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# NATIONAL IQS PREDICT DIFFERENCES IN SCHOLASTIC ACHIEVEMENT IN 67 COUNTRIES

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**Summary.** This paper examines the relationship of the national IQs reported by Lynn & Vanhanen (2002, 2006) to national achievement in mathematics and science among 8th graders in 67 countries. The correlation between the two is 0·92 and is interpreted as establishing the validity of the national IQs. The correlation is so high that national IQs and educational achievement appear to be measures of the same construct. National differences in educational achievement are greater than differences in IQ, suggesting an amplifier effect such that national differences in IQs amplify differences in educational achievement. Controlling for national differences in IQ, slight inverse relationships of educational achievement are observed with political freedom, subjective well-being, income inequality, and GDP. However, public expenditure on education (as % of GDP) was not a significant predictor of differences in educational achievement.

## Introduction

Lynn & Vanhanen (2002, 2006) have demonstrated that the average level of intelligence varies greatly among nations. In their first study Lynn & Vanhanen (2002) presented a compilation of results from 81 nations and reported average IQs ranging from a low of 59 in Equatorial Guinea to a high of 107 in Hong Kong. The IQs of 98 additional countries were estimated from the IQs of neighbouring countries. In their second study they expanded the list of countries with measured IQs to 113, and gave estimated IQs for 79 additional countries (Lynn & Vanhanen, 2006).

Since the publication of Lynn & Vanhanen's 2002 compilation, national IQ has been found to be a close correlate of national wealth (Lynn & Vanhanen, 2006), economic growth (Weede & Kämpf, 2002), measures of education (Barber, 2005), cultural value systems (Meisenberg, 2004) and suicide (Voracek, 2004). Thus intelligence appears to be a major component of 'human development', and a determinant of many cultural and economic differences among nations.

There are substantial relationships at the level of individuals of IQ with school grades and the performance on scholastic achievement tests (Luo *et al*., 2003). In a number of studies in several countries, the correlation of IQ with these educational outcomes has typically been found to be around 0·5 to 0·7 (e.g. Jencks, 1972; Jensen, 1998; Mackintosh, 1998), and sometimes as high as 0·80 (Deary *et al*., 2006). Hence it would be expected that the same relationships would be present across countries. The objective of the present paper is to address the following questions:

(1) Are IQ and school achievement scores sufficiently similar to be alternative measures of the same construct?
(2) Are correlations between school achievement and IQ produced by their common dependence on the level of economic development?
(3) Can school achievement scores be used as substitute measures of IQ for countries for which no measured IQs are available?
(4) Are there country-level factors that predict school achievement in addition to and independent of IQ?

## Methods

The national IQs are taken from Lynn & Vanhanen (2006). IQs were most often measured with Raven's Progressive Matrices, a non-verbal reasoning test. For some countries IQs were measured with a variety of other non-verbal tests including the Cattell Culture Fair and the Goodenough Draw-a-Person test. The data are of uneven quality, but in many cases the results were obtained with representative population samples and in the context of national test standardizations. National IQs were calculated in relation to a mean IQ of 100 and standard deviation of 15 in Britain. The data span more than half a century, and therefore the increases in intelligence known as the Flynn effect were taken into account in these calculations.

National scores in mathematics and science achievement tests are available from the 8th-grade assessments of the Third International Mathematics and Science Study (TIMSS) and the 2003 mathematics assessment of the Programme for International Student Assessment (PISA) of the OECD. In all, 68 countries participated in at least one of these assessments, and fourteen countries participated in all four assessments.

In 1995, 1999 and 2003, the 8th-grade assessments of TIMSS included samples from 40, 38 and 47 countries, respectively. A sampling design was used in which both schools and classrooms within schools were selected randomly. Similar sampling procedures were used for the 2003 mathematics assessment of PISA, which included 40 countries. The TIMSS results are publicly available at http://timss.bc.edu/timss2003.html, and the 2003 PISA results at http://www.pisa.oecd.org/dataoecd/58/41/33917867.pdf. All results are scaled to a mean of 500 and a within-country standard deviation of 100.

The publications by Mullis *et al*. (2004) and by Martin *et al*. (2004) also give subtest scores for different areas of mathematics (i.e. number, algebra, measurement, geometry and use of data) and science, respectively. However, subtest scores of these assessments are so highly intercorrelated that they have been interpreted as measuring the same construct (Rindermann, 2006, 2007). In the present study, therefore, only the summary scores are used.

In the three TIMSS assessments, the average correlation between mathematics and science scores was 0·935. The average correlation with IQ was 0·892 for the mathematics scores and 0·855 for the science scores. Because mathematics and science scores were highly correlated with each other, and each was highly correlated with IQ, the science and mathematics scores for each of the three TIMSS assessments were averaged into a single score. Only a mathematics score was available for the PISA assessment.

Thus there were a total of four assessments, each scaled to a mean of 500 and a within-country standard deviation of 100: TIMSS 1995, 1999 and 2003, and PISA 2003. Minor corrections were applied to eliminate trend effects that were evident in the raw data. A global score of 'school achievement' was formed by averaging all available scores for each country.

Two methods were used to convert these trend-adjusted, averaged scores into the IQ metric. Linear regression with Lynn & Vanhanen's (2006) measured IQs was employed to address the question of whether school achievement scores can substitute for IQ scores. However, to study the causes of discrepancies between school achievement and IQ, the trend-adjusted, averaged school achievement scores were converted directly from a mean of 500 and a standard deviation of 100 to a mean score of 100 for Britain and a standard deviation of 15. The latter method was required to investigate the reasons for systematic differences between the standard deviations of IQ and school achievement.

Among the variables other than IQ and school achievement, gross domestic product (GDP, average 1975–2005) was obtained from the World Development Indicators of the World Bank. This data set can be purchased at: http://publications.worldbank.org/subscriptions. Data on the combined school enrolment ratio for primary, secondary and tertiary schools (proportion of children of eligible age enrolled in school), youth literacy, public expenditure for education (as % of GDP), life expectancy and the Gini index of income inequality were from the Human Development Report of the United Nations. The most recent version of this report is available at http://hdr.undp.org/reports/global/2005/pdf/hdr05_HDI.pdf. Scores for political freedom on a 0-to-6 scale (1988–2005 average, reversed score) were averaged from data about political rights and civil liberties published by Freedom House at http://www.freedomhouse.org/research/freeworld. Corruption scores on a 0-to-9 scale (1999–2005 average, reversed score) were from Transparency International at http://www.transparency.org. Skin reflectance data were from Jablonski & Chaplin (2000), with missing data points extrapolated from neighbouring countries. Scores for religiosity and subjective well-being were formed from the results of the 2000 wave of the World Values Survey. Raw data are available (on CD) with Inglehart *et al.* (2004).

## Results

The national IQs for 67 countries given by Lynn & Vanhanen (2006) and the national scores of the four assessments in science and mathematics (without correction for trend) are given in Table 1. Ten of the national IQs are asterisked to show that they are not measured in the country, but estimated from the IQs of neighbouring

**Table 1.** IQs and school achievement scores

| | | TIMSS 1995 | | TIMSS 1999 | | TIMSS 2003 | | PISA 2003 | |
|---|---|---|---|---|---|---|---|---|---|
| | IQ | Orig. | IQ equiv. | Orig. | IQ equiv. | Orig. | IQ equiv. | Orig. | IQ equiv. |
| Armenia | 94* | | | | | 469·5 | 93·2 | | |
| Australia | 98 | 537·5 | 98·5 | 532·5 | 99·7 | 516 | 98·1 | 524 | 100·8 |
| Austria | 100 | 548·5 | 99·7 | | | | | 506 | 98·9 |
| Bahrain | 83* | | | | | 419·5 | 87·9 | | |
| Belgium | 99 | 528 | 97·5 | 546·5 | 101·2 | 526·5 | 99·2 | 529 | 101·3 |
| Botswana | 70* | | | | | 365·5 | 82·2 | | |
| Brazil | 87 | | | | | | | 356 | 83·1 |
| Bulgaria | 93 | 552·5 | 100·1 | 514·5 | 97·8 | 477·5 | 94 | | |
| Canada | 99 | 529 | 97·6 | 532 | 99·7 | 532 | 99·8 | 532 | 101·7 |
| Chile | 90 | | | 406 | 86·4 | 400 | 85·9 | | |
| Colombia | 84 | 398 | 83·8 | | | | | | |
| Cyprus | 91* | 468·5 | 91·2 | 468 | 92·9 | 450 | 91·1 | | |
| Czech Rep. | 98 | 569 | 101·8 | 529·5 | 99·4 | | | 516 | 100 |
| Denmark | 98 | 490 | 93·5 | | | | | 514 | 99·8 |
| Egypt | 81 | | | | | 413·5 | 87·3 | | |
| Estonia | 99 | | | | | 541·5 | 100·7 | | |
| Finland | 99 | | | 527·5 | 99·2 | | | 544 | 102·9 |
| France | 98 | 518 | 96·4 | | | | | 511 | 99·4 |
| Germany | 99 | 520 | 96·7 | | | | | 503 | 98·6 |
| Ghana | 71 | | | | | 265·5 | 71·7 | | |
| Greece | 92 | 490·5 | 93·6 | | | | | 445 | 92·5 |
| Hong Kong | 108 | 555 | 100·3 | 556 | 102·2 | 571 | 103·9 | 550 | 103·6 |
| Hungary | 98 | 545·5 | 99·3 | 542 | 100·7 | 536 | 100·2 | 490 | 97·2 |
| Iceland | 101 | 490·5 | 93·6 | | | | | 515 | 99·9 |
| Indonesia | 87 | | | 419 | 87·8 | 415·5 | 87·5 | 360 | 83·6 |
| Iran | 84 | 449 | 89·2 | 435 | 89·5 | 432 | 89·2 | | |
| Ireland | 92 | 532·5 | 98 | | | | | 503 | 98·6 |
| Israel | 95 | 523 | 97 | 467 | 92·8 | 492 | 95·5 | | |
| Italy | 102 | 486 | 93·1 | 487·5 | 95 | 487·5 | 95·1 | 466 | 94·7 |
| Japan | 105 | 588 | 103·8 | 564·5 | 103·1 | 561 | 102·8 | 534 | 101·9 |
| Jordan | 84 | | | 439 | 90 | 449·5 | 91·1 | | |
| Korea, Rep.of | 106 | 586 | 103·6 | 568 | 103·5 | 573·5 | 104·1 | 542 | 102·7 |
| Kuwait | 86 | 411 | 85·2 | | | | | | |
| Latvia | 98* | 489 | 93·4 | 504 | 96·7 | 510 | 97·4 | 483 | 96·5 |
| Lebanon | 82 | | | | | 413 | 87·2 | | |
| Lithuania | 91 | 476·5 | 92·1 | 485 | 94·7 | 510·5 | 97·5 | | |
| Luxembourg | 100* | | | | | | | 493 | 97·6 |
| Macau | | | | | | | | 527 | 101·1 |
| Macedonia | 91* | | | 452·5 | 91·3 | 442 | 90·3 | | |
| Malaysia | 92 | | | 505·5 | 96·9 | 509 | 97·3 | | |
| Mexico | 88 | | | | | | | 385 | 86·2 |
| Moldova | 96* | | | 464 | 92·5 | 466 | 92·8 | | |
| Morocco | 84 | | | 330 | 78·4 | 391·5 | 85 | | |

**Table 1.** *Continued*

| | IQ | TIMSS 1995 Orig. | TIMSS 1995 IQ equiv. | TIMSS 1999 Orig. | TIMSS 1999 IQ equiv. | TIMSS 2003 Orig. | TIMSS 2003 IQ equiv. | PISA 2003 Orig. | PISA 2003 IQ equiv. |
|---|---|---|---|---|---|---|---|---|---|
| Netherlands | 100 | 550·5 | 99·9 | 542·5 | 100·8 | 536 | 100·2 | 538 | 102·3 |
| New Zealand | 99 | 516·5 | 96·3 | 500·5 | 96·4 | 507 | 97·1 | 523 | 100·7 |
| Norway | 100 | 515 | 96·1 | | | 477·5 | 94 | 495 | 97·8 |
| Palestine | 86 | | | | | 412·5 | 87·2 | | |
| Philippines | 86 | | | 345 | 80 | 377·5 | 83·5 | | |
| Poland | 99 | | | | | | | 490 | 97·2 |
| Portugal | 95 | 467 | 91·1 | | | | | 466 | 94·7 |
| Romania | 94 | 484 | 92·9 | 472 | 93·4 | 472·5 | 93·5 | | |
| Russia | 97 | 536·5 | 98·4 | 527·5 | 99·2 | 511 | 97·5 | 468 | 94·9 |
| Saudi Arabia | 84* | | | | | 365 | 82·2 | | |
| Serbia | 89 | | | | | 472·5 | 93·5 | 437 | 91·7 |
| Singapore | 108 | 625 | 107·7 | 586 | 105·3 | 591·5 | 106 | | |
| Slovakia | 96 | 545·5 | 99·3 | 534·5 | 99·9 | 512·5 | 97·7 | 498 | 98·1 |
| Slovenia | 96 | 550·5 | 99·9 | 531·5 | 99·6 | 506·5 | 97·1 | | |
| South Africa | 72 | 340 | 77·7 | 259 | 70·9 | 254 | 70·5 | | |
| Spain | 98 | 502 | 94·8 | | | 488 | 95·1 | 485 | 96·7 |
| Sweden | 99 | 527 | 97·4 | | | 511·5 | 97·6 | 509 | 99·2 |
| Switzerland | 101 | 533·5 | 98·1 | | | | | 527 | 101·1 |
| Taiwan | 105 | | | 577 | 104·4 | 578 | 104·6 | | |
| Thailand | 91 | 523·5 | 97 | 474·5 | 93·6 | | | 417 | 89·6 |
| Tunisia | 83* | | | 439 | 89·9 | 407 | 86·6 | 359 | 83·5 |
| Turkey | 90 | | | 431 | 89 | | | 423 | 90·2 |
| Uruguay | 96 | | | | | | | 422 | 90·1 |
| United Kingdom | 100 | 518·5 | 96·5 | 517 | 98·1 | 513 | 97·8 | | |
| USA | 98 | 517 | 96·3 | 508·5 | 97·2 | 515·5 | 98 | 483 | 96·5 |

*An asterisk indicates that the IQ was estimated from the IQs of neighbouring countries. Both the published scores and the IQ equivalents (extrapolated by linear regression) are given for the TIMSS and PISA results.

countries. The remaining 57 are measured IQs. The IQ for Palestine has been reported in Lynn (2006).

Table 2 shows the Pearson correlations of IQ with the four scholastic assessments, and also with the average of all 8th-grade assessments that are available for any given country. The correlations are given for all countries (column 2) and for measured IQ countries (column 4).

When school achievement scores are converted into the IQ metric by linear regression, the average difference between 'school achievement IQ' and the IQs reported by Lynn & Vanhanen (2006) is 2·46 points for countries with measured IQ ($n=57$) and 3·22 points for countries with estimated IQ ($n=10$). For the IQs reported by Lynn & Vanhanen (2002), the corresponding differences are 2·55 points ($n=49$) and 3·07 points ($n=16$), respectively. For those countries for which Lynn and

**Table 2.** Correlation coefficients of 'national IQ' (from Lynn & Vanhanen, 2006) with each of the four 8th-grade school assessment results, and with the average of all school assessments available for each country

| | All countries | | Measured IQ countries | |
|---|---|---|---|---|
| Assessment | Corr. coeff. | *n* | Corr. coeff. | *n* |
| TIMSS 1995 | 0·830 | 40 | 0·832 | 38 |
| TIMSS 1999 | 0·894 | 38 | 0·903 | 33 |
| TIMSS 2003 | 0·924 | 47 | 0·931 | 38 |
| PISA 2003 | 0·872 | 38 | 0·850 | 35 |
| Average | 0·913 | 67 | 0·919 | 57 |

Vanhanen provided IQ estimates in 2002 and measured IQs in 2006, the average difference between the two IQs is 3·54 points ($n$=26). Thus the average difference between measured IQ and IQ extrapolated from school achievement scores (2·46 or 2·55 points) is smaller than the average difference between measured IQ and IQ estimated from the IQs of neighbouring countries (3·54 points).

These results suggest that IQ tests and school achievement tests are not only correlated, but that they measure the same construct. This interpretation predicts that the average difference between a single IQ assessment and a single school assessment (SA) in the same country is not significantly larger than either the difference between two IQ assessments, or the difference between two school assessments. The actual differences for the IQs reported by Lynn & Vanhanen (2006) are:

IQ–IQ: 3·7 points
SA–SA: 1·8 points
IQ–SA: 3·2 points

Using the Lynn & Vanhanen (2002) IQs, the corresponding difference scores are:

IQ–IQ: 4·2 points
SA–SA: 1·8 points
IQ–SA: 2·6 points

The school assessments have greater reliability than the IQ tests, presumably because they were performed within a narrow time range (1995–2003), and the samples were selected to be representative of the whole school-age population in the country. The IQs, by contrast, were collected over more than half a century, in different age groups and with different tests, and in some cases with samples whose representativeness is open to doubt. The observation that the average difference between one IQ assessment and one assessment of school achievement is intermediate between the differences between two school assessments and two IQ assessments confirms that the two types of assessment measure essentially the same trait.

The hypothesis that standardized IQ tests and standardized school achievement tests measure the same construct also predicts that both measures have the same non-obvious correlates. If this construct is different from economic development, it can further be predicted that the correlations of the criterion variable with IQ and

**Table 3.** Correlations (Pearson's *r*) of the measured IQs reported by Lynn & Vanhanen (2006) and Lynn (2006), averaged school achievement scores (SchAch) and logGDP with criterion variables

| Criterion | IQ | SchAch | logGDP | *n* |
|---|---|---|---|---|
| logGDP | 0·740 | 0·666 | 1·000 | 57 |
| SER | 0·616 | 0·592 | 0·761 | 52 |
| Youth literacy | 0·525 | 0·495 | 0·464 | 49 |
| PuExEdu | 0·249 | 0·343 | 0·498 | 52 |
| Life expectancy | 0·760 | 0·716 | 0·757 | 57 |
| Gini index | − 0·521 | − 0·627 | − 0·422 | 52 |
| Skin reflectance | 0·689 | 0·711 | 0·624 | 57 |
| Political freedom | 0·615 | 0·493 | 0·784 | 55 |
| Corruption | − 0·617 | − 0·552 | − 0·821 | 57 |
| Religiosity | − 0·696 | − 0·705 | − 0·631 | 50 |
| SWB | 0·243 | 0·107 | 0·544 | 50 |

SER, school enrolment ratio; Youth literacy refers to literacy in the 15–24 years age group; PuExEdu, public expenditure for education, as percentage of GDP; SWB, subjective well-being.

school achievement are more similar to one another than their correlation with measures of wealth. Table 3 uses the logarithm of *per capita* GDP (adjusted for purchasing power) as a measure of national wealth. The logarithmic transformation is used because GDPs have a highly skewed distribution, and the logarithmic transformation brings them closer to a normal distribution. Table 3 shows that correlations with IQ and school achievement are indeed similar for most criterion variables. Life expectancy is about equally related to IQ/school achievement and logGDP. Some others (school enrolment ratio, political freedom, corruption, subjective well-being, public expenditure for education) are related more closely to logGDP, and others again (skin reflectance, youth literacy, Gini index, religiosity) are more closely related to IQ and school achievement.

Although quite high, the correlations of IQ and logGDP with the criterion variables in Table 3 are lower than most of the correlations that have been reported elsewhere. For example, Templer & Arikawa (2006) reported a correlation of 0·92 between IQ and skin colour, and Meisenberg (2004) reported a correlation of 0·89. The reason for the lower correlation of 0·69 in Table 3 is that the TIMSS and PISA assessments are heavily biased toward economically advanced countries with high school achievement, high IQ, high GDP and light skin colour. Inevitably, with respect to the totality of countries in the world today, all correlations reported in Table 3 are subject to substantial range restriction. Correlations would be higher if more nations at low levels of 'human development' were included in the sample.

If school achievement were determined only by the children's IQ, we would expect that between-country differences in school achievement, relative to within-country differences, would be as great as those for IQ. Actually, however, between-country differences in school achievement scores are greater than between-country differences in IQ. When the school achievement scores are converted into the IQ metric directly rather than by linear regression, the between-country standard deviation is 0·53 within-country standard deviations for IQ, and 0·70 within-country standard deviations for school achievement, counting only those 57 countries for which both measured IQ and a school achievement score are available.

Therefore school achievement is not simply an expression of the children's intelligence, but children in high-IQ countries tend to over-perform in school relative to their IQ, whereas children in low-IQ countries tend to under-perform. This result is expected if school systems are more efficient in high-IQ countries than in low-IQ countries.

To identify the country-level factors that are responsible for over- or underachievement in mathematics and science, the difference score was formed between school achievement scores (directly converted into the IQ metric) and IQ. Then each variable in Table 3 was used in turn to identify those that predict over- or underachievement in the school assessments relative to IQ.

As single predictor, many of the variables in Table 3 produced statistically significant results ($p<0{\cdot}05$). However, the most conspicuous effects were produced by IQ and school achievement themselves, which strongly predicted overachievement in the mathematics and science assessments. Since the outcome measure is a difference score between school achievement and IQ, a measure of 'intellectual competence' was formed by averaging the standardized scores for school achievement and IQ. This variable could be used as an unbiased predictor for 'overachievement'. As a single predictor, intellectual competence predicted overachievement on the mathematics and science assessments with $p<0{\cdot}0001$.

Table 4 shows the results of regression models in which scholastic overachievement was predicted by this composite measure of intellectual competence and one of the variables in Table 3. In these two-predictor models, high levels of political freedom, subjective well-being, income inequality (high Gini index) and log GDP were independently related to underachievement in mathematics and science.

More specific predictors related to teacher training, school climate and home environment are provided in the TIMSS international science report for the grade eight assessment in 2003 (Martin *et al.*, 2004). Table 5 shows the correlations between these predictors and mathematics scores in grade 8. All these correlations are substantially lower than the correlation between TIMSS science scores and IQ. Regression analysis for the 8th-grade mathematics results revealed only one statistically significant predictor – IQ. Not one of the variables that were offered as possible predictors of school achievement by Martin *et al.* (2004) had any statistically significant relationship with TIMSS results independent of IQ. Nor does any of the school and educational variables listed in Table 5 have a significant effect on the extent to which students over- or underperformed on the 2003 TIMSS science assessment, relative to the country IQ. This is because these variables correlate about as highly with IQ as with school achievement.

## Discussion

The high correlation of 0·92 between national IQ and achievement in mathematics and science establishes the validity of the IQs that have been reported by Lynn &

**Table 4.** The effects of country-level variables on 'overachievement' (relative to IQ) in standardized mathematics and science assessments

| | Partial correlations | | | |
|---|---|---|---|---|
| 2nd variable | Intell. Comp. | 2nd variable | $r^2$ | $n$ |
| logGDP | 0·588*** | − 0·290* | 0·383 | 57 |
| SER | 0·533*** | − 0·098 | 0·347 | 52 |
| Youth literacy | 0·569*** | − 0·101 | 0·364 | 49 |
| PuExEdu | 0·506*** | 0·227 | 0·348 | 52 |
| Life expectancy | 0·528*** | − 0·198 | 0·353 | 57 |
| Gini index | 0·408** | − 0·309* | 0·424 | 52 |
| Skin reflectance | 0·412** | 0·049 | 0·328 | 57 |
| Political freedom | 0·666*** | − 0·382** | 0·447 | 55 |
| Corruption | 0·578*** | 0·219 | 0·359 | 57 |
| Religiosity | 0·442** | 0·003 | 0·333 | 50 |
| SWB | 0·621*** | − 0·321* | 0·401 | 50 |

The outcome measure is the difference score of school achievement minus IQ. In all models, a second variable (column 1) was used along with intellectual competence to predict overachievement. Partial correlations in these two-predictor models and significance levels are reported.
*$p$<0·05; **$p$<0·01; ***$p$<0·001.

Vanhanen (2002, 2006). In essence, if we contend that national IQ is unrelated to important real-world outcomes, we will have to admit that the learning of mathematics and science is not important in the real world.

In fact national IQs and achievement in mathematics and science are so closely related that they appear to measure the same construct. This conclusion is supported by the following observations: (1) The correlation of school achievement with IQ is substantially higher than the correlations of school achievement with logGDP and the other indicators of 'human development' summarized in Table 3. (2) When school achievement scores are transformed into the IQ metric by linear regression, a single school-based assessment of mathematics and science achievement is at least as accurate as a single IQ assessment as an estimate of 'national IQ'. (3) In regression models that include a measure of intelligence or 'intellectual competence', other predictors have only minor effects on school achievement. (4) IQ and school achievement have similar correlates, and in many cases these are different in magnitude from the correlations of the criterion variable with logGDP.

These results are not surprising. Analysing data at the level of individuals, Ceci (1991, 1996) already argued that there is no clear psychometric distinction between tests of intelligence and tests of school achievement. It can be concluded that the same is also true for comparisons between countries.

Traditionally, school achievement is credited mainly to the efficiency of the educational system whereas intelligence is believed to depend more on genetic factors than on schooling. However, neither of these assumptions is accurate. Schooling

**Table 5.** The correlation coefficients between TIMSS test results in 8th-grade science and school characteristics

| | Mean TIMSS | IQ LYNN | Textbook Pr | Class Size | Teach Uni | Sc Cl low | Stud safe | Income | >50%ED | Computer | Stud desk |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean TIMSS | 1·000 | | | | | | | | | | |
| IQ LYNN | 0·922 | 1·000 | | | | | | | | | |
| Textbook Pr | 0·332 | 0·315 | 1·000 | | | | | | | | |
| Class Size | − 0·370 | − 0·375 | − 0·147 | 1·000 | | | | | | | |
| Teach Uni | 0·365 | 0·429 | 0·163 | − 0·148 | 1·000 | | | | | | |
| Sc Cl low | − 0·443 | − 0·510 | − 0·277 | 0·193 | − 0·312 | 1·000 | | | | | |
| Stud safe | 0·641 | 0·658 | 0·392 | − 0·661 | 0·225 | − 0·313 | 1·000 | | | | |
| Income | 0·495 | 0·596 | 0·022 | − 0·293 | 0·185 | − 0·464 | 0·364 | 1·000 | | | |
| >50% ED | − 0·743 | − 0·734 | − 0·289 | 0·557 | − 0·410 | 0·545 | − 0·581 | − 0·640 | 1·000 | | |
| Computer | 0·663 | 0·701 | 0·116 | − 0·376 | 0·249 | − 0·587 | 0·407 | 0·812 | − 0·738 | 1·000 | |
| Stud desk | 0·744 | 0·687 | 0·223 | − 0·427 | 0·277 | − 0·459 | 0·578 | 0·468 | − 0·744 | 0·640 | 1·000 |
| Par Uni | 0·356 | 0·429 | 0·272 | − 0·447 | 0·492 | − 0·369 | 0·555 | 0·462 | − 0·511 | 0·356 | 0·505 |

Mean TIMSS – arithmetical average of the TIMSS 8th-grade science sub-tests; IQ Lynn – national IQ from Lynn & Vanhanen (2006); Textbook Pr – percentage of students taught by teachers who report textbook as primary bases for lessons; Class Size – average class size; Teach Uni – percentage of students whose teachers have finished university or equivalent or higher; Sc Cl low – percentage of students whose principals assess school climate low; Stud safe – percentage of students who assess high their being safe in schools; Income – gross national income *per capita* in $US; >50% ED – percentage of students in schools with more than 50% economically disadvantaged students according to school principals' reports; Computer – percentage of students who have computer in the home; Stud desk – percentage of students who have study desk/table in the home; Par Uni – percentage of students whose parents finished university or equivalent or higher.

determines not only the performance on tests of those kinds of knowledge and skills that are taught explicitly in school, but also the performance on IQ tests. Ceci (1991), in a review of the worldwide evidence, concluded that each additional year in school raises the children's IQ by between 0·25 and 6 points. For the United States, Winship & Korenman (1997) offered an estimate of 2 to 4 points per year. Even among young people in a developing country, the educational level was found to be about equally related to scores on a vocabulary test and on the non-verbal Raven test (Meisenberg *et al.,* 2005). These results suggest that to a substantial extent, cognitive skills acquired in school generalize to tasks that are not taught explicitly in school.

To further illustrate this point, children who were unable to attend school in the Netherlands during World War II had IQs 5 points lower than those who were at school (De Groot, 1951). Several similar studies have been reviewed by Mackintosh (1998). More recently the positive effect of education on IQ has been confirmed by Whalley *et al.* (2005) who have found that in Britain, the level of education is an independent predictor of intelligence at age 64 after controlling for childhood IQ and other predictors. Further evidence has been provided by Blair *et al.* (2005).

The effects of schooling on IQ do not show that IQ is 'nothing but' the consequence of formal education. Yule *et al.* (1982) have demonstrated that IQ measured at age 5 years is a strong predictor for educational attainment at age 16 years in English and mathematics ($r=0{\cdot}61$ and 0·72, respectively). This, in turn, should not be understood as showing that school achievement is 'nothing but' the consequence of pre-existing intelligence.

Also, the common belief that IQ but not school achievement is heavily influenced by genetic factors is not supported by the evidence. Wainwright *et al.* (2005) calculated a heritability of 0·72 for results on the Queensland Core Skills Test in a study based on 256 monozygotic and 326 dizygotic twins. The reported heritability is virtually the same as the heritability that is typically found for IQ. The authors concluded that the relationship between academic achievement and IQ is largely due to common genetic influences. Similarly, Kovas *et al.* (2005) calculate that approximately two-thirds of the genetic variance for mathematical ability is attributable to genetic variance for general intelligence. A specific region of chromosome 2 has recently been linked to performance on the Queensland Core Skills Test, suggesting that 'genes for school achievement' can be identified (Wainwright *et al.*, 2006).

These observations in combination show that intelligence is a broad trait that can be measured both by IQ tests and, among schooled people, by tests of school achievement. This trait is genetically based but requires for its full development environmental inputs, including schooling.

Standardized international assessments of mathematics and science achievement are intended to provide feedback about the effectiveness of the educational system, and to identify the inputs that are most effective in raising school achievement. For example, it can be expected that country-level factors such as financial inputs into the school system, high qualifications of the teachers, and positive attitudes toward learning would cause children to perform well in school-related subjects. It would be surprising if the children's IQ were the only input that has any measurable effects on their school performance.

The observation that the between-country standard deviation (relative to the within-country standard deviation) is higher for school achievement than for IQ shows that the results cannot be explained as a simple translation of the child's IQ into school achievement. The results show that 'overachievement' in mathematics and science is best predicted by intelligence itself, which is of course a reason for the extraordinarily high correlation of 0·92 between school achievement and IQ overall. The most plausible explanation is that the quality of mathematics and science instruction depends primarily on the competence of the teachers; and the teachers in countries with high IQ and school achievement are, on average, more competent than the teachers in countries with low IQ and school achievement.

This amounts to a cultural amplifier effect that enhances and perpetuates differences in school achievement between countries. Similar cultural amplifier effects have been proposed for IQ as well. They have been postulated as important for secular IQ gains (Dickens & Flynn, 2001) and for the great magnitude of IQ differences among countries (Meisenberg, 2003). Dickens & Flynn (2001) proposed specifically that the intellectual level of the people in a child's environment is the most important amplifier for the child's IQ. The present results show that this specific type of cultural amplifier exists, and that it is more important for between-country differences in school achievement than for between-country differences in IQ.

The high correlation between school achievement and IQ makes it impossible to interpret the results of international mathematics and science achievement tests without appropriate controls for national IQ.

With the strategy of predicting 'overachievement' in the school-related subjects, it was possible to identify four variables that are detrimental to mathematics and science achievement: political freedom, subjective well-being, income inequality and logGDP. Interestingly, the public expenditure for education (as % of GDP) was not a significant predictor of overachievement, although there was a non-significant trend in the expected direction (Table 4).

These results suggest that in addition to student and teacher intelligence, attitudinal factors play at least a limited role as determinants of school achievement. Attitudes that prevail in liberal democracies, and in wealthy countries in general, seem to inhibit the learning of mathematics and science. Possibly the values that prevail in these countries undermine discipline and, more importantly, the self-discipline that is required for sustained effort in school. The observation that a high level of subjective well-being is associated with underachievement in school points in the same direction. Perhaps happy people place less emphasis on the study of mathematics and science; or else, the successful learning of mathematics and science makes children permanently unhappy. It is not clear whether the apparent detrimental effect of high income inequality on mathematics and science achievement is related to attitudes and values that prevail in inegalitarian societies, or to a neglect of mass education in these societies.

However, all these effects are of small magnitude. A decline of school achievement *relative to IQ* by the equivalent of 5 IQ points (0·33 standard deviations) is associated with a 13·6-fold rise in GDP (the difference between Pakistan and Britain), a rise in political freedom from that in Iran to that in Japan, a rise in economic inequality from that in Denmark to that in Colombia, and a rise in subjective well-being from that in Ukraine to that in Denmark. Even for intellectual competence, a rise by 18 IQ points – the difference between India and Britain – is required to make children overachieve in school by the equivalent of 5 IQ points.

One implication of the findings is that school achievement scores can be used as substitute IQ measures for those countries in which no satisfactory IQ assessments are available. The difference between measured IQ and IQ extrapolated from national mathematics and science assessments (2·5 points) is somewhat smaller than the difference between measured IQ and IQ extrapolated from the IQs of neighbouring countries (3·5 points). This means that instead of estimating missing data points from the IQs of neighbouring countries, as done by Lynn & Vanhanen (2002, 2006), investigators who use intelligence as an explanatory variable in the study of differences among nations can also use the results of standardized mathematics and science assessments. There are currently ten countries for which school achievement data are available but measured IQs are not.

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