# علاقة النوع ومهارة الاستدلال بالتحصيل الأكاديمى

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**ملخص البحث**

هدفت الدراسة الحالية إلى فحص أثر النوع (بنين / بنات) على التحصيل الأكاديمى "التقديرات المدرسية فى العلوم واللغات) والقدرة الاستدلالية كمتغير وسيط . وقد بينت نتائج البحث : تجاوزت البنات البنين فى التحصيل الأكاديمى للغات ، بينما تجاوز البنين البنات فى التحصيل الأكاديمى للعلوم والقدرة الاستدلالية . كما أظهر التحليل متعدد المستويات تأثير غير مباشر صغير للنوع على التقديرات المدرسية و القدرة الاستدلالية ، وأمكن تفسير الفروق في العلوم تبعا للنوع بواسطة القدرة الاستدلالية وليس بواسطة عوامل أخرى كنسبة البنين ونسبة البنات داخل الفصل و السرعة العقلية . كما بينت نتائج الدراسة أن القوة التنبؤية للقدرة الاستدلالية في اللغات كانت أكبر فى الفصول ذات المتوسط الكبير فى القدرة الاستدلالية ، بينما الفروق فى النوع في اللغات تختلف اختلافاً دالاً عبر الفصول الدراسية ، وأن القدرة الاستدلالية منبئ جيد بالتحصيل الأكاديمي في العلوم .

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*vital component in predicting Academic achievement. These authors, however, used Academic achievement tests and not SG, which might have resulted in higher correlations between mental speed and achievement due to time limits in the latter. Gender-ratio did not display a significant effect, with a single exception: At the group level, classrooms with a higher proportion of boys received better mean languages SG.*

*This was possibly a result of the higher proportion of boys in the higher tracks, which in turn on average received better SG. The mediating effect of reasoning ability was not moderated by gender-ratio, however, nor was the direct effect. It appears that for the assessment of Academic achievement using SG, gender-ratio in the classroom bears no relevance.*

***Limitations.***

*SG were assessed retrospectively in this study, therefore causal conclusions cannot be drawn. The statistical equivalence of a mediator and a confounder variable (MacKinnon et al., 2000), however, ensures that the results obtained in this study can be interpreted in a different way, with reasoning ability as a confounding variable obscuring the true relationship between gender and mental speed. Because of convenience, however, reasoning ability was designated a mediator in this study.*

*Latent variable models were not used here because it is currently infeasible to estimate lower level mediation models with random direct and indirect effects among latent variables, because random slopes cannot be estimated (e.g., Bentler & Yiang, 2003). However, because our focus was on multilevel modelling here and due to the satisfactory scale reliabilities, we chose to work with single variables.*

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*A final point worth mentioning refers to the fact that we used different school forms in this study, which varied with respect to educational standards. The same grade, therefore, might imply different degrees of Academic achievement. This might have lowered the effects observed, although they were of satisfying magnitude. Future studies should combine SG with Academic aptitude tests in order to provide a more complete picture of Academic achievement and its relation with gender and reasoning ability, while taking the multilevel data structure often encountered in educational settings into account.*

*gender differences in Academic achievement, and if so, are these moderated by reasoning ability? SG were investigated here, because they are relevant real-life criteria and often requested for selection purposes. Because of the clustered data structure, we used multilevel analyses in order to exclude erroneous parameter estimates and biased statistical tests, as would have been obtained using standard regression models.*

*Further, the combination of mediation analysis with multilevel modelling allowed us to extract substantial evidence from the data that otherwise would have gone unnoticed.*

*In line with previous results reported, we found gender differences in languages, favoring girls. However, boys were found to have higher SG in sciences. This might be due to the fact that the sample investigated consistent to large degrees of highly intelligent students, many of whom were visiting specialized schools for the gifted. It is a well documented fact that males are over-represented in programs and schools for the gifted (Kerr& Nipcon, 2003). However, when investigating gender differences in sciences for each school type, we found that girls in the gifted track actually had better sciences SG than boys ($d = -0.24$). In line with previous research, we found a small advantage of boys in reasoning ability, whereas girls surpassed their male peers in mental speed, albeit not to a significant degree. Reasoning ability mediated the effect of gender on both languages and sciences. Whereas for sciences, we observed a fully inconsistent mediation, resulting in a total effect that was not significant, the positive partial mediation of languages SG by reasoning ability could not fully neutralize the direct effect of gender on languages SG, producing a total effect favoring girls. Reasoning ability, obviously, was not a decisive factor in languages SG, but it was so for sciences, countervailing the direct effect of gender on grades favoring girls.*

*Two possible explanations can be given for this. Firstly, as can be seen in Figure 2, in classrooms with a lower average reasoning ability, the relationship between reasoning ability and languages SG was sometimes especially low, but no significant variation in the effect of reasoning ability on sciences SG between classrooms was found. Secondly, girls are known to exhibit a higher degree of self-discipline (Duckworth & Seligman, 2006), which was shown to mediate the effect of gender on SG. We did not include any measures of self-discipline or other personality traits in this study, therefore the remaining advantage of girls in languages after controlling for reasoning ability cannot be easily explained.*

*Mental speed did not significantly lower the indirect effect exerted by reasoning ability for either sciences or languages. This contradicts the results reported in Luo et al. (2003, 2006), who report that mental speed is a*

3 (Table 6), which were very close to those in Model 4. Two results were especially striking, and differed from the analysis in 3.1. Firstly, the direct effect of gender on languages SG was not constant across classrooms, as indicated by the significant variance of c'. Gender therefore is more important for languages SG in some classrooms than in others. Secondly, the slope of languages SG regressed on reasoning ability varied between groups as well, as shown in Figure 2. The latter fact reveals that reasoning ability predicted languages SG to differing degrees across classrooms: In those with a higher average intelligence (of female students), the predictive power of reasoning is higher, as evidenced by the covariance between dM and b.

***Table 6: Variances and covariances of random effects in Model 3***

| | $d_M$ | $a$ | $d_Y$ | $b$ | $c'$ |
|---|---|---|---|---|---|
| $d_M$ | 0.59** | | | | |
| $a$ | -0.03 | 0.05 | | | |
| $d_Y$ | 0.17** | -0.05* | 0.13** | | |
| $b$ | 0.12** | -0.01 | 0.03 | 0.04* | |
| $c'$ | -0.10 | 0.01 | -0.06 | 0.03 | 0.12** |

*Note.* **p < .01. *p < .05.

*In order to assess the significance of direct and total effects in Model 3 and Model 4, we once more utilized the parametric bootstrap procedure outlined above. Results were similar for Model 3 and Model 4, therefore only results for Model 3 are reported. The average indirect effect differed from zero and was positive (CI_lo = 0.02, CI_hi = 0.13), whereas the average total effect was negative (CI_lo = -0.54, CI_hi = -0.24). Again, the effect of reasoning ability partly mediated the effect of gender on languages SG, although the direct effect was large enough to yield a strong negative total effect, thereby resulting in inconsistent mediation.*

*In a final step, we again used the regression residuals of reasoning (with mental speed as a predictor) and recalculated Models 3 and 4 using these residuals as predictor. This did not in any way alter the results, neither for the indirect effect (CI_lo = 0.02, CI_hi = 0.13) nor the total effect (CI_lo = -0.54, CI_hi = -0.24).*

## 4. Discussion

*In this paper, we took a new look at an old question, that is, are there*

### 3.2 Multilevel mediation analysis for languages

*Table 5 summarizes the fixed effects in the lower level mediation model gender → reasoning ability → SG sciences (Model 3) and the moderated lower level mediation model (Model 4). Model fit was again very similar, although the BIC slightly favored Model 4 (BIC = 5056 for Model 3, BIC = 5046 for Model 4). As seen before, gender predicted reasoning ability, which in turn predicted languages SG. However, a significant negative direct effect of gender on languages SG could be observed, indicating that girls got higher grades in languages irrespective of reasoning ability. Gender-ratio was found to directly affect languages SG: Classrooms that had a larger proportion of boys received higher grades than classrooms with lower proportions of boys. No other effects of gender-ratio were found, and the indirect effect was not moderated significantly, ▯ 2(2) = 0.09, p = 0.96.*

**Table 5: Fixed effects of lower level mediation (Model 3) and moderated lower level mediation (Model 4) of gender → reasoning ability → SG languages**

| | Model 3 | | | Model 4 | | |
|---|---|---|---|---|---|---|
| Parameter | Estimate | SE | *t* | Estimate | SE | *t* |
| $d_M$ | -0.09 | 0.10 | -0.83 | -0.09 | 0.11 | -0.87 |
| $d_Y$ | 0.13 | 0.06 | 2.16* | 0.16 | 0.06 | 2.50* |
| $a$ | 0.23 | 0.05 | 4.62** | 0.23 | 0.05 | 4.51** |
| $b$ | 0.39 | 0.04 | 8.97** | 0.39 | 0.04 | 9.14** |
| $c'$ | -0.43 | 0.07 | -6.63** | -0.46 | 0.07 | -6.85** |
| $m*d_M$ | | | | 0.91 | 0.70 | 1.30 |
| $m*d_Y$ | | | | 0.87 | 0.40 | 2.15* |
| $m*a$ | | | | 0.11 | 0.34 | 0.30 |
| $m*b$ | | | | -0.02 | 0.28 | -0.05 |
| $m*c'$ | | | | 0.08 | 0.45 | 0.18 |

*Note.* $d_M$ = intercept of mediator equation (reasoning), $d_Y$ = intercept of outcome equation (sciences SG), $m$ = moderator (gender-ratio)
**p < .01, *p < .05.

*We then analyzed the variances of covariances of random effects in Model* *reasoning ability varied in magnitude between classrooms, as indicated by the variance of parameter a, providing evidence for the fact that mean gender differences in reasoning were not equal across classrooms. Finally, the significant negative covariance between parameters dM and c' points to the fact that in classrooms with brighter females, the effect of gender on science grades tends to be stronger, i.e. males receive better science grades in such classrooms even when controlling for reasoning ability.*

***Table 4: Variances and covariances of random effects in Model 1***

| | $d_M$ | $a$ | $d_Y$ | $b$ | $c'$ |
|---|---|---|---|---|---|
| $d_M$ | 0.59** | | | | |
| $a$ | -0.03 | 0.05* | | | |
| $d_Y$ | 0.00 | -0.04 | 0.11** | | |
| $b$ | 0.05 | 0.00 | -0.01 | 0.01 | |
| $c'$ | -0.10* | 0.05 | -0.05 | 0.01 | 0.06 |

*Note.* **$p < .01$. *$p < .05$.

*We then used the parametric bootstrap procedure (10,000 draws) outlined in MacKinnon et al. (2004) to estimate 95% confidence intervals (CIs) of the indirect and total effects in Model 1 and 2, respectively. Results were similar, we therefore only report the Cis of Model 1. CIs showed that the indirect effect significantly differed from zero in both models (CI_lo = 0.06, CI_hi = 0.19), whereas the total effect did not differ from zero in both models (CI_lo = -0.09, CI_hi = 0.20). In this case, therefore, inconsistent mediation occurred, with countervailing direct and indirect effects; that is, no gender differences in sciences grades were observed after taking reasoning ability into account.*

*Finally, we regressed reasoning ability on mental speed and recalculated Models 1 and 2 using the residuals as predictors, thereby eliminating all mental speed variance in reasoning ability. We found the pattern of direct and indirect effects to be similar as above, with an indirect effect significantly different from zero (CI_lo = 0.06, CI_hi = .15), and a total effect that was not significant (CI_lo = -0.10, CI_hi = 0.20). Mental speed therefore did not appear to play a decisive role in predicting science SG.*

*reasoning ability, which in turn predicted sciences SG well. Interestingly, the indirect effect c' of gender on sciences SG was no longer significant when taking reasoning ability into account, although it was negative. However, there was no significant interaction between gender-ratio and any other variables, and the statistical test of the moderation of the indirect effect did not reach significance either, $\alpha\ 2(2) = 0.41$, $p = 0.81$. Gender-ratio does not seem to affect direct or indirect effects on sciences SG.*

**Table 3: Fixed effects of lower level mediation (Model 1) and moderated lower level mediation (Model 2) of gender → reasoning ability → SG sciences**

| | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| Parameter | Estimate | SE | *t* | Estimate | SE | *t* |
| $d_M$ | -0.10 | 0.11 | -0.88 | -0.09 | 0.11 | -0.85 |
| $d_Y$ | -0.03 | 0.06 | -0.43 | -0.03 | 0.06 | -0.52 |
| *a* | 0.24 | 0.05 | 4.64** | 0.23 | 0.05 | 4.47* |
| *b* | 0.56 | 0.03 | 16.46** | 0.56 | 0.03 | 16.52** |
| *c'* | -0.07 | 0.06 | -1.16 | -0.07 | 0.06 | -1.18 |
| $m^*d_M$ | | | | 0.92 | 0.70 | 1.31 |
| $m^*d_Y$ | | | | 0.56 | 0.39 | -0.42 |
| $m^*a$ | | | | 0.08 | 0.34 | 0.22 |
| $m^*b$ | | | | 0.13 | 0.23 | 0.57 |
| $m^*c'$ | | | | 0.43 | 0.41 | 1.06 |

*Note.* $d_M$ = intercept of mediator equation (reasoning), $d_Y$ = intercept of outcome equation (sciences SG). *m* = moderator (gender-ratio)
**p < .01. *p < .05.

*As a next step, we investigated the level 2-variances and covariances of the random effects in Model 1 (Table 4) that were nearly identical with those in Model 2. As can be seen, the variances of both intercepts (dM and dY, respectively) significantly differed from zero, Gender, reasoning ability, and Academic achievement 14 indicating that females differed in their mean reasoning ability and that mean science grades differed significantly across classrooms, respectively. Further, the relationship between gender and*

### 3. Results

*Table 2 shows standardized effect sizes of mean differences between male and female students in SG and cognitive abilities across the entire sample. Effect sizes were generally small, and gender difference in mental speed failed to reach statistical significance, although females had slightly higher means. In line with previous assumptions, females had significantly better SG in languages, while boys excelled in reasoning ability. Unexpectedly, however, boys showed significantly better grades in sciences.*

**Table 2: Standardized mean differences in cognitive abilities and Academic achievement between male and female students**

| Ability/SG | *d* | *t* |
|---|---|---|
| Reasoning ability | -0.34 | -5.67** |
| Mental speed | 0.12 | 1.93 |
| Languages | -0.23 | -3.81** |
| Sciences | 0.13 | 2.21* |

*Note.* Gender was dummy-coded with male = 1.
*p < .05. **p < .01.

*Next, we computed the intra-class correlations (ICC) in order to assess the effect of class membership on outcome variables. The ICC reflects the degree of variance that is explained by group membership, and therefore can be used as an indicator of when multilevel analyses are required. Hence, we calculated empty multilevel models without predictors, estimating group and residual variances in order to determine the ICC. The ICC for languages and sciences were .26 and .17, respectively, and all group-level variance components significantly differed from zero. Multilevel analyses therefore were required in order to achieve adequate standard errors and effect estimates.*

### 3.1 Multilevel mediation analysis for sciences

*Table 3 provides an overview of the fixed effects obtained for the lower level mediation model (Model 1) and the moderated lower level mediation model (Model 2) for the mediated relationship gender → reasoning ability → SG sciences, with gender-ratio being centered to the population mean (0.53). Model fit was comparable (BIC = 5133 for Model 1, BIC = 5130 for Model 2). As can be seen, in both models gender was a significant predictor of*

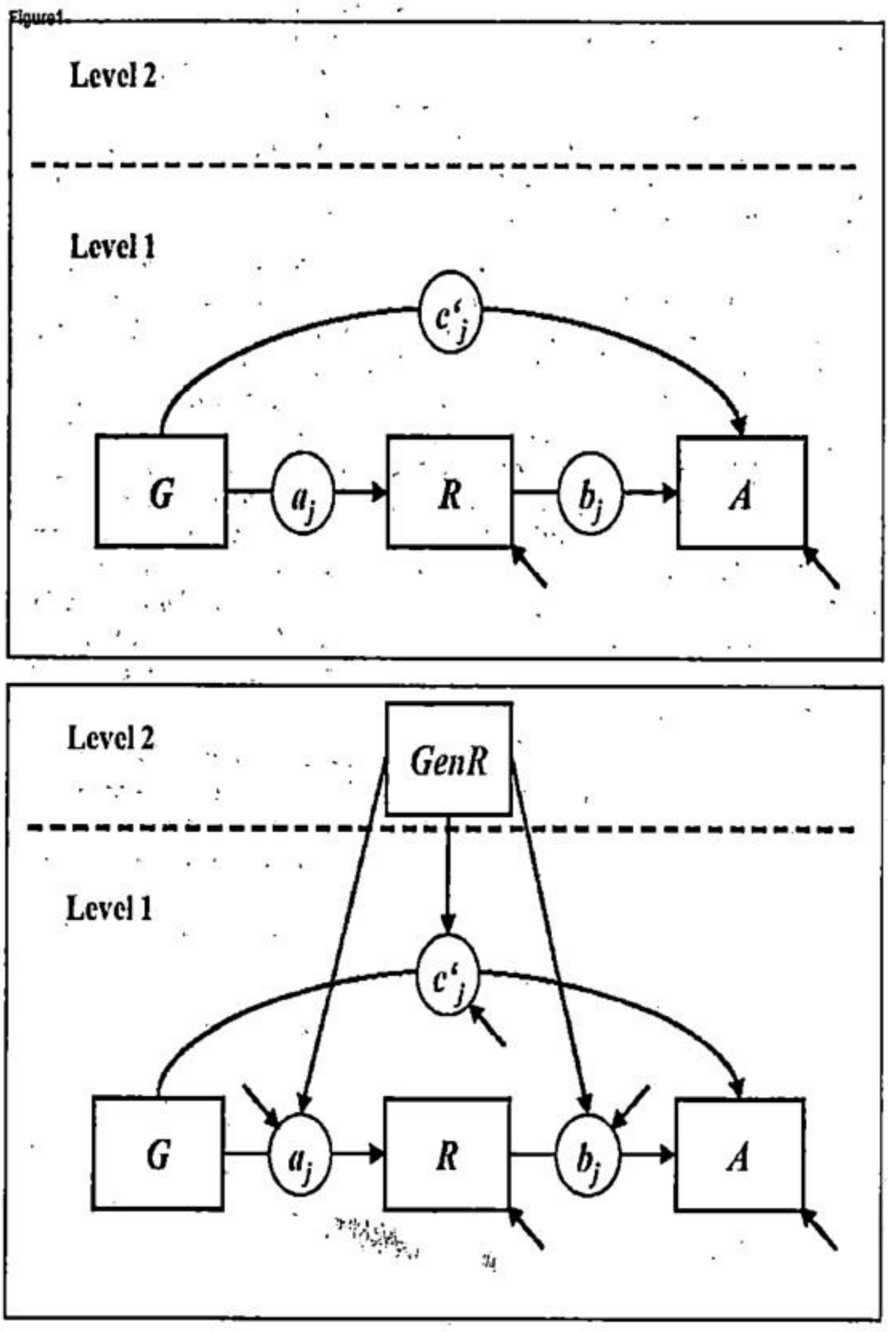


***Figure 1: Lower level mediation (upper panel) and moderated lower level mediation (lower panel)***

*and Kenny (1986) to analyze mediation in this paper, because it suffers from several shortcomings. For example, these authors mention that the direct effect of the predictor on the outcome should be significant. However, this procedure can obscure the fact that a countervailing mediation effect could lower the direct effect, thus rendering it statistically insignificant (Edwards & Lambert, 2007). Instead, we estimated all direct and indirect effects simultaneously in this paper, as proposed by Bauer et al. (2006).*

*Multilevel mediation analysis was initially conducted without using level 2-predictors. In this lower level mediation model, as initially proposed by Kenny et al. (2003), we allowed all intercepts (both those of the mediator and outcome equation) and all regression coefficients (aj, bj and c'j in Figure 1, respectively) to vary between classrooms in the model (the subscript j indicates that these parameters can take different values across groups). That is, we estimated level 2-variances of the direct effect of gender on SG (c'j), level 2-variances of the components of the indirect effect of gender on SG mediated by reasoning ability (aj and bj) and intercept variances and then tested whether these significantly differed from zero. In order to estimate confidence intervals for the average indirect (aj □ bj) and total effects (aj bj + c'j), we utilized the Monte Carlo procedure outlined in MacKinnon, Lockwood and Williams (2004), in which the sampling distributions of the effects are not assumed to be normal.*

*Additionally, we tested whether direct and indirect effects in the lower level mediation model were moderated by gender-ratio as a level 2-predictor We therefore investigated the statistical interactions of gender-ratio with parameters aj, bj and c'j, respectively, and further checked whether gender-ratio explained variance in the intercepts (i.e., we tested the assumption that gender-ratio was related to average reasoning ability in the classroom or to average Academic achievement). In order to statistically test a possible moderation of the indirect effect by gender-ratio, we followed the multiparameter testing strategy outlined in Raudenbush and Bryk (2002, pp. 57-61), testing the null hypothesis that the effect of gender-ratio on both aj and bj is zero.*

*In a final step, we regressed reasoning ability on mental speed, and used the residuals in the same analyses as above to predict SG. Hence, we could check whether the magnitude of the indirect effect was drastically lowered, as predicted by hypothesis 2.*

## 2. Method

### 2.1 Participants

*1,098 students in 55 classrooms were retained from the original sample, with 9 classrooms from the lower track, 8 classrooms from the middle track, 20 classrooms from the higher track and 18 classrooms from the gifted track. 516 students were female, 582 were male. Students came from grades 7 to 10, with a mean age of 14.46 years (SD = 1.06). Table 1 provides the number of male and female students for each school type, along with means and standard deviations of gender-ratio per classroom and classroom size.*

**Table 1: Number of male and female students and means of gender-ratio and classroom size per school type**

| School type | Males | Females | Gender-ratio[a] | Classroom size |
|---|---|---|---|---|
| Lower track | 86 | 79 | .52 (.12) | 18.95 (3.96) |
| Middle track | 86 | 94 | .48 (.13) | 24.19 (5.32) |
| Higher track | 208 | 225 | .48 (.16) | 22.28 (3.64) |
| Gifted track | 202 | 118 | .63 (.12) | 18.48 (3.49) |

*Note.* Standard deviations are given in brackets. [a]Gender was dummy-coded with male = 1.

### 2.2 Academic achievement

*Participating students reported their most recent SG, which were aggregated into two different composite scores: Sciences (mathematics, physics and chemistry) and languages (English as well as Spanish and French as foreign languages). Spanish SG range from 1 to 6, with 1 being the best grade a student can obtain and 6 the worst. This scoring system was reversed in our analysis in order to enhance interpretation of results.*

### 2.3 Procedure and statistical analysis

*Prior to all analyses, composite SG scores and cognitive ability scores were transformed using normal scoring in order to approximate multivariate normality as closely as possible. All variables were standardized (M = 0, SD = 1) across the entire sample. We did not conduct within-classroom standardization of SG in order to refrain from masking between-classroom differences, which is diametrically opposed to the purposes of a multilevel analysis.*

*We did not follow the classical causal steps procedure outlined in Baron*

*In the case of consistent mediation, direct and indirect effects have the same sign, whereas in inconsistent mediation, they have opposite signs, resulting in a possibly nonsignificant total effect. A third aspect of mediation analysis refers to the role of potential moderators of a mediating effect, implying that the strength of an indirect effect depends on the magnitude of a moderator variable, resulting in moderated mediation (Edwards & Lambert, 2007).*

*Methods of mediational analysis have been developed mainly in the context of linear regression and path analysis (e.g., Baron & Kenny, 1986; Shrout & Bolger, 2002). The independence assumption of such models, however, is violated in case of correlated data in clustered observation units. For example, it is highly likely that students in the same classroom share many experiences. Therefore, it can plausibly be assumed that scores on outcome variables are correlated across students within this same classroom. Because the independence assumption is violated in this case, standard errors in multiple linear regression models will be underestimated, resulting in alpha inflation (e.g., Hox, 2002).*

*Recently, several papers have extended mediation analysis to the case of multilevel modelling (Bauer, Preacher, & Gil, 2006; Kenny, Korchmaros, & Bolger, 2003; Krull & MacKinnon, 2001). Multilevel models explicitly take clustered data structures into account and therefore are capable of accurately estimating effects and standard errors. Extending mediational analysis to a multilevel modelling framework enables researchers to let direct and indirect effects vary randomly across groups, to statistically test the magnitude of this variation, and to integrate higher-level predictors into their models in order to explain between-group variability in these effects. Bauer et al. (2006) present a multivariate multilevel model to simultaneously estimate direct and indirect effects in the case of clustered data. We follow this approach here.*

### *1.5 Research hypotheses in the present study*

*Based on the literature review above, the following hypotheses were explored:*

*(1) The direct effect of gender on SG is mediated by reasoning ability.*

*(2) When statistically controlling for mental speed, the mediating effect of reasoning ability shows a significant drop in size.*

*(3) Direct and indirect effects significantly vary between classrooms.*

*(4) Gender-ratio moderates the mediating effect of reasoning.*

*memory and spatial reasoning, whereas females tend to score higher on perceptual speed and verbal ability.*

### *1.3 Specific cognitive abilities and Academic achievement*

*Reasoning ability has proved to be a core component of general intelligence, while simultaneously showing higher correlations with working memory components than other facets of intelligence (Carroll, 1993). Reasoning was shown to predict variance in SG above working memory, but not vice versa (Rohde & Thompson, 2007). Some authors report evidence supporting the idea that reasoning ability is a better predictor of Academic achievement than the g factor itself (Wittmann1999). Importantly, performance in mathematics and natural sciences usually depends more heavily on reasoning capabilities than other subjects like languages or humanities, presumably because those subjects are more hierarchically structured (Deary et al., 2007; Rindermann & Neubauer, 2004). In predicting Academic achievement, reasoning ability therefore is of central importance.*

*Several papers have investigated the effect of mental speed on Academic achievement. For example, Luo, Thompson and Detterman (2003) showed that mental speed effectively mediated the relationship between WISC-R intelligence scores and Academic achievement, dramatically reducing the shared variance of intelligence and Academic achievement. In a later study, the same authors report results supporting this evidence (Luo, Thompson, Detterman, 2006): A compound factor of working memory and mental speed surpassed the explanatory power of fluid intelligence. A study conducted by Rindermann and Neubauer (2004) adds to the fold, as these authors report results most supportive of a model in which the effect of mental speed on Academic achievement is largely mediated by intelligence and creativity, although the direct effect of mental speed on SG was relatively modest. Mental speed therefore appears to play a decisive role in predicting Academic achievement.*

### *1.4 Mediation and moderated mediation in hierarchical data structures*

*Mediation refers to the effect that a key predictor exerts on an outcome variable through an intermediate variable. For example, Duckworth and Seligman (2006) investigated the effect of gender on Academic achievement as mediated by self-discipline. Depending on the pattern of relations between the variables inspected, the intermediate variable may be called mediator, confounder or suppressor (MacKinnon, Krull, & Lockwood, 2000). The main aim of mediational analysis is to determine whether the effect of the predictor on the outcome variable can be ascribed, wholly or in part, to the intermediate variable. A further goal is to determine whether consistent or inconsistent mediation is present (Tzelgov & Henik, 1991).*

*to the worst (norm-referenced grading). In sum, SG therefore often reflect a mixture between norm-referenced and criterion-referenced grading. As a consequence, students in different classrooms who have obtained the same SG might differ in their actual degree of Academic achievement. This fact could partially dilute the relationship between SG and intelligence. However, Stricker et al. (1993) found that adjusting GPA for course-by-course differences in grading standards did not significantly affect the relationship between gender and grades in a sample of university students.*

*An additional factor potentially affecting Academic achievement is class gender-ratio. A recent study showed that gender-ratio in the classroom negatively affects the academic self-concept of girls, but not of boys (Preckel, Zeidner, Goetz, & Schleyer, in press). The academic self-concept is largely shaped by social comparison processes among students and shows a positive correlation with Academic achievement (e.g., Zeidner & Schleyer, 1999). Girls' academic self-concept is especially vulnerable in case they form a minority in the classroom. Therefore, the assumption that boys gain higher SG in classrooms with a higher percentage of boys seems warranted. To our knowledge, this question has not been investigated extensively in the literature.*

### *1.2 Gender differences in intelligence*

*An overwhelming portion of the literature supports the notion that gender differences in general intelligence (g) are practically nonexistent (Halpern, 2000; Jensen, 1998; Mackintosh, 1996). There are reliable differences in specific cognitive abilities, however. For example, females have been reported to outperform males on perceptual speed (Kimura, 1999) and components of verbal ability (Hyde & Linn, 1988), whereas males outperform females in spatial abilities. Differences in specific tests or subtests have been reported as well. Male university students score higher in the Raven Progressive Matrices (Irwing & Lynn, 2005), and males outperform females on the working memory factor in the WISC-III. In contrast, female schoolchildren surpassed their male counterparts in verbal reasoning, but the effect was small (Strand, Deary, & Smith, 2006).*

*Further, female students aged 14 to 18 had significantly higher means than males in the subtests Spelling and Language of the Differential Aptitude Test (Feingold, 1992).*

*Gender differences in specific cognitive abilities appear more pronounced when g is statistically controlled for, thereby supporting the idea that g might mask the actual magnitude of gender differences in specific cognitive abilities (Johnson & Bouchard, 2007). In sum, although gender differences in g have usually not been found, males often excel in subtests requiring working*

*GPA of about half a standard deviation, with a smaller gender difference in a standardized achievement test (d = .30). In a sample of high school students, similar results were observed (Wright & Houck, 1995). Even in subject areas such as math and science, girls have often been found to outperform boys with respect to SG (Dwyer & Johnson, 1997; Halpern, 2000). Results look different when focusing on standardized achievement test scores. There is some evidence that boys often score higher than girls in achievement tests such as the SAT (e.g., Stricker, Rock, & Burton, 1993). Further evidence from a meta-analysis and large-scale assessments supports the notion of a moderate advantage for males with respect to math achievement test scores in later youth and adult age, which appears most pronounced in mathematical problem solving and understanding of mathematical concepts (Hyde, Fennema, & Lamon, 1990; Johnson, 1996; Mills, Ablard, & Stumpf, 1993). With respect to general verbal ability, a female advantage of d = .20 has been reported (Hyde & Linn, 1988).*

*The different relationships of gender with SG and standardized achievement scores, respectively, can have different reasons. There has been some controversy with respect to SG as measures of educational achievement, which have been criticized for their sometimes-mediocre psychometric properties compared to standardized achievement tests. However, SG are valid predictors of real-life criteria such as academic or vocational training success (Schuler, Funke, & Baron-Boldt, 1990), and high correlations between SG and achievement tests have been reported. Moreover, teachers are able to validly predict their students' academic achievement (e.g., Feinberg & Shapiro, 2003). Further, standardized achievement tests often are measures of g without explicitly stating so (see, for example, Frey & Detterman, 2004), which could at least partially explain the higher correlations between intelligence tests and Academic achievement tests compared to the relationship between SG and intelligence (e.g., Schaefer & McDermott, 1999).*

*A related point of criticism with respect to SG pertains to the fact that assessment*

*standards can vary between classrooms. Basically, teachers in Germany are supposed to*

*compare the performance of a student to standards defined by the educational authorities*

*(criterion-referenced grading; Tent, 1998). However, while taking these standards into*

*account, in practice, teachers often choose a class-specific frame of reference for assessment, assigning good SG to the best students and bad SG*

# *Gender, Reasoning Skill, and Academic Achievement*

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## *1. Introduction*

*A large body of psychological research has focused on the prediction of Academic and educational achievement from intelligence test scores (e.g., Deary, Strand, Smith, & Fernandes, 2007; Jensen, 1998; Rohde & Thompson, 2007). This is not surprising, because one of the main motivations for the development of the first intelligence scales was the prediction of school examination scores (Spearman, 1904). Generally, intelligence has been shown to be one of the best predictors of Academic performance, with an average correlation of IQ scores and school performance between 0.4 and 0.7 (Kuncel, Hezlett, & Ones, 2004; Mackintosh, 1998; Naglieri & Bornstein, 2003; Neisser et al., 1996; Rindermann & Neubauer, 2004; Süß, 2001). Results pertaining to gender differences in specific cognitive abilities have been reliably reported as well, with girls usually performing better in tests requiring verbal and speed abilities, while boys often excel in tasks requiring spatial abilities (Hyde & Lynn, 1988; Voyer, Voyer, & Bryden, 1995).*

*However, the literature investigating the relationship of specific cognitive abilities*

*with Academic achievement while simultaneously taking gender differences into account is sparse. In addition, the fact that the clustered data structure of students within classrooms has often been ignored in past analyses might have resulted in possibly biased results. This study therefore is concerned with a systematic analysis of gender effects on Academic achievement as mediated through various specific cognitive abilities. In order to investigate whether possible mediational effects were homogenous across different classrooms, and whether predictors on classroom level moderated the magnitude of this effect, a multilevel mediation analysis with moderators was conducted.*

### *1.1 Gender and Academic achievement*

*It has been a consistent finding in the literature that girls receive better school grades (SG) than boys. In a study with elementary school children, for example, Pomerantz, Altermatt and Saxon (2002) reported standardized mean differences between female and male students' SG ranging from d = 0.14 (math) to d = 0.28 (language arts), favoring girls. In a sample of eight-grade students, Duckworth and Seligman (2006) found gender differences in*

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***English Abstract :***

*The present study investigates gender differences in Academic achievement (school grades in sciences and languages) as mediated by reasoning ability in a large sample with a clustered data structure from an educational context. Whereas girls outperformed boys in languages, boys excelled in sciences and reasoning. Multilevel analyses indicated a small indirect effect of gender on school grades mediated by reasoning ability. Gender differences in sciences, but not in languages were largely explained by reasoning ability, but not by factors such as gender-ratio in the classroom or mental speed. The predictive power of reasoning ability for languages, but not sciences was larger in classrooms with higher mean reasoning ability, whereas gender differences in languages, but not sciences varied significantly across classrooms. Reasoning ability appears to be important for predicting Academic achievement in sciences, whereas languages are more affected by gender.*