Concomitants of Achievement in Mathematics: A Comparative Analysis[1]

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Abstract

The study explores attitudinal concomitants of school achievement in a comparative perspective. It is based on data for France, Japan and the United States collected in IEA's Second International Mathematics study. Attention is directed both at the feasibility of models of trans-nationally valid relationships between variables related to achievement and at cultural specificities in such relations. Based upon separate factor analyses for the three countries, trans-nationally valid attitude scales are constructed. Path and regression analyses are performed to test and explore models of relationships between home background variables, psychological constructs and achievement with special emphasis upon the self-concept of mathematical ability and the importance of mathematics as perceived by the students.

1 Introduction

The large-scale international studies of IEA have considerably enriched the knowledge base of comparative education both substantively and methodologically. There has never been such a wealth of information available. In addition to assessing numerous dimensions of student achievement, these data describe the structure of school systems, the selectivity and retentivity of these systems, a broad spectrum of national, regional and local curricular goals, both official and as actually implemented, plus a host of other factors that may influence student performance in different countries, schools and classrooms.

It is a great service to the research community that IEA makes this wealth of information freely available for the purpose of further analysis. Many have gratefully taken advantage of this opportunity.

IEA data were used for two purposes. First, by including IEA test items in the data gathering efforts, an integration of the findings against the backdrop of international data is endeavored. Second, an attempt is made to replicate findings of the research by parallel reanalysis of IEA data. The analyses presented here belong in the latter context.[2]

These analyses focus on the relationships among mathematical achievement, family background, gender and gender stereotypes, importance of mathematics for the individual student, enjoying mathematics and self-concept of mathematical ability. The source of the data is IEA's Second International Study of Mathematics Achievement (SIMS), for which data were collected between 1980 and 1982 (Travers & Westbury 1989; Robitaille & Garden 1989; Burstein 1993. Compare Kifer and Robitaille's chapter on "Attitudes, Preferences and Opinions" in Robitaille and Garden 1989 for a first analysis of attitudinal data.). Our analyses are restricted to Population A (14 year olds) in three highly developed educational systems: France, Japan and the USA.

Among the reasons for this choice are: a remarkable achievement differential among these systems, the explanation of which is less obvious than in comparisons between countries at different levels of development; closeness in age to the cohort in a related study now being conducted. The relative familiarity with thethree systems; and, the fact that information in these three cases is nearly complete.

One criticism sometimes levied against IEA is that the survey methods it employs are ill suited for an in-depth interpretation of factors that may explain cross-cultural differences in educational outcomes. While such limitations do, of course, exist, IEA has taken great efforts to at least partially overcome them. In response to such criticism, it must further be emphasized that IEA has the unquestionable merit of having drawn world wide attention to previously unnoticed cross-national outcome differences, a deeper understanding of which is important to those interested in educational development. Finally, there is no reason to assume that survey methods are inherently unsuited to generate well-founded hypotheses regarding differences in cross-cultural educational achievement. The present research may be regarded as a small exploratory step in this quest. The objectives of this study are to explore the feasibility of examining specified relationships between school achievement and both sociological and psychological variables in a transculturally valid causal model and, secondly, to detect and interpret culture specificities in these relationships.

The relationship between ability beliefs and school achievement has been examined in a number of studies, some of which have been carried out at the intercultural level (Boehnke 1988, 1991; Helmke 1989, 1990; Shavelson & Bolus 1982; Song & Hattie 1984; Watkins & Gutierrez 1989; Watkins & Regmi 1989). One of the consistent results of this research is that the correlation between ability beliefs and achievement is stronger when children's are measured at a specific (e.g. mathematics) than at a general (e.g. overall academic ability) level. Effort and anxiety have been explored as variables which mediate the relationship between ability beliefs and achievement. The factors that influence the beliefs children form in their own abilities have also been studied. The determinants of children's ability beliefs have been shown to include: learning histories and current levels of achievement; the evaluations made by significant others (such as parents, teachers and peers); the social, criterion-referenced and intraindividual comparisons made by children, and the subjective relevance students attribute to self-related feedback.

As described below, the variables available for this study appear to represent some part of this network of relationships. For example parental support - including parental expectations and father's education - may be regarded as indicators of the cultural resources that may influence achievement either directly (e.g. through the choice of school or courses) or indirectly. Thus, it can be presumed that parents' expectations and support for learning mathematics affect their children's belief in their own mathematical abilities as well as their opinion about the importance of mathematics, which itself is taken as an indicator of the subjective relevance that students attribute to learning mathematics. It is further assumed that a positive evaluation of mathematical knowledge reflects aspirations toward learning mathematics, and it is expected that such aspirations will directly affect achievement.

Relationships between these variables are assumed to be transculturally valid. Therefore, intercultural differences can be expected to show up in the strength of interrelations rather than in the structure of the model. Family help with homework is not included in the model because it is not seen as a positive indicator of home support but rather of the difficulties the child encounters when doing (mostly routine) mathematical tasks. This weakness may also be responsible for the negative correlation previously found between amount of homework and achievement (Robitaille & Garden 1989, Chapter 10).

Although the focus is not on explaining cross-national differences in achievement, such differences must be kept in mind when interpreting the findings. On the average, Japanese students outperform their French and

American peers, although Japanese students were tested in grade seven instead of grade eight and were half a year younger. The French sample excludes students in the prevocational branch of secondary schools. The United States sample demonstrates the comparatively lowest average achievement in mathematics.

2 Design and Results of the Study

It is a prerequisite for quantitative international comparisons that the motivational and attitudinal constructs measured have the same meaning and possess metric equivalence cross-nationally. To be reasonably certain that this condition is met, seperate factor analyses were performed (PCA) for the three samples with the items of the questionnaire "Personal Perceptions of Mathematics", plus those from the subscale "Utility of Mathematics" (Robitaille & Garden 1989). After deleting several items with uneven and low loadings, the analysis was repeated leading to the results presented in Table 1.

Five factors were extracted that lend themselves to a straightforward interpretation. Factor 1, "Parental Support" denotes the importance of learning mathematics that parents convey and how much they encourage hard work in this field. Factor 2, "Self-Concept of Mathematical Ability" consists of negative statements on the student's ability and on the futility of effort in this subject. The negative byloadings on factor 5, "Mathematics is Fun", demonstrate the interaction of cognitive and emotional reactions to the learning of mathematics. Factor 3 clearly denotes "Gender Stereotyping" with items stating the superiority of males in this field. Factor 4 "Importance of Mathematics" is made up of items asserting the uselessness of mathematics in different spheres of life.

The factor structure is nearly identical for all three samples with high loadings for those items that characterise each factor. One can be reasonably confident, therefore, that the five constructs have an identical meaning in the three different cultures. This appears to be true even beyond these three highly developed nations, as shown by the same factor analysis performed on an international random sample drawn from 18 nations participating in SIMS including the developing countries Nigeria, Swasiland, and Thailand. It was also possible to perform the path and regression analyses reported below for the French, Japanese, and US samples on the international sample leading to apparently meaningful results.

Table 1: Rotated Factor Matrix Based on the Motivational Variables and Attitudes Towards Mathematics, Split by Country. Variance Explained by all Five Factors: France 63.1%, Japan and USA 60.5%.

Item	*Factor 1* Parental Support			*Factor 2* Self-concept of Mathematical Ability			*Factor 3* Gender Stereotyping			*Factor 4* Importance of Mathematics			*Factor 5* Mathematics is fun		
	FRA	JPN	USA	FRA	JPN	USA	FRA	JPN	USA	FRA	JPN	USA	FRA	JPN	USA
My mother thinks that learning math is very important for me.	.78	.78	.82												
My father thinks that learning math is very important for me.	.79	.75	.80												
My parents encourage me to learn as much math as possible.	.79	.65	.76												
My parents want me to do very well in math class.	.82	.73	.71												
My parents really want me to do well in mathematics.	.73	.65	.46									-.24			
I am not so good at math.				.79	.75	.80							-.32	-.22	-.24
Math is harder for me than for most persons.				.76	.79	.80									
No matter how hard I try I still do not do well in math.				.81	.68	.82					.25				
I could never be a good mathematician.				.71	.62	.71							-.35	-.26	-.28
Boys have more natural ability in math than girls.							.82	.84	.84						
Men make better scientists and engineers than women.							.82	.80	.82						
Boys need to know more math than girls.							.80	.78	.80						
A knowledge of math is not necessary in most occupations.										.71	.83	.66			
Math is not needed in everyday living.										.77	.82	.72			
Most people do not use mathematics in their jobs.										.69	.73	.61			
I can get along well in everyday life without using mathematics.										.67	.70	.61			-.30
Working with numbers makes me happy.					-.21								.79	.78	.81
I think mathematics is fun.				-.31	-.41	-.31					-.20		.69	.69	.78
I am looking forward to taking more mathematics.						-.31							.76	.79	.73

For statistical analyses employing stepwise multiple regression (SPSSx) and LISREL VII for path analysis, factor scores based on the five factors were used.

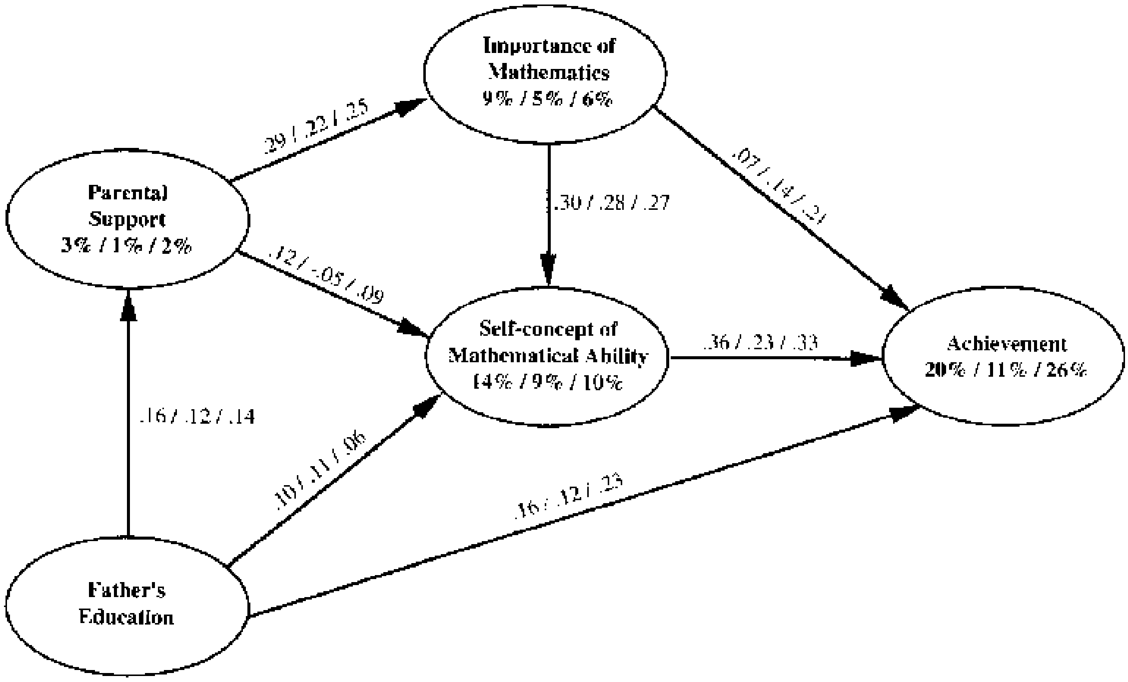
In addition to the measure of achievement in mathematics, eleven variables were available for the statistical analyses. Of these, four were background variables: gender, mother's education, father's education, and father's vocational status. Another five variables included factor scores for "Self-concept of mathematical ability", "Importance of mathematics", "Parental support", "Gender stereotyping", and "Mathematics is fun". Two further variables which were probably thought to indicate a special dimension of home support and effort invested were included: "Family help with homework", and "Amount of homework" as reported by the student. Overall sample sizes were 8778 for France, 7785 for Japan, and 7935 for the USA, with specific analyses based on smaller samples due to missing observations. As samples of this size yield significance with very small regression coefficients, it was stipulated that a variable must uniquely explain 0.5% of criterion variance to be included in the model. Although this is a weak requirement for inclusion, a more stringent one would have incurred the risk of losing information of interest.

Mathematics achievement for the present study was measured by a test consisting of the 40 core items of the test used in the longitudinal part of the IEA study.

The analysis will be restricted to cross-sectional data and will not deal with the longitudinal information also available in SIMS. IEA-terminology deals with achievement status as opposed to learning or growth as a criterion variable in a causal model (see Robitaille & Garden 1989, Chapter 10, and Burstein 1993, Chapter 12, for a discussion of the implications of this decision). The rationale for this decision is practical rather than theoretical: as a test of prior achievement is by far the strongest predictor of later achievement, including it in the analysis would leave little variance to be accounted for by other variables, with the consequence of underestimating their specific contribution to achievement. Among the constructs employed in the present analysis this would probably most strongly affect the explanatory potential of the "Self-concept of mathematical ability" which correlates highest with achievement. (Path analyses performed with achievement growth as criterion show that our assumptions were correct: the model can be fitted, but it explains only between 1.6% (France) and 4% (USA) of criterion variance.) Another difficulty of a causal analysis of correlates of growth, however, remains: the attitude questionnaires were administered only at the time of the second measurement of the longitudinal study.

As illustrated in Figure 1, path analyses confirm the expectation based on previous research that ability beliefs and perceived importance of mathematics are important mediators between background variables and achievement. That only moderate amounts of variance are explained was to be expected as the model contains only a few of the important correlates of mathematical achievement and, more importantly, the constructs employed may not be fully indicated by the items upon which they are based. Compared to the French and US samples the variance explained in achievement is considerably lower for the Japanese sample. Father's education influences achievement both directly and indirectly through ability beliefs. The direct influence of father's education is strongest in the US sample.

Figure 1: Path Analysis of the Relationship Between Motivational and Family Background Variables and Achievement (France/Japan/USA).



The most remarkable finding from the path analysis seems to be that the path from parental support to the self-concept of ability is negative for the Japanese sample. Taken together with the finding that ability beliefs have clearly less explanatory power with the Japanese students, these results suggest non-trivial cultural differences. An inspection of the raw mean scores takes this analysis one step further: Japanese students have the lowest values for both parental support and for ability beliefs. As parental support includes parents' expectations for high achievement and for intense effort on the part of their children, this "support" may be more threatening than helpful to students who are already working hard and who are rather moderate in their ability beliefs. A further, not necessarily alternative explanation might be that Japanese parents, conscious of these psychological mechanisms, rather refrain from expressing such expectations too openly.

Table 2 presents three indices for the quality of fit of the path model: Chi2, The Adjusted Goodness of Fit Index AGFI, and the Root-Mean-Squared-Residual (RMSR), an index of variance not explained by the model. The Chi2 test is not well suited for very large samples as employed in the present study as it is very sensitive to small differences between the observed and reproduced covariance matrices. For the other two indices, there is no test of statistical significance. (Boehnke 1991, p. 103 proposes an upper limit of .10 for RMSR.) As shown in Table 2, the best model fit is achieved for the Japanese data. The model has to be rejected for the US data. Hints for modifications given in the LISREL programm suggest an additional path from "Father's education" to "Perceived importance". This clearly improves the fit of the model (Chi2 = 0.81, df = 1, p = .369; AGFI = .999; RMSR = .059).

Table 2: Criteria of Goodness of LISREL Path Models for Achievement in France, Japan and USA.

Criteria	*France*	*Japan*	*USA*
Chi^2	16.75	4.61	40.95
df	2	2	2
p	.000	.100	.000
AGFI	.991	.995	.975
RMSR	.274	.241	1.653

In the next section the results of regression analyses will be reported with the dual aims of further exploring cultural differences and of further analysing the cultural constructs of the path model. In interpreting these results, it should be kept in mind that reciprocal effects for achievement and ability beliefs have been found in a number of longitudinal studies. Such effects cannot, of course, be analysed using cross-sectional data. The less than optimal alternative chosen in the present analysis is to provide bi-directional regression coefficients which give an indication of the relative strength of the influence of ability beliefs on achievement and vice versa. In our case the coefficients are in most cases of comparable magnitude, thus generally concurring with previous research evidence (not reported).

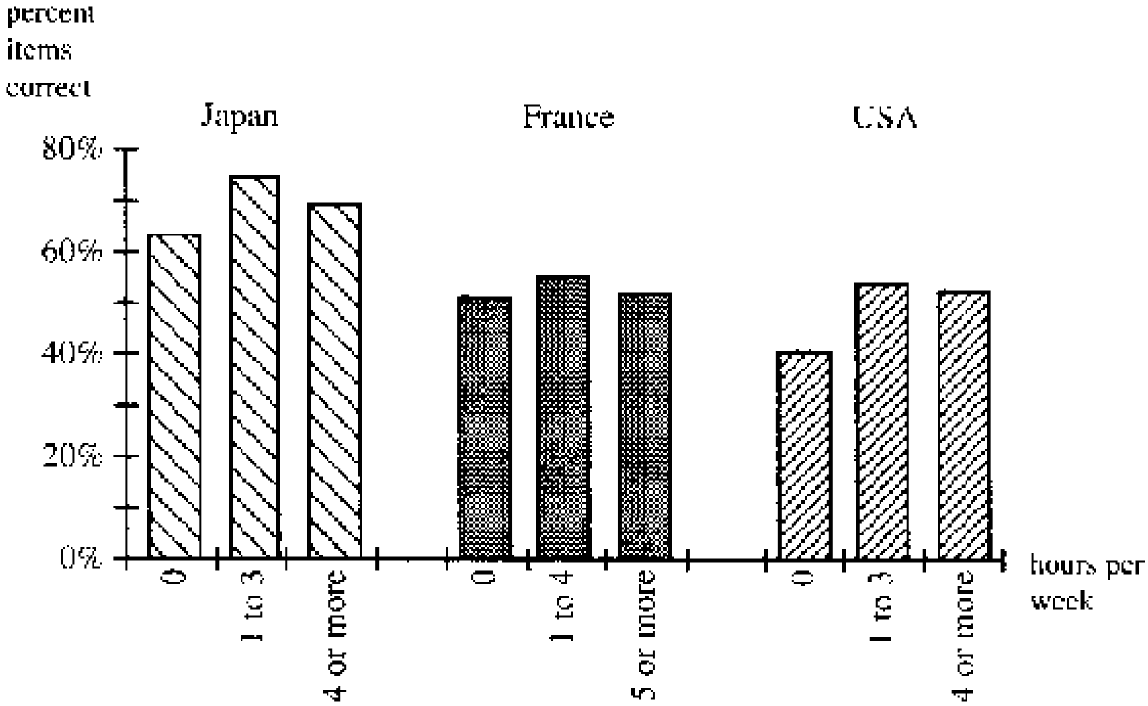
Stepwise multiple regression analyses were conducted with achievement as the criterion variable and eleven independent variables for the three national samples (see Tab. 3).

Table 3: Predictors of Mathematics Achievement.

Predictors	*France*	*Japan*	*USA*
Self-concept of Mathematical Ability	.37	.22	.35
Amount of Homework for Mathematics		-.12	–
Father's Education	.19	.13	.18
Importance of Mathematics	–	.13	.21
Family Help for Mathematics	-.08	-.07	-.13
Mother's Education	–	–	.11
Gender	.07	–	–
Explained Variance (N)	21% (4531)	13% (2597)	29% (4680)

Prediction of achievement again proves to be most successful for the US and least successful for Japan, with about half the amount of variance explained in the Japanese as in the US sample. The predictors retained in all three analyses are Family help, Father's education, and Ability beliefs, which proved to be the best predictor of achievement in all three samples. In all cases, the coefficient for Help with homework is negative: as stated above, the interpretation proffered by Robitaille and Garden (1989, Chapters 9 and 10) that higher levels of parental help indicate lower achievement and that such help tends to be insufficient to overcome performance deficits in mathematics is followed. Only in France is Gender related to achievement, with boys outperforming girls. In Japan, weekly homework time is negatively related to achievement. As seen in Figure 2, this negative relationship is an artifact of a method which presupposes strictly linear associations. Based on the distribution of amount of homework within each sample, three groups were formed: students doing no homework, students with average amounts of homework, and students with a high load of homework. In all cases, the mathematics achievement of students doing no homework and those reporting very high amounts of homework is lower than that of students doing moderate amounts of homework. This curvilinear relationship is most distinctive in the Japanese sample. (Groups are established separately for each sample because distributions of homework time differ in the three samples.)

Figure 2: Amount of Homework and Mathematics Achievement.
The regression analyses, employing more variables than the path analyses



result in a slightly different "transcultural model" of mathematics achievement. Variables appearing as significant predictors in all three regression analyses include "Ability beliefs", "Family help with homework" with negative coefficients throughout, and "Father's education". "Perceived importance of mathematics" is not significant for the French sample. This corresponds, however, to the low path coefficient apparent in the path analysis. Only in France, gender is related to achievement, indicating weaker performance of girls. In none of the three analyses "Gender stereotyping" is retained. That "Liking mathematics", too, is not retained in any of the analyses may be due to the high correlation with "Ability beliefs" (see Table 4). The regression analysis confirms the results of the path analyses that the predictive potential of the set of variables employed in our analyses is likely to be considerably lower for the Japanese model.

In our path model "Ability beliefs" and "Importance of mathematics" have a central position as mediators between background variables indicating cultural resources of the family and achievement. We, therefore, performed further regression analyses using the same set of predictors (excluding achievement and, in the case of "Perceived importance", also "Ability beliefs") in which these two constructs served as criterion variables. Results for "Ability beliefs" are presented in Table 4.

Table 4: Predictors of Self-concept of Mathematical Ability.

Predictors	*France*	*Japan*	*USA*
Mathematics is fun	.45	.49	.46
Father's Education		.09	.09
Importance of Mathematics	.18	.13	.17
Family Help for Mathematics		–	-.10
Mother's Education	.09		–
Gender	.14	.09	.12
Parental Support	–	-.09	
Explained Variance (N)	33% (5396)	31% (2611)	31% (4916)

Differences among countries in the amount of variance accounted for are less marked than in the case of achievement. The three regression models are also rather similar in substance: They all include "Liking Mathematics" as the dominant predictor which seems to tap the emotional dimension of ability beliefs, as well as "Perceived Importance" and an indicator for the "cultural capital" of the family (i.e. mother's or father's education). In all three samples boys have a more positive "Self-concept of ability". However, "Gender stereotyping" is not related to "Ability beliefs". The negative impact of "Parental support" found for the Japanese sample in the path analysis is replicated here. In the US sample, the negative relationship between "Help with homework" and "Ability beliefs" suggests that students interpret parental help as an indication of their own deficits.

Table 5: Predictors of Importance of Mathematics.

Predictors	*France*	*Japan*	*USA*
Mathematics is fun	.24	.30	.21
Father's Education	–	–	.09
Gender Stereotyping	.08		.21
Parental Support	.23	.18	.16
Explained Variance (N)	15% (5435)	14% (2618)	6% (5016)

Regression analyses were run, with "Perceived importance of mathematics" as the criterion (see Tab. 5). Here two positive predictors, "Liking Mathematics" and "Parental Support" appear in all three countries. This configuration, then, is interpreted as the basic "transcultural model" of "Perceived Importance of mathematics". For Japanese students, this reveals a source of psychological conflict. The combined results of the path and regression analyses show that, as defined here, "Parental support" transmits beliefs in the importance and utility of learning mathematics and, simultaneously, negatively affects children's confidence in their ability to succeed in this subject.

For both French and US students, "Gender stereotyping" (i.e. convictions about male superiority in this area) is negatively related to beliefs in the importance of mathematics. Only in the US sample is a measure of family background, father's education, moderately related to Perceived Importance.

Again, an inspection of the raw scores for the constructs used in these analyses may be helpful in the exploration of cultural differences. (The differences reported below are all highly significant, with p-values of F ratios $\leq .0001$.) In comparing average raw scores for the scales, US students with one exception represent the positive end of the distribution. They express the strongest liking for mathematics; they have the most positive self-concept of mathematical ability; they indicate the strongest parental support for succeeding in the field; they have the strongest convictions about the importance of mathematics. In all of these comparisons, the Japanese students represent the opposite extreme, or more precisely, they are less prone to express strong agreement or disagreement. Their average scores are close to the theoretical mean of the five point scales. The one exception is gender stereotyping. The French students are most likely to disagree with statements of male superiority in mathematics. US students' average scores are only slightly higher, while Japanese students are clearly more prone to agree with statements indicating gender-stereotyped beliefs.

This leads to a somewhat paradoxical configuration of results: in the French system, students are least prone to gender stereotyping, but girls show significantly lower achievement and a more negative self-concept of mathematical ability. In the Japanese system, where students are more prone to stereotyping only a weak relationship between gender and achievement and no correlation with self-concept are found. In the US sample, gender is not related to achievement, but girls have weaker beliefs in their mathematical ability, and stereotyping seems to weaken beliefs in the importance of mathematics.

There are intriguing differences between the three cultures concerning the relation between gender, gender stereotyping and achievement. The variation in absolute achievement accounted for by gender (Eta Squared) is zero for the US sample, 0.2% for the Japanese sample, and 2.5% for the French sample. In terms of items correct, the achievement difference between French boys and girls amounts to about 1.4 items. Gender related differences in achievement appear to be too small to deserve further exploration. This is not the case for the influence of gender on gender stereotyping. In the French and

US samples, gender accounts for, respectively, 17.2% and 22.7% of the variation of gender stereotyping. In both cases boys are more likely to assert male superiority in mathematics. In the Japanese sample, this polarising effect is almost entirely absent: girls' mean scores on the stereotyping scale are almost as high as boys' scores, and the variance of stereotyping accounted for by gender is much lower: 3.4%. Why such stereotyped beliefs do not influence Japanese girls' beliefs in their own mathematical abilities nor the amount of effort they invest in learning mathematics (taking high achievement and a greater amount of homework as indicating effort; see Robitaille & Garden 1989, p. 79f. for gender differences in homework) deserves further study. One explanation may be that Japanese students generally appear to be quite modest in their self-attributions of ability and are comparatively least convinced of the utility and importance of mathematics.

Furthermore, the descriptive data on curricula, students and teachers published in volume I and II of the SIMS report support the interpretation that Japanese students' attitudes toward mathematics learning, as well as their high achievement, reflect a highly demanding curriculum in school and beyond. In addition to average hours of homework, many of them receive special mathematics tutoring (compare Stevenson & Baker 1992 for "Shadow Education" in Japan). Thus, it may be understandable that they, compared to their US and less markedly to their French peers, are the least enthusiastic about taking even more mathematics and that they express significantly more anxiety regarding mathematics learning. These are at least the findings of analyses of variance conducted with questionnaire items that were not retained in the factor analysis. These items included: "I will work a long time in order to understand a new idea in mathematics", "It scares me to have to take mathematics", "When I cannot figure out a problem, I feel as though I am lost in a maze and cannot find my way out", "I feel challenged when I am given a difficult mathematics problem", "I refuse to spend a lot of my own time doing mathematics", "If I had a choice I would not learn any more mathematics". For most of these items, the mean score of the French students is closer to the mean of the Japanese students than to the mean of the US students who tended to show the most enthusiasm and least anxiety of the three groups. Though not very large, these cross-national differences are highly consistent across the set of attitudinal items.

Strikingly, then, the sample with the most positive psychological disposition to successful mathematics learning shows the comparatively lowest achievement and vice versa. A model of achievement that has a certain validity within each of the three cultures appears to be reversed in the intercultural comparison.

3 Summary and Discussion

The study reported here - a reanalysis of data from IEA's Second International Mathematics Study (SIMS) - is aimed at exploring concomitants of school achievement in a cross-cultural comparative perspective. The analysis is directed both at the feasibility of constructing transculturally valid causal models of determinants of achievement and at exploring cultural specificities. Statements about direction of causality remain speculative because only cross-sectional data are used, but as results are consistent with evidence from previous longitudinal studies they are presented with some confidence. Attitudinal correlates of achievement, with special emphasis on the self-concept of ability, are the focus of the study.

A first step of the analysis was the attempt to construct scales that allow a reliable and transculturally valid measurement of attitudes in the three cultures selected for study, France, Japan, and the USA. For this purpose, separate Principle Component Analyses were performed with data from the attitude questionnaires administered to students of SIMS' Population A. The analyses produced five Factors with almost identical loadings for the three national samples: "Parental support", "Self-concept of mathematical ability", "Gender stereotyping", "Perceived importance of mathematics", and "Liking mathematics". The scales built on the items loading high on these five factors appear to be metrically equivalent and to have equal meaning in the three cultures and, therefore, are well suited for intercultural comparison. Factor scores for these scales were used for further analysis.

Based on relevant research evidence, a path model was specified and fitted (employing LISREL VII) for the three samples. Since this model shows an acceptable fit for the data of all three samples, it may be regarded as a transcultural model in which differences in magnitude and sign of path coefficients potentially have a meaningful culture-specific interpretation, given relevant additional information. The model links achievement to attitude constructs that mediate effects of background variables indicative of pedagogical qualities of parent-child interaction and availability of cultural resources of the family.

The three most important results of the path analyses that point to cultural specificities are: 1. Although showing equally acceptable fit for the Japanese data the model has clearly less explanatory potential; 2. The self-concept of mathematical ability for Japanese students does not predict achievement as well as in the other two samples; 3. Only in the Japanese sample is parental support negatively related to Ability Beliefs. The inspection of the mean raw scores of the two scales lends some credence to the intepretation that Japanese students experience mental conflict between a comparatively low self-concept of mathematical ability and the expectations of their parents which may seem threatening to a child who is already working quite hard.

In a third step of the analysis, stepwise multiple regression analysis with eleven independent variables and achievement as the criterion is employed in order to more fully exploit the information available in the SIMS data set. Attention is again directed at "transcultural regression models" defined as the set of predictors common to all three analyses and at exploring cultural peculiarities. It is shown that the transcultural model should at least include the predictors "Self-concept of mathematical ability", a variable indicating the cultural resources of the family (parents' education), and, perhaps, "Perceived Import" (although not appearing as a direct predictor of achievement in the French sample).

Only in the French system is gender related to achievement although not very strongly. The negative coefficent for the amount of homework in the Japanese sample is shown to be an artefact of the linearity assumption in regression analysis. In fact, low achievement is related to doing no homework, and highest relative mean achievement with moderate amounts of homework. This curvilinear relationship is most conspicuous in the Japanese sample.

As "Self-concept of mathematical ability" and "Perceived importance of mathematics" are central constructs in our path model of achievement, they too were used as criterion variables in regression analyses with a slightly reduced set of predictors. The "transcultural regression model" for ability beliefs includes "Liking mathematics" as the dominant predictor, "Perceived importance of mathematics", and a variable indicating cultural resources of the family. In all three countries girls have less confidence in their mathematical ability than their male peers.

The transcultural regression model for "Perceived importance of mathematics" includes "Liking mathematics" and "Parental support".

In a final step the analysis is focused on intercultural differences in "Gender stereotyping". In the Japanese culture, gender seems to be much less an issue that polarizes female and male students. Girls' mean scores on the stereotyping scale are almost as high as those of boys. But this seems not to affect their achievement although gender is weakly correlated to their ability beliefs. Nevertheless, these appear to be highly relevant for girls' career choices: their participation in advanced mathematics in the upper secondary school is markedly lower than that of male students. Over the more than 15 years between IEA's first and second mathematics study, contrary to trends in other educational systems, even a decline in this respect is observed in Japan (Travers & Westbury 1989, p. 189).

Overall results are interpreted in the light of different demands of mathematics curricula both in and out of school. A combination of high demands and a lower salience of ability attributions for successful learning in the Japanese culture seem to be at the core of some of the intercultural differences suggested by the present study. This is consistent with evidence from previous research. Thus Hess et al. (1986) found that Japanese mothers and their children compared to American mothers and their children, were much more prone to attribute failure to lack of effort than to low ability (for an overview of relevant research compare Holloway 1988; Stevenson & Stigler 1992). The report on the analysis of SIMS data provides an interesting comparison of Japanese teachers with those from other national systems with respect to reasons given "for lack of satisfactory progress by students". In this international comparison, the Japanese teachers are least prone to select "student lack of ability" as a reason and instead follow Christian Gotthilf Salzmann's pedagogical maxim, to search for reasons of failure in the actions of the educator: Thus, "Insufficient proficiency on my part in dealing with students having the kinds of difficulties found in the target class", is the reason most often given by Japanese teachers (Burstein 1993, p. 53). As shown in our analysis, Japanese students recognise ability as one determinant of success in mathematics learning, however, like their teachers and parents, Japanese students ascribe less importance to ability than do their French and American peers.

Our suggestion that this reflects both a general culturally imposed modesty in selfassessment and the high demands of the mathematics curriculum is, furthermore, consistent with two noteworthy findings reported by Kifer and Robitaille in their analysis of students' and teachers' responses to the "Mathematics in School" questionnaire. The instrument gathered students' and teachers' ratings of the importance, difficulty and enjoyability of various categories of activities (e.g. "Solving word problems", "Using a calculator"), the particular content of which may substantially differ across the curricula of different countries. In other words, for example, cross-national differences in the perceived difficulty of solving word problems are likely to reflect actual differences in the difficulty of the word problems being solved in different countries, rather than different perceptions of the difficulty of an analogous set of word problems. On importance ratings, Japanese students, like their French and American peers, were close to the international average. On both difficulty and enjoyability ratings, however, the Japanese students were at the extreme end of the distribution: relative to their international cohorts they found the tasks set before them to be more difficult and less enjoyable (Robitaille & Garden 1989, p. 185f.). Japanese teachers' ratings were similar to those of their students on the dimensions of importance and enjoyability. Though they were less extreme than their students on ratings of difficulty, Japanese teachers still found their math activities to be more demanding than teachers from most other countries found the activities pursued in their classrooms (loc. cit. p. 205f.). It is obvious that these judgements are not reflective of incompetencies on the part of Japanese teachers. They must, therefore, be seen to indicate higher levels of task difficulty, a characteristic of the Japanese curriculum that is even more strongly reflected in the responses of Japanese students than in those of their teachers.

This interpretation is supported by more recent analyses of SIMS data conducted by Ian Westbury (1992, 1993) and by David Baker and his colleagues (Baker 1993a, b; Schaub & Baker 1991). Westbury shows that the kinds of tasks that comprise the SIMS mathematics test tend to be covered more thoroughly in Japanese than in US classrooms. US students who follow a curriculum comparable to that implemented in the Japanese system attain levels of performance similar to that of their Japanese peers. Many of these US students are tracked in "Algebra" or "Enriched" classrooms. Together with other between-classroom curricular differences, such formal tracking practices contribute to the substantially larger cross-classroom achievement variation found in the US than in Japan.

Another way to highlight these differences is to separately compare the top and the bottom halves of classes in the two countries (Westbury 1993, p. 24). This comparison shows the performance of students in the top half of US classes to be roughly equivalent to that of students in the top half of Japanese classrooms; in contrast, it shows almost no overlap between the achievement distributions for the bottom half of classes. In a critical comment on Westbury's (1992) analysis, Baker (1993a, b) presents evidence that the achievement differences between the two systems cannot be fully accounted for by differences in the opportunity to learn item content. Drawing on earlier analyses (Schaub & Baker 1991), Baker argues that differences in teaching methods and classroom management practices are additional determinants of cross-national differences in achievement: the methods and managing practices that predict achievement in both systems are more frequently found in the Japanese classrooms. Despite their differences, these analyses all support the interpretation that the Japanese curriculum is, on the whole, the more demanding of the two. This is particularly true, of course, for the less successful Japanese math students. The research conducted so far shows that the Japanese students meet these heightened demands with concomitant efforts; it has yet to solve the riddle of how Japanese teachers and parents succeed in motivating particularly those students for whom the mathematics curriculum presents the greatest challenge.

Notes:

1. The authors gratefully acknowledge the many hours of work sacrificed by Dr. Jeffrey Strange in his efforts to improve their text.

2. This research is based primarily on a thesis written by Sabine Gruehn (1993) as part of the requirements for the diploma in Education.
The larger research project alluded to is a longitudinal study on "School Achievement and Adolescent Development" jointly conducted by the Max Planck Institute for Human Development and Education (Prof. Dr. Peter M. Roeder) and the Institute for the Didactics of Science (Prof. Dr. Jürgen Baumert).

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