Marsh II (2005) developed a 40-statement instrument assessing self-confidence, value of mathematics, enjoyment of mathematics, and motivation.

In the context of computer attitude, the operationalized dimensions of this construct have been, for example, computer anxiety, computer confidence, computer liking, and computer usefulness (Loyd & Gressard, 1986) or affective component, perceived usefulness component, perceived control component, and behavioral component (Selwyn, 1997). By simultaneously administering four instruments measuring computer attitude, Woodrow (1991) found three underlying attitude dimensions: computer anxiety, computer liking, and social and educational impact of computers (with a remark that confidence and anxiety are usually viewed as opposites of the same construct). Note that in the context of technology-assisted learning of mathematics, the dimensions of students' mathematics and technology attitudes can, according to Pierce, Stacey and Barkatsas (2007), be mathematics confidence (students' self-assurance in handling difficulties in mathematics), confidence with technology (students' self-assurance in working with technology), attitude towards learning mathematics with technology (perceived value of using technology for learning mathematics), affective engagement (students' feelings about the subject), and behavioral engagement (students' behaviors in learning the subject).

According to Hart (1989), mathematics attitude should be viewed as a predisposition to respond in an unfavorable or favorable way to mathematics. By accepting this view, mathematics attitude includes relevant beliefs (e.g. "Mathematics helps me understand science lessons"), behavior (e.g. "I will apply for a job involving mathematics") and attitudinal or emotional reactions (e.g. "I like solving mathematical problems", "I feel upset when solving mathematical problems"). In other words, by extrapolating from Key (1993), it can be said that an instrument measuring mathematics attitude should sample cognitive, affective and behavioral domains, possibly represented, as the previous analysis suggests, by self-confidence in learning mathematics, liking mathematics and usefulness of mathematics, for example.

Characterizing theoretically-grounded TIMSS data on mathematics attitude

Although TIMSS 2003 Grade 8 Student Questionnaire (see http://timss.bc.edu/timss2003i/PDF/T03_Student_8.pdf) did not explicitly and extensively sample cognitive, affective and behavioral domains – nor did the project explicitly attempt to assess mathematics attitude and some of its dimensions – the utilized TIMSS attitudinal statements concerning mathematics allow researcher to assess self confidence in learning mathematics (e.g. TIMSS statement "I usually do well in mathematics"), liking mathematics (e.g. TIMSS statement "I would like to take more mathematics in school") and usefulness of mathematics (e.g. TIMSS statement "I need mathematics to learn other school subjects"). These three dimensions can be defined as follows:

(1) self confidence denotes perceived ease, or difficulty, of learning mathematics;
(2) liking mathematics stands for student's affective, emotional and behavioral reactions concerning liking, or disliking, mathematics;
(3) usefulness of mathematics denotes student's beliefs concerning the contribution of mathematics to his/her educational and vocational performance.

Although these three definitions are influenced by the available TIMSS data, they are still given in a general rather than particular context. Recall that some forty years ago Neale (1969) viewed student's mathematics attitude in terms of his/her belief that he/she is good or bad at mathematics, his/her liking or disliking of mathematics, his/her belief that mathematics is useful or useless, and his/her tendency to participate in or avoid mathematical activities. As Ma and Kishor (1997a) remark, mathematics attitude often also includes student's affective responses to the previous two issues concerning perceived ability and usefulness.

Making use of reliable and valid measures derived from TIMSS data on mathematics attitude

In order to infer confident conclusions about the features in question, this research made use of the approach applied by Kadijevich (2006), who developed the measures of the three attitudinal dimensions, which are psychometrically valid and reliable for more than thirty countries participating in the TIMSS 2003 project. This was achieved by transforming the subjects' scores on the chosen attitudinal indicators into Guttman's (1953) image form scores. Note that the applied transformation, which eliminates measurement error, is defined by $TR = RID(I - R^{-1}U^2)$, where TR, RID, I, R and U^2 are, respectively, the matrix of true results, the matrix of raw initial data, the identity matrix, the matrix of the intercorrelation among the measured variables (attitudinal indicators in this research), and the matrix of the estimate of the variance of measurement error given by $(\text{diag}R^{-1})^{-1}$.

METHOD

Sample

This study used a sample of 137,346 students from thirty three countries that participated in the TIMSS 2003 Grade 8 project. Table 1 presents basic facts about this sample by country. Note that only students with complete data on the examined variables were included in this study.

Table 1. Sample size and percentage of students originally assessed by country

Country	**N**	**% of students originally assessed**
Australia	4,429	92.4
Bahrain	3,809	90.7
Belgium (Flemish)	4,700	94.6
Bulgaria	3,618	87.9
Chile	6,130	96.1
Chinese Taipei	5,243	97.5
Cyprus	3,643	91.0
England	2,581	91.2
Estonia	3,809	94.3
Hong Kong SAR	4,843	97.4
Hungary	3,131	94.8
Indonesia	5,180	89.9
Israel	3,858	89.3
Italy	4,054	94.8
Japan	4,627	95.3
Jordan	3,808	84.8
Korea, Rep. of	5,179	97.6
Latvia	3,474	95.7
Lithuania	4,187	84.3
Macedonia, Rep. of	3,233	83.0
Malaysia	5,122	96.4
Moldova, Rep. of	3,694	91.6
Morocco	2,160	73.4
New Zealand	3,484	91.7
Norway	3,740	90.5
Romania	3,584	87.3
Russian Federation	4,417	94.6
Scotland	3,318	94.4
Serbia	3,909	91.0
Slovak Republic	4,001	94.9
Sweden	3,819	89.7
Tunisia	4,138	83.9
United States	8,424	94.5

Design

This study utilized correlative design. The variables were: Mathematics Achievement, Self-Confidence in Learning Mathematics, Liking Mathematics, and Usefulness of Mathematics. The following two subsections respectively explain how the values of these four variables were determined and in what way the correlative design was implemented.

Instruments

As student's score on the entire assessment was obtained by means of the IRT (Item Response Theory) scaling that uses the so-called plausible values methodology (Gonzales, Galia & Li, 2004), his/her Mathematics Achievement (MA) was represented by the average of five plausible achievement estimators. The reliability (Cronbach's alpha) of MA was determined for each country by the TIMSS Data Processing Centre. According to Mullis *et al.* (2004, p. 368), this reliability was 0.74 for Morocco, 0.77 for Tunisia, and over 0.80 for all remaining thirty one countries.

Self-Confidence in Learning Mathematics (SCLM) was measured by a 4-item Likert scale administered by means of statements "I usually do well in mathematics", "Mathematics is more difficult for me than for many of my classmates", "Mathematics is not one of my strengths", and "I learn things quickly in mathematics" (see statements 8a, 8c, 8f and 8g of the TIMSS 2003 Grade 8 Student Questionnaire at the Internet address given above; to achieve positive meaning, scoring from 1 to 4 was reversed for items 8a and 8g).

Liking Mathematics (LM) was measured by a 3-item Likert scale administered by means of statements "I would like to take more mathematics in school", "I enjoy learning mathematics", and "I would like a job that involved using mathematics" (see statements 8a, 8d and 9d of the Questionnaire; to achieve positive meaning, scoring 1-4 was reversed for all these items).

Usefulness of Mathematics (UM) was measured by a 4-item Likert scale administered by means of statements "I think learning mathematics will help me in my daily life", "I need mathematics to learn other school subjects", "I need to do well in mathematics to get into the faculty/university of my choice", and "I need to do well in mathematics to get the job I want" (see statements 9a, 9b, 9c and 9e of the Questionnaire; to achieve positive meaning, scoring 1-4 was reversed for all these items).

As already mentioned in the Introduction, this study made use of the subjects' scores (numerically coded responses to the eleven above-listed attitudinal statements) transformed into Guttman's (1953) image form scores.

For each of the three attitudinal variables (SCLM, LM and UM), student's agreement with given statements was represented by the average of the corresponding transformed scores. For each of the participating thirty three countries, the reliability (Cronbach's alpha) of these three variables was over 0.90.

Statistical analysis

The TIMSS 2003 international database and its user guide (Martin, 2005) were downloaded from the Internet (http://timss.bc.edu/timss2003i/userguide.html). The data were analysed by the SPSS program that always made use of official within-country sampling weights (Joncas, 2004) given in the database. In order to adjust for clustering and dependency due to multiple stratifications in data collection, correlative design used in this study had to make use of SPSS macros *JackReg* and *JackRegP* provided by Martin (2005). Because MA was made equal to the average of the five plausible achievement estimators, only SPSS macro *JackReg* was needed. Note that correlation and regression coefficients obtained by using *JeckReg* would be equal to those obtained by using the SPSS standard commands (CORELATIONS and REGRESSION) provided that the analyzed cases are weighted by the official TIMSS sampling weight termed *houwgt*. More precisely, bearing in mind that all students with missing or incomplete data on the examined variables were excluded from this study (causing that the sum of all values of houwgt was not any more equal to the size of such a reduced sample), student's weight *stuwgt* is to be equal *n* * *totwgt* / *TOTWGT*, where *n* was the sample size, *totwgt* student's total weight given in the official data files, and *TOTWGT* the sum of all students' individual weights.

RESULTS

Table 2 reports the correlations among MA, SCLM, UM and LM by country. Apart from two correlations (-0.02 for Indonesia and 0.00 for Macedonia), all reported correlations were significant at a 0.01 level. Because the applied Guttman's transformation eliminated the error of measurement, high correlations among SCLM, LM and UM (these are dimensions of the same construct) should not be surprising.

Table 2. Correlations among the measured variables by country

Country	Correlation of					
	MA & SCLM	MA & LM	MA & UM	SCLM & LM	SCLM & UM	LM & UM
Australia	0.48	0.30	0.20	0.80	0.64	0.84
Bahrain	0.45	0.23	0.17	0.81	0.63	0.83
Belgium (Flemish)	0.25	0.24	0.18	0.84	0.67	0.83
Bulgaria	0.40	0.22	0.17	0.80	0.63	0.81
Chile	0.35	0.09	0.06	0.76	0.57	0.79
Chinese Taipei	0.57	0.46	0.38	0.87	0.72	0.86
Cyprus	0.56	0.38	0.25	0.81	0.64	0.82
England	0.33	0.17	0.11	0.79	0.61	0.82
Estonia	0.51	0.29	0.20	0.79	0.61	0.81
Hong Kong SAR	0.43	0.35	0.30	0.84	0.64	0.83
Hungary	0.54	0.30	0.16	0.81	0.60	0.79
Indonesia	0.04	-0.02	0.04	0.79	0.63	0.81
Israel	0.41	0.11	0.10	0.73	0.57	0.80
Italy	0.49	0.36	0.26	0.87	0.72	0.85
Japan	0.50	0.38	0.27	0.79	0.58	0.81
Jordan	0.43	0.26	0.26	0.79	0.66	0.83
Korea, Rep. of	0.61	0.48	0.40	0.85	0.69	0.85
Latvia	0.52	0.30	0.21	0.79	0.60	0.79
Lithuania	0.54	0.33	0.25	0.79	0.61	0.78
Macedonia, Rep. of	0.29	0.06	0.00	0.81	0.65	0.83
Malaysia	0.46	0.32	0.25	0.80	0.62	0.81
Moldova, Rep. of	0.33	0.21	0.17	0.79	0.66	0.83
Morocco	0.33	0.17	0.15	0.78	0.59	0.80
New Zealand	0.47	0.19	0.13	0.77	0.60	0.83
Norway	0.61	0.37	0.27	0.79	0.63	0.82
Romania	0.46	0.30	0.24	0.80	0.65	0.82
Russian Federation	0.50	0.35	0.24	0.79	0.60	0.79
Scotland	0.39	0.17	0.16	0.78	0.65	0.82
Serbia	0.58	0.27	0.14	0.76	0.57	0.79
Slovak Republic	0.51	0.27	0.17	0.79	0.61	0.79
Sweden	0.54	0.30	0.21	0.78	0.60	0.81
Tunisia	0.44	0.33	0.28	0.86	0.69	0.83
United States	0.41	0.23	0.17	0.82	0.64	0.82

Having in mind positive relations of MA and SCLM, MA and LM and MA and UM, a series of linear regression analyses with MA as dependent variable, and SCLM, LM and UM as independent variables, were performed. Table 3 reports the obtained regression coefficients by country, among which about twenty coefficients (mostly those concerning the predictor UM) were statistically equal to zero at a 0.01 level. Apart from Belgium (Flemish) and Indonesia, the major predictor of MA was SCLM. The impact of LM on MA when SCLM and UM were held constant was negative for thirty countries. Multiple correlations between the three attitudinal dimensions (SCLM, LM and UM)[1] taken together and MA varied from 0.13 for Indonesia to 0.64 for Norway and Serbia.

Table 3. Regression coefficients by country (sorted by multiple R)

Country	Multiple R	Regression coefficient				R SCLM Only
		SCLM	LM	UM	Const.	
Norway	0.64	89	-25	-9	311	0.61
Serbia	0.64	97	-36	-15	355	0.58
Korea, Rep. of	0.61	95	-22	4	401	0.61
Hungary	0.60	101	-40	-16	407	0.54
Cyprus	0.58	85	-11	-18	313	0.56
Sweden	0.58	99	-38	-6	336	0.54
Chinese Taipei	0.57	98	-18	-2	401	0.57
Lithuania	0.56	85	-28	-3	359	0.54
Slovak Republic	0.56	99	-41	-10	378	0.51
Estonia	0.55	81	-39	0	413	0.51
Latvia	0.55	80	-33	-3	395	0.52
New Zealand	0.54	97	-52	1	363	0.47
Italy	0.51	80	-22	-13	365	0.49
Russian Federation	0.51	71	-16	-4	374	0.50
Australia	0.50	81	-18	-13	372	0.48
Bahrain	0.50	86	-46	3	280	0.45
Japan	0.50	75	-3	-2	419	0.50

[1] Variance inflation factors (VIPs) – obtained by the SPSS REGRESSION command processing the data weighted by *houwgt or stuwgt* – were less than 10 (a cut-off criterion for multicollinearity problem; see Everitt, 1996) even for Chinese Taipei, Italy, Korea, and Tunisia – four countries with highest correlations among SCLM, LM and UM (see Table 2). These factors were: 4.220 for SCLM, 8.126 for LM and 4.049 for UM (Chinese Taipei); 4.249 for SCLM, 7.565 for LM and 3.726 for UM (Italy); 3.572 for SCLM, 6.528 for LM and 3.559 for UM (Korea); 3.763 for SCLM, 6.327 for LM and 3.269 for UM (Tunisia).

Israel	0.49	96	-59	7	348	0.41
Malaysia	0.47	86	-24	4	329	0.46
Romania	0.47	88	-28	3	317	0.46
Jordan	0.46	88	-52	23	247	0.43
United States	0.45	78	-40	2	382	0.41
Chile	0.44	92	-56	2	278	0.35
Scotland	0.44	79	-44	6	369	0.39
Tunisia	0.44	49	-19	6	312	0.44
Bulgaria	0.43	74	-30	-1	364	0.40
Hong Kong SAR	0.43	56	-19	16	448	0.43
Macedonia, Rep. of	0.43	84	-49	-11	386	0.29
England	0.37	66	-29	-4	404	0.33
Morocco	0.37	56	-34	9	303	0.33
Moldova, Rep. of	0.34	64	-12	-6	345	0.33
Belgium (Flemish)	0.26	18	17	-7	474	0.25
Indonesia	0.13	31	-55	31	381	0.04

statistically equal to zero at a 0.01 level

Bearing in mind that correlation coefficients are affected by restrictions of range in data values (see Schumacker & Lomax, 2004), the departure of data from a normal distribution was examined for each of the four measured variables. Because the distribution was not normal for each of them (MA: *K-S Z* = 3.893, *p* = 0.000; SCLM: *K-S Z* = 10.176, *p* = 0.000; LM: *K-S Z* = 9.830, *p* = 0.000; UM: *K-S Z* = 19.472, *p* = 0.000), their values were normalized for all 137,346 students with weight *stuwgt* switched on.[2] The applied correlative analysis was then repeated for ten randomly selected countries. Table 4 presents the correlation coefficients in question. Undoubtedly, the same findings emerged.

[2] Although the distribution was not normal for three variables (N_MA: *K-S Z* = 0.591, *p* = 0.876; N_SCLM: *K-S Z* = 1.879, *p* = 0.002; N_LM: *K-S Z* = 1.863, *p* = 0.002; N_UM: *K-S Z* = 1.893, *p* = 0.002), as regards restrictions of range in data values, these three variables (N_SCLM, N_LM and N_UM) should not be considered different.

Table 4. Correlations among the normalized variables by country

Country	Correlation of					
	MA & SCLM	MA & LM	MA & UM	SCLM & LM	SCLM & UM	LM & UM
Australia	0.48	0.30	0.20	0.81	0.66	0.85
Bulgaria	0.40	0.23	0.17	0.80	0.66	0.83
Chile	0.36	0.10	0.09	0.75	0.61	0.81
Estonia	0.51	0.28	0.21	0.80	0.62	0.82
Hong Kong SAR	0.43	0.35	0.30	0.83	0.65	0.83
Hungary	0.54	0.30	0.18	0.82	0.64	0.81
Indonesia	0.04	-0.02	0.04	0.79	0.64	0.81
Macedonia, Rep. of	0.29	0.05	0.00	0.81	0.67	0.85
Malaysia	0.46	0.33	0.26	0.80	0.63	0.81
Serbia	0.57	0.27	0.16	0.77	0.60	0.82

DISCUSSION

Four important findings emerged from this study. First, each dimension of mathematics attitude alone was positively related to mathematics achievement for almost all of the thirty three countries. Second, self-confidence in learning mathematics was primarily related to mathematics achievement for thirty one countries. Third, when the two other dimensions were held constant, self-confidence in learning mathematics was positively related to mathematics achievement for thirty three countries, liking mathematics was negatively related to mathematics achievement for thirty countries, whereas usefulness of mathematics was not related to mathematics achievement for twenty one countries. Fourth, positive collective relationships of self-confidence in learning mathematics, liking of mathematics and usefulness of mathematics to mathematics achievement considerably varied from country to country.

Individual relationships of the three attitudinal dimensions to mathematics achievement

Three positive relationships. Apart from liking mathematics for Indonesia and usefulness of mathematics for Macedonia, each dimension of mathematics attitude alone was positively related to mathematics achievement. Such an outcome, supporting the validity of the three sub-scales, is consistent with previous research in the TIMSS context concerning mathematics. For example, Wilkins (2004) found a positive relationship between 8^{th} graders' achievement and self-concept for almost all countries that participated in TIMSS 1995. Furthermore, Shen (2002) reports a positive relationship for almost all countries that participate in TIMSS 1999 not only between 8^{th} graders' achievement and self-perceived competence, but also between their achievement and how much they like the subject.

The correlation of self-confidence in learning mathematics and mathematics achievement considerably varied from country to country (from 0.04 for Indonesia to 0.61 for Korea). Such variability, though at a smaller scale, was found for the correlation of liking mathematics and mathematics achievement (from 0.02 for Indonesia to 0.48 for Korea) as well as the correlation of usefulness of mathematics and mathematics achievement (from 0.00 for Macedonia to 0.40 for Korea). The same patterns can be found in Shen (2002) and Wilkins (2004). For the TIMSS 1995 8^{th} grade data, the correlation of self-concept and achievement varies from -0.02 for Philippines to 0.46 for Korea (Wilkins, 2004). For the TIMSS 1999 8^{th} grade data, the correlation of self-perceived competence and achievement varies from -0.06 for Indonesia to 0.55 for Korea, whereas the correlation of liking the subject and the achievement varies from -0.16 for Moldova to 0.46 for Chinese Taipei (Shen, 2002).

Why did these correlations vary from country to country?

An additional correlative analysis (where each country was treated equally) showed a positive relationship between mathematics achievement and each of the three correlations ($r_{\mathrm{MA},\ r\mathrm{SCLM,MA}} = 0.438$, $df = 31$, $p = 0.011$; $r_{\mathrm{MA},\ r\mathrm{LM,MA}} = 0.601$, $df = 31$, $p = 0.000$; $r_{\mathrm{MA},\ r\mathrm{UM,MA}} = 0.547$, $df = 31$, $p = 0.001$). Although Shen (2002) and Wilkins (2004) did not examine this question, our analysis of the data reported in Wilkins (2004) evidenced that countries with higher mathematics achievement had a stronger relationship between mathematics self-concept and mathematics achievement ($r_{\mathrm{MA},\ r\mathrm{MSC,\ MA}} = 0.618$, $df = 39$, $p = 0.000$). It thus seems that countries with more demanding mathematics curriculum (those that had higher mathematics achievement) have a stronger relationship between mathematics achievement and mathematics attitude dimensions.

Strongest positive relationships. Self-confidence in learning mathematics was primarily related to mathematics achievement in thirty one countries. An exception was found only for Belgium (Flemish) and Indonesia, where self-confidence in learning mathematics and other dimension of mathematics attitude (liking mathematics for Belgium, whereas usefulness of mathematics for Indonesia) were equally correlated with the achievement.

Although, as already underlined, research has not examined which dimension, if any, of mathematics attitude is mostly related to mathematics achievement, several studies contain data that are related to the pattern reported in this part. Let us briefly summarize them.

- Our analysis of relevant correlations given in Ethington (1992) showed that mathematical self-concept, difficulty of mathematics and value of mathematics were equally related to mathematics achievement (statistically and in absolute terms) for both males and females.
- According to the meta-analysis done by Hembree (1992), the mean correlation between self-confidence in mathematics and problem-solving performance was 0.35, whereas such correlation between attitudes toward mathematics and this performance was just 0.23. Confidence intervals (99%) for these mean correlations were (0.29, 0.44) and (0.18, 0.28), respectively.
- Our statistical analysis of relevant correlations given in Shen (2002) evidenced that, for most countries, a positive relationship of students' achievement and agreement with the statement "I do well in math" was stronger than a positive relationship of students' achievement and agreement with the statement "I like math".
- This study also analyzed relevant correlations reported in Simpkins, Davis-Kean & Eccles (2006) and found that 6^{th} grade math self-concept correlated with 5^{th} grade math course grades higher than did 6^{th} grade math importance or 6^{th} grade interest in math (similar to our variable LM) for girls; this outcome applied for boys too, but only numerically, not statistically. For the 10^{th} grade measures of these four variables, math self-concept was mostly related to math course grades for both boys and girls.

It thus follows that self-confidence in learning mathematics may indeed be primarily related to mathematics achievement, which, due to large samples and confident measures utilized in this study, attains a sort of general validity, especially having in mind the content of Table 4. It should be noted that, to the author's reading, a theoretical framework supporting this outcome has not been developed. It is true that an attribution theory examines success in terms of perceived ability and that a goal theory relates success to perceived value (see, for example, Middleton & Spanias, 1999), but there is no unified theory that ranks relationships between mathematics achievement and different dimensions of mathematics attitude according to their size.

Collective relationship of the three attitudinal dimensions to mathematics achievement

Different patterns of partial relationships. The data presented in Table 3 reveal the following issues:

- when liking mathematics and usefulness of mathematics are held constant, self-confidence in learning mathematics is positively related to mathematics achievement for all countries;
- when self-confidence in learning mathematics and usefulness of mathematics are controlled, liking mathematics is positively related to mathematics achievement for Belgium (Flemish), not related for Japan and Moldova, and negatively related for all remaining thirty countries;
- when self-confidence in learning mathematics and liking mathematics are held constant, usefulness of mathematics is positively related to mathematics achievement for Hong Kong, Indonesia, Jordan and Tunisia, negatively related for Australia, Cyprus, Hungary, Italy, Macedonia, Norway, Serbia and Slovak Republic, and not related for the remaining twenty one countries. Stated briefly, partial relationships between three attitudinal dimensions and mathematics achievement are positive for self-confidence in learning mathematics for all countries, negative for liking mathematics for almost all countries, and null for usefulness of mathematics for the majority of the examined countries.

All partial relationships were expected to be positive or null, with the positive ones occurring more frequently. However, these relationships were positive in 38 cases, null in 23 cases, and negative in 38 cases. The consistent negative partial relationships between liking mathematics and mathematics achievement were particularly surprising. Although to the authors' reading there is no theory to explain such an outcome, a possible reason, extrapolated from Shen (2002), may be that high performing students like mathematics less due to their more demanding mathematics learning (contributing to their high performance). Similarly, negative partial relationships between usefulness of mathematics and mathematics achievement may apply because high performing students, due to their more demanding mathematics learning, view mathematics in a more rigorous way and thus find it less useful. Of course, these explanations are only an initial attempt to understand these negative patterns caused by, among other issues, teachers' internal academic standards (e.g. higher standards → more demanding learning → higher achievement → less liking the subject). For a better understanding of the pattern, suitable theoretical grounds need to be developed and applied.[3]

[3] For each country, the four indicators of usefulness of mathematics highly loaded only on the first or the second principal component. Because of that, null partial relationships for useful-

Different size of positive collective relationships. As evidenced by Table 3, the multiple correlations between the three attitudinal dimensions and mathematics achievement were positive for all countries. Furthermore, these correlations varied considerably: from 0.13 for Indonesia to 0.64 for Norway and Serbia. In other words, the portion of the variance of mathematics achievement explained jointly by self-confidence in learning mathematics, liking mathematics and usefulness of mathematics varied from 2% (0.13^2 x 100%) for Indonesia to 41% for Norway and Serbia. Why did these multiple correlations vary from country to country considerably?

Bearing in mind that apart from liking mathematics for Indonesia and usefulness of mathematics for Macedonia, each dimension of mathematics attitude alone was positively related to mathematics achievement, an additional curve estimation regression analysis with the multiple correlation as dependent variable and mathematics achievement as independent variable was performed by treating each country equally. Of all SPSS curve estimation models, only logarithmic and inverse models yielded regression equations where all coefficients were not equal to zero at a 0.05 level. The equation based upon inverse model was

$$r_{\text{multiple}} \approx 0.821 - \frac{164.510}{MA}$$

with $F(1, 31) = 4.479$, $p = 0.043$, and each regression coefficient different from zero at a 0.05 level. This equation showed that for countries with a more demanding mathematics curriculum (those that had higher mathematics achievement), self-confidence in learning mathematics, liking mathematics and usefulness of mathematics better jointly predicted mathematics achievement. Because mathematics achievement could only explain 13% of the variance of the multiple correlation, to better understand the variability in question, other predictors, reflecting previously developed theoretical grounds (missing at present), are to be examined.

Implications for research and practice

Although some fifteen years ago McLeod (1992, p. 590) underlined that “all research in mathematics education can be strengthened if researchers will integrate affective issues into studies of cognition and instruction”, there is no ready made theory to explain individual and collective relationships of affective dimensions concerning mathematics with achievement in this

ness of mathematics cannot be connected with the size of the underlying principal component (it was not the smallest one as it might be concluded).

subjects. Particularly, such a theory should help us explain interactions of attitudinal dimensions with mathematics achievements, enabling proper instructional approaches. Further research may thus focus on developing and testing this theory, taking into account the outcomes presented in this report. Having in mind that a better understanding of the relationships among different categories of mathematics-related beliefs is lacking (De Corte, Op ‘t Eynde & Verschaffel, 2002), a better understanding of the relationships among different attitudinal dimensions is indeed an important research direction.

Three findings of this study are particularly relevant for practice. With exceptions for few countries, these findings can be summarized in the following way: (1) each dimension of mathematics attitude alone was positively related to mathematics achievement; (2) self-confidence in learning mathematics was mostly related to mathematics achievement; and (3) the partial relationship between liking mathematics and mathematics achievement was mostly negative. Although there is no evidence from this study of any causal (direct or partial) relationship between each of the three dimensions of mathematics attitude and mathematics achievement, the consistent positive relations between them across the examined countries suggest that mathematics teaching should be more active in promoting the three examined dimensions. Because self-confidence in learning mathematics was mostly related to mathematics achievement, mathematics teachers may primarily help their students develop and maintain positive beliefs about their mathematical competency. Bearing in mind that mathematics achievement influences mathematics attitude more than vice versa (Ma & Xu, 2004), a portion of learning tasks should be designed in a way that helps students build their self-confidence in learning mathematics. Such tasks are, for example, those that are at least partially solvable by learner, enabling and encouraging him/her to use knowledge and skills from arithmetic, geometry, or algebra, or a combination of these two or three domains. [By using able technology, for example, more students can do more mathematics and in more ways (see, for example, Kadijevich, 2007).] Designed in this way, these tasks can respect students’ knowledge and skills more, giving space for their further development. Applying this approach to larger extent than found at present may also introduce more pleasure to mathematics learning, not resulting in the negative partial relationship between liking mathematics and mathematics achievement found in this study. This means that a key to better mathematics education may be in designing and applying learning tasks that enable building self-confidence in learning mathematics in a (more) pleasurable way (cf. Eisenberg, 1991). Although this study did not examine mathematics teachers, there is no doubt these tasks should be first and foremost widely utilized in pre-service and in-service professional development of mathematics teachers because teacher's self-confidence as mathematics teacher is usually influenced by his/her self-confidence as mathematics learner (see Stipek *et al*., 2001).

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Ђорђе Кадијевић

TIMSS 2003: ПОВЕЗИВАЊЕ ДИМЕНЗИЈА СТАВОВА ПРЕМА МАТЕМАТИЦИ СА ПОСТИГНУЋЕМ У МАТЕМАТИЦИ

Апстракт

Ова студија, реализована на узорку од 137 346 ученика из 33 земље које су учествовале у пројекту TIMSS 2003 у осмом разреду основне школе, разматрала је појединачне и групне утицаје три димензије става према математици на математичко постигнуће (МП), трагајући за димензијом која највише утиче на то постигнуће. Те три димензије су биле: увереност у сопствене могућности учења математике (СМУМ), допадљивост математике (ДМ) и корисност математике (КМ). Користећи психометријски валидне и поуздане мере ове три димензије, установљено је следеће: (1) свака димензија, појединачно, је била позитивно повезана са МП у скоро све 33 земље; (2) СМУМ су највише утицале на МП у 31 земљи; (3) када је утицај остале две димензије био контролисан (третиран као константан), СМУМ су биле позитивно повезане са МП у 33 земље, ДМ је била негативно повезана са МП у 30 земаља, док КМ није била повезана са МП у 21 земљи; (4) позитивне групне релације СМУМ, ДМ и КМ са МП су значајно варирале од земље до земље. У раду су наведене импликације ових налаза за даља истраживања и наставу математике.

Кључне речи: TIMSS, став према математици, увереност у сопствене могућности учења математике, допадљивост математике, корисност математике, математичко постигнуће.

Джордже Кадиевич

TIMSS 2003: ОТНОШЕНИЕ МЕЖДУ ПОЗИЦИЕЙ К МАТЕМАТИКЕ И МАТЕМАТИЧЕСКИМ ПОСТИЖЕНИЕМ

Резюме

В данном исследовании, выполненном на корпусе 137 346 учащихся из 33 стран, которые приняли участие в проекте TIMSS 2003 в восьмом классе основной школы, рассматривались отдельные и групповые влияния трех измерений позиции к математике на математическое постижение (МП) с целью выявления того измерения, которое решительным образом воздействует на МП. Среди этих измерений оказались: уверенность в собственных возможностях овладения математикой (СВОМ), привлекательность математики (ПривМ) и полезность математики (ПолМ). При использовании психометрически валидных и надежных мерок упомянутых измерений, автор пришел к следующим выводам: (1) каждое из упомянутых измерений, отдельно взятое, было положительным образом связано с МП во всех 33 странах; (2) СВОМ решительным образом воздействовали на ПМ в 31 стране; (3) когда воздействие оставшихся двух измерений было контролируемым (трактовалось как постоянное), СВОМ были положительно связаны с МП в 33 странах, ПривМ была отрицательно связана с МП в 30 странах, тогда как ПолМ не была связана с МП в 21 стране; (4) положительные групповые реляции между СВОМ, ПривМ и ПолМ значительно варьировались в разных странах. В работе излагаются и импликации полученных результатов для дальнейших исследований и преподавания математики.

Ключевые слова: TIMSS, позиция к математике, уверенность в собственных возможностях овладения математикой, привлекательность математики, математическое постижение.