Chapter 4

Effects of Home Background on Student Achievement in Reading, Mathematics, and Science at the Fourth Grade

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Introduction

One of the most stable and consistently observed phenomena in the field of education is the impact of students' home background on achievement. Students whose parents have a higher level of education, a more prestigious occupation, or greater income tend to have higher achievement than students whose parents have a lower standing on such socio-economic status (SES) indicators (e.g., Sirin, 2005). Many theories have been proposed to account for this phenomenon, but there is little consensus about which explanation is the most powerful. One reason is that, in spite of the stability of the phenomenon,

there is also considerable variation in strength of effects across educational systems and learning domains (Barone, 2006). So far there has been little research on this variation, and on the mechanisms which give rise to it.

Gender is another student characteristic which tends to be related to achievement differences. However, here too considerable variation can be observed across learning domains, student age, and countries, and the nature and reasons for this variation is not well understood

Taking advantage of the opportunities offered by the data collected in TIMSS and PIRLS 2011 at the fourth grade, the main aim of the research reported in this chapter is twofold: first, to describe the patterns of variation across countries and domains of learning (i.e., reading, mathematics, and science) in the relationship between student background characteristics and achievement; and second, to gain insight into some of the mechanisms which generate these relationships. A crucial design characteristic of the TIMSS and PIRLS 2011 fourth grade data used in this study is that the students were assessed in all three domains of learning—reading, mathematics, and science—which allowed simultaneous analysis of outcomes in domains where both literacy and numeracy skills are essential. A second important design feature of these data is that the students' parents were asked to supply information in a Home Questionnaire about, among other things, different kinds of activities with the child, the child's numeracy and literacy skills, and resources in the home. Given that home factors are likely to exert much of their influence before the start of formal schooling, the information in the Home Questionnaire is essential for understanding the mechanisms through which factors such as parental education and student gender influence school achievement. A third important design feature of the TIMSS and PIRLS 2011 data is the number of countries that participated. Altogether, 34 countries and 3 benchmarking entities took part in the study, enabling investigation of differences in the impact of home background factors on student achievement across a wide variety of school systems and cultures.

In analyzing these data we have adopted a path modeling approach in order to investigate how the effect of parental education and gender on children's achievement is mediated via the availability of home resources, early literacy and numeracy activities in the home, and literacy and numeracy skills when beginning school. Based on theoretical expectations and previous empirical results, we have constructed a model in which these hypothesized determinants have been included in chronological order. By estimating the strength of the

paths between these factors, and their direct and indirect effects on achievement in reading, mathematics and science at the fourth grade, this study seeks to gain a better understanding of the mechanisms through which educational inequalities are reproduced.

This study has two main aims: to investigate to what extent parental education and gender influence fourth grade student achievement in reading, mathematics, and science in different countries; and to investigate the mechanisms through which parental education and gender influence achievement via books in the home, literacy and numeracy activities, and the child's ability to carry out literacy and numeracy tasks when starting school.

Relationships Between Student Background Factors and Achievement

Typically, the correlation between SES and student achievement is about .30 at the individual student level (Sirin, 2005; White, 1982). However, SES is a complex and multidimensional concept. The term cultural capital has been used to label the most important dimension of SES-influence on achievement. In most countries, parents' formal educational level has been identified as the key component of cultural capital (Yang, 2003).

One theoretical framework which is often used to explain the effect of parental education on achievement is Bourdieu's Cultural Capital Theory (Bourdieu & Passeron, 1977). This theory basically argues that social classes preserve a strong cultural identity, and that social origins have a strong influence on students' cultural resources. Skills, attitudes, and use of language, to take a few examples, thus are differentiated according to class origins. Furthermore, pedagogical practices and assessment procedures are to a large extent related to the culture of the upper class, which contributes to making cultural capital the main determinant of school and occupational success.

Barone (2006) used PISA 2000 data from 25 countries to test the Cultural Capital Theory, using indices of cultural capital from the PISA questionnaire and SES and parental education as indicators of social class. Barone concluded that the indicators of family cultural capital had only modest explanatory power, and observed that the effects of these variables may be better interpreted as indirect signs of the importance of cognitive resources. He also suggested that the limited explanatory power of Cultural Capital Theory may be due to the existence of other causal mechanisms that mediate the influence of social origins, such as occupational ambitions.

Influences of Home Environment on Child Development

Much research has focused on what is important for developing children's language and cognitive skills that can ultimately lead to educational success (Park, 2008). One such factor is parental reading habits, which can create a favorable reading climate (De Graaf, De Graaf, & Kraaykamp, 2000). A great deal of research on child development, especially in the United States, also has highlighted the importance of home literacy environments that stimulate the development of the child's cognitive and language skills (e.g., Farkas & Beron, 2004). Researchers have found substantial differences in home literacy environments of children from high and low SES families, which in turn explain educational differences between the two groups of children (Brooks-Gunn, Klebanov, & Duncan, 1996; Duncan, Brooks-Gunn, & Klebanov, 1994). In the following section we review some of the main lines of research on development of literacy and numeracy skills.

HOME ENVIRONMENT AND THE ACQUISITION OF LITERACY SKILLS In order to understand how parental education and gender influence the development of early literacy and numeracy skills, it is useful to take as a starting point what is known about the general mechanisms and factors which are important for the acquisition of these skills. Much more research has been conducted on literacy than on numeracy skills, so we begin with the literacy research.

The U.S. National Early Literacy Panel (2008) has conducted a research synthesis in the form of multiple meta-analyses of approximately 500 empirical early literacy studies. The synthesis, titled *Developing Early Literacy*, identified six variables as being important precursors and predictors of reading skills, including the following: alphabet knowledge; phonological awareness (the ability to detect, manipulate, or analyze the auditory aspects of spoken language independent of meaning); ability to write letters in isolation or write one's name; phonological memory (the ability to remember spoken information for a short period of time); and rapid automatized naming of letters/digits and of objects/colors.

Additional meta-analyses included in *Developing Early Literacy* focused on the effects of different types of interventions in determining the effectiveness of instructional strategies, programs, or practices in teaching literacy skills or the precursor skills. For example, code-focused interventions are designed to teach skills related to cracking the alphabetic code, and typically included phonological awareness instruction. This type of intervention yielded moderate

to large effects on the predictors of literacy and on conventional measures of literacy. Shared reading interventions basically involved reading books to children. Book-sharing interventions produced moderate-size effects on children's oral language skills and print knowledge. There were no differences in the effects of shared reading based on whether parents or teachers did the reading.

Parent and home programs interventions use parents as agents of intervention and include interventions that teach parents instructional techniques for use with their children at home. These interventions yielded a moderate to large effect on oral language outcomes and on general cognitive abilities. However, the design of the programs varied greatly, with some having general goals of improving children's health, behavior, or cognitive functioning, and others more specific goals such as improving children's oral language skills. Language enhancement interventions examined the effectiveness of instructional efforts aimed at improving young children's language development. These interventions succeeded in increasing children's oral language skills to a large degree.

There was little evidence that literacy interventions were differentially effective in terms of gender or SES. However, this may be because few studies reported the results of such interactions.

The findings from these meta-analyses of interventions suggest that parents and preschools can influence the literacy development of young children. These studies show that learning resulted from teaching children phonological awareness, reading to the child, involving parents in their children's learning, and teaching oral language skills. The fact that these effects have been demonstrated with experimental designs and systematic syntheses of findings is important, because this makes inferences about causality credible. The problem of explaining why parental education and gender is associated with educational achievement cannot easily be approached with experimental designs, but in cross-sectional surveys we can take advantage of results based on experimental studies. Thus, if it can be demonstrated that parents with a higher level of education to a larger extent are involved in activities and practices that have been shown through experimental work to have positive effects on literacy development than are parents with a lower level of education, this provides support for an explanation of the effects of parental education as being mediated by these activities and practices.

As has already been pointed out, a large body of literature has demonstrated strong effects of SES, in particular parental education, on the reading skills and academic achievements of the child (e. g. Davis-Kean, 2005; Hecht, Burgess, Torgesen, Wagner, & Rashotte, 2000; Lyster, 2002; Myrberg & Rosén, 2009; Raz & Bryant 1990; Sénéchal & LeFevre, 2002). In general, this relationship has been attributed to parents' beliefs, values, expectations, attitudes and behaviors: well educated parents appear to have high expectations of their children, while at the same time adapting their expectations to the performance of their children. In contrast, parents with little education tend to have lower, or sometimes unrealistically high, expectations of their children. Also, high parental education is related to a warm, social climate in the home (Duncan, Brooks-Gunn & Klebanov, 1994).

Along similar lines, parents with higher education tend to interact more verbally with their child; they use more abstract words, more complex syntax, and invite their child more often into decontextualized discourse (Bernstein, 1971), book-sharing, and dialogical reading (Jordan, Snow, & Porsche, 2000). These language practices mirror the language of books and school and foster good literacy skills (Tabors, Snow, & Dickinson, 2001).

Sénéchal and LeFevre (2002) found that informal shared reading of storybooks during preschool years seemed unrelated to parents' teaching of reading. The authors demonstrated in a longitudinal study that different types of activities also are associated with different outcomes. The link between parents' reports of teaching reading and reading storybooks with children was indirect and mediated through children's emergent literacy skills. The variables that were directly related to reading skills at the end of the first grade were those most closely tied to the mechanics of reading. However, the pathways for reading achievement in the third grade were different. Reading storybooks at home predicted children's receptive language skills both concurrently and longitudinally. Sénéchal and LeFevre found that children's exposure to storybooks at home began to show a strong link to reading performance once the mechanics of reading were under control and children were reading fluently. Their results thus indicate that children must acquire sufficiently fluent decoding skills before receptive language skills can exert their full influence.

As noted by Snow, Burns, and Griffin (1998), vocabulary knowledge has been shown in several studies to be a major correlate of reading comprehension, and comprehension is diminished by lack of relevant word knowledge. Hart and Risley (1995) studied vocabulary development of one- to three-year-olds

as related to parental communication patterns. Parents with an academic background made use, on average, of three times as many words per hour as parents on welfare, and their children's vocabulary development appeared to mirror this difference: by age three the children in "the academic group" had a vocabulary of 1500 versus 500 in the "welfare group." The authors argued that differences in parental language pattern contributed to a "language gap" between children from high and low social classes of many thousands of words at later ages.

The meta-analyses included in *Developing Early Literacy* also suggest that phonological awareness is causally related to early reading acquisition. Raz and Bryant (1990) concluded on the basis of a longitudinal study that SES differences in decoding skills can be entirely explained by the influences of SES factors on phonological awareness. Hecht, Burgess, Torgesen, Wagner, and Rashotte (2000) also found that social class differences in early reading acquisition could partly be accounted for by differences in phonological abilities and that levels of print knowledge (i.e., knowledge about books and reading) to a large extent accounted for SES differences.

Based on the literature reviewed above, it is reasonable to hypothesize that SES effects on reading acquisition are mediated via both phonological and vocabulary skills, and that the SES effects are largely caused by variations in experiences of language and text (Noble, McCandless, & Farah, 2007). Taken together, these studies emphasize the importance of both the volume and quality of verbal activities and interactions in the home.

HOME ENVIRONMENT AND THE ACQUISITION OF NUMERACY SKILLS Compared to the number of research studies on early literacy, very few have been conducted on early numeracy, and even fewer have simultaneously investigated early literacy and early numeracy. One reason for this is that early numeracy (also referred to as quantitative literacy, or mathematical literacy) is more difficult to define than reading literacy. While there is consensus that number skills form an important aspect of numeracy, many researchers offer a broader view of the nature of numeracy. Thus, Diezman and Yelland (2000) argue that the foundational processes of numeracy are representation, manipulation, reasoning, and problem solving. Classification of objects and shapes, estimating, measuring, and reproducing number patterns are other examples of skills associated with numeracy (Ewers-Rogers & Cowan, 1996). Also, literacy and numeracy often are intertwined (Aiken, 1972). This may be a reason why there are few programs

that are intended to support parental promoting of numeracy development for their children. Furthermore, it has been argued that any program developing language and problem-solving skills at young age will have consequential numeracy effects (Doig, McCrae, & Rowe, 2003).

Anders et al. (2012) report a study which investigated the domain specificity of numeracy and literacy stimulation in home and preschool settings in order to disentangle the effects of the two domains. They argued that it is reasonable to assume that numeracy-related activities and stimulation are especially beneficial for the development of numeracy skills. However, they also recognized that verbal and pre-reading related activities and stimulation may foster the development of numeracy skills. In a longitudinal study, they followed a sample of 532 children attending 97 preschools from ages 3 to 5. There were three waves of measurement at which information about the children's verbal and numeracy skills were collected, along with detailed information about, among other things, literacy- and numeracy-related activities in the home, and measures of preschool structural and process quality.

The study combined interviews and questionnaires with observations in the family setting. Using information from these sources, a literacy scale containing the following ten items was constructed: toys for free expression, number of children's books, books in the household, stimulation to learn the alphabet, stimulation to learn to read, questions in interaction, amount of free discussion, interactions regarding letters, phonological cues, and frequency of shared book reading. A numeracy scale consisting of the following ten items also was constructed: toys to teach colors and shapes, toys to teach numbers, stimulation to learn shapes, stimulation to learn colors, stimulation to learn spatial relationships, stimulation to learn digits, stimulation to learn counting, interaction regarding digits, interaction regarding shape and space, and interaction regarding comparing and classifying. The correlation between the two scales was $r = 0.62$, indicating a moderate degree of relationship.

The data were used to investigate several research questions, but this chapter focuses on results pertaining to effects of the home learning environment on numeracy development. Growth curve modeling was used as the main analytic method. First age, and a set of background variables, were included in the model, and then the literacy and numeracy indicators were included separately as additional predictors. The quality of the home learning environment explained substantial variance in numeracy at the first assessment, but there was no significant effect of home learning environment

on development after the first assessment. The results also showed that the quality of the home environment in terms of promoting literacy skills was more strongly correlated with initial numeracy skills than was the quality of the home environment in terms of promoting numeracy skills.

In addition, the results showed that the influence of maternal educational level and SES decreased when home learning environment was included in the model, suggesting that part but not all of the relationship between family background and numeracy is explained by the quality of the home learning environment. This effect was more pronounced for literacy environment than for numeracy environment.

The study thus showed that the effect on numeracy skills was stronger for quality of literacy stimulation than it was for quality of numeracy stimulation. This was contrary to expectations, and Anders et al. (2012) observed that one reason for this may be that the assessment used to measure numeracy skills required not only numeracy but also language skills. They also argued that adequate language skills are a prerequisite for the acquisition of mathematical knowledge; thus, the quality of the home learning environment with respect to verbal literacy at this early age may have more impact than its quality to promote numeracy. Another possible interpretation was that the literacy scale captured more general beneficial characteristics of home learning environment (e.g., routines) than the numeracy scale. The relative rarity of numeracy-related resources and parental activities also was noted as a possible contributory factor.

GENDER DIFFERENCES The pattern of gender differences in achievement in mathematics and science varies as a function of the age of the students. In analyses of the TIMSS 1995 data, Mullis, Martin, Fierros, Goldberg, and Stemler (2000) found few differences in average mathematics achievement at the fourth and eighth grades, but substantial differences at the twelfth grade. A similar pattern of results was found for science, although gender differences already were present in many countries by the fourth grade.

Other studies also have demonstrated that a male performance advantage in mathematics and science achievement emerges only after elementary school and that it grows larger with increasing age (see Spelke, 2005, for a review). Furthermore, meta-analyses have revealed that most gender differences in cognitive abilities underpinning achievement in these areas are small (Hyde, 2005). In a review of the literature, Spelke (2005) concluded that male and female infants do not differ in the cognitive abilities that form the foundations

of mathematical and scientific thinking, and that male and female children master the concepts and operations of elementary mathematics in the same way at the same time.

Baker and Jones (1993) proposed a gender stratification hypothesis to account for observed gender differences in mathematics and science achievement in the higher grades. The gender stratification hypothesis holds that, in patriarchal cultures, the achievement of male students is linked to their future opportunities. Female students see mathematics and science as less important for their future and are socialized into this mode of thinking by teachers, parents, and friends. Thus, according to the gender stratification hypothesis, opportunity structures shape socialization processes that shape performance. Furthermore, the hypothesis proposes that where there is more societal stratification based on gender, females will perform less well on mathematics and science achievement tests than will males.

Else-Quest, Hyde, and Linn (2010) describe various psychological theories that identify socialization processes accounting for the effects of gender stratification. One of these is the expectancy-value theoretical model proposed by Eccles (1994) to explain the gender gap in mathematics achievement, attitudes, and the underrepresentation of women in fields such as science and engineering. According to this model, people need to value a task to undertake it, and they need to have some expectation of success. Perceptions of the task's value are influenced by, among other things, the culture and cultural stereotypes related to gender and by the person's short-term and long-term goals. Expectations of success are influenced by self-concept, which in turn are influenced by parents' and teachers' attitudes and expectations, which often are gender stereotyped.

Bandura's (1986) cognitive social learning theory also identifies social processes that contribute to the development of gender-typed behavior. According to this theory, role models, socializing agents, and perceptions of gender-appropriate behavior influence an individual's actions and choices. Like the expectancy-value theory, this theory emphasizes the role of self-efficacy in gender-typed behaviors. The theory proposes that girls are attentive to the behaviors that women in their culture engage in, and thus feel efficacious in and model those behaviors. In its emphasis on observational learning and the internalization of cultural norms, the cognitive social learning theory provides an individual-level explanation of why girls act in ways that reproduce societal-level gender stratification.

Given that the students participating in the TIMSS and PIRLS 2011 fourth grade assessment were still quite young (around 10 years old), we do not expect any large gender differences to be seen in mathematics and science achievement. However, gender differences in reading achievement at this level have consistently been found in international assessments (see, e.g., Mullis, Martin, Gonzalez, & Kennedy, 2003; Mullis, Martin, & Kennedy, 2007; Mullis, Martin, Foy, & Drucker, 2012). Research also consistently identifies gender differences in attitudes to reading and in reading motivation. Ming Chui and McBride-Chang (2006) analyzed gender differences in reading comprehension in 43 countries participating in PISA with samples of 15-year-olds and concluded that girls outperformed boys in each and every country. However, even though the size of the gender difference varied across countries, it proved difficult to find variables that mediated the gender difference. Reading enjoyment did mediate the difference to some extent, but this variable could be seen as another outcome variable rather than as an explanatory variable.

It is reasonable to expect that gender differences in reading achievement are partly due to differential opportunities for boys and girls to acquire early literacy skills in the home and preschool. Thus, if it can be demonstrated that girls are more involved in activities and practices shown to have positive effects on literacy development than boys, this can explain some of the observed gender differences in reading achievement.

Results from Previous PIRLS Path Analyses

Given that a Home Questionnaire has been available since the first PIRLS assessment in 2001, there have previously been opportunities for analyzing determinants of reading literacy with path modeling techniques. Park (2008) used data from PIRLS 2001 to compare the ways in which home literacy environment influence reading achievement at the fourth grade in 25 countries. Three measures were used as indicators of home literacy environment: Early Home Literacy Activities Index, which is an average of six items; Number of Books at Home; and Parents Attitudes Toward Reading, which is an index based on four items. Ordinary least squares regression models were developed for each country separately, in which the effects on reading achievement of these three home literacy variables were estimated. A second series of OLS-models investigated the extent to which the home literacy variables mediated the effect of parental education by comparing the gap in reading score between students from high and low parental education groups in models with and without the

three variables. Park reported small mediating effects of early home literacy activities, as it did not reduce the difference between students from the parental education groups by more than 10 percent in any country. The reduction remained modest (20–30%) for most countries also when all three home literacy environment variables were included in the model, even though the reduction exceeded 50 percent for some countries. Separate analyses indicated that Early Home Literacy Activities and Parental Attitudes toward Reading had smaller effects than did Number of Books at Home in 20 of 25 countries. One reason for this may be that the activities and attitudes indices were more influenced by errors of measurement than was the Books variable.

Myrberg and Rosén (2009) used data from the Swedish participation in PIRLS 2001 to estimate the effect of parents' education on children's reading achievement, and to estimate the indirect effects of different mediating factors. Effects of parental education were hypothesised to be mediated through the number of books in the home, via early reading activities with the children during the preschool years and via the children's early reading abilities.

The study made use of structural equation modelling with latent variables. In the first step, the measurement model was created, in which the latent variables were defined in terms of their relation to observed variables. The measurement model included four latent variables: Parental Education, with mother's education and father's education as indicators; Books at Home, measured by number of books in the home and by number of children's books in the home; Early Reading Activities, measured by two items from the Home Questionnaire (read with child, and tell stories to child); and Early Reading Abilities at School Start, measured by three items (recognize letters, read words and read sentences).

Based on the measurement model, the path model specified how the latent variables were expected to influence each other and the reading achievement outcome variable. The latent variables were ordered chronologically and logically as follows: Parental Education preceded Books at Home, which preceded the Early Reading Activities with the preschool child, which preceded Early Reading Abilities at School Start (the child's emergent literacy at the beginning of first grade), which preceded the PIRLS reading achievement score.

While the direct effect of Parental Education on reading achievement was modest (.17), the total effect was substantial (.34). This estimate agreed with what has been found in previous research (White, 1982; Yang, 2003). The total indirect effect, which is the difference between the total effect and direct effect,

thus accounted for about 50 percent of the total effect. The strongest indirect effects went via Books at Home, of which the most important was directly from Books at Home to achievement. Two minor indirect effects were mediated through Early Reading Activities, one directly to reading achievement and one via Early Reading Abilities. Finally, there was an indirect effect of Parental Education via Early Reading Abilities. The model thus explains a part of the effect of parents' education on achievement in terms of books at home and use of those books for literacy purposes.

Method

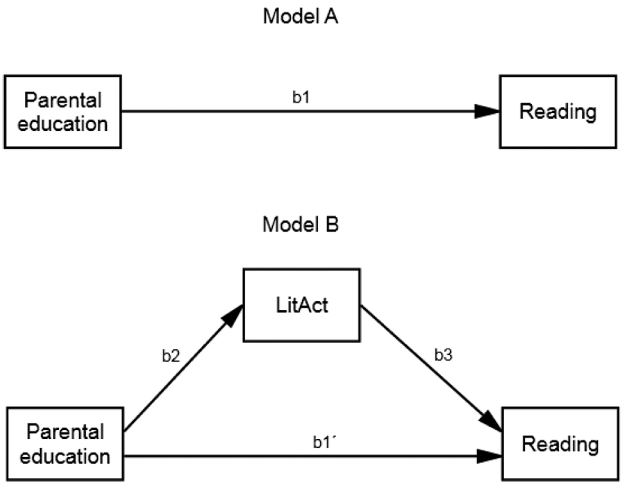
The model applied in this study is an extension of the Myrberg and Rosén (2009) model. Besides parental education, the present study includes gender as an independent variable. Also, the TIMSS and PIRLS 2011 Home Questionnaire inquired about numeracy *and* literacy activities in addition to numeracy *and* literacy skills when beginning primary school; therefore, in this extended model, the numeracy-literacy distinction is central. Furthermore, the extended model includes three outcome achievement variables: reading, mathematics, and science.

The Modeling Approach

This study aims to investigate the effects of the two independent variables—parental education and gender—on the three dependent variables—reading, mathematics, and science achievement—allowing for the possibility that there are both direct relationships between the independent variables and the dependent variables, and relationships involving other variables, which simultaneously behave as independent and dependent variables.

We may, for example, hypothesize that one reason why we observe a relationship between parental education and reading achievement is that the frequency of literacy activities (LitAct) is higher in homes with more highly educated parents than in homes where the parents have a lower level of education. Another way to express this is to say that parental education influences LitAct, which in turn influences reading achievement. In Exhibit 4.1, two simple models are shown: Model A, and Model B. In Model A, there is a direct relationship between Parental Education and Reading. The regression coefficient (b1) expresses the "direct" effect of Parental Education on Reading achievement. In this model, the direct effect also is the "total" effect because the regression expresses the maximum linear relationship between the independent and the dependent variables.

Exhibit 4.1: Two Path Models for Relationships between Parental Education and Reading Achievement



In Model B there is a path between Parental Education and LitAct, with regression coefficient b2, and also a path between LitAct and Reading (b3). These two relationships constitute an indirect relationship between Parental Education and Reading and the product of b2 and b3 represents the strength of this relationship. In Model B there also is a direct relationship between Parental Education and Reading achievement (b1´). The coefficient b1´ is not the same as coefficient b1 in Model A because b1 = b1´+ b2b3. This means that the total effect of Parental Education on Reading (i.e., b1) can be decomposed into one direct effect (b1´) and one indirect effect (b2b3). If b2 and b3 both are positive (which of course is not necessarily the case), b1´ will be smaller than b1. In substantive terms, Model B partially explains the relationship between Parental Education and Reading achievement in terms of a mediating mechanism, through which parents with higher levels of education involve their children in literacy activities to a larger extent than parents with lower levels of education, and these literacy activities in turn have a positive effect on reading achievement.

The mediating effect may account for only a part of the total effect, in which case further mediating variables and mechanisms might be sought for. It may also be that the indirect effect is as large as the total effect, so that there is no direct effect. This is referred to as "complete mediation."

This simple example describes the general principles for distinguishing between total, direct, and indirect effects, which we apply in this study in analyzing the effects of parental education and gender on fourth grade student achievement.

The extension of the Myrberg and Rosén (2009) model described above has guided the construction of the models that we have tested against the data in this study. The translation of a conceptual model to a path model that can be estimated and tested empirically involves several steps. The first step is to specify the variables to be included in the model and the second step is to propose a hypothesized path model. In the third step, the model is estimated from data and the goodness-of-fit of the model is evaluated. The fourth and final step is to compute the total and indirect effects, and to interpret these. Each of these steps are described in the following section.

Developing the Measurement Model

The Home Questionnaire inquires about both numeracy and literacy activities in the home, and about the child's abilities in performing numeracy and literacy tasks. The starting point for the selection of items to be included in the analysis was the items in the four TIMSS and PIRLS 2011 background scales: Early Literacy Activities Before Beginning Primary School (9 items), Early Numeracy Activities Before Beginning Primary School (6 items), Could Do Early Literacy Tasks When Began Primary School (5 items), and Could Do Early Numeracy Tasks When Began Primary School (6 items). The items in these scales are presented in Exhibit 4.2.

Exhibit 4.2: Items in the Scales Measuring Literacy and Numeracy Activities, and Literacy and Numeracy Skills at Start of School

Items in the Early Litreracy Activities Before Beginning Primary School Scale

Before your child began primary/elementary school, how often did you or someone else in your home do the following activities with him or her?

	Often	Sometimes	Never or almost never
1) Read books	○	○	○
2) Tell stories	○	○	○
3) Sing songs	○	○	○
4) Play with alphabet toys (e.g., blocks with letters of the alphabet)	○	○	○
5) Talk about things you had done	○	○	○
6) Talk about what you had read	○	○	○
7) Play word games	○	○	○
8) Write letters or words	○	○	○
9) Read aloud signs and labels	○	○	○

Exhibit 4.2: Items in the Scales Measuring Literacy and Numeracy Activities, and Literacy and Numeracy Skills at Start of School (Continued)

Items in the Early Numeracy Activities Before Beginning Primary School Scale

Before your child began primary/elementary school, how often did you or someone else in your home do the following activities with him or her?

	Often	Sometimes	Never or almost never
1) Say counting rhymes or sing counting songs	○	○	○
2) Play with number toys (e.g., blocks with numbers)	○	○	○
3) Count different things	○	○	○
4) Play games involving shapes (e.g., shape sorting toys, puzzles)	○	○	○
5) Play with building blocks or construction toys	○	○	○
6) Play board games or card games	○	○	○

Items in the Could Do Early Literacy Tasks When Began Primary School Scale

How well could your child do the following when he/she began primary/elementary school?

	Very well	Moderately well	Not very well	Not at all
1) Recognize most of the letters of the alphabet	○	○	○	○
2) Read some words	○	○	○	○
3) Read sentences	○	○	○	○
4) Write letters of the alphabet	○	○	○	○
5) Write some words	○	○	○	○

Items in the Could Do Early Numeracy Tasks When Began Primary School Scale

Could your child do the following when he/she began primary/elementary school?

	Up to 100 or higher	Up to 20	Up to 10	Not at all
1) Count by himself/herself	○	○	○	○

	More than 4 shapes	3–4 shapes	1–2 shapes	None
2) Recognize different shapes (e.g., square, triangle, circle)	○	○	○	○

	All 10 numbers	5–9 numbers	1–4 numbers	None
3) Recognize the written numbers from 1–10	○	○	○	○
4) Write the numbers from 1–10	○	○	○	○

	Yes	No
5) Do simple addition	○	○
6) Do simple subtraction	○	○

These scales have been carefully constructed and their psychometric properties are well documented (Martin, Mullis, Foy, & Arora, 2012). However, the relatively limited number of items in the scales causes their reliabilities, which vary between .66 and .90, to be somewhat too low to be used as manifest variables in a path model. One solution to this problem could have been to define error-free latent variables with the items in the scales as indicators. However, this would have required 26 variables for this part of the model alone, which would have caused the complete model to be unwieldy and tedious to estimate. Instead, a compromise solution was adopted, where "testlets" were created by dividing the items in each scale into two random halves and using these as indicators of latent variables.

A major advantage of using latent variables when investigating chains of relationships among different determinants is that the relationships are not affected by errors of measurement in the observed variables (see, e.g., Brown, 2006). However, latent variable models often are afflicted by other problems. A common problem encountered in application of latent variable models is multicollinearity, which occurs when two or more independent variables are highly correlated. In this situation, there is too little unique information available for each independent variable, making it impossible to achieve stable and interpretable estimates of the influence of these variables on the dependent variable.

The fact that variables are sometimes difficult to separate from one another is, however, above all a conceptual problem. A common reason for overlap between observed variables is that, to a large extent, they measure the same underlying variable. For example, when parents estimate how often literacy and numeracy activities have taken place in the home, it may be that their responses reflect a general level of educationally-oriented activities with the child, rather than specifically whether the activities were of literacy or numeracy kinds. If that is the case, the literacy and numeracy scales would be highly correlated and multicollinearity problems would occur if both were used as independent variables.

At the same time, because we may expect differences between families with respect to the general level of activities, it is also reasonable to expect that the balance of numeracy and literacy activities varies between families, such that in some families there is more of literacy activities than numeracy activities while in other families there is more of numeracy activities than literacy activities. There also may be differences between countries in these respects. A model with two correlated latent variables representing the amount of numeracy and literacy activity, respectively, allows us to determine the impact that the two types of

activity have on educational achievement. These impacts are determined in such a way that the effect of literacy activity is determined with the level of numeracy kept constant, and vice versa. However, with this approach to measurement it is not possible to see the effect of differences in level of activity on achievement, because these differences only affect the correlation between the two variables. If this correlation is high, the analysis will be affected by multicollinearity and we still will not be able to determine any effects of general level of activity, because general level of activity is not represented by any variable.

While the traditional approach to measurement would suggest construction of two separate, but correlated, measures of literacy and numeracy activities, other approaches also are possible. In many fields of research, there is a need to identify both broader, more general aspects of phenomena, and more narrow or specific aspects (Gustafsson & Åberg-Bengtsson, 2010). Some examples of such fields are research on cognitive abilities, educational achievement, and personality, where it is easy to identify variables which have a broad scope of reference and variables which have a narrow scope of reference (Gustafsson, 2002).

Recently, special techniques have been developed for modeling data with latent variables of different degrees of generality. These modeling approaches are referred to as "bi-factor models" (e.g., Reise, 2012) or as "nested-factor models" (Gustafsson & Balke, 1993). With this approach, a general latent variable is typically identified for a domain of observations, along with narrow latent variables which account for observed differences on subsets of variables.

Such a bi-factor modeling approach is suitable in this case because we are interested in determining the effects both of the general level of activities in the home, and of the balance between numeracy and literacy activities. A latent variable model has therefore been constructed in such a manner that there is one general activity variable (Activity), which is taken to be positively related to the four manifest testlet variables, and there is one latent variable which represents

a contrast between numeracy activities on the one hand and literacy activities on the other hand. This latent variable (NumLitAct) has fixed relationships of positive unity to the two testlets representing literacy activity (LITACT1 and LITACT2) and fixed relations of negative unity to the two testlets representing numeracy activity (NUMACT1 and NUMACT2). The NumLitAct variable thus represents the degree of balance between the two types of activity, with positive values indicating more literacy than numeracy activity and negative values indicating more numeracy than literacy activity.

A similar line of reasoning can be applied to the parents' reports of how well the child could do various numeracy and literacy tasks before beginning primary school. Here, too, there is reason to expect a high level of correlation between the measures from the two domains, suggesting that a more appropriate approach would be to define one latent variable representing ability to do both kinds of tasks (Ability), and a second latent variable representing ability to do literacy tasks better than numeracy tasks (NumLitAb). These two latent variables were constructed in the same manner as the two activity latent variables. Thus, the NumLitAb variable was specified to have fixed relations of unity to the two testlets representing literacy skills (LITAB1 and LITAB2) and fixed relations of negative unity to the two testlets representing numeracy skills (NUMAB1 and NUMAB2). The Ability variable was specified to be related to all these four testlets.

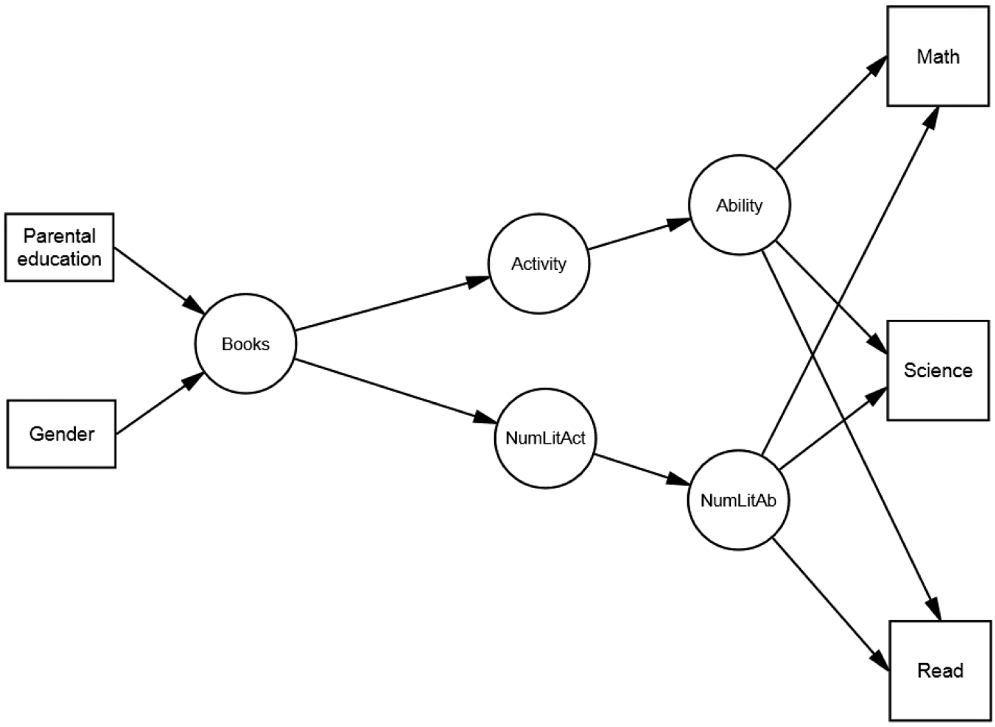
The measurement model included one additional latent variable representing literacy resources in the home. The Books latent variable had two indicators: the number of books in the home (NBOOK), and the number of children's books in the home (NCBOOK), as reported by the parents.

The model also included two independent variables, parental education and gender. Parental Education was defined as the highest level of education of either parent, and Gender was represented by a binary variable (boy = 0 and girl = 1).

The Hypothesized Path Model

Exhibit 4.3 presents a schematic and highly simplified version of the hypothesized path model.

Exhibit 4.3: A Schematic Description of the Hypothesized Path Model



While Exhibit 4.3 presents the two independent variables (Parental Education and Gender) and all of the latent variables in the model, as well as the three dependent variables (achievement in mathematics, science, and reading). For clarity, the observed variables that serve as indicators of the latent variables are not shown. According to this model, the latent variable Books influences Activity and NumLitAct, and these in turn influence Ability and NumLitAb, respectively. The latter two latent variables are assumed to influence the three achievement variables. This model thus formulates the hypothesis that Parental Education and Gender influence the extent to which Books are available in the home, and that these in turn influence both the general level of Activity of educational tasks in the home and the balance between numeracy and literacy activities, which in turn influence the child´s Abilities at the start of primary school.

Compared to the model that was actually estimated, the model shown in Exhibit 4.3 presents only a small subset of the relationships among variables. The estimated model was a "saturated" model in which each variable in the

path model was related to every other variable to the right of it. Thus, each and every variable was predicted by Parental Education and Gender, Books predicted all the latent variables, and so on. Many of these direct effects were found to be non-significant, but no attempts were made to prune away non-significant relationships from the models.

In addition to estimation of the direct effect of one variable on another, total and indirect effects were computed. The total effect of an independent variable on a dependent variable is the sum of the direct effect and of all indirect effects. A specific indirect effect is a function of the product of the path coefficients encountered along a particular route from the independent variable to the dependent variable. The total indirect effect is the sum of all possible specific indirect effects.

Estimation

In the first step of estimation, a single model based on the combined data from all 37 participants was fitted. This Common model was estimated using the two-level modeling technique available in the Mplus program (Muthén & Muthén, 1998–2012), with country as the between-level, and students within country as the within-level. For the between-level, a saturated model was fitted which freely estimated the covariances among the country means. For the within-level, the saturated path model was fitted. This model thus was fitted to the pooled-within matrix for all the participating countries, which is not influenced by any mean differences across countries.

In the next step of analysis, a separate model was fitted for each country. These models were estimated with the Mplus 7.11 program (Muthén & Muthén, 1998–2012), using the MLR estimator. This estimator takes non-normality of the distributions of the observed variables into account, and corrects for the underestimation of standard errors that is caused by deviations from the assumption of multivariate normality that the maximum likelihood estimator is based upon. The so called "Complex option" in Mplus also was used, with school as the cluster variable, to correct for underestimated standard errors due to the cluster sampling techniques employed in drawing the samples in each country. In the analysis, individual student case weights (HOUWGT) were used.

The analyses took into account all five plausible values (PVs) available for each of the three achievement measures by relying on the Mplus Imputation facility, which computes one analysis for each PV and then combines these into a single parameter estimate and a single estimate of the standard error. However,

this procedure was not available for the estimation of total and indirect effects; therefore, in order to obtain estimates based on all five PVs a special program written using the Model Constraints facility available in Mplus. All of the parameter estimates and standard errors presented in this chapter thus are based on five plausible values.

The fit of the model to the data was evaluated with a set of tests and indices computed by the Mplus program. One basic source of information about the degree of fit of a model to data is the chi-square goodness-of-fit test, which for a well-fitting model should be non-significant. Mplus computes the test once for each plausible value, and reports the mean and standard deviation of the five results. A difficulty with the chi-square test statistic is that it increases as a function of sample size; therefore, given the large number of observations in our data, the test is practically always significant, indicating that the model should be rejected as not fitting the data. However, this is because the large number of observations provides statistical power to detect even trivial deviations between the model and data. Thus, for these analyses there was a need for indices of fit that provide information about the degree of deviation between the model and data.

One such measure is the Root Mean Square Error of Approximation (RMSEA), which indicates the degree of deviation between model and data, taking into account both model complexity and sample size. RMSEA should be as low as possible, preferably lower than .05 (or .07-.08). Another useful measure is the Comparative Fit Index (CFI), which should be higher than .95 and as close to unity as possible. The Standardized Root Mean Square Residual (SRMR) measures the amount of deviation between the elements of the observed covariance matrix and the model-implied matrix, and according to the rules of thumb this measure should be lower than .08.

Descriptive Statistics

Exhibit 4.4 presents the means and standard deviations of the independent and mediating variables used in the analyses. The variables have been coded in such a way that higher values imply a higher level on the dimension measured, except for the dummy variable Gender where boys = 0 and girls = 1.

The Parental Education variable is based on the ISCED coding. The highest levels of Parental Education were reported for United Arab Emirates (Dubai),

Norway, the Russian Federation, Canada (Quebec), Australia, Qatar, Finland, and Sweden, and the lowest levels were reported for Honduras, Morocco, Botswana, Iran, and Oman. The proportion of girls varied between .52 (Norway, Saudi Arabia, and Botswana) and .48 (Morocco, Poland, and Romania).

The highest means for number of Books at home were observed for Sweden, Norway, Australia, Germany, and Finland, while the lowest means were observed for Morocco, Honduras, Botswana, Iran, and Azerbaijan. For children's books the highest means were observed for Australia, Sweden, Finland, Malta, and Norway and the lowest means were observed for the same group of countries as had the smallest number of books at home. The country level correlation between the two measures of book availability in the home was 0.92.

The results for the two Activity variables have been computed from the IRT-scaled indices in the TIMSS and PIRLS 2011 International Database. The highest level of literacy activities was reported by Northern Ireland, the Russian Federation, Australia, Ireland, and Croatia, while the highest level of numeracy activities was reported by Northern Ireland, Hungary, the Slovak Republic, the Czech Republic, and the Russian Federation. There was a general tendency for countries that reported a high level of literacy activity to also report a high level of numeracy activity, with a correlation of .82.

For literacy skills the highest means were observed for Singapore, Honduras, Hong Kong SAR, and Qatar; for numeracy skills, the highest means were observed for Hong Kong SAR, Chinese Taipei, Singapore, and Finland. Here, too, there was quite a substantial correlation (.73) between the literacy and numeracy measures.

At the country level, there were negative correlations between the two activity variables on the one hand, and the two skills variables on the other hand, with correlations ranging between -.26 and -.51. The two measures of number of books in the home correlated positively with the two activity measures, and negatively with the measures of literacy skills, while there was no correlation with the numeracy skills measure. These results suggest that the pattern of interrelations among the variables at country level may be quite different from the pattern of intercorrelations within countries.

Exhibit 4.4: **Descriptive Statistics**

Country	Parental Education		Gender		Books at Home		Childrens Books	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Australia	5.16	0.90	0.49	0.50	3.68	1.17	3.91	1.07
Austria	4.55	0.92	0.49	0.50	3.43	1.21	3.33	1.18
Azerbaijan	4.56	1.11	0.47	0.50	2.14	1.07	1.64	0.85
Chinese Taipei	4.58	1.00	0.47	0.50	2.79	1.29	2.94	1.40
Croatia	4.53	0.88	0.50	0.50	2.74	1.18	2.38	1.10
Czech Republic	4.52	0.88	0.49	0.50	3.44	1.14	3.29	1.05
Finland	5.07	0.96	0.49	0.50	3.53	1.16	3.70	1.04
Georgia	4.97	1.00	0.48	0.50	3.28	1.32	2.26	1.15
Germany	4.45	1.28	0.49	0.50	3.55	1.22	3.46	1.11
Hong Kong, SAR	4.00	1.22	0.46	0.50	2.62	1.20	2.68	1.28
Hungary	4.08	1.39	0.49	0.50	3.43	1.33	3.10	1.27
Iran, Islamic Republic of	3.62	1.35	0.49	0.50	2.03	1.14	1.87	1.08
Ireland	4.87	1.10	0.49	0.50	3.23	1.26	3.48	1.21
Italy	4.24	1.10	0.50	0.50	2.99	1.26	2.67	1.14
Lithuania	4.78	1.09	0.48	0.50	2.91	1.24	2.49	1.14
Malta	3.99	1.22	0.49	0.50	3.21	1.26	3.70	1.05
Morocco	3.02	1.28	0.48	0.50	1.68	0.97	1.52	0.90
Northern Ireland	4.51	1.36	0.50	0.50	3.31	1.23	3.68	1.14
Norway	5.37	0.87	0.52	0.50	3.72	1.18	3.68	1.08
Oman	3.96	1.44	0.49	0.50	2.26	1.13	1.71	0.93
Poland	4.31	1.28	0.48	0.50	3.09	1.17	2.95	1.12
Portugal	4.08	1.39	0.49	0.50	2.84	1.27	2.91	1.22
Qatar	5.11	1.27	0.47	0.50	2.57	1.27	2.22	1.21
Romania	3.98	1.19	0.48	0.50	2.41	1.31	2.11	1.14
Russian Federation	5.29	0.82	0.49	0.50	3.23	1.16	2.96	1.13
Saudi Arabia	4.32	1.50	0.52	0.50	2.28	1.23	1.67	0.96
Singapore	4.78	1.17	0.49	0.50	2.80	1.21	3.24	1.22
Slovak Republic	4.51	0.98	0.49	0.50	3.01	1.17	2.74	1.09
Slovenia	4.65	0.89	0.48	0.50	3.13	1.15	3.06	1.11
Spain	4.41	1.35	0.49	0.50	3.30	1.23	3.07	1.18
Sweden	5.05	0.99	0.49	0.50	3.78	1.19	3.76	1.12
United Arab Emirates	5.01	1.29	0.50	0.50	2.43	1.23	2.14	1.17
Sixth Grade Countries								
Botswana	3.31	1.46	0.52	0.50	1.81	1.06	1.57	0.93
Honduras	2.91	1.40	0.51	0.50	1.76	1.05	1.42	0.84
Benchmarking Participants								
Quebec, Canada	5.24	0.85	0.50	0.50	3.11	1.21	3.39	1.13
Abu Dhabi, UAE	4.94	1.31	0.50	0.50	2.36	1.21	2.03	1.11
Dubai, UAE	5.38	1.07	0.47	0.50	2.71	1.28	2.62	1.31

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.4: Descriptive Statistics (Continued)

Country	Literacy Activities		Numeracy Activities		Literacy Skills		Numeracy Skills	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Australia	10.87	2.09	10.66	1.93	9.74	1.72	9.23	1.84
Austria	10.02	1.74	10.45	1.64	9.22	1.87	9.39	1.85
Azerbaijan	9.50	1.83	9.09	1.81	9.61	2.16	9.43	2.20
Chinese Taipei	8.69	1.91	9.18	2.18	10.70	1.48	11.65	1.41
Croatia	10.75	1.76	10.53	1.70	10.66	1.71	10.37	1.67
Czech Republic	10.29	1.62	11.02	1.53	9.79	1.83	9.97	1.71
Finland	9.78	1.51	9.50	1.43	10.22	1.98	10.64	1.77
Georgia	10.70	1.93	9.46	2.08	9.64	2.18	9.99	1.92
Germany	10.20	1.72	10.43	1.64	9.23	1.79	9.74	1.77
Hong Kong, SAR	8.70	1.72	9.15	1.92	11.06	1.57	11.66	1.33
Hungary	10.29	1.69	11.11	1.70	8.89	2.08	9.69	1.89
Iran, Islamic Republic of	8.91	1.87	9.25	1.97	9.71	2.18	9.40	2.19
Ireland	10.80	2.02	10.90	1.94	–	–	–	–
Italy	10.50	1.74	10.30	1.72	9.42	1.74	9.04	1.82
Lithuania	10.05	1.72	9.94	1.64	10.19	1.54	9.90	1.86
Malta	10.43	1.94	10.34	2.01	10.36	1.77	10.14	1.78
Morocco	8.42	2.70	8.19	2.33	10.20	2.29	9.22	2.52
Northern Ireland	11.19	2.04	11.20	1.89	9.31	1.69	8.59	1.74
Norway	10.08	1.78	9.81	1.61	9.22	1.91	9.49	1.81
Oman	9.25	1.70	8.93	1.88	10.86	1.75	10.47	1.87
Poland	10.41	1.76	10.76	1.64	10.08	1.86	9.67	1.88
Portugal	10.00	1.88	9.86	1.82	9.46	1.70	9.40	1.79
Qatar	9.69	1.88	9.76	2.05	11.02	1.79	10.61	1.87
Romania	9.95	2.52	9.74	2.48	9.24	2.15	9.90	2.34
Russian Federation	11.09	1.95	10.90	1.86	9.92	1.94	10.36	1.86
Saudi Arabia	9.55	1.84	9.46	1.96	10.76	2.05	10.32	1.94
Singapore	9.44	2.07	9.70	2.14	11.19	1.60	11.37	1.50
Slovak Republic	10.52	1.83	11.08	1.78	8.62	1.86	9.32	2.01
Slovenia	10.62	1.78	10.41	1.65	9.34	2.01	9.30	1.86
Spain	10.38	1.77	9.96	1.73	10.97	1.81	10.33	1.80
Sweden	9.99	1.78	9.43	1.69	10.39	1.77	10.24	1.78
United Arab Emirates	9.64	1.78	9.91	1.90	10.61	1.82	10.26	1.90
Sixth Grade Countries								
Botswana	8.68	2.05	8.26	2.19	10.17	2.04	9.05	2.25
Honduras	9.63	2.24	8.15	2.44	11.13	1.83	10.33	1.94
Benchmarking Participants								
Quebec, Canada	10.18	1.80	10.38	1.74	9.61	1.71	9.39	1.83
Abu Dhabi, UAE	9.53	1.74	9.79	1.87	10.60	1.85	10.40	1.87
Dubai, UAE	9.97	1.86	10.17	1.92	10.64	1.78	9.99	1.91

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Results from the Common Model for Pooled Data

The path model for the pooled data was estimated as a two-level model, using the procedures described above. The model involved the 34 participating countries and 3 benchmarking entities, which represented the between level, and 185,475 students. For each variable and each observation, the deviation from the international mean was used to compute the pooled within covariance matrix, to which the model was fitted.

As expected, the chi-square test was highly significant, with a mean across the five estimations of 1512.86 (df = 78) and a standard deviation of 10.77. From a strict statistical point of view this would imply that the model should be rejected as not fitting the data. However the mean estimate of RMSEA was 0.01 with a standard deviation across replications of 0, which indicates excellent fit. The CFI estimate was .986, again with a standard deviation of 0. Thus, this index also indicates an excellent fit between model and data. Finally, the Standardized Root Mean Square Residual (SRMR) for the within level was only 0.012, which again indicates a well-fitting model. Thus, we may conclude that the model provides an adequate representation of the data.

The Measurement Model for Pooled Data

As was described in the Method section, two testlets were built from the items included in each of the scales constructed to measure numeracy activities (NUMACT1, NUMACT2) and literacy activities (LITACT1, LITACT2), in addition to numeracy skills (NUMAB1, NUMAB2) and literacy skills (LITAB1, LITAB2) at the start of school. Given that these four scales comprise a relatively limited number of items, each of the eight testlets only included between two and five items. The small number of items makes the two testlets in each pair less than perfectly comparable as indicators of the latent variable. This was apparent in the form of some rather large modification indices for the relationships between the observed and latent variables. However, no attempt was made to adjust for this, for example by moving items from one testlet to another.

It will be remembered that one general latent Activity variable was hypothesized; with positive relationship with NUMACT1, NUMACT2, LITACT1 and LITACT2, and also that a general latent Ability variable was hypothesized, with a positive relationship with NUMAB1, NUMAB2, LITAB1 and LITAB2. It also was hypothesized that there would be a bipolar NumLitAct latent variable, with a negative relationship with NUMACT1 and NUMACT2 and a positive relationship with LITACT1 and LITACT2, as well as a bipolar

NumLitAb latent variable with a negative relationship with NUMAB1 and NUMAB2 and a positive relationship with LITAB1 and LITAB2. When estimating the model, the bipolar factors were defined by assigning fixed values of -1 and 1 to the unstandardized factor loadings, while for the two general factors one of the indicators was assigned a fixed value of unity and the loadings for the other three indicators were freely estimated. The standardized factor loadings are easier to interpret, however, so discussion focuses on these (see Exhibit 4.5).

Exhibit 4.5: Standardized Factor Loadings in the Measurement Model for the Common Model

	Activity		NumLitAct		Ability		NumLitAb		Books	
Indicator	Beta	t-value	Beta	t-value	Beta	t-value	Beta	t-value	Beta	t-value
LITACT1	0.78	95.69	0.23	56.97						
LITACT2	0.78	99.35	0.22	52.95						
NUMACT1	0.78	82.01	-0.20	-57.63						
NUMACT2	0.77	100.88	-0.19	-47.87						
LITAB1					0.90	234.47	0.29	79.81		
LITAB2					0.88	169.87	0.28	85.77		
NUMAB1					0.75	79.62	-0.47	-45.05		
NUMAB2					0.74	73.67	-0.43	-51.70		
NBOOK									0.80	58.12
NCBOOK									0.80	66.03

For the latent variable Activity, all four indicators had large positive loading of equal magnitude (0.78). The loadings were smaller for the bipolar NumLitAct variable, with absolute values of around .20, meaning that this latent variable accounted for only around 4 percent of the observed variance in each testlet. Positive values on this bipolar latent variable indicate more literacy than numeracy activities, while negative values indicate more numeracy than literacy activities.

For the latent variable Ability, there also were large positive loadings for the four indicators. However, loadings were larger for the two indicators of literacy abilities (around .90) than for the two indicators of numeracy abilities (around .75). For the latent variable NumLitAb, the bipolar pattern was evident, and this latent variable had stronger relationships with the testlets than had the bipolar activity factor, and particularly so with respect to the numeracy testlets. These patterns of relationships indicate that the literacy skills are of greater importance as indicators of a general ability, while the numeracy skills tend to be a narrower dimension. Nevertheless, the interpretation of the NumLitAb factor is that positive values indicate relatively higher literacy than numeracy skills, while negative values indicate relatively higher numeracy skills.

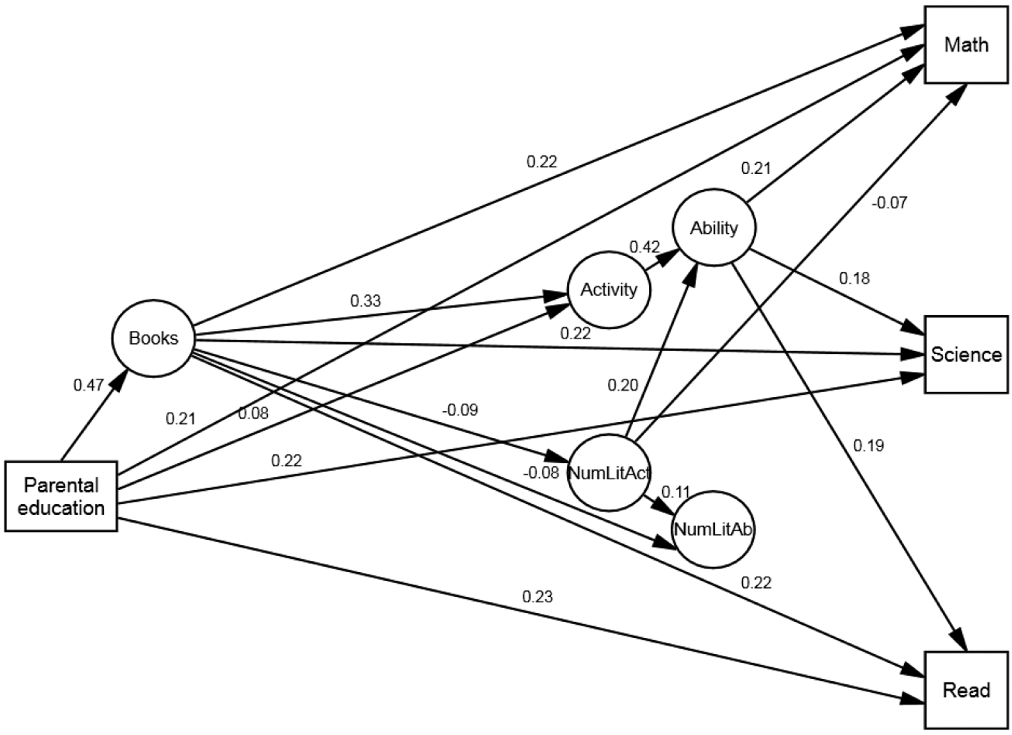
For the latent variable Books, there were two indicators: number of books in the home (NBOOK), and number of children's books in the home (NCBOOK). Both of these indicators had strong and equal relations (.80) to the latent variable.

The Path Model for Pooled Data

Given the complexity of the full path model and the large number of relationships estimated, it was necessary to simplify the presentation of results. This was accomplished by presenting the results for Gender and Parental Education separately. Because there was no correlation between these two variables, this does not cause any loss of information.

EFFECTS OF PARENTAL EDUCATION The total effects of Parental Education were .33, .35, and .35 for mathematics, science, and reading, respectively. While these estimates were computed from the direct and indirect effects in the model, we could also have computed a correlation between Parental Education and each of the three achievement variables to obtain the same results. According to the model, the total indirect effects were .12, .12, and .13 for mathematics, science, and reading, respectively. The difference between the total effect and the total indirect effect is the direct effect. Exhibit 4.6 presents all standardized direct effects larger than .05.

Exhibit 4.6: **Path Diagram for Relations between Parental Education and Achievement (All Participants, Pooled Data)**



As may be seen from this Exhibit, the direct effects of Parental Education on the three achievement variables agree, within rounding errors, with our expectations. These direct effects represent effects of Parental Education that the path model cannot account for via mediating variables. It is obvious from the model, however, that Books is an important mediating variable, with a strong relationship (0.47) between Parental Education and Books, and a direct effect of Books on the achievement variables of 0.22, similar to that of Parental Education.

Parental Education also had an indirect effect via the sequence Books, Activity, and Ability to achievement. All links in this chain were fairly strong and this indirect effect agrees with the theoretical expectations and with findings in previous empirical research. Thus, this path is theoretically and empirically important and it will be referred to as the Main Path of influence of Parental Education on achievement. There also was another important path, overlapping the Main Path to a great extent, which went directly from Parental Education to Activity, circumventing Books. It should also be pointed out that there was no direct effect of Activity on achievement in the Main Path, the entire effect being mediated via Ability.

In the Common model there was no direct effect of Parental Education on NumLitAct, and only a very weak indirect effect via Books, which was negative. Thus, NumLitAct did not mediate effects of Parental Education on achievement.

There was, however, a pattern of indirect effects of NumLitAct on the three achievement variables that went via Ability. There also was a negative direct effect of NumLitAct on Mathematics achievement. These results mean that homes which reported a stronger emphasis on literacy activities than on numeracy activities also reported a higher level of Ability, which in turn had a positive direct effect on achievement in all three domains. This is an interesting result, and one possible interpretation is that emphasis on literacy activities has a positive effect on development of both literacy and numeracy skills. A partially different interpretation is that numeracy skills at the beginning of primary school tend to involve both reading and writing, because expression of numeracy skills often requires use of literacy skills.

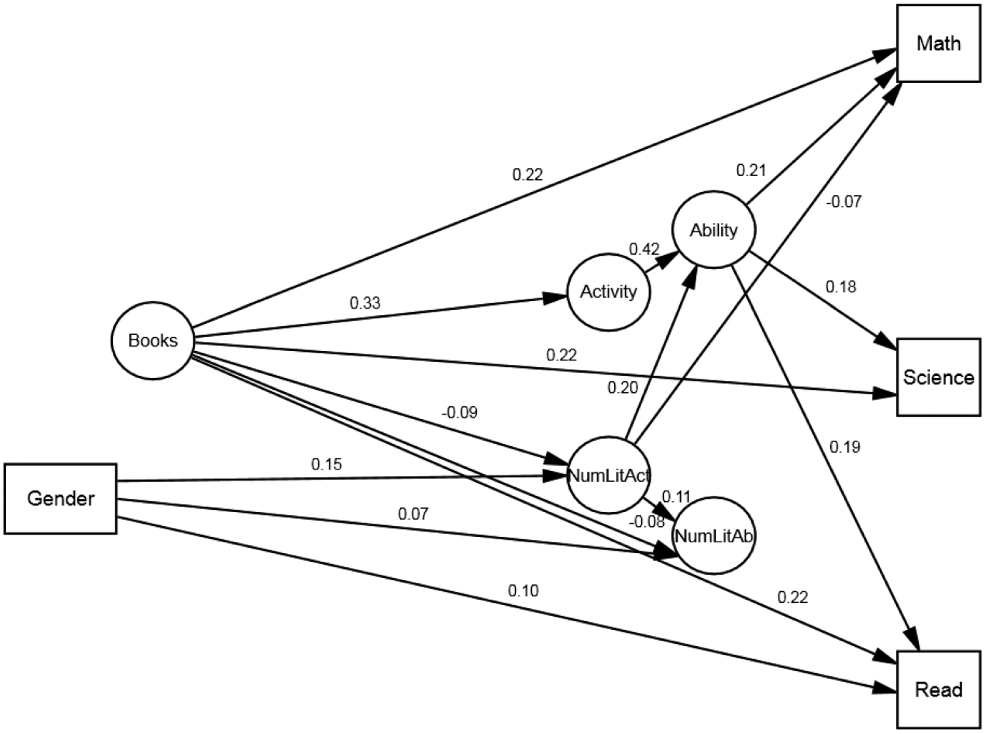
It may seem strange that there was a negative direct effect of NumLitAct on mathematics achievement. However, there was a positive indirect effect of NumLitAct on mathematics achievement, which was mediated via Ability. This positive indirect effect of NumLitAct on mathematics achievement thus partially balances out the negative direct effect of NumLitAct. Because there was no negative direct effect of NumLitAct on science or reading achievement, the net effect is that the emphasis on literacy activity will cause a profile of achievement with a relative strength in reading and science compared to mathematics.

Thus, even though NumLitAct did not mediate effects of Parental Education on achievement in the current model, the NumLitAct variable does seem to be involved in interesting patterns of relations.

EFFECTS OF GENDER The total effects of Gender were .00, .02 and .12 on mathematics, science, and reading, respectively. These results imply that in the pooled data there was essentially no gender difference in mathematics or science, but a rather substantial Gender difference in favor of girls with respect to reading achievement. The total indirect effects of Gender were .01, .01 and .02 on mathematics, science, and reading, respectively, so only a small part of the Gender effect was mediated via the variables in the model.

Exhibit 4.7 presents the path diagram in which Gender is the independent variable in focus.

Exhibit 4.7: **Path Diagram for Relations between Gender and Achievement (All Participants, Pooled Data)**



As may be expected from the total and indirect effects, there was a direct effect of .10 on reading. There was no direct effect of Gender on Books or Activity so the Main Path did not mediate any of the effect of Gender on achievement.

There was an effect of Gender on NumLitAct, which implies that for girls activities in the home tended to be more oriented towards literacy than numeracy. NumLitAct in turn influenced Ability, which had direct effects on all three fourth grade student achievement variables, so there were indirect effects of NumLitAct on achievement. There also was a weaker direct effect of Gender on NumLitAb, as well as an indirect effect via NumLitAct. However, because there was no direct effect of NumLitAb on any of the three achievement variables, NumLitAb did not mediate much of the total Gender effect.

Discussion of Results from the Common Model for Pooled Data

The analyses of indirect effects of Parental Education on achievement provide strong support for the hypothesized chain of influence via Books, Activity, and Ability to achievement. While this Main Path is important theoretically and empirically it may be noted that important indirect effects went through

other paths. Thus, Books was an important variable through which Parental Education exerted influence, and was not only part of the Main Path but also had substantial direct effects on the three achievement variables. These direct effects may be assumed to be mediated via variables not included in the model, such as parental expectations, and parents' function as role models with respect to reading activities.

It was expected that NumLitAct would affect NumLitAb, which it did, albeit to a limited extent. However, NumLitAct was more strongly related to Ability, and because Ability had effects on achievement, the mediating effect of NumLitAct on achievement went via Ability, causing similar effects on all three domains of achievement. There was, however, some differential effect because of the negative direct effect of NumLitAct on mathematics achievement.

Overall Description of Results from Country by Country Analyses

The Common model discussed in the previous section provides a synopsis of the general pattern of relationships among the variables, but it does not give any information about differences in the pattern of relationships among the variables across countries. In order to investigate such differences, we have fitted the path model separately to the data for each of the 37 participants. This section provides an overview of the results, while the next section presents the models country by country.

Total, Direct, and Total Indirect Effects of Parental Education and Gender on Achievement

This section reports the pattern of outcomes across countries with respect to total, direct, and total indirect effects.

TOTAL EFFECTS OF PARENTAL EDUCATION AND GENDER ON ACHIEVEMENT Exhibit 4.8 presents estimates of the total effects of Parental Education and Gender on the three fourth grade student achievement variables.

Parental Education had an average effect on achievement across countries of around .34. These estimates agree almost perfectly with those obtained in the analysis of the pooled data. But here we can see that there was a considerable variation across countries, and also across the three achievement domains.

For Hungary, Iran, Romania, Poland, and Botswana Parental Education had total effects which exceeded .40 in all three domains. The lowest impact of Parental Education was observed for Azerbaijan and Hong Kong SAR, where

Exhibit 4.8: Estimates of Total Standardized Effects

Country	Total Effect of Parental Education			Total Effect of Gender		
	Mathematics	Science	Reading	Mathematics	Science	Reading
Australia	0.333 (0.024)	0.351 (0.025)	0.330 (0.023)	–0.025 (0.020)	–0.001 (0.021)	0.122 (0.019)
Austria	0.307 (0.019)	0.334 (0.021)	0.317 (0.019)	–0.069 (0.019)	–0.086 (0.019)	0.063 (0.018)
Azerbaijan	0.109 (0.024)	0.137 (0.024)	0.148 (0.023)	0.036 (0.023)	0.032 (0.023)	0.099 (0.019)
Chinese Taipei	0.370 (0.022)	0.387 (0.019)	0.335 (0.019)	0.014 (0.018)	–0.046 (0.019)	0.100 (0.016)
Croatia	0.309 (0.023)	0.318 (0.024)	0.305 (0.022)	–0.084 (0.021)	–0.038 (0.019)	0.123 (0.022)
Czech Republic	0.306 (0.024)	0.289 (0.023)	0.285 (0.024)	–0.08 (0.019)	–0.094 (0.021)	0.061 (0.019)
Finland	0.289 (0.023)	0.280 (0.023)	0.275 (0.020)	–0.062 (0.021)	–0.012 (0.019)	0.166 (0.018)
Georgia	0.282 (0.024)	0.289 (0.022)	0.313 (0.021)	0.044 (0.020)	0.057 (0.023)	0.153 (0.019)
Germany	0.359 (0.020)	0.380 (0.019)	0.361 (0.018)	–0.068 (0.017)	–0.088 (0.025)	0.064 (0.018)
Hong Kong SAR	0.160 (0.028)	0.150 (0.027)	0.116 (0.026)	–0.054 (0.021)	–0.069 (0.020)	0.131 (0.019)
Hungary	0.549 (0.020)	0.550 (0.021)	0.530 (0.021)	–0.026 (0.018)	–0.03 (0.019)	0.099 (0.015)
Iran, Islamic Rep. of	0.441 (0.025)	0.446 (0.024)	0.433 (0.023)	–0.023 (0.029)	–0.034 (0.028)	0.112 (0.026)
Ireland	0.334 (0.020)	0.341 (0.021)	0.343 (0.023)	–0.02 (0.027)	–0.001 (0.028)	0.113 (0.022)
Italy	0.238 (0.025)	0.275 (0.022)	0.298 (0.021)	–0.063 (0.022)	–0.053 (0.018)	0.033 (0.018)
Lithuania	0.356 (0.022)	0.352 (0.022)	0.345 (0.023)	–0.007 (0.019)	–0.008 (0.019)	0.148 (0.019)
Malta	0.339 (0.023)	0.449 (0.022)	0.444 (0.022)	–0.041 (0.022)	–0.037 (0.023)	0.095 (0.024)
Morocco	0.185 (0.036)	0.193 (0.032)	0.241 (0.033)	0.029 (0.019)	0.040 (0.019)	0.132 (0.018)
Northern Ireland	0.378 (0.029)	0.387 (0.029)	0.361 (0.028)	0.016 (0.023)	0.018 (0.025)	0.130 (0.021)
Norway	0.253 (0.027)	0.278 (0.026)	0.263 (0.023)	–0.04 (0.022)	–0.006 (0.024)	0.133 (0.023)
Oman	0.304 (0.023)	0.305 (0.024)	0.319 (0.024)	0.131 (0.016)	0.138 (0.017)	0.204 (0.014)
Poland	0.427 (0.018)	0.441 (0.017)	0.431 (0.016)	–0.059 (0.024)	–0.024 (0.018)	0.109 (0.019)
Portugal	0.303 (0.031)	0.298 (0.029)	0.314 (0.023)	–0.042 (0.022)	–0.032 (0.021)	0.111 (0.017)
Qatar	0.394 (0.025)	0.383 (0.028)	0.395 (0.024)	0.061 (0.030)	0.105 (0.033)	0.144 (0.027)
Romania	0.430 (0.035)	0.466 (0.031)	0.490 (0.028)	–0.017 (0.018)	–0.006 (0.018)	0.079 (0.018)
Russian Federation	0.265 (0.026)	0.269 (0.024)	0.298 (0.022)	0.008 (0.018)	–0.008 (0.020)	0.137 (0.017)
Saudi Arabia	0.176 (0.032)	0.248 (0.029)	0.243 (0.028)	0.064 (0.051)	0.199 (0.046)	0.274 (0.041)
Singapore	0.393 (0.019)	0.437 (0.017)	0.408 (0.017)	0.020 (0.017)	–0.028 (0.017)	0.101 (0.016)
Slovak Republic	0.371 (0.028)	0.375 (0.028)	0.376 (0.024)	–0.045 (0.015)	–0.046 (0.016)	0.079 (0.018)
Slovenia	0.376 (0.019)	0.386 (0.024)	0.347 (0.020)	–0.061 (0.022)	–0.016 (0.024)	0.123 (0.021)
Spain	0.373 (0.022)	0.333 (0.027)	0.314 (0.027)	–0.082 (0.019)	–0.071 (0.019)	0.034 (0.018)
Sweden	0.324 (0.025)	0.340 (0.026)	0.339 (0.025)	–0.046 (0.019)	–0.027 (0.021)	0.108 (0.020)
United Arab Emirates	0.386 (0.017)	0.402 (0.016)	0.415 (0.015)	0.040 (0.023)	0.090 (0.023)	0.136 (0.023)
Sixth Grade Countries						
Botswana	0.405 (0.037)	0.445 (0.035)	0.478 (0.035)	0.101 (0.019)	0.061 (0.019)	0.148 (0.018)
Honduras	0.343 (0.058)	0.355 (0.054)	0.338 (0.056)	–0.08 (0.023)	–0.064 (0.026)	0.071 (0.025)
Benchmarking Participants						
Quebec, Canada	0.252 (0.026)	0.293 (0.025)	0.273 (0.023)	–0.082 (0.021)	–0.061 (0.023)	0.107 (0.018)
Abu Dhabi, UAE	0.399 (0.024)	0.392 (0.024)	0.397 (0.024)	0.077 (0.032)	0.144 (0.030)	0.185 (0.028)
Dubai, UAE	0.405 (0.025)	0.420 (0.025)	0.421 (0.025)	–0.01 (0.035)	0.020 (0.037)	0.071 (0.039)
International Avg.	0.326 (0.024)	0.340 (0.024)	0.335 (0.023)	0.042 (0.022)	0.085 (0.022)	0.116 (0.020)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

effects were lower than .16 in all three achievement domains. Thus, there were considerable differences in the amount of relationship between Parental Education and achievement across countries, even though it also may be noted that for many countries effects were between .30 and .40. From the list of countries with high and low impact it is not possible to determine any simple and clear grouping of countries which may explain the differences. Among participants with high impact, some were East European countries. However, the Russian Federation was among the countries with lowest impact, thus the pattern is far from clear. Among East Asian countries there were both examples of countries with the highest impact (Singapore) and the lowest impact (Hong Kong SAR). Similarly among developing countries, there were examples of high impact of Parental Education (Botswana) and low impact (e.g., Morocco). These examples indicate that the amount of effect of Parental Education on educational achievement cannot be accounted for in simple terms.

In addition, results presented in Exhibit 4.8 indicate that there was no significant average effect of Gender on achievement in mathematics or science, while there was an average effect of .12 on reading. This average agrees with the estimate obtained in the analysis of the pooled data, and it agrees with previous findings of consistent differences in favor of girls on reading literacy.

However, even though there were no overall average gender differences in mathematics and science, there were countries were either boys or girls excelled. Significant differences in mathematics achievement in favor of girls were observed for five participants: Oman, Botswana, the Emirate of Abu Dhabi, Saudi Arabia, and Qatar. Among these participants, there also were significant differences for girls in science achievement. This same group of participants, with a few exceptions, also had considerable differences in reading achievement, with standardized coefficients as high as around .20. Finland also had a considerable advantage for girls in reading achievement.

For about a dozen participants, there were significant differences in favor of boys in mathematics, but in no case larger than 0.08 (e.g., Croatia, the Canadian province of Quebec, Spain, the Czech Republic, Hungary, Austria, and Germany). Most of these countries had a similar pattern of differences in science achievement. For only two countries (Spain and Italy) a non-significant gender difference was observed for reading achievement. For the countries with small differences in favor of girls for reading, there tended to be a significant advantage for boys in mathematics and science.

DIRECT EFFECTS OF PARENTAL EDUCATION AND GENDER ON ACHIEVEMENT The total effects presented above arise from direct effects and indirect effects. In order to understand the composition of the total effect in the different countries, it is useful to examine these two sources of effects separately. This section first discusses the direct effects, and then investigates the indirect effects. Exhibit 4.9 presents the direct effects of Parental Education on the other variables in the path model.

The mean standardized regression coefficient (β) for the direct effect of Parental Education on mathematics achievement was 0.19 (sd = 0.07), as compared to 0.33 for the total effect. Countries with the smallest direct effects of Parental Education on mathematics achievement ($\beta < .13$) were Azerbaijan, Hong Kong SAR, Saudi Arabia, Austria, Portugal, and Sweden. Countries with the largest direct effects of Parental Education on mathematics achievement ($\beta > .27$) included Botswana, Honduras, Qatar, Poland, and Hungary. There was a very high level of agreement between the pattern of results for mathematics and science achievement; the correlation between the parameter estimates for mathematics and science was 0.92.

The mean direct effect of Parental Education on reading achievement was about the same as for mathematics and science (mean = 0.20, sd = 0.07). The correlation between the parameter estimates for reading and mathematics was 0.89, while the correlation was 0.97 for reading and science. Thus, there was more agreement in the pattern of outcomes for reading and science than for reading and mathematics. For reading, particularly small direct effects of Parental Education were observed for Hong Kong SAR and for the Nordic countries.

The mean effect of Gender on mathematics achievement was small (mean = -0.03, sd = 0.05). However, in about half of the countries, there were significant direct effects in favor of boys. The countries with the largest direct effects included Slovenia, Sweden, Croatia, Spain, and the Czech Republic. For two countries (Botswana and Oman) there was a significant direct effect in favor of girls.

For science, too, the mean direct effect of Gender was small (mean = -0.02, sd = 0.07), although the pattern of direct effects of gender differed across countries. For about half of the countries, there was a significant direct effect in favor of boys, and was largest in Hong Kong SAR, Sweden, the Czech Republic, the Canadian province of Quebec, Spain, and Germany. For seven countries, there was a significant direct effect in favor of girls, and was largest in Saudi Arabia, Oman, the Emirate of Abu Dhabi, Qatar, and United Arab Emirates.

Exhibit 4.9: Standardized Direct Effects of Parental Education and Gender on Achievement, Grade 4

Country	Parental Education			Gender		
	Mathematics	Science	Reading	Mathematics	Science	Reading
Australia	0.225 (0.027)	0.216 (0.028)	0.212 (0.026)	−0.021 (0.020)	−0.006 (0.021)	0.115 (0.019)
Austria	0.092 (0.021)	0.100 (0.023)	0.095 (0.021)	−0.046 (0.021)	−0.082 (0.018)	0.051 (0.017)
Azerbaijan	0.060 (0.028)	0.078 (0.027)	0.114 (0.026)	0.031 (0.025)	0.032 (0.025)	0.100 (0.021)
Chinese Taipei	0.200 (0.022)	0.220 (0.021)	0.200 (0.021)	−0.004 (0.018)	−0.068 (0.018)	0.068 (0.017)
Croatia	0.173 (0.024)	0.169 (0.028)	0.161 (0.025)	−0.095 (0.022)	−0.054 (0.020)	0.085 (0.023)
Czech Republic	0.166 (0.023)	0.129 (0.025)	0.129 (0.022)	−0.085 (0.018)	−0.1 (0.021)	0.048 (0.019)
Finland	0.160 (0.024)	0.130 (0.027)	0.117 (0.022)	−0.076 (0.020)	−0.037 (0.020)	0.108 (0.020)
Georgia	0.148 (0.024)	0.146 (0.023)	0.174 (0.022)	0.042 (0.021)	0.051 (0.023)	0.140 (0.020)
Germany	0.169 (0.022)	0.150 (0.026)	0.152 (0.023)	−0.048 (0.019)	−0.086 (0.026)	0.052 (0.020)
Hong Kong SAR	0.072 (0.025)	0.051 (0.029)	0.038 (0.025)	−0.084 (0.020)	−0.11 (0.020)	0.091 (0.020)
Hungary	0.272 (0.027)	0.264 (0.025)	0.288 (0.024)	−0.006 (0.016)	−0.018 (0.017)	0.103 (0.014)
Iran, Islamic Rep. of	0.248 (0.025)	0.251 (0.026)	0.251 (0.024)	−0.013 (0.029)	−0.023 (0.027)	0.122 (0.025)
Ireland	0.165 (0.023)	0.156 (0.025)	0.158 (0.027)	−0.037 (0.027)	−0.014 (0.028)	0.089 (0.021)
Italy	0.146 (0.025)	0.139 (0.023)	0.163 (0.024)	−0.059 (0.023)	−0.064 (0.020)	0.009 (0.020)
Lithuania	0.187 (0.020)	0.175 (0.022)	0.159 (0.022)	−0.044 (0.021)	−0.063 (0.022)	0.077 (0.019)
Malta	0.208 (0.027)	0.303 (0.026)	0.299 (0.027)	−0.062 (0.022)	−0.058 (0.020)	0.073 (0.021)
Morocco	0.181 (0.027)	0.162 (0.031)	0.191 (0.027)	0.023 (0.017)	0.030 (0.019)	0.118 (0.017)
Northern Ireland	0.247 (0.036)	0.225 (0.033)	0.219 (0.033)	−0.014 (0.026)	−0.017 (0.029)	0.090 (0.025)
Norway	0.155 (0.033)	0.109 (0.027)	0.107 (0.025)	−0.04 (0.025)	−0.04 (0.025)	0.078 (0.023)
Oman	0.214 (0.023)	0.222 (0.023)	0.225 (0.023)	0.107 (0.016)	0.114 (0.017)	0.178 (0.014)
Poland	0.273 (0.023)	0.282 (0.019)	0.288 (0.020)	−0.077 (0.026)	−0.06 (0.020)	0.070 (0.018)
Portugal	0.127 (0.039)	0.128 (0.040)	0.138 (0.036)	−0.029 (0.023)	−0.028 (0.022)	0.109 (0.020)
Qatar	0.307 (0.026)	0.302 (0.028)	0.316 (0.026)	0.047 (0.028)	0.084 (0.030)	0.122 (0.025)
Romania	0.213 (0.034)	0.227 (0.033)	0.251 (0.032)	−0.031 (0.018)	−0.02 (0.018)	0.063 (0.018)
Russian Federation	0.154 (0.025)	0.143 (0.024)	0.166 (0.021)	−0.013 (0.019)	−0.029 (0.019)	0.108 (0.017)
Saudi Arabia	0.086 (0.041)	0.151 (0.037)	0.159 (0.030)	0.025 (0.051)	0.164 (0.048)	0.230 (0.042)
Singapore	0.247 (0.017)	0.267 (0.016)	0.243 (0.015)	−0.01 (0.015)	−0.065 (0.015)	0.061 (0.014)
Slovak Republic	0.161 (0.027)	0.162 (0.026)	0.162 (0.023)	−0.046 (0.015)	−0.059 (0.017)	0.067 (0.017)
Slovenia	0.228 (0.021)	0.213 (0.027)	0.176 (0.020)	−0.1 (0.022)	−0.065 (0.024)	0.069 (0.022)
Spain	0.206 (0.027)	0.143 (0.028)	0.155 (0.029)	−0.089 (0.023)	−0.088 (0.018)	0.003 (0.018)
Sweden	0.128 (0.030)	0.095 (0.028)	0.119 (0.029)	−0.096 (0.021)	−0.103 (0.022)	0.009 (0.020)
United Arab Emirates	0.248 (0.016)	0.269 (0.015)	0.261 (0.015)	0.028 (0.022)	0.074 (0.022)	0.118 (0.021)
Sixth Grade Countries						
Botswana	0.316 (0.034)	0.341 (0.031)	0.375 (0.031)	0.085 (0.020)	0.046 (0.018)	0.138 (0.018)
Honduras	0.312 (0.054)	0.307 (0.050)	0.291 (0.052)	−0.082 (0.024)	−0.062 (0.026)	0.072 (0.025)
Benchmarking Participants						
Quebec, Canada	0.175 (0.027)	0.183 (0.027)	0.170 (0.025)	−0.075 (0.022)	−0.095 (0.027)	0.055 (0.021)
Abu Dhabi, UAE	0.267 (0.024)	0.270 (0.023)	0.251 (0.023)	0.052 (0.030)	0.113 (0.028)	0.152 (0.026)
Dubai, UAE	0.247 (0.024)	0.259 (0.024)	0.252 (0.024)	−0.039 (0.031)	−0.015 (0.032)	0.032 (0.034)
International Avg.	0.183 (0.026)	0.181 (0.026)	0.184 (0.025)	0.043 (0.022)	0.078 (0.022)	0.088 (0.020)
International Std. Dev.	0.060 (0.006)	0.067 (0.005)	0.066 (0.005)	0.029 (0.006)	0.048 (0.006)	0.046 (0.005)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

The direct effect of Gender on reading achievement was positive (mean = 0.09, sd = 0.05). In no country was there a direct effect in favor of boys; however, for four countries (Spain, Italy, Sweden, and the Emirate of Dubai) there was no significant effect. For all other countries, there was a significant direct effect of Gender in favor of girls.

TOTAL INDIRECT EFFECTS OF PARENTAL EDUCATION AND GENDER ON ACHIEVEMENT The total indirect effect is due to the sum of all the indirect effects, and Exhibit 4.10 presents the total indirect effects for Parental Education and Gender. This Exhibit also presents the percentage that the total indirect effect amounts to of the total effect. It should be observed, however, that for Gender the percentages are only presented for reading, because the total effect was in many cases close to zero or negative for Gender with respect to mathematics and science.

The average of the total indirect effect of Parental Education on mathematics was 0.14 (sd = 0.06). On average internationally, 41 percent of the total effect was indirect (sd = 13). The largest proportions of indirect effects were observed for Austria, Sweden, Portugal, the Slovak Republic, and Hong Kong, where in all cases 55 percent or more of the total effect was indirect. The relatively smallest indirect effects were observed for Morocco, Honduras, Botswana, and Qatar, where in all cases less than 22 percent of the total effect was indirect.

For science, the average total indirect effect of Parental Education was 0.15 (sd = 0.06). On average internationally, 45 percent of the total effect was indirect (sd = 14). The proportions of the total effects accounted for by the indirect effects where similar to those observed for mathematics. For reading, the pattern of results was highly similar to the pattern observed for science.

For the effects of Gender on mathematics and science, as mentioned above, generally it is not meaningful to compute the percentage of indirect effects out of the total effect, because the latter in many cases was close to zero. There were, however, significant indirect effects of Gender on both mathematics and science achievement for eleven participants: Hong Kong SAR, Lithuania, Oman, Saudi Arabia, Singapore, Slovenia, Sweden, United Arab Emirates, the Emirates of Dubai and Abu Dhabi, and Northern Ireland.

For a majority of the countries, the indirect effect of Gender on reading achievement was significant. The average total indirect effect was 0.03 (sd = 0.02), which indicates considerable variation across countries. The indirect effect comprised more than 90 percent of the total effect for Sweden and Spain, and it comprised more than 40 percent for Italy, the Emirate of Dubai, Lithuania, the Canadian province of Quebec, Slovenia, Norway, and Singapore. The indirect effect was close to zero for Iran, Hungary, Honduras, Azerbaijan, Portugal, Australia, Botswana, and Georgia.

Exhibit 4.10: Total Indirect Standardized Effects

Country	Total Indirect Effect of Parental Education					
	Mathematics		Science		Reading	
	Effect	% of Total	Effect	% of Total	Effect	% of Total
Australia	0.107 (0.014)	32	0.135 (0.014)	38	0.117 (0.015)	35
Austria	0.216 (0.016)	70	0.234 (0.015)	70	0.223 (0.013)	70
Azerbaijan	0.049 (0.015)	45	0.060 (0.015)	44	0.034 (0.014)	23
Chinese Taipei	0.170 (0.013)	46	0.167 (0.014)	43	0.134 (0.013)	40
Croatia	0.136 (0.016)	44	0.149 (0.016)	47	0.144 (0.015)	47
Czech Republic	0.140 (0.013)	46	0.160 (0.015)	55	0.156 (0.014)	55
Finland	0.129 (0.020)	45	0.150 (0.016)	54	0.158 (0.013)	57
Georgia	0.134 (0.022)	48	0.143 (0.022)	49	0.138 (0.019)	44
Germany	0.189 (0.017)	53	0.230 (0.020)	61	0.210 (0.016)	58
Hong Kong SAR	0.088 (0.019)	55	0.100 (0.019)	67	0.078 (0.017)	67
Hungary	0.277 (0.025)	50	0.286 (0.023)	52	0.242 (0.023)	46
Iran, Islamic Rep. of	0.193 (0.025)	44	0.195 (0.024)	44	0.182 (0.023)	42
Ireland	0.169 (0.015)	51	0.185 (0.018)	54	0.185 (0.016)	54
Italy	0.091 (0.014)	38	0.136 (0.016)	49	0.135 (0.013)	45
Lithuania	0.170 (0.016)	48	0.177 (0.016)	50	0.186 (0.015)	54
Malta	0.131 (0.018)	39	0.146 (0.016)	33	0.145 (0.017)	33
Morocco	0.004 (0.022)	2	0.031 (0.020)	16	0.050 (0.019)	21
Northern Ireland	0.131 (0.023)	35	0.162 (0.025)	42	0.142 (0.023)	39
Norway	0.098 (0.020)	39	0.169 (0.020)	61	0.156 (0.020)	59
Oman	0.090 (0.008)	30	0.083 (0.009)	27	0.094 (0.009)	29
Poland	0.154 (0.016)	36	0.159 (0.014)	36	0.143 (0.015)	33
Portugal	0.177 (0.028)	58	0.170 (0.029)	57	0.176 (0.028)	56
Qatar	0.087 (0.018)	22	0.081 (0.016)	21	0.079 (0.015)	20
Romania	0.216 (0.026)	50	0.238 (0.024)	51	0.240 (0.023)	49
Russian Federation	0.111 (0.014)	42	0.125 (0.014)	46	0.132 (0.013)	44
Saudi Arabia	0.090 (0.025)	51	0.097 (0.023)	39	0.085 (0.023)	35
Singapore	0.146 (0.012)	37	0.170 (0.012)	39	0.165 (0.012)	40
Slovak Republic	0.209 (0.020)	56	0.214 (0.019)	57	0.214 (0.019)	57
Slovenia	0.148 (0.016)	39	0.173 (0.016)	45	0.171 (0.016)	49
Spain	0.167 (0.019)	45	0.190 (0.020)	57	0.160 (0.019)	51
Sweden	0.196 (0.018)	60	0.245 (0.017)	72	0.220 (0.017)	65
United Arab Emirates	0.137 (0.011)	35	0.134 (0.011)	33	0.154 (0.011)	37
Sixth Grade Countries						
Botswana	0.089 (0.018)	22	0.104 (0.016)	23	0.103 (0.016)	22
Honduras	0.031 (0.017)	9	0.048 (0.017)	14	0.047 (0.017)	14
Benchmarking Participants						
Quebec, Canada	0.078 (0.015)	31	0.111 (0.014)	38	0.103 (0.014)	38
Abu Dhabi, UAE	0.132 (0.020)	33	0.122 (0.021)	31	0.146 (0.022)	37
Dubai, UAE	0.158 (0.017)	39	0.161 (0.016)	38	0.169 (0.016)	40
International Avg.	0.142 (0.018)	43	0.159 (0.018)	47	0.152 (0.017)	46
International Std. Dev.	0.054 (0.005)	12	0.056 (0.004)	13	0.052 (0.004)	13

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.10: Total Indirect Standardized Effects (Continued)

Country	Total Indirect Effect of Gender			
	Mathematics Effect	Science Effect	Reading	
			Effect	% of Total
Australia	–0.003 (0.012)	0.005 (0.012)	0.007 (0.011)	6
Austria	–0.023 (0.014)	–0.005 (0.012)	0.012 (0.013)	19
Azerbaijan	0.005 (0.013)	0.000 (0.013)	0.000 (0.012)	0
Chinese Taipei	0.017 (0.010)	0.022 (0.009)	0.032 (0.008)	32
Croatia	0.011 (0.010)	0.016 (0.008)	0.038 (0.009)	31
Czech Republic	0.005 (0.010)	0.006 (0.010)	0.012 (0.009)	20
Finland	0.014 (0.014)	0.025 (0.013)	0.059 (0.013)	36
Georgia	0.002 (0.008)	0.006 (0.008)	0.012 (0.007)	8
Germany	–0.019 (0.015)	–0.001 (0.014)	0.012 (0.013)	19
Hong Kong SAR	0.029 (0.008)	0.040 (0.008)	0.040 (0.008)	31
Hungary	–0.02 (0.008)	–0.012 (0.008)	–0.004 (0.007)	-4
Iran, Islamic Rep. of	–0.01 (0.012)	–0.011 (0.012)	–0.01 (0.012)	-9
Ireland	0.018 (0.009)	0.013 (0.011)	0.024 (0.010)	21
Italy	–0.004 (0.009)	0.011 (0.010)	0.024 (0.010)	73
Lithuania	0.037 (0.014)	0.055 (0.014)	0.071 (0.012)	48
Malta	0.021 (0.008)	0.021 (0.009)	0.022 (0.009)	23
Morocco	0.006 (0.009)	0.009 (0.008)	0.014 (0.007)	11
Northern Ireland	0.031 (0.014)	0.036 (0.015)	0.039 (0.013)	30
Norway	–0.001 (0.017)	0.034 (0.016)	0.056 (0.015)	42
Oman	0.024 (0.006)	0.024 (0.006)	0.025 (0.006)	12
Poland	0.018 (0.010)	0.037 (0.011)	0.039 (0.009)	36
Portugal	–0.014 (0.010)	–0.004 (0.009)	0.001 (0.010)	1
Qatar	0.014 (0.009)	0.021 (0.008)	0.022 (0.007)	15
Romania	0.014 (0.007)	0.014 (0.007)	0.016 (0.007)	20
Russian Federation	0.021 (0.007)	0.021 (0.008)	0.030 (0.007)	22
Saudi Arabia	0.039 (0.014)	0.035 (0.014)	0.044 (0.014)	16
Singapore	0.029 (0.007)	0.038 (0.008)	0.040 (0.007)	40
Slovak Republic	0.002 (0.009)	0.013 (0.009)	0.012 (0.009)	15
Slovenia	0.039 (0.011)	0.049 (0.010)	0.055 (0.009)	45
Spain	0.008 (0.012)	0.017 (0.012)	0.031 (0.010)	91
Sweden	0.050 (0.015)	0.076 (0.016)	0.099 (0.016)	92
United Arab Emirates	0.012 (0.005)	0.016 (0.006)	0.018 (0.006)	13
Sixth Grade Countries				
Botswana	0.016 (0.007)	0.015 (0.007)	0.010 (0.007)	7
Honduras	0.001 (0.007)	–0.003 (0.008)	–0.001 (0.007)	-1
Benchmarking Participants				
Quebec, Canada	–0.007 (0.014)	0.034 (0.015)	0.051 (0.016)	48
Abu Dhabi, UAE	0.026 (0.008)	0.031 (0.008)	0.033 (0.009)	18
Dubai, UAE	0.029 (0.012)	0.035 (0.011)	0.040 (0.011)	56
International Avg.	0.019 (0.011)	0.024 (0.010)	0.030 (0.010)	27
International Std. Dev.	0.013 (0.003)	0.017 (0.003)	0.022 (0.003)	24

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

RELATIONSHIPS AMONG DIRECT AND TOTAL INDIRECT EFFECTS The results presented above suggest that the strength of the direct and the total indirect effects of Parental Education are more or less independent on a particular subject matter domain while the effects seem similar across the three domains. In order to obtain more precise information about the pattern of relations among direct and total indirect effects across domains, correlations among the effect estimates for the 37 participants have been computed (see Exhibit 4.11).

Exhibit 4.11: Correlations among Direct and Total Indirect Effects of Parental Education on Mathematics, Science, and Reading

	Direct Effects			Total Indirect Effects		
Direct Effects	**Mathematics**	**Science**	**Reading**	**Mathematics**	**Science**	**Reading**
Mathematics	1.00					
Science	0.88	1.00				
Reading	0.88	0.98	1.00			
Indirect Effects						
Mathematics	0.18	0.06	0.08	1.00		
Science	0.15	0.06	0.08	0.94	1.00	
Reading	0.23	0.13	0.16	0.90	0.95	1.00

The correlations among the direct effects were very large, and particularly so for science and reading (r = 0.98). The correlations between the direct effect of Parental Education on mathematics and the effects on science and reading were somewhat smaller (0.88). The correlations among the total indirect effects showed a similar pattern, with the correlation for reading and science being the largest (r = 0.95) and the correlation for mathematics and reading being the smallest (r = 0.90). The correlation among the total indirect effects for mathematics and science also was large (r = 0.94).

The correlations among the direct and indirect effects of Parental Education were all close to zero, and none of these was significant. The absence of correlations between direct and total indirect effects implies that countries can have all possible combinations of large and small estimates of direct and indirect effects. These results indicate that there are different mechanisms at work behind the direct effects and the indirect effects. The direct effects are effects for which no testable explanatory mechanism has yet been proposed. It is, however, interesting to note the very high correlation between the direct effects for science and reading, which suggests that reading skills are important for achievement in the science domain.

Direct Effects of Parental Education and Gender on the Mediating Variables

This section will primarily focus on the indirect effects, because a closer analysis of these effects can inform us about the mechanisms through which Parental Education and Gender influence the achievement outcomes in the three domains.

The indirect effects are created by two or more direct effects, linking the independent variables Parental Education and Gender and the dependent variables (i.e., the fourth grade student achievement measures). Because the indirect effect is a function of the product of the path coefficients involved in the path, a description of which direct relations are small and which are large is important for understanding the indirect effects. In the description of indirect effects we are, in particular, interested in the relations among variables which build what we have labeled the Main Path, i.e., the path from Parental Education to achievement via Books, Activity, and Ability.

Below, we analyze the direct effects of Parental Education and Gender on the mediating variables of the path model (i.e., Books, Activity, NumLitAct, Ability and NumLitAb), and then we analyze the pattern of interrelations among these mediating variables. Estimated direct effects of Parental Education on the mediating variables are presented first, followed by the results for Gender.

DIRECT EFFECTS OF PARENTAL EDUCATION Exhibit 4.12 presents the estimated standardized direct effects of Parental Education on the mediating variables in the path model. Discussion begins by focusing on the relation between Parental Education and Books, which is the first link in the Main Path.

As indicated in this Exhibit, the mean standardized regression coefficient (β) was 0.48 (sd = 0.09). This is a substantial relationship, though there was variation across countries. The highest relationships were observed in Hungary, Romania, Portugal, Iran, Spain, and the Slovak Republic, and the lowest relationships were observed in Qatar, the Emirate of Dubai, the Canadian province of Quebec, and Oman. There does seem to be an over-representation of East European countries in the group with high relationships, though there are exceptions; for example, the Russian Federation and the Czech Republic both had values below the mean (β = 0.41 and β = 0.45, respectively).

The mean β coefficient for the relationship between Parental Education and Activity was 0.05 (sd = 0.08) (see Exhibit 4.12). This is a small estimate, which suggests that the effects of Parental Education only to a small extent are due to direct effects of Parental Education on Activity. There were, however, differences across countries. While non-significant relationships were observed for many countries, two had significant negative relationships (Botswana and Morocco) and 16 had significant positive relationships, the highest of which were observed for Malta, Oman, Finland, Italy, Hong Kong SAR, and Sweden.

It will be remembered that the NumLitAct variable is bipolar, such that positive values represent a relatively stronger emphasis on literacy activities than on numeracy while negative values represent a stronger emphasis on numeracy activities than on literacy activities. The mean direct effect of Parental Education on NumLitAct across the 37 participants was 0.01 (sd = 0.07). Thus, as was observed also in the Common model, there is no general effect that holds across countries. There were, however, substantial country differences. Four countries had significant negative relations: Iran, Honduras, Oman, and Chinese Taipei. In other words, in these countries, highly educated parents tended to put more emphasis on numeracy than on literacy activities. Seven countries had significant positive relations: Sweden, Finland, Slovenia, Norway, Morocco, the Czech Republic, and Saudi Arabia. In these countries, that is, highly educated parents placed more emphasis on literacy-oriented activities than on activities that were numeracy-oriented.

The mean of the β coefficients for the regression of Ability on Parental Education was .02 (sd = 0.05). For one country (Hong Kong SAR) there was

Exhibit 4.12: Standardized Direct Effects of Parental Education on the Mediating Variables

Country	Books	Activity	NumLitAct	Ability	NumLitAb
Australia	0.401 (0.027)	0.025 (0.031)	0.025 (0.055)	0.045 (0.026)	–0.044 (0.028)
Austria	0.508 (0.016)	–0.004 (0.021)	0.039 (0.050)	0.041 (0.025)	–0.008 (0.025)
Azerbaijan	0.385 (0.025)	0.113 (0.029)	–0.047 (0.044)	0.063 (0.024)	–0.088 (0.027)
Chinese Taipei	0.549 (0.016)	0.091 (0.022)	–0.093 (0.033)	0.015 (0.020)	–0.024 (0.029)
Croatia	0.525 (0.020)	–0.016 (0.024)	0.010 (0.040)	–0.012 (0.021)	–0.024 (0.024)
Czech Republic	0.452 (0.021)	–0.096 (0.026)	0.095 (0.044)	–0.004 (0.023)	–0.018 (0.024)
Finland	0.406 (0.022)	–0.039 (0.023)	0.122 (0.050)	0.099 (0.024)	–0.005 (0.024)
Georgia	0.521 (0.022)	–0.008 (0.025)	–0.019 (0.043)	–0.016 (0.023)	–0.104 (0.029)
Germany	0.545 (0.019)	–0.016 (0.026)	–0.003 (0.053)	–0.009 (0.027)	–0.064 (0.028)
Hong Kong SAR	0.540 (0.023)	0.041 (0.025)	0.017 (0.030)	–0.073 (0.025)	0.059 (0.030)
Hungary	0.688 (0.015)	–0.067 (0.025)	–0.016 (0.044)	0.028 (0.025)	–0.086 (0.028)
Iran, Islamic Rep. of	0.621 (0.022)	0.032 (0.025)	–0.22 (0.054)	–0.038 (0.026)	–0.104 (0.029)
Ireland	0.473 (0.022)	–0.015 (0.025)	0.010 (0.042)	0.024 (0.025)	–0.083 (0.028)
Italy	0.487 (0.016)	0.000 (0.024)	–0.008 (0.034)	–0.039 (0.021)	–0.016 (0.024)
Lithuania	0.507 (0.021)	–0.026 (0.023)	0.039 (0.039)	0.073 (0.021)	0.047 (0.024)
Malta	0.511 (0.023)	0.069 (0.026)	–0.059 (0.035)	–0.018 (0.025)	0.113 (0.028)
Morocco	0.417 (0.030)	0.142 (0.028)	0.095 (0.032)	0.092 (0.017)	–0.026 (0.027)
Northern Ireland	0.506 (0.028)	–0.007 (0.035)	–0.057 (0.050)	–0.03 (0.030)	–0.09 (0.036)
Norway	0.471 (0.022)	0.037 (0.029)	0.101 (0.047)	–0.026 (0.024)	–0.064 (0.033)
Oman	0.361 (0.019)	0.150 (0.024)	–0.101 (0.042)	0.032 (0.017)	0.073 (0.023)
Poland	0.564 (0.017)	–0.012 (0.029)	0.060 (0.037)	0.030 (0.024)	–0.048 (0.030)
Portugal	0.639 (0.020)	–0.026 (0.030)	0.020 (0.063)	–0.037 (0.039)	–0.078 (0.042)
Qatar	0.301 (0.033)	0.135 (0.027)	–0.056 (0.045)	0.049 (0.020)	–0.044 (0.025)
Romania	0.649 (0.021)	0.272 (0.036)	0.077 (0.052)	0.070 (0.027)	–0.125 (0.033)
Russian Federation	0.405 (0.022)	0.075 (0.027)	0.005 (0.040)	0.099 (0.020)	–0.032 (0.031)
Saudi Arabia	0.405 (0.025)	0.086 (0.035)	0.093 (0.045)	0.049 (0.027)	–0.1 (0.031)
Singapore	0.423 (0.018)	0.142 (0.016)	–0.007 (0.025)	0.090 (0.018)	0.043 (0.019)
Slovak Republic	0.569 (0.021)	0.036 (0.037)	–0.067 (0.034)	–0.002 (0.021)	–0.015 (0.027)
Slovenia	0.495 (0.020)	–0.012 (0.026)	0.109 (0.042)	–0.037 (0.024)	–0.063 (0.027)
Spain	0.570 (0.020)	–0.022 (0.028)	–0.019 (0.044)	0.040 (0.025)	0.049 (0.027)
Sweden	0.486 (0.019)	0.088 (0.027)	0.128 (0.049)	0.088 (0.031)	–0.053 (0.029)
United Arab Emirates	0.413 (0.014)	0.119 (0.015)	0.041 (0.022)	0.028 (0.013)	0.117 (0.019)
Sixth Grade Countries					
Botswana	0.392 (0.033)	0.224 (0.024)	–0.069 (0.040)	0.122 (0.022)	–0.116 (0.028)
Honduras	0.363 (0.053)	0.193 (0.038)	–0.136 (0.046)	0.007 (0.024)	–0.124 (0.035)
Benchmarking Participants					
Quebec, Canada	0.358 (0.026)	0.015 (0.023)	0.079 (0.042)	0.008 (0.025)	–0.106 (0.025)
Abu Dhabi, UAE	0.441 (0.022)	0.116 (0.026)	0.061 (0.039)	0.061 (0.022)	0.097 (0.029)
Dubai, UAE	0.343 (0.026)	0.126 (0.019)	0.022 (0.035)	–0.014 (0.015)	0.147 (0.027)
International Avg.	0.494 (0.021)	0.092 (0.027)	0.060 (0.042)	0.056 (0.024)	0.072 (0.028)
International Std. Dev.	0.089 (0.004)	0.064 (0.005)	0.042 (0.009)	0.028 (0.005)	0.031 (0.005)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

a significant negative relationships between Ability and Parental Education, while for a dozen countries there were significant positive relations. The highest relationships were observed for Botswana, the Russian Federation, Finland, Morocco, Singapore, and Sweden.

One would expect that students with more highly educated parents also are better able to perform numeracy and literacy tasks at school start. There may, however, be many reasons for why this relationship does not appear for all countries. One reason may be that the effect of Parental Education only is indirect, via Books and Activity. Another reason may be that parents with more education evaluate their children's task performance against stricter standards. Yet another reason may be that, in some educational systems, school begins at such an early age that the students have not yet developed much of the numeracy and literacy skills asked about. The latter hypothesis may be tested by investigating how the level of relationship between Parental Education and Ability varies as a function of the age of the students, given that the students in almost all cases were assessed at the fourth grade (exceptions were Botswana and Honduras where students were assessed at Grade 6, and Malta, where students were assessed at Grade 5). The relationship between student mean age at country level and the β coefficient was .40, which supports the hypothesis that student age at the time of beginning primary school is of importance, with

respect to the level of numeracy and literacy skills that can be demonstrated at that time.

The mean of the β coefficients for the relationship between Parental Education and NumLitAb (i.e., the tendency for the parents to assess the child as relatively stronger in literacy tasks then numeracy tasks on the one hand) was -0.03 (sd = 0.07). For about a dozen countries, the parents with a high level of education rated numeracy skills higher than literacy skills. This was most pronounced in Romania, Honduras, Botswana, the Canadian province of Quebec, Georgia, and Iran. For about half a dozen countries, the parents with a high level of education rated literacy skills higher than numeracy skills. This was most pronounced in the United Arab Emirates, Malta, and Oman.

In summary, there was a very strong direct effect of Parental Education on Books. For no other variable in the path model was there a noteworthy general effect of Parental Education. Judging from the results obtained in the Common model, the main reason for this is that the effect of Parental Education on the variables further down the chain is mediated via Books. However, it also may be noted that, for the majority of the relationships investigated, there was heterogeneity in the pattern of results for different countries, which will be discussed in the analyses of models for different countries.

DIRECT EFFECTS OF GENDER Exhibit 4.13 presents estimates of direct effects of Gender on the mediating variables in the path model.

In comparison with Parental Education, there were fewer direct effects of Gender, indicating that parents tend to interact in similar ways with boys and girls. There were, however, several interesting exceptions to this pattern.

First, there was a weak significant positive effect of Gender on Books in about a dozen countries (e.g., Lithuania, Ireland, the Emirate of Dubai, Malta, Sweden, Singapore, Slovenia, and Iran). Thus, in these countries, the parents reported a somewhat higher frequency of books when the child is a girl than when the child is a boy. The significant effects were between .05 and .07.

For the Activity variable, a significant Gender effect also was found in some cases. For example, in Malta, a higher level of activity was reported when the child was a boy; however, for about ten countries, a higher level of activity was reported for girls (e.g., Saudi Arabia, the Emirate of Abu Dhabi, Morocco, Oman, and Austria).

In most countries, there was a considerable effect of Gender for the NumLitAct variable, in such a way that more emphasis on literacy activities than on numeracy activities was reported for girls than for boys. The mean effect was 0.16 (sd = 07). For two countries only (Morocco and Saudi Arabia) was there no significant effect. The countries with the strongest direct effect of gender ($\beta > .24$) were Norway, Lithuania, Sweden, the Canadian province of Quebec, Germany, Finland, and Poland.

For the Ability variable, there was only a small mean effect of 0.03 (sd = 0.04), but there were a small number of countries where boys were rated higher in ability (Austria and Azerbaijan), and about a dozen countries were girls were rated as having better skills in doing literacy and numeracy tasks. Countries with the largest gender effect were Northern Ireland, Saudi Arabia, Hong Kong SAR, Chinese Taipei, Finland, Norway, and Singapore.

For the NumLitAb variable, there was a direct effect of Gender, the mean effect being 0.07 (sd = 0.05). The positive effect implies that girls were assessed as being relatively better at doing literacy tasks than at doing numeracy tasks. There was a significant positive effect in most countries, with the largest effects being observed for Sweden, Croatia, the Canadian province of Quebec, Slovenia, and Norway.

In summary, the results show fewer and smaller direct effects of Gender than of Parental Education. However, in almost all countries, the parents reported a stronger emphasis on literacy activities than on numeracy activities

Exhibit 4.13: Standardized Direct Effects of Gender on the Mediating Variables

Country	Books	Activity	NumLitAct	Ability	NumLitAb
Australia	–0.016 (0.025)	0.031 (0.026)	0.153 (0.042)	0.035 (0.024)	0.134 (0.027)
Austria	0.036 (0.017)	0.046 (0.016)	0.227 (0.035)	–0.054 (0.023)	0.129 (0.026)
Azerbaijan	–0.012 (0.019)	–0.001 (0.019)	0.215 (0.036)	–0.048 (0.022)	0.032 (0.026)
Chinese Taipei	0.015 (0.015)	0.022 (0.015)	0.177 (0.025)	0.079 (0.020)	0.070 (0.022)
Croatia	0.036 (0.015)	0.012 (0.017)	0.195 (0.033)	0.051 (0.019)	0.158 (0.019)
Czech Republic	0.009 (0.021)	0.043 (0.021)	0.074 (0.035)	0.024 (0.020)	0.042 (0.022)
Finland	0.017 (0.019)	0.032 (0.021)	0.243 (0.033)	0.077 (0.021)	0.114 (0.021)
Georgia	–0.002 (0.018)	0.013 (0.018)	0.084 (0.035)	0.064 (0.016)	0.095 (0.022)
Germany	0.025 (0.018)	0.028 (0.019)	0.257 (0.041)	–0.005 (0.023)	0.089 (0.029)
Hong Kong SAR	0.007 (0.022)	–0.004 (0.019)	0.147 (0.021)	0.083 (0.016)	0.008 (0.020)
Hungary	0.003 (0.014)	0.027 (0.016)	0.138 (0.024)	–0.003 (0.017)	0.055 (0.020)
Iran, Islamic Rep. of	0.046 (0.023)	–0.016 (0.024)	0.161 (0.038)	0.038 (0.020)	0.037 (0.022)
Ireland	0.066 (0.023)	–0.029 (0.021)	0.146 (0.032)	0.031 (0.020)	0.130 (0.031)
Italy	0.025 (0.017)	0.032 (0.018)	0.196 (0.030)	–0.013 (0.019)	0.097 (0.023)
Lithuania	0.075 (0.017)	0.028 (0.022)	0.307 (0.031)	0.041 (0.023)	0.130 (0.024)
Malta	0.061 (0.019)	–0.046 (0.020)	0.138 (0.031)	0.047 (0.021)	0.055 (0.024)
Morocco	0.019 (0.018)	0.060 (0.026)	–0.011 (0.030)	0.036 (0.017)	0.014 (0.025)
Northern Ireland	0.055 (0.029)	0.042 (0.029)	0.212 (0.037)	0.098 (0.026)	0.053 (0.033)
Norway	0.020 (0.021)	0.024 (0.028)	0.323 (0.038)	0.068 (0.025)	0.138 (0.029)
Oman	0.003 (0.015)	0.055 (0.015)	0.133 (0.025)	0.023 (0.015)	0.068 (0.016)
Poland	0.030 (0.017)	0.042 (0.017)	0.236 (0.029)	0.005 (0.018)	0.049 (0.023)
Portugal	0.018 (0.021)	0.037 (0.021)	0.160 (0.038)	–0.011 (0.021)	0.058 (0.022)
Qatar	0.040 (0.023)	0.030 (0.021)	0.084 (0.038)	0.026 (0.019)	0.029 (0.027)
Romania	0.031 (0.014)	0.023 (0.016)	0.076 (0.027)	0.047 (0.016)	0.004 (0.026)
Russian Federation	0.023 (0.017)	0.044 (0.018)	0.120 (0.029)	0.035 (0.017)	0.051 (0.022)
Saudi Arabia	0.070 (0.041)	0.134 (0.027)	0.033 (0.035)	0.093 (0.030)	0.070 (0.026)
Singapore	0.050 (0.018)	0.016 (0.013)	0.117 (0.019)	0.067 (0.013)	0.040 (0.015)
Slovak Republic	0.040 (0.016)	0.039 (0.018)	0.153 (0.031)	–0.022 (0.015)	0.059 (0.018)
Slovenia	0.049 (0.017)	0.009 (0.017)	0.181 (0.034)	0.046 (0.023)	0.144 (0.025)
Spain	–0.007 (0.018)	0.016 (0.017)	0.204 (0.033)	–0.001 (0.020)	0.107 (0.021)
Sweden	0.050 (0.021)	0.035 (0.021)	0.281 (0.039)	0.063 (0.025)	0.177 (0.030)
United Arab Emirates	0.008 (0.015)	0.032 (0.012)	0.107 (0.020)	0.023 (0.012)	0.028 (0.020)
Sixth Grade Countries					
Botswana	–0.002 (0.020)	0.039 (0.019)	0.152 (0.029)	0.028 (0.018)	0.006 (0.022)
Honduras	0.000 (0.023)	–0.02 (0.022)	0.113 (0.038)	0.000 (0.027)	–0.009 (0.031)
Benchmarking Participants					
Quebec, Canada	0.017 (0.023)	0.012 (0.019)	0.267 (0.030)	0.011 (0.020)	0.150 (0.026)
Abu Dhabi, UAE	0.018 (0.023)	0.076 (0.021)	0.127 (0.035)	0.031 (0.021)	0.048 (0.029)
Dubai, UAE	0.065 (0.026)	0.024 (0.013)	0.150 (0.030)	0.034 (0.021)	–0.005 (0.031)
International Avg.	0.033 (0.019)	0.035 (0.020)	0.170 (0.032)	0.050 (0.020)	0.077 (0.024)
International Std. Dev.	0.021 (0.005)	0.023 (0.004)	0.070 (0.006)	0.024 (0.004)	0.047 (0.004)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

when their child was a girl than when their child was a boy. Furthermore, in most countries, the parents assessed girls' literacy skills to be stronger than their numeracy skills. There also was a tendency for the parents to report more books in the home for girls, and also a tendency towards a higher level of activity with girls.

Direct Effects Among the Mediating Variables

This section looks closer at the relationships among the mediating variables: Books, and the Activity and Ability variables. These relationships are, of course, the same when we investigate effects of Parental Education and Gender.

EFFECTS OF BOOKS Exhibit 4.14 presents standardized direct effects of Books on the variables in the path model.

As is presented in Exhibit 4.14, there was a large direct effect of Books on Activity, the mean β being 0.34 (sd = 0.07). There also was a sizeable variation in the strength of the relationship across countries. The smallest effects were around .20 and were observed for Honduras, Botswana, Morocco, the Czech Republic, Italy, and Azerbaijan. The largest effects were higher than 0.40 and were observed for Portugal, Chinese Taipei, Malta, Austria, Georgia, and Ireland.

For the direct effect of Books on the variable NumLitAct, the mean was 0.09 (sd = 0.09), indicating that parents who reported a larger number of books in the home also tended to report that activities were more literacy oriented than numeracy oriented. For two countries (Georgia and Hungary) the effect was negative and significant, while for around 20 countries the effect was positive and significant. The largest positive effects were observed for Italy, Chinese Taipei, Lithuania, Germany, and Sweden.

The mean direct effect of Books on Ability was 0.0, but there was large variability across countries (sd = 0.10). For eight countries the effect was negative and significant, most markedly so in Austria, Ireland, Germany, and Australia. For ten countries the effect was positive and significant, with the strongest relationships in Singapore, Russian Federation and Lithuania.

For the direct effect of Books on the variable NumLitAb, the mean estimate of β was close to 0, and for only one country (Portugal) was there a weak significant positive effect.

The Books variable had strong direct effects on the three achievement variables: 0.22 for mathematics, 0.24 for science and 0.23 for reading. However, there also was considerable variation across countries (sd between .09 and .10).

Exhibit 4.14: Standardized Direct Effect of Books on the Variables in the Path Model

Country	Activity	NumLitAct	Ability	NumLitAb	Mathematics	Science	Reading
Australia	0.381 (0.028)	0.118 (0.060)	–0.147 (0.030)	0.036 (0.027)	0.226 (0.033)	0.270 (0.034)	0.233 (0.034)
Austria	0.417 (0.020)	0.082 (0.061)	–0.245 (0.029)	0.034 (0.026)	0.441 (0.035)	0.447 (0.031)	0.422 (0.029)
Azerbaijan	0.262 (0.034)	0.073 (0.046)	0.069 (0.026)	0.031 (0.026)	0.083 (0.038)	0.095 (0.039)	0.061 (0.036)
Chinese Taipei	0.440 (0.020)	0.213 (0.038)	0.069 (0.029)	0.036 (0.022)	0.227 (0.023)	0.237 (0.028)	0.179 (0.023)
Croatia	0.329 (0.024)	0.081 (0.039)	0.055 (0.022)	0.026 (0.019)	0.221 (0.023)	0.255 (0.027)	0.246 (0.024)
Czech Republic	0.257 (0.026)	0.109 (0.051)	–0.001 (0.028)	0.034 (0.022)	0.280 (0.024)	0.317 (0.026)	0.297 (0.026)
Finland	0.328 (0.021)	0.149 (0.060)	0.078 (0.035)	0.037 (0.021)	0.194 (0.035)	0.264 (0.032)	0.237 (0.031)
Georgia	0.415 (0.028)	–0.177 (0.045)	0.086 (0.027)	0.033 (0.022)	0.208 (0.038)	0.222 (0.042)	0.220 (0.036)
Germany	0.312 (0.027)	0.192 (0.059)	–0.16 (0.030)	0.038 (0.029)	0.375 (0.034)	0.412 (0.037)	0.373 (0.033)
Hong Kong SAR	0.392 (0.025)	0.133 (0.037)	0.080 (0.028)	0.031 (0.020)	0.154 (0.033)	0.165 (0.031)	0.119 (0.032)
Hungary	0.381 (0.027)	–0.157 (0.054)	–0.04 (0.030)	0.031 (0.020)	0.324 (0.030)	0.366 (0.027)	0.307 (0.029)
Iran, Islamic Rep. of	0.371 (0.022)	0.027 (0.068)	0.004 (0.026)	0.036 (0.022)	0.223 (0.034)	0.215 (0.029)	0.201 (0.030)
Ireland	0.396 (0.024)	0.157 (0.056)	–0.169 (0.027)	0.042 (0.031)	0.348 (0.029)	0.368 (0.039)	0.378 (0.028)
Italy	0.258 (0.028)	0.221 (0.038)	–0.09 (0.027)	0.030 (0.023)	0.203 (0.028)	0.267 (0.033)	0.261 (0.026)
Lithuania	0.277 (0.027)	0.195 (0.041)	0.126 (0.029)	0.033 (0.024)	0.207 (0.025)	0.220 (0.028)	0.229 (0.026)
Malta	0.418 (0.029)	0.087 (0.045)	–0.012 (0.031)	0.034 (0.024)	0.201 (0.033)	0.226 (0.029)	0.193 (0.030)
Morocco	0.243 (0.031)	0.093 (0.040)	0.062 (0.022)	0.034 (0.025)	0.032 (0.028)	0.056 (0.028)	0.034 (0.026)
Northern Ireland	0.331 (0.036)	0.168 (0.059)	–0.131 (0.035)	0.049 (0.033)	0.268 (0.042)	0.332 (0.047)	0.268 (0.040)
Norway	0.350 (0.032)	0.085 (0.055)	–0.035 (0.029)	0.042 (0.029)	0.227 (0.038)	0.304 (0.033)	0.291 (0.034)
Oman	0.310 (0.022)	0.079 (0.036)	0.028 (0.020)	0.022 (0.016)	0.130 (0.021)	0.096 (0.021)	0.126 (0.022)
Poland	0.357 (0.033)	0.164 (0.045)	–0.028 (0.027)	0.031 (0.023)	0.212 (0.028)	0.211 (0.027)	0.179 (0.029)
Portugal	0.489 (0.025)	0.085 (0.072)	0.027 (0.037)	0.045 (0.022)	0.269 (0.044)	0.236 (0.049)	0.259 (0.045)
Qatar	0.278 (0.029)	0.138 (0.035)	–0.054 (0.029)	0.027 (0.027)	0.228 (0.046)	0.173 (0.043)	0.193 (0.042)
Romania	0.385 (0.033)	–0.077 (0.057)	0.062 (0.034)	0.038 (0.026)	0.228 (0.036)	0.220 (0.036)	0.229 (0.035)
Russian Federation	0.378 (0.022)	0.026 (0.041)	0.154 (0.023)	0.027 (0.022)	0.144 (0.029)	0.177 (0.029)	0.186 (0.025)
Saudi Arabia	0.354 (0.041)	0.040 (0.043)	0.090 (0.027)	0.032 (0.026)	0.138 (0.053)	0.155 (0.047)	0.103 (0.042)
Singapore	0.336 (0.018)	0.147 (0.029)	0.195 (0.019)	0.025 (0.015)	0.208 (0.020)	0.251 (0.020)	0.235 (0.018)
Slovak Republic	0.318 (0.031)	0.101 (0.045)	0.023 (0.022)	0.030 (0.018)	0.358 (0.032)	0.366 (0.032)	0.348 (0.027)
Slovenia	0.324 (0.025)	0.060 (0.045)	0.038 (0.027)	0.029 (0.025)	0.295 (0.026)	0.327 (0.023)	0.309 (0.022)
Spain	0.378 (0.028)	0.140 (0.051)	0.075 (0.031)	0.031 (0.021)	0.214 (0.033)	0.249 (0.035)	0.191 (0.033)
Sweden	0.267 (0.028)	0.189 (0.049)	–0.051 (0.034)	0.039 (0.030)	0.315 (0.035)	0.404 (0.032)	0.310 (0.031)
United Arab Emirates	0.325 (0.014)	0.114 (0.025)	–0.037 (0.019)	0.018 (0.020)	0.241 (0.024)	0.203 (0.024)	0.252 (0.023)
Sixth Grade Countries							
Botswana	0.212 (0.031)	–0.036 (0.038)	0.061 (0.022)	0.023 (0.022)	0.054 (0.024)	0.047 (0.023)	0.055 (0.023)
Honduras	0.162 (0.042)	–0.011 (0.037)	–0.02 (0.025)	0.028 (0.031)	0.041 (0.030)	0.064 (0.029)	0.062 (0.031)
Benchmarking Participants							
Quebec, Canada	0.368 (0.027)	0.149 (0.051)	–0.067 (0.030)	0.033 (0.026)	0.206 (0.031)	0.257 (0.034)	0.183 (0.030)
Abu Dhabi, UAE	0.302 (0.026)	0.102 (0.044)	–0.02 (0.036)	0.032 (0.029)	0.183 (0.045)	0.129 (0.047)	0.193 (0.048)
Dubai, UAE	0.354 (0.021)	0.108 (0.043)	–0.091 (0.026)	0.026 (0.031)	0.356 (0.030)	0.335 (0.029)	0.353 (0.026)
International Avg.	0.346 (0.027)	0.120 (0.048)	0.073 (0.028)	0.033 (0.024)	0.232 (0.032)	0.253 (0.032)	0.233 (0.030)
International Std. Dev.	0.060 (0.006)	0.054 (0.011)	0.047 (0.005)	0.006 (0.004)	0.084 (0.008)	0.094 (0.007)	0.088 (0.006)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

The correlations between the βs for the three relations were from .94 to .96. For the following countries a strong direct effect of Books on achievement in all three domains was observed: Austria, Germany, the Slovak Republic, Ireland, Sweden, the Emirate of Dubai, and Hungary.

In summary, the results show, as expected, a substantial positive direct effect of Books on Activity, but also a large variation across countries. For the majority of countries there also was a positive effect of Books on NumLitAct, which implies that homes with many books tended to be engaged in more literacy than numeracy activities. There was no overall effect of Books on Ability, though there were differences across country.

EFFECTS OF THE ACTIVITY VARIABLES Exhibit 4.15 presents the standardized direct effects of the activity variables on the other variables in the path model.

As noted in Exhibit 4.15, the Activity variable had a direct effect of 0.40 (sd = 0.08) on Ability, and the positive effect was significant in all countries. The smallest effects (.31 or lower) were observed for Finland, Spain, Hong Kong SAR, and Croatia, while the largest effects (.51 or higher) were observed for Romania, Morocco, Azerbaijan, and the Slovak Republic.

The average effect of the Activity variable on NumLitAb was close to 0, but there was variation across countries (sd = 0.07). For five countries there was a significant negative effect, implying that a high level of Activity was related to higher numeracy skills than literacy skills at school start. Interestingly, these five countries were all are East European countries: Romania, the Russian Federation, Hungary, the Slovak Republic, and the Czech Republic. Three countries, Morocco, Singapore, and Ireland, had a significant positive relationship.

The average direct effect of Activity was close to zero for all three achievement measures, but there was variability across countries (sd between 0.06 and 0.07). The correlations between the βs for the three relations were .92 to .93. For mathematics there were significant negative direct effects for 18 countries, with the largest effects being observed for Morocco, Singapore, Slovenia, the Russian Federation, and Norway. Significant positive direct effects were observed for the United Arab Emirates and the two Emirates of Abu Dhabi and Dubai. For science there were significant negative relationships for eight countries, including all of the aforementioned, with significant negative relationships between Activity and mathematics achievement. There were significant positive effects on science achievement in six countries, among

which were those with significant positive effects on mathematics achievement. There was a negative direct effect of Activity on reading for five countries, and a positive effect for six countries, the results largely being in agreement with those observed for science.

With respect to the estimated direct effects of NumLitAct, this variable had a strong direct effect on the Ability variable with an average of 0.20 (sd = 0.08). This finding implies that activities which emphasize literacy rather than numeracy are positively related to a high level of skills in performing both literacy and numeracy tasks at the beginning of primary school. While there was variability in the estimated β coefficients, they were significant and positive in all countries. The estimates ranged from a low of .06 in Singapore to a high of .40 in Azerbaijan. Other countries with large estimated direct effects included Austria, Hungary, Germany, Oman, and Slovenia.

The NumLitAct variable also had a rather large direct effect on the NumLitAb variable, the average effect being 0.13 (sd = 0.10). Only in Georgia was the effect significantly negative; rather, it was positive and significant in most countries. These positive relations thus imply that activities which emphasize literacy more than numeracy are related to higher literacy skills than numeracy skills.

The NumLitAct variable had an average direct effect on mathematics achievement that was negative (-0.07, sd = 0.06). The negative effect was significant for 16 countries, while the effect was non-significant for all other participants. The largest negative effects were observed for Finland, Morocco, Hungary, Iran, and Norway. At a general level, it is perhaps reasonable to expect that activities which emphasize literacy rather than numeracy would have a negative direct effect on mathematic achievement.

The NumLitAct variable had a negative direct effect on science achievement in six countries: Iran, Morocco, Hungary, Romania, Croatia, Ireland, and Chinese Taipei. However, NumLitAct had a positive direct effect on reading achievement for three participants (the Canadian province of Quebec, Sweden, and Spain), and a negative direct effect in three participants (Iran, Romania, and Hungary).

In summary, Activity had a substantial relationship with Ability, supporting the idea of the Main Path. There was no general effect of Activity on NumLitAb or on any of the three achievement variables, but there were small direct effects that varied across countries. As expected, NumLitAct had a significant effect on NumLitAb in almost all countries, even though the effect

Exhibit 4.15: Standardized Direct Effects of the Activity Variables on the Other Variables in the Path Model

Country	Activity				
	Ability	NumLitAb	Mathematics	Science	Reading
Australia	0.396 (0.028)	0.026 (0.038)	−0.039 (0.033)	0.015 (0.034)	0.002 (0.034)
Austria	0.387 (0.022)	0.017 (0.034)	−0.082 (0.031)	−0.012 (0.026)	−0.002 (0.029)
Azerbaijan	0.530 (0.025)	−0.052 (0.047)	−0.021 (0.037)	0.015 (0.035)	0.009 (0.035)
Chinese Taipei	0.386 (0.018)	0.039 (0.029)	−0.022 (0.020)	−0.038 (0.020)	−0.033 (0.020)
Croatia	0.309 (0.021)	−0.037 (0.024)	−0.042 (0.020)	0.000 (0.025)	−0.028 (0.019)
Czech Republic	0.377 (0.019)	−0.106 (0.029)	−0.086 (0.023)	−0.081 (0.025)	−0.058 (0.023)
Finland	0.246 (0.026)	−0.034 (0.026)	−0.058 (0.023)	−0.048 (0.029)	−0.056 (0.023)
Georgia	0.490 (0.023)	−0.042 (0.038)	−0.093 (0.033)	−0.044 (0.034)	−0.033 (0.033)
Germany	0.388 (0.023)	0.056 (0.030)	−0.087 (0.026)	−0.038 (0.025)	−0.03 (0.027)
Hong Kong SAR	0.303 (0.022)	0.012 (0.022)	−0.043 (0.022)	−0.049 (0.022)	−0.035 (0.032)
Hungary	0.465 (0.025)	−0.12 (0.044)	−0.006 (0.024)	−0.02 (0.031)	0.004 (0.030)
Iran, Islamic Rep. of	0.504 (0.030)	−0.027 (0.031)	−0.063 (0.026)	−0.02 (0.028)	−0.025 (0.024)
Ireland	0.374 (0.019)	0.067 (0.024)	−0.007 (0.027)	0.032 (0.032)	0.008 (0.028)
Italy	0.382 (0.020)	0.029 (0.030)	−0.016 (0.029)	0.036 (0.025)	0.016 (0.024)
Lithuania	0.369 (0.019)	−0.033 (0.028)	−0.085 (0.024)	−0.101 (0.023)	−0.098 (0.022)
Malta	0.334 (0.022)	0.021 (0.027)	0.051 (0.027)	0.051 (0.025)	0.092 (0.026)
Morocco	0.569 (0.034)	0.162 (0.039)	−0.274 (0.045)	−0.204 (0.041)	−0.174 (0.037)
Northern Ireland	0.397 (0.025)	0.033 (0.044)	−0.041 (0.034)	−0.044 (0.037)	0.008 (0.036)
Norway	0.466 (0.023)	0.009 (0.044)	−0.117 (0.033)	−0.06 (0.035)	−0.063 (0.037)
Oman	0.435 (0.019)	0.047 (0.025)	0.038 (0.022)	0.047 (0.022)	0.042 (0.020)
Poland	0.470 (0.022)	0.014 (0.034)	−0.05 (0.023)	−0.029 (0.025)	0.005 (0.025)
Portugal	0.356 (0.023)	0.007 (0.034)	−0.071 (0.031)	−0.009 (0.036)	−0.073 (0.030)
Qatar	0.352 (0.020)	−0.002 (0.024)	−0.005 (0.029)	0.037 (0.025)	0.009 (0.023)
Romania	0.587 (0.032)	−0.213 (0.045)	−0.088 (0.042)	−0.032 (0.039)	−0.026 (0.031)
Russian Federation	0.467 (0.023)	−0.121 (0.036)	−0.125 (0.029)	−0.105 (0.036)	−0.089 (0.027)
Saudi Arabia	0.425 (0.030)	0.013 (0.036)	0.010 (0.037)	0.004 (0.039)	0.030 (0.030)
Singapore	0.363 (0.016)	0.069 (0.021)	−0.134 (0.017)	−0.104 (0.014)	−0.088 (0.015)
Slovak Republic	0.511 (0.028)	−0.117 (0.035)	−0.104 (0.036)	−0.088 (0.034)	−0.051 (0.031)
Slovenia	0.383 (0.022)	−0.047 (0.029)	−0.131 (0.023)	−0.079 (0.026)	−0.062 (0.023)
Spain	0.288 (0.025)	−0.022 (0.032)	0.008 (0.028)	0.031 (0.028)	0.022 (0.029)
Sweden	0.344 (0.023)	0.049 (0.032)	−0.062 (0.027)	−0.008 (0.028)	−0.005 (0.027)
United Arab Emirates	0.367 (0.013)	0.026 (0.017)	0.056 (0.018)	0.089 (0.018)	0.083 (0.015)
Sixth Grade Countries					
Botswana	0.472 (0.029)	0.029 (0.032)	0.050 (0.030)	0.068 (0.028)	0.066 (0.023)
Honduras	0.419 (0.026)	0.069 (0.039)	−0.041 (0.041)	−0.048 (0.040)	−0.03 (0.039)
Benchmarking Participants					
Quebec, Canada	0.334 (0.024)	0.014 (0.030)	−0.057 (0.027)	−0.022 (0.035)	0.032 (0.028)
Abu Dhabi, UAE	0.375 (0.021)	0.000 (0.029)	0.064 (0.030)	0.105 (0.027)	0.092 (0.024)
Dubai, UAE	0.338 (0.016)	0.025 (0.026)	0.093 (0.027)	0.111 (0.027)	0.115 (0.023)
International Avg.	0.407 (0.023)	0.039 (0.032)	0.033 (0.028)	0.032 (0.029)	0.025 (0.027)
International Std. Dev.	0.081 (0.005)	0.036 (0.008)	0.023 (0.007)	0.025 (0.007)	0.030 (0.006)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.15: Standardized Direct Effects of the Activity Variables on the Other Variables in the Path Model (Continued)

Country	NumLitAct				
	Ability	NumLitAb	Mathematics	Science	Reading
Australia	0.176 (0.039)	0.164 (0.051)	–0.061 (0.046)	0.008 (0.046)	0.032 (0.043)
Austria	0.393 (0.046)	0.314 (0.064)	–0.133 (0.057)	–0.046 (0.049)	0.000 (0.054)
Azerbaijan	0.398 (0.041)	0.157 (0.074)	0.065 (0.057)	0.032 (0.063)	0.009 (0.061)
Chinese Taipei	0.114 (0.024)	0.033 (0.032)	–0.113 (0.031)	–0.060 (0.027)	–0.005 (0.030)
Croatia	0.232 (0.037)	0.135 (0.039)	–0.126 (0.035)	–0.086 (0.041)	0.002 (0.040)
Czech Republic	0.194 (0.039)	0.109 (0.048)	–0.024 (0.038)	0.026 (0.040)	0.074 (0.040)
Finland	0.189 (0.040)	0.260 (0.050)	–0.182 (0.044)	–0.034 (0.053)	0.041 (0.044)
Georgia	0.199 (0.033)	–0.117 (0.049)	–0.084 (0.038)	–0.032 (0.038)	–0.002 (0.040)
Germany	0.320 (0.045)	0.352 (0.058)	–0.139 (0.059)	–0.027 (0.055)	0.007 (0.054)
Hong Kong SAR	0.147 (0.029)	0.081 (0.028)	–0.083 (0.032)	–0.025 (0.028)	–0.005 (0.026)
Hungary	0.332 (0.036)	0.276 (0.046)	–0.179 (0.036)	–0.109 (0.039)	–0.080 (0.037)
Iran, Islamic Rep. of	0.203 (0.033)	0.174 (0.044)	–0.176 (0.039)	–0.178 (0.037)	–0.166 (0.035)
Ireland	0.173 (0.032)	0.022 (0.043)	–0.061 (0.035)	–0.070 (0.034)	–0.033 (0.033)
Italy	0.228 (0.035)	0.151 (0.045)	–0.062 (0.039)	0.007 (0.043)	0.063 (0.038)
Lithuania	0.159 (0.042)	0.201 (0.041)	–0.080 (0.037)	–0.012 (0.041)	0.014 (0.040)
Malta	0.155 (0.031)	–0.042 (0.035)	–0.018 (0.031)	–0.034 (0.027)	–0.022 (0.026)
Morocco	0.274 (0.037)	0.243 (0.114)	–0.180 (0.060)	–0.137 (0.057)	–0.118 (0.067)
Northern Ireland	0.153 (0.035)	0.117 (0.052)	–0.045 (0.047)	–0.022 (0.052)	0.002 (0.042)
Norway	0.237 (0.036)	0.170 (0.051)	–0.158 (0.052)	0.022 (0.046)	0.037 (0.047)
Oman	0.285 (0.029)	0.091 (0.035)	–0.008 (0.034)	–0.020 (0.034)	–0.031 (0.032)
Poland	0.260 (0.030)	0.220 (0.039)	–0.045 (0.034)	0.054 (0.040)	0.043 (0.034)
Portugal	0.139 (0.046)	0.088 (0.043)	–0.084 (0.037)	–0.041 (0.035)	–0.007 (0.038)
Qatar	0.158 (0.037)	0.049 (0.040)	–0.089 (0.029)	–0.035 (0.032)	–0.004 (0.032)
Romania	0.112 (0.030)	0.124 (0.035)	–0.103 (0.039)	–0.109 (0.040)	–0.087 (0.028)
Russian Federation	0.232 (0.031)	0.045 (0.047)	–0.013 (0.037)	–0.013 (0.043)	0.031 (0.036)
Saudi Arabia	0.201 (0.043)	0.096 (0.055)	0.023 (0.035)	0.012 (0.037)	0.004 (0.033)
Singapore	0.062 (0.019)	0.045 (0.027)	–0.083 (0.019)	–0.039 (0.019)	–0.017 (0.019)
Slovak Republic	0.208 (0.027)	0.240 (0.035)	–0.065 (0.036)	0.008 (0.039)	–0.015 (0.034)
Slovenia	0.281 (0.033)	0.171 (0.052)	–0.038 (0.037)	0.057 (0.039)	0.068 (0.035)
Spain	0.109 (0.040)	0.076 (0.043)	–0.015 (0.047)	0.028 (0.041)	0.069 (0.033)
Sweden	0.236 (0.051)	0.134 (0.062)	–0.075 (0.042)	0.063 (0.046)	0.133 (0.045)
United Arab Emirates	0.115 (0.019)	0.095 (0.023)	–0.001 (0.018)	0.014 (0.021)	0.036 (0.020)
Sixth Grade Countries					
Botswana	0.120 (0.042)	0.115 (0.045)	0.013 (0.034)	–0.005 (0.033)	–0.036 (0.029)
Honduras	0.135 (0.043)	–0.080 (0.050)	–0.018 (0.044)	–0.060 (0.043)	–0.038 (0.039)
Benchmarking Participants					
Quebec, Canada	0.188 (0.040)	0.094 (0.046)	–0.064 (0.044)	0.068 (0.042)	0.139 (0.043)
Abu Dhabi, UAE	0.139 (0.030)	0.113 (0.036)	–0.018 (0.030)	–0.002 (0.031)	0.020 (0.031)
Dubai, UAE	0.103 (0.028)	0.112 (0.033)	–0.025 (0.032)	0.012 (0.034)	0.039 (0.031)
International Avg.	0.209 (0.035)	0.148 (0.047)	0.044 (0.039)	0.028 (0.040)	0.037 (0.038)
International Std. Dev.	0.080 (0.007)	0.085 (0.016)	0.030 (0.010)	0.020 (0.010)	0.035 (0.011)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

was relatively small. NumLitAct also had a significant direct effect on Ability in every country, and this relationship was not expected. This implies that, in homes where there is greater emphasis on literacy activities than on numeracy activities, both numeracy skills and literacy skills at school start are higher. It also was unexpected to find that NumLitAct had a significant negative effect on mathematics achievement in about half of the countries. There may be several explanations for these unexpected relationships, which will be discussed later.

EFFECTS OF THE ABILITY VARIABLES Exhibit 4.16 presents standardized direct effects of the Ability variables on the three achievement variables.

As shown in Exhibit 4.16, the average of the direct effects of Ability on mathematics achievement was 0.25 (sd = 0.10). For both science and reading the direct effects of Ability were 0.21 (sd = 0.08). The direct effect was significant in every country except Azerbaijan.

The average effect of NumLitAb on mathematics achievement was close to zero, but there was variability across countries (sd = 0.07). Significant negative direct effects on mathematics achievement were observed in 14 countries. Such negative effects are to be expected, given that negative scores on NumLitAb express stronger numeracy skills than literacy skills. Significant positive effects were found for seven countries, with the largest effects found for the Emirate of Abu Dhabi, Morocco, Qatar, the United Arab Emirates, the Emirate of Dubai, and Oman.

The average effect of NumLitAb on science achievement was close to zero, though again there was variation across countries (sd = 0.07). There were significant negative direct effects for twelve countries, while there were significant positive direct effects for eight countries.

The average direct effect of NumLitAb on reading achievement was close to zero, similar to mathematics and science, but ten countries had significant negative effects while eleven countries had significant positive effects. The negative effects were rather weak.

In summary, the expected positive direct effects of Ability on the three fourth grade student achievement measures were observed in all countries, except for one. For the NumLitAb variable, there were no general effects on achievement. However, both positive and negative significant effects within different countries were observed.

Exhibit 4.16: Standardized Direct Effects of the Ability Variables on Achievement, Grade 4

Country	Ability			NumLitAb		
	Mathematics	Science	Reading	Mathematics	Science	Reading
Australia	0.320 (0.029)	0.262 (0.029)	0.231 (0.027)	−0.080 (0.027)	−0.071 (0.027)	−0.070 (0.026)
Austria	0.289 (0.039)	0.123 (0.030)	0.116 (0.036)	−0.095 (0.027)	−0.081 (0.029)	−0.044 (0.029)
Azerbaijan	0.024 (0.040)	0.028 (0.042)	0.019 (0.047)	−0.128 (0.028)	−0.102 (0.027)	−0.034 (0.027)
Chinese Taipei	0.301 (0.021)	0.275 (0.022)	0.262 (0.020)	0.012 (0.021)	−0.004 (0.022)	0.019 (0.021)
Croatia	0.379 (0.021)	0.243 (0.025)	0.262 (0.020)	−0.063 (0.024)	−0.009 (0.023)	0.011 (0.023)
Czech Republic	0.254 (0.025)	0.172 (0.026)	0.183 (0.024)	−0.129 (0.023)	−0.106 (0.026)	−0.075 (0.025)
Finland	0.471 (0.021)	0.286 (0.021)	0.315 (0.023)	−0.035 (0.027)	−0.044 (0.026)	0.025 (0.028)
Georgia	0.211 (0.029)	0.198 (0.028)	0.209 (0.025)	−0.090 (0.027)	−0.086 (0.030)	−0.055 (0.023)
Germany	0.290 (0.035)	0.150 (0.036)	0.163 (0.030)	−0.086 (0.032)	−0.092 (0.031)	−0.073 (0.029)
Hong Kong SAR	0.379 (0.023)	0.395 (0.020)	0.359 (0.020)	0.033 (0.026)	0.066 (0.027)	0.105 (0.028)
Hungary	0.215 (0.028)	0.157 (0.026)	0.178 (0.027)	−0.089 (0.022)	−0.068 (0.021)	−0.044 (0.021)
Iran, Islamic Rep. of	0.198 (0.024)	0.175 (0.027)	0.179 (0.026)	−0.102 (0.024)	−0.086 (0.025)	−0.085 (0.023)
Ireland	0.199 (0.032)	0.141 (0.027)	0.163 (0.027)	−0.041 (0.023)	−0.055 (0.032)	−0.025 (0.024)
Italy	0.205 (0.025)	0.091 (0.031)	0.105 (0.025)	−0.044 (0.023)	−0.023 (0.026)	−0.004 (0.025)
Lithuania	0.422 (0.028)	0.390 (0.030)	0.379 (0.024)	0.005 (0.019)	0.003 (0.021)	0.048 (0.024)
Malta	0.194 (0.021)	0.165 (0.021)	0.191 (0.019)	0.003 (0.025)	0.060 (0.020)	0.084 (0.021)
Morocco	0.268 (0.057)	0.244 (0.053)	0.313 (0.042)	0.097 (0.035)	0.127 (0.032)	0.063 (0.037)
Northern Ireland	0.223 (0.033)	0.192 (0.036)	0.193 (0.036)	−0.067 (0.032)	−0.049 (0.036)	−0.072 (0.033)
Norway	0.390 (0.030)	0.302 (0.032)	0.286 (0.034)	−0.063 (0.032)	−0.131 (0.026)	−0.030 (0.027)
Oman	0.216 (0.024)	0.234 (0.026)	0.219 (0.026)	0.052 (0.016)	0.051 (0.019)	0.095 (0.017)
Poland	0.326 (0.020)	0.241 (0.023)	0.247 (0.020)	−0.049 (0.019)	−0.033 (0.021)	0.009 (0.018)
Portugal	0.158 (0.034)	0.124 (0.029)	0.205 (0.022)	−0.089 (0.033)	−0.072 (0.034)	−0.068 (0.027)
Qatar	0.196 (0.029)	0.225 (0.029)	0.211 (0.027)	0.085 (0.024)	0.110 (0.024)	0.094 (0.026)
Romania	0.238 (0.041)	0.219 (0.034)	0.212 (0.030)	−0.079 (0.026)	−0.110 (0.024)	−0.084 (0.024)
Russian Federation	0.295 (0.028)	0.278 (0.028)	0.284 (0.029)	−0.025 (0.026)	−0.030 (0.027)	0.008 (0.022)
Saudi Arabia	0.149 (0.038)	0.143 (0.040)	0.179 (0.037)	0.010 (0.028)	−0.028 (0.028)	0.008 (0.023)
Singapore	0.364 (0.020)	0.341 (0.018)	0.325 (0.019)	−0.027 (0.018)	0.009 (0.018)	0.034 (0.016)
Slovak Republic	0.164 (0.033)	0.133 (0.034)	0.162 (0.029)	−0.043 (0.030)	−0.045 (0.035)	−0.039 (0.026)
Slovenia	0.340 (0.020)	0.201 (0.025)	0.243 (0.020)	−0.017 (0.025)	0.011 (0.024)	0.011 (0.024)
Spain	0.291 (0.023)	0.258 (0.027)	0.253 (0.024)	0.040 (0.020)	0.052 (0.031)	0.097 (0.020)
Sweden	0.383 (0.022)	0.205 (0.027)	0.235 (0.021)	0.012 (0.034)	0.037 (0.026)	0.053 (0.027)
United Arab Emirates	0.110 (0.014)	0.119 (0.015)	0.099 (0.014)	0.083 (0.015)	0.096 (0.015)	0.111 (0.015)
Sixth Grade Countries						
Botswana	0.190 (0.031)	0.216 (0.026)	0.202 (0.025)	−0.005 (0.026)	−0.026 (0.023)	−0.006 (0.021)
Honduras	0.168 (0.040)	0.185 (0.036)	0.206 (0.036)	−0.079 (0.038)	−0.102 (0.035)	−0.070 (0.029)
Benchmarking Participants						
Quebec, Canada	0.240 (0.026)	0.202 (0.023)	0.201 (0.023)	−0.048 (0.028)	−0.010 (0.027)	−0.020 (0.025)
Abu Dhabi, UAE	0.162 (0.028)	0.172 (0.027)	0.150 (0.027)	0.103 (0.023)	0.110 (0.021)	0.117 (0.023)
Dubai, UAE	0.086 (0.017)	0.085 (0.020)	0.068 (0.018)	0.081 (0.021)	0.108 (0.022)	0.111 (0.023)
International Avg.	0.264 (0.028)	0.210 (0.029)	0.218 (0.027)	0.039 (0.025)	0.057 (0.026)	0.051 (0.024)
International Std. Dev.	0.098 (0.009)	0.083 (0.007)	0.077 (0.007)	0.035 (0.005)	0.041 (0.005)	0.039 (0.005)

( ) Standard errors appear in parentheses.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Discussion of Overall Results from the Country-by-Country Analysis

This analysis of country differences in direct effects in the path model demonstrates both similarities and differences. We can first conclude that, for all countries, the links were supported in the hypothesized Main Path from Books to Activity, to Ability, and finally to achievement at the fourth grade. Given that there also was a strong direct effect of Parental Education on Books, this Main Path mediates a part of the total effect of Parental Education on achievement. However, there was no general effect of Gender on Books, even though there was a weak tendency for the parents to report more books in the home for girls; therefore, the Main Path does not mediate much of the Gender differences in achievement.

Unexpectedly, NumLitAct had a direct effect on Ability in all countries. This effect implies that, in homes that place greater emphasis on literacy activities than numeracy activities, the child will develop a greater general Ability to do both numeracy and literacy tasks by the beginning of primary school. One possible explanation of this finding is that literacy activities have a broader range of influence, so that they positively impact both literacy and numeracy skills. A partially different interpretation is that numeracy skills at the beginning of primary school tend to involve both reading and writing, because expression of numeracy skills often is accomplished via literacy skills.

Another possible interpretation is that this relationship is due to the fact that the Ability variable has a bias towards literacy skills. From the presentation of the measurement model in the Common model, it will be remembered that the two indicators of literacy skills had higher loadings on the latent Ability variable than had the two indicators of numeracy skills. This suggests that the Ability variable could be biased in the literacy direction, which would cause the positive relationship with the NumLitAct variable. However, even though this line of argument may be valid, it must be asked why the literacy tasks have such a strong relationship to the Ability variable. One interpretation of this would be that the literacy skills indicators are better indicators of a general Ability to perform school-related tasks than are the numeracy skills indicators. The fact that the latent Ability variable had relatively high relations with all of the fourth grade student achievement measures supports this line of reasoning. Thus, if the latent Ability variable is to have the desirable property of predicting school achievement, it may need to have an emphasis on literacy skills rather than on numeracy skills.

It also is interesting to note that, in nearly all countries, the parents reported a stronger emphasis on literacy activities than on numeracy activities when the child was a girl than when the child was a boy. This suggests that the direct effect of NumLitAct on Ability is an important mediator of gender differences in achievement. For some countries there also were either positive or negative effects of Parental Education on NumLitAct, which implies that this link may mediate a part of the total effect of Parental Education on achievement as well. For the majority of countries, there also was a positive effect of Books on NumLitAct.

Except for the Main Path and the NumLitAct–Ability link, these analyses did not identify other possible mediating paths that hold across countries. However, considerable variability across countries was observed in almost each and every relationship within the model. To more clearly see and interpret these relationships, it seems necessary to investigate the full set of relationships for each country. Thus, the next section reports results from country-by-country analyses based on the path diagrams.

Country Results

This section presents more detailed information about the pattern of results for each participating country. For each country, one path diagram displays effects of Parental Education on achievement, and another path diagram shows effects of Gender on achievement.

For each country, a saturated model was fitted, which included all relationships from a particular variable to all variables to the right of it in the path diagram. However, the path diagrams presented here only report relationships that are significant at the .05 level.

Exhibit 4.17 presents results from the statistical goodness-of-fit test and from the indices RMSEA, CFI and SRMR. As may be seen the model fits the data from all countries excellently.

In the following section, results are presented individually for each country and benchmarking entity (except for Ireland, where data is missing on some variables) in the form of one path diagram for effects of Parental Education and another path diagram for effects of Gender. Brief interpretive comments relative to each path diagram are included.

Exhibit 4.17: Tests and Indices of Model Fit

Country	Chi–2	df	CFI	RMSEA	SRMR	N
Australia	286.45	50	0.990	0.028	0.021	5943
Austria	884.30	50	0.971	0.060	0.041	4587
Azerbaijan	144.81	50	0.994	0.020	0.017	4871
Chinese Taipei	154.90	50	0.997	0.022	0.011	4265
Croatia	359.65	50	0.990	0.037	0.018	4545
Czech Republic	247.59	50	0.990	0.030	0.021	4433
Finland	263.98	50	0.990	0.031	0.019	4541
Georgia	167.52	50	0.996	0.022	0.013	4774
Germany	749.95	50	0.976	0.060	0.042	3928
Hong Kong SAR	129.41	50	0.997	0.020	0.010	3802
Hungary	437.59	50	0.988	0.039	0.028	5149
Iran, Islamic Rep. of	261.64	50	0.995	0.027	0.015	5734
Ireland	278.87	50	0.987	0.032	0.024	4383
Italy	160.54	50	0.996	0.023	0.014	4125
Lithuania	189.57	50	0.995	0.025	0.015	4584
Malta	338.41	50	0.991	0.041	0.022	3492
Morocco	166.95	50	0.995	0.018	0.014	7614
Northern Ireland	201.95	50	0.990	0.030	0.022	3467
Norway	319.07	50	0.984	0.042	0.024	3054
Oman	281.29	50	0.994	0.021	0.013	10237
Poland	351.74	50	0.991	0.035	0.019	4962
Portugal	236.96	50	0.991	0.031	0.014	3991
Qatar	171.90	50	0.994	0.024	0.014	4104
Romania	123.81	50	0.998	0.018	0.008	4643
Russian Federation	205.16	50	0.991	0.026	0.014	4450
Saudi Arabia	149.22	50	0.994	0.021	0.013	4470
Singapore	249.72	50	0.997	0.025	0.012	6208
Slovak Republic	256.38	50	0.994	0.027	0.016	5561
Slovenia	432.05	50	0.986	0.042	0.027	4433
Spain	183.76	50	0.994	0.026	0.013	4105
Sweden	457.37	50	0.981	0.043	0.024	4482
United Arab Emirates	473.34	50	0.995	0.024	0.013	14377
Sixth Grade Countries						
Botswana	139.52	50	0.998	0.021	0.016	4165
Honduras	136.57	50	0.995	0.021	0.023	3830
Benchmarking Participants						
Quebec, Canada	270.68	50	0.989	0.033	0.019	4142
Abu Dhabi, UAE	177.27	50	0.996	0.025	0.014	4100
Dubai, UAE	280.46	50	0.996	0.028	0.015	5922

Reported values are means over analyses of five plausible values.

SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Summary of Country Results

The path diagrams for the TIMSS and PIRLS 2011 assessment participants indicate both similarities and differences across countries. The similarities manifest themselves in several different ways. For nearly all countries, the effects of Parental Education on achievement were mediated via Parental Education, Books, Activities, and Abilities, or what we have termed the Main Path. In addition, for most countries, there also were substantial effects of Books on achievement. Furthermore, for most of the countries, we observed a pattern where a stronger emphasis on literacy than on numeracy activities was associated with a higher level of Ability, which in turn had positive effects on achievement in all domains.

The differences also manifested themselves in several ways. One major source of differences was the strength of the estimated direct effects, and therefore also the size of the indirect effects. Such differences may be reflections of real differences in strength of relationships between variables; however, they also may be due to issues of measurement, such as floor and ceiling effects. Another source of differences was that the estimated coefficients sometimes had different signs in different countries, such as the relationship between Parental Education and the NumLitAct variable. Differences in sign of relationship seem more likely to reflect substantive differences than problems of measurement.

The similarities and differences combine in such a way as to make the pattern of relationships appear markedly different from one country to another, in spite of the fact that it also is possible to recognize the three basic patterns of mediating relationships between Parental Education and achievement, described above.

For Gender, both the total effects and the mediating mechanisms were quite different across the achievement domains. Even though there were effects for mathematics and science, these tended to vary from country to country. For reading, though, the general pattern was one of an achievement advantage for girls, and in many countries it was possible to explain this in terms of a stronger emphasis on literacy activities than on numeracy activities for girls.

Discussion of the Empirical Findings

First, it may be noted that the estimates of the standardized regression coefficients that we obtained with the Common model for pooled data are very close to the means of the standardized parameter estimates for the individual countries. The Common model clearly brings out how the effect of Parental

Education on achievement follows the Main Path, i.e., that it is mediated via Books, Activities, and Abilities. The Common model also showed how Books mediates Parental Education through its direct effects on the three achievement measures. Furthermore, the Common model identified the effect of a stronger emphasis on literacy activities than numeracy abilities on Ability, which in its turn had effects on the three domains of achievement. However, according to the Common model, this mechanism did not mediate the effect of Parental Education on achievement, except for a trivially small effect via Books. This was because of heterogeneity in the relationship between Parental Education and NumLitAb across the countries.

However, for Gender, the Common model identified a stronger emphasis on literacy activities than on numeracy activities for girls as the first part of a mechanism that accounts for gender differences in reading achievement. The second part of this mechanism is that the emphasis on literacy activities influences the ability to perform both literacy and numeracy tasks at the age children begin primary school. In the Common model there were no other mediating relations between Gender and achievement.

Given that this study did not predict the effect on Ability of a stronger emphasis on literacy than numeracy activities, it may be asked whether this is a dependable phenomenon and how it should be interpreted. The fact that this pattern of relationships has been identified in practically every country indicates a high degree of empirical consistency. When the measurement model for the Common model for pooled data was estimated, it was observed that the literacy skills measures had higher loadings on the Ability factor than had the numeracy skills measures. This could be taken as an indication that Ability is biased in favor of literacy, which could explain the positive relationship with NumLitAct. However, another interpretation of this finding is that literacy skills are more generally applicable than are numeracy skills. For example, numeracy tasks are often presented in written form and require written responses.

Previous research reviewed in the Introduction supports the view that numeracy activities and tasks tend to be subordinate to literacy activities and tasks. Thus, there are few, if any, interventions which focus more exclusively on development of numeracy, and it has been hypothesized that numeracy skills develop as a function of training in language and problem-solving skills at young age (Doig, McCrae, & Rowe, 2003). Interestingly enough, Anders et al. (2012) found that numeracy skills were more highly related to the quality of the home learning environment with respect to literacy than with respect

to numeracy. These authors also observed that numeracy activities tend to be less frequent than literacy activities, which both makes it difficult to measure numeracy activities reliably, and to identify their effects on development of skills. Even though further research is needed to clarify the nature of literacy and numeracy skills, it does seem that both theory and previous empirical research support the idea that literacy activities can influence the development of both literacy and numeracy skills.

Effects of Parental Education

For practically all countries, support was obtained for the Main Path, or the sequence Parental Education, Books, Activity, Ability, and fourth grade student achievement in mathematics, science, and reading. The high degree of generality of this mechanism across countries is an interesting phenomenon, which has been observed many times before, and for which at least intuitive explanations have been offered. We will not pursue theoretical discussions here, but it can be noted that even though all links in the Main Path are significant they do vary in strength across countries. This variation can be due to issues of measurement, such as floor and ceiling effects in certain countries, and it also can have substantive grounds. It is an important task for further research to investigate different sources of variation across countries more closely.

In addition to the indirect effect via the Main Path, the Books variable also had strong direct effects on all three achievement variables, though with large variation across countries. To account for these direct effects we need other hypothesized mechanisms and further mediating variables. In previous research many such hypotheses have been investigated, and the results show, among other things, that parental expectations and the parents' function as role models are important mediating mechanisms to account for the effects of Parental Education on achievement. It is reasonable to expect that the number of books in the home can play an important part in such mediating mechanisms.

We also have identified another path between Parental Education and achievement, which was unexpected, but which is present in the majority of the countries. The core of this path is the relationship between NumLitAct and Ability, which implies that in homes where there is stronger emphasis on literacy activities than numeracy activities there is a positive effect on the ability to perform both numeracy and literacy tasks at the beginning of primary school. In some countries, there was a direct effect (positive or a negative) of Parental Education on NumLitAct, while in other countries, there was an indirect effect

via Books. There also were countries in which both the direct and the indirect effect could be observed, and some countries in which there was neither a direct, nor an indirect effect of Parental Education on NumLitAct.

A positive effect of Parental Education on NumLitAct was observed for seven countries, while a negative effect was observed for four countries. Thus, in the former group of countries, parents with a higher level of education placed more emphasis on literacy activities than on numeracy activities, while in the latter group these parents placed more emphasis on numeracy activities than on literacy activities. However, within both groups of countries, the direct effect of NumLitAct on Ability was positive and approximately the same size (0.23 vs. 0.18). This indicates that the mechanism of influence of the two types of activities on ability is invariant across these two categories of countries.

All three participating Nordic countries (Finland, Norway, and Sweden) showed a positive effect of Parental Education on NumLitAct, along with the Czech Republic, Morocco, Saudi Arabia, and Slovenia. In the Nordic countries there is a long tradition of literacy and reading aloud for the children is a common practice, particularly among parents with a higher level of education.

One hypothesis to account for the different directions of the effect of Parental Education on NumLitAct may be that, in certain countries, higher education places more emphasis on fields such as technology and science, while in other countries there is more emphasis on letters and arts. The four countries with a negative effect of Parental Education on NumLitAct (implying greater emphasis on numeracy than on literacy activities) were Chinese Taipei, Honduras, Iran, and Oman; for at least some of these, higher education may be more oriented towards technology and science.

The direct effect of Books on NumLitAct was significant and positive for around 20 countries. Thus, availability of books was a mediator for activities oriented towards literacy.

It also is interesting to observe that, in many cases, there was not only a positive indirect effect of NumLitAct on the three achievement variables via Ability, but there were also direct effects of NumLitAct on the achievement

variables. A negative effect on mathematics achievement was the most frequently observed outcome, but in some cases there were negative effects on mathematics and science, and in other cases a positive effect on reading. The combination of the indirect effects and these direct effects creates an uneven profile of achievement, with a relatively higher level of achievement in reading than in mathematics.

There also were some other frequently recurring patterns of relations in the path model. Thus, the NumLitAb variable, which indicates whether literacy skills at school start are rated higher than numeracy skills or vice versa, had for many countries a negative influence from Books, and it often also had negative direct effects on achievement. For many countries there also was a direct effect NumLitAct on NumLitAb. However, these effects tended to be weak and sometimes difficult to interpret.

Effects of Gender

As previously discussed, only in reading was a strong total effect for Gender observed, and only in reading was the study able to identify mediating mechanisms that were reasonably consistent across countries. The most powerful path accounting for gender differences in reading achievement was the direct effect of NumLitAct on Ability, which in turn had positive direct effects on achievement. Here, too, a negative direct effect of NumLitAct on mathematics achievement was frequently observed.

For any mediating effect to occur, it is, of course, also necessary that there be a Gender effect on NumLitAct, such that greater emphasis on literacy than on numeracy activities is reported for girls. This effect was positive and significant in all but two countries (Morocco and Saudi Arabia). The participants with the strongest direct effect of gender on NumLitAct were Norway, Lithuania, Sweden, the Canadian province of Quebec, Germany, Finland, and Poland. It is quite interesting to observe such strong differentiation of activities between boys and girls in societies that emphasize gender equality, particularly the three Nordic countries. One tentative explanation for this may be that the parents, following strong literacy traditions, offer book-sharing activities with their children, but

that boys are less interested in participating in such activities than girls because of their perceptions of what are appropriate activities for girls and boys.

Another mediating path went through NumLitAb, on which Gender had a positive effect in most countries. This positive effect implies that girls were assessed as being relatively better at doing literacy tasks than at doing numeracy tasks at the beginning of primary school. The NumLitAb variable was positively related to reading in many countries, or to reading and science in other countries, or negatively related to mathematics in yet other countries.

Limitations and Future Research

While this study has identified several interesting mediating mechanisms that at least partly explain the effects of Parental Education and Gender on fourth grade student achievement, it also generated many questions that need to be addressed in future research. Some of these questions are discussed below.

From a statistical point of view, the indirect effects identified in many of the models are quite small, and it may be asked whether they are large enough to warrant any strong conclusions. However, it must be remembered that the information about the mediating variables in the model is based on a limited number of responses to questionnaire items. Further, given the well-known problems of reliability and validity of such information, it is surprising that it has been possible to identify so many consistent and meaningful patterns of relationships among the variables. Yet, because of the problems of measurement, it is likely that the strength of the relationships among the variables is underestimated, which in turn causes the indirect effects to be underestimated.

A modeling approach with latent variables was used to at least partially address the measurement problems. However, for practical reasons a "testlet" approach was adopted, and this approach does not fully utilize the information available in the item responses. It would therefore be useful to put further effort into the development of the measurement model, through using item level data rather than testlet data.

Yet another measurement problem is that the parents provided the information retrospectively; retrospective information tends to be unreliable, and there also is risk for systematic bias caused by selective memory and reinterpretation of earlier events in light of later events and developments. It is difficult to assess to what extent such threats to the validity of the Home Questionnaire data are present in the current data. However, the fact that the assessment is low-stakes implies that no gains are made from misreporting of

facts. A more optimal approach for collecting information about the quality of home learning environments for literacy and numeracy was used by Anders et al. (2012), who relied on a combination of self-report questionnaires, interviews, and observations. While such data-collection techniques cannot be used in large-scale international assessments, they may be useful for investigating the measurement characteristics of questionnaire data and for optimizing the design of questionnaire items.

It also should be acknowledged that there is further information in the TIMSS and PIRLS 2011 data that could be used to extend the model. For example, there are data on parental attitudes towards reading and on parental reading practices, both of which may be hypothesized to influence actual use of books. The model also could be extended with more student variables, reflecting, for example, attitudes towards reading, reading practices, and computer use. Thus, there are many possibilities to extend the current study in different directions.

Conclusion

The aims of this study were twofold: to investigate the extent to which parental education and gender influence fourth grade student achievement in reading, mathematics, and science in different countries; and to investigate the mechanisms through which parental education and gender influence achievement in these three core subjects via books in the home, literacy and numeracy activities, and the child's ability to carry out literacy and numeracy tasks when starting school. Through applying path modeling techniques to data from the TIMSS and PIRLS 2011 assessments and Home Questionnaires, it had been possible to identify some important mechanisms through which Parental Education and Gender influence achievement in mathematics, science, and reading at the fourth grade.

For nearly all countries, the effects of Parental Education on achievement were mediated via Parental Education, Books, Activities, and Abilities, or what we have termed the Main Path. According to this mechanism, parental education influences the number of books available in the home. In turn, the number of books is related to the frequency of home activities oriented towards both literacy and numeracy, and these activities influence the general level of literacy and numeracy skills that the child has developed upon beginning primary school. The literacy and numeracy skills that the child brings to school influence achievement at the fourth grade. In addition, for most countries,

there also were substantial direct effects of number of books in the home on achievement.

Another mechanism is that a stronger emphasis on literacy than on numeracy activities influences the general level of literacy and numeracy skills children have developed by the time they begin primary school, and this in turn influences achievement at the fourth grade. It is more common for girls than for boys to have such an emphasis, which partially explains the higher level of reading achievement for girls. In homes with a larger number of books there is in many countries also a tendency to put more emphasis on literacy than on numeracy activities, which influences the general level of numeracy and literacy skills at school start, which influences achievement.

For reading, though, the general pattern was one of an achievement advantage for girls.

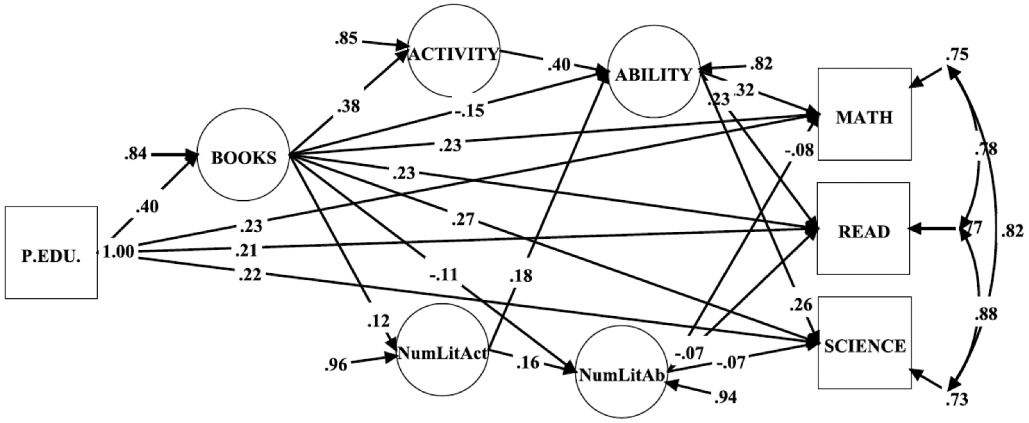
In terms of gender differences, both the total effects and the mediating mechanisms were quite different across the achievement domains. Even though there were effects for mathematics and science, these tended to vary from country to country, and so it is difficult to generalize the effects for mathematics and science across countries. However, for reading, the general pattern was one of an achievement advantage for girls, and in many countries it was possible to explain this in terms of a stronger emphasis on literacy activities than on numeracy activities for girls.

While the abovementioned mechanisms could be identified in almost all of the 37 participating countries and benchmark entities, interesting differences among the countries also could be identified, both with respect to the strength of estimated relationships, and in the patterns of relationships among variables.

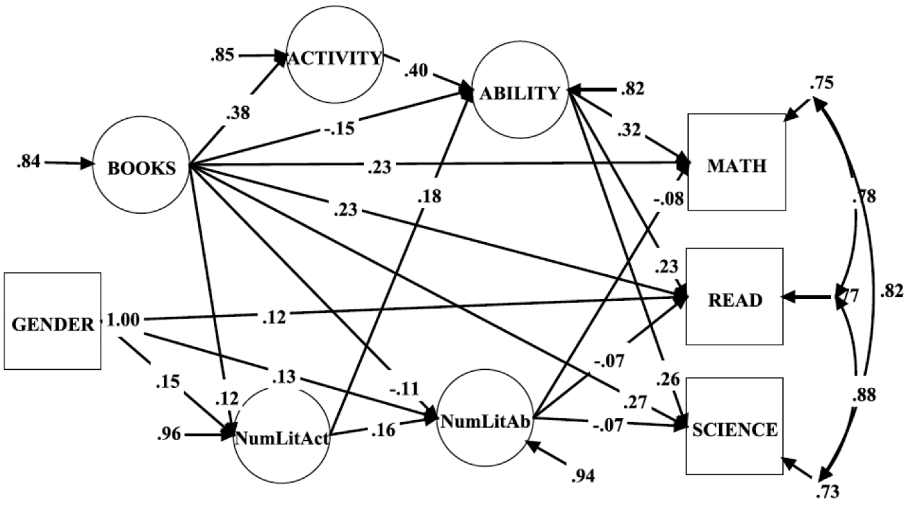
The research presented in this chapter can be extended in many different ways in order to obtain better estimates of the relationships in the model, as well as to allow investigations of further variables and hypothesized mechanisms.

Exhibit 4.18: Australia

PARENTAL EDUCATION The total effects were .33, .35, and .33 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .11, .14, and .12. Most of the indirect effect was mediated via Books and via the Main Path. However, the number of books in the home also was related to more literacy than numeracy activity, which in turn influenced Ability positively, and Ability had significant direct effects on achievement in all three domains. There also were weak indirect effects via NumLitAb.



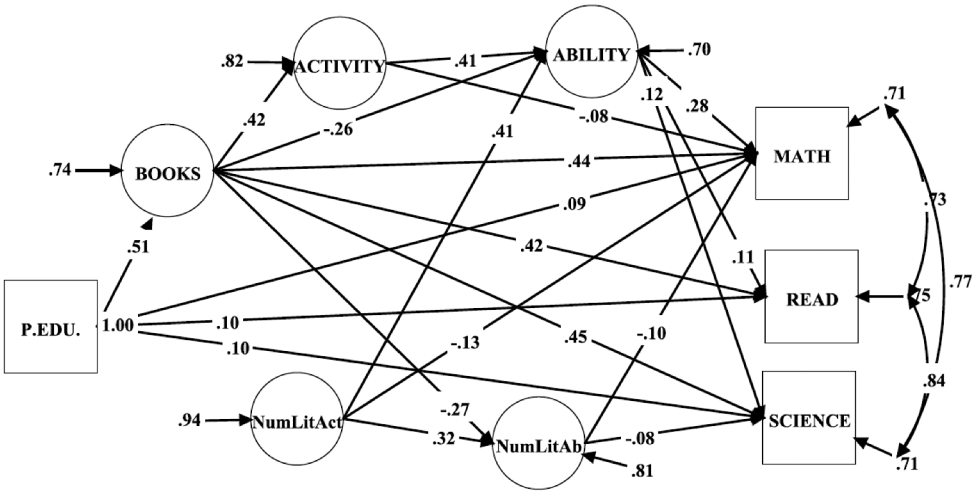
GENDER The total effects were -.03, .00, and .12 for mathematics, science, and reading, respectively. The total indirect effects were all close to 0. Most of the Gender effect on reading was direct. However, Gender was related to an overrepresentation of literacy activity, which had a positive effect on achievement in all three domains via Ability. Gender also was related to a relatively higher assessment of literacy skills than numeracy skills, which was negatively related to achievement in all three domains.



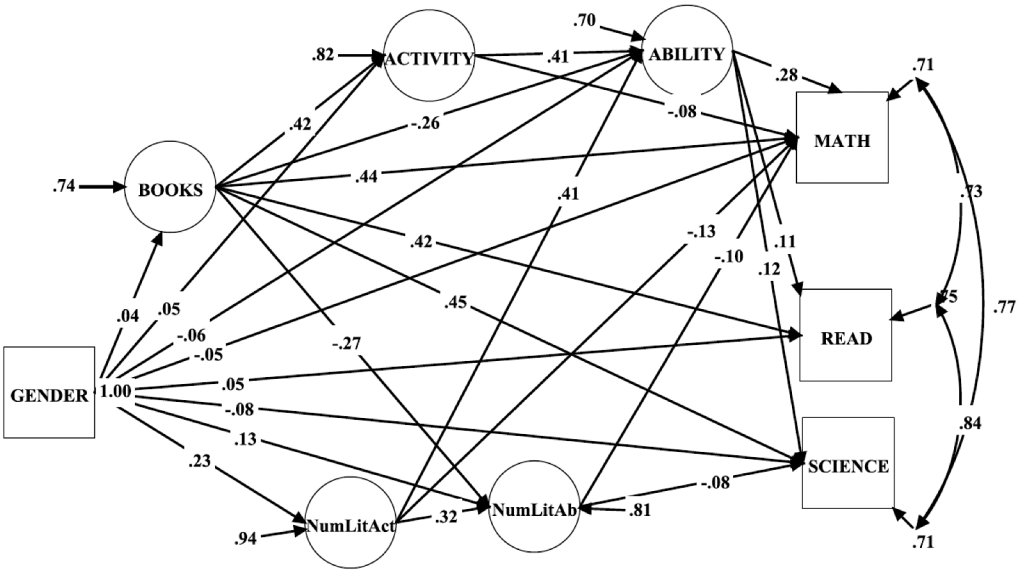
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.19: Austria

PARENTAL EDUCATION The total effects were .31, .33, and .32 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .22, .23, and .22. Thus, a substantial proportion of the total effect was indirect. Most of the indirect effects were mediated via Books and via the Main Path. However, the number of books in the home also was associated with higher assessed numeracy skills than literacy skills, which in turn was associated with achievement in mathematics and science.

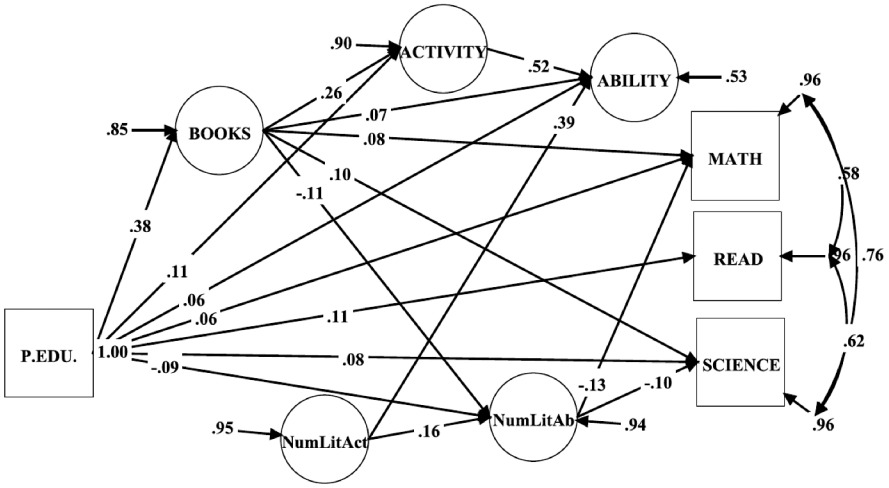


GENDER The total effects of Gender were -.07, -.09, and .06 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were -.02, -.01, and .01. There was more literacy than numeracy activity for girls, which affected achievement positively via Ability, and mathematics achievement negatively through a direct effect. There also were higher ratings of literacy than numeracy skills for girls, which was associated with a lower level of performance in mathematics and science.

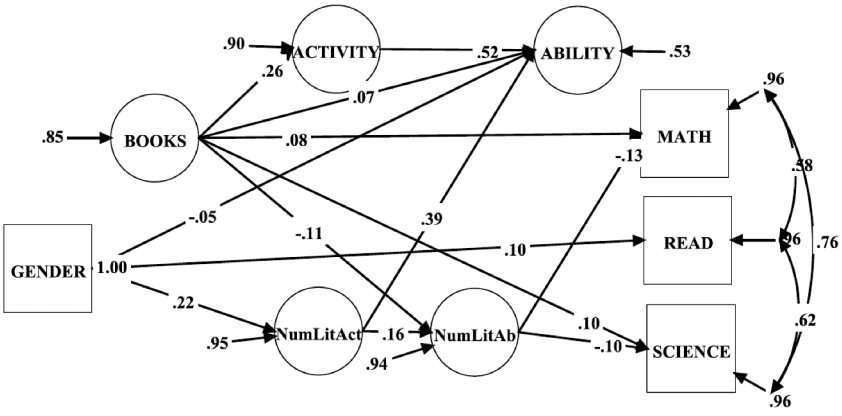


SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

PARENTAL EDUCATION The total effects were .11, .14, and .15 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .05, .06, and .03. Thus, the total effects were among the lowest observed. However, for mathematics and science a rather large proportion of the total effect was mediated. These indirect effects were mediated via Books and via Books and NumLitAb. The Books variable predicted a higher ability to do numerical tasks than literacy tasks and the NumLitAb variable was negatively related to mathematics and science achievement, implying positive effects of having higher ability to do numerical tasks.



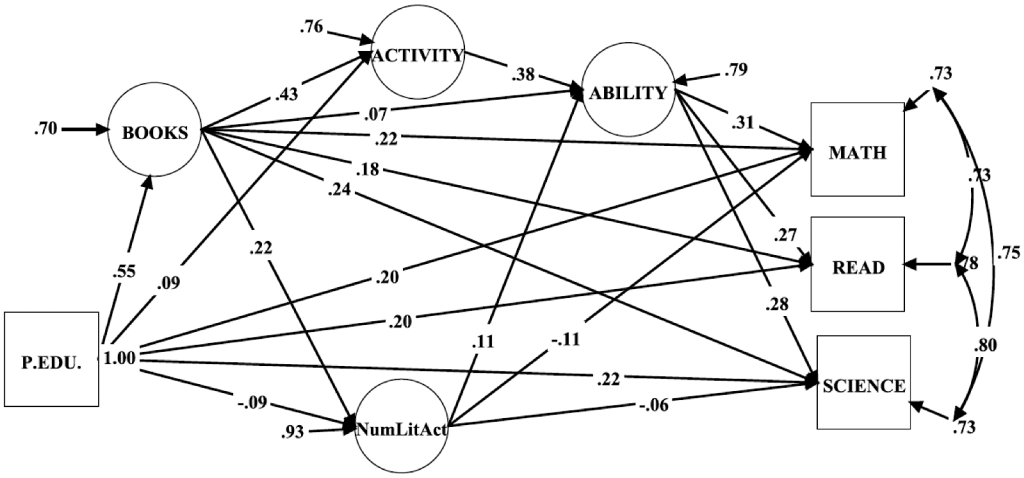
GENDER The total effects were .04, .03, and .10 for mathematics, science, and reading, respectively. The total indirect effects were all close to 0. However, there were significant negative indirect effects of Gender on mathematics and science. This was because Gender predicted more literacy than numeracy activity, which in turn was positively related to the NumLitAb variable, which was negatively related to mathematics and science achievement.



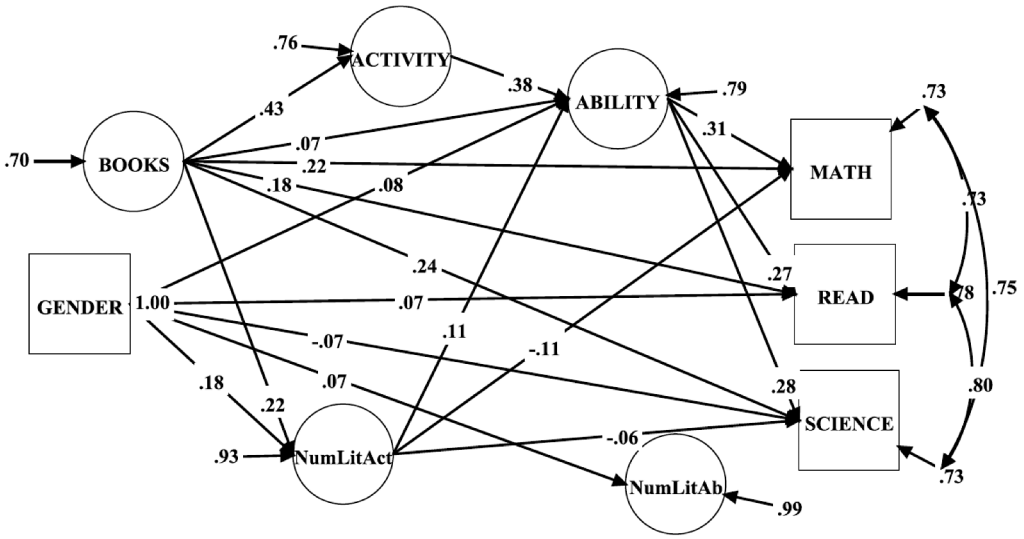
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.21: Chinese Taipei

PARENTAL EDUCATION The total effects of Parental Education were .37, .39, and .34 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .17, .17, and .13. The indirect effects were mediated via the Main Path and via Books. However, there also was a direct effect of Parental Education on Activity. Parental Education also was associated with more numeracy than literacy activity, which influenced mathematics and science achievement positively.



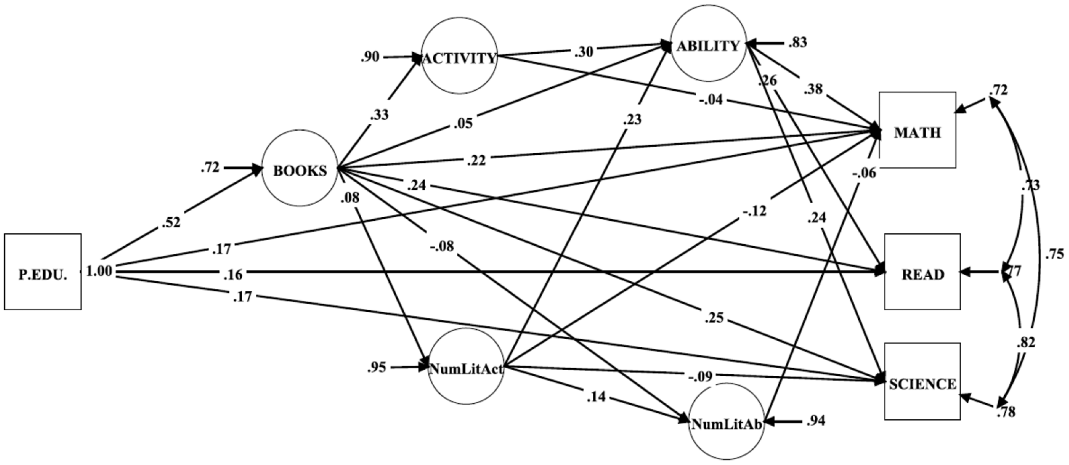
GENDER The total effects of Gender were .01, -.05, and .10 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .02, .02, and .03. Thus, girls outperformed boys in reading, while boys had higher achievement in science. There was a positive indirect effect via Ability on achievement for girls in all domains. For girls, there was more of an emphasis on literacy activities than on numeracy activities. This had a positive effect on achievement in all three domains via Ability, and negative direct effects on mathematics and science achievement for girls.



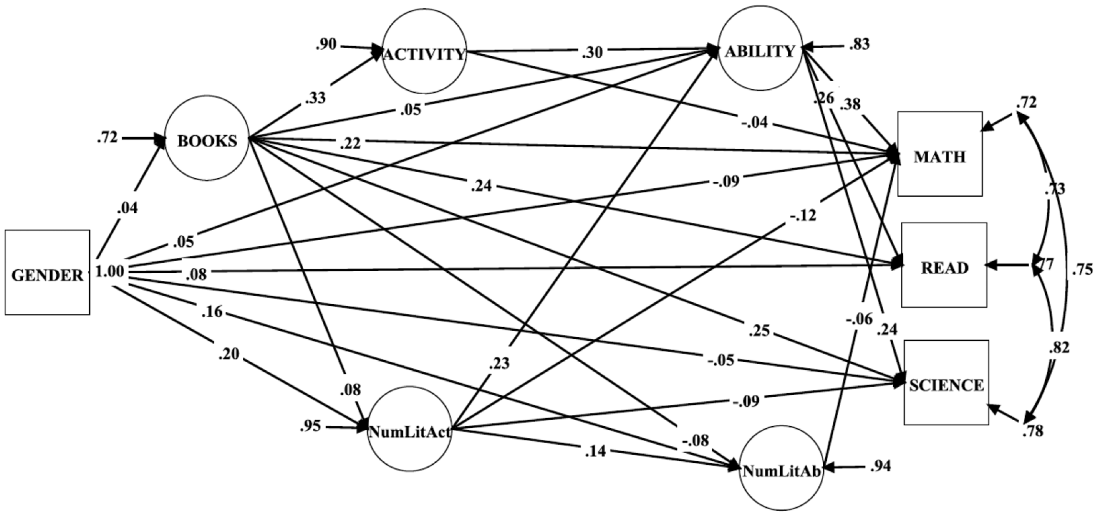
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.22: Croatia

PARENTAL EDUCATION The total effects of Parental Education were .31, .32, and .31 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .14, .15, and .14. The indirect effects were mediated via the Main Path and via Books. The number of books in the home also was related to an overrepresentation of literacy activity, which influenced achievement via Ability, and there also was a positive effect of Books on mathematics achievement via NumLitAb.



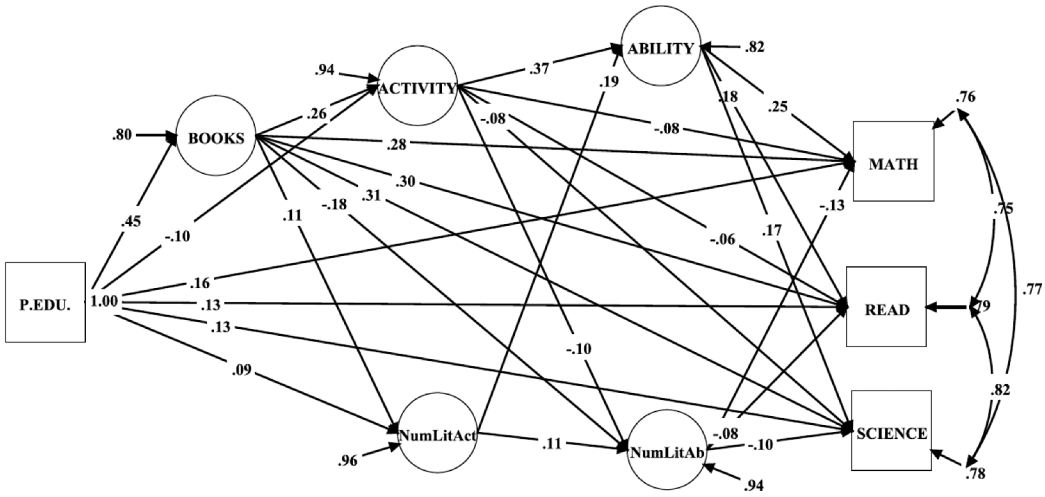
GENDER The total effects of Gender were -.08, -.04, and .12 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .02, and .04. Girls thus outperformed boys in reading, while boys had higher achievement in mathematics and science. For girls there was an overrepresentation of literacy activities, which had a positive indirect effect on achievement in all domains via Ability, but also negative direct effects on mathematics and science achievement. Girls furthermore had higher rated literacy skills than numeracy skills, which was negatively related to mathematics achievement.



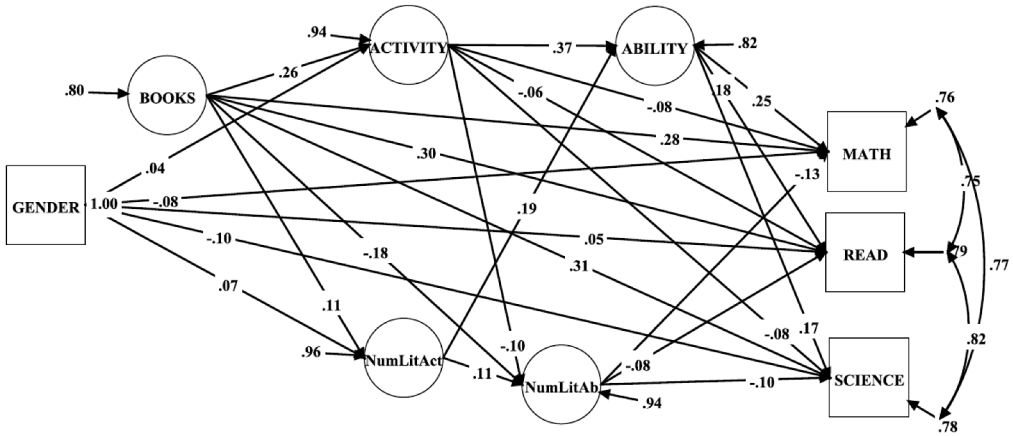
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.23: Czech Republic

PARENTAL EDUCATION The total effects of Parental Education were .31, .29, and .29 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .14, .16, and .16. The indirect effect was to a large extent mediated via the Main Path and via Books. Both Parental Education and Books also were related to a stronger emphasis on literacy activity than on numeracy activity, which had positive effects on achievement in all three domains via Ability. Books and Activity also were related to higher assessed numeracy skills than literacy skills.

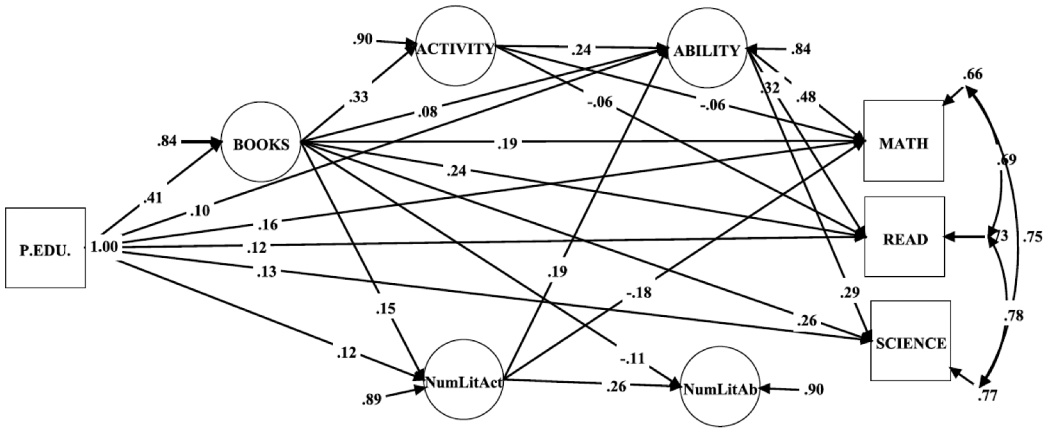


GENDER The total effects of Gender were -.08, -.09, and .06 for mathematics, science, and reading, respectively and the corresponding total indirect effects were .01, .01 and .01. Girls thus outperformed boys in reading, while boys had higher achievement in Mathematics and science. The advantage for girls in reading was, to a small extent, mediated via activities that emphasized literacy more than numeracy for girls, and the effect of which was mediated via Ability. The NumLitAb variable also mediated effects from Activity and NumLitAct.

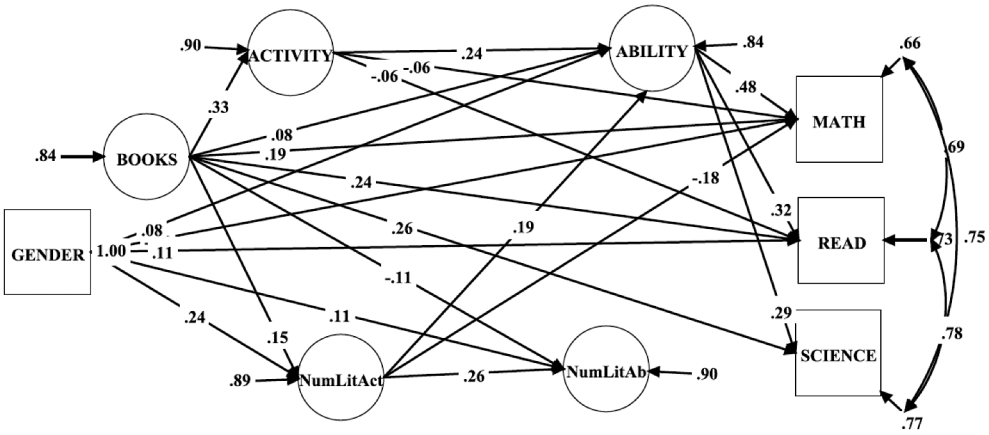


SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

PARENTAL EDUCATION The total effects of Parental Education were .29, .28, and .28 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .13, .15, and .16. The indirect effect was to a large extent mediated via the Main Path and via Books. Parental Education influenced mathematics achievement negatively via activities that emphasized literacy more than numeracy, while this influenced achievement in all domains positively via Ability.



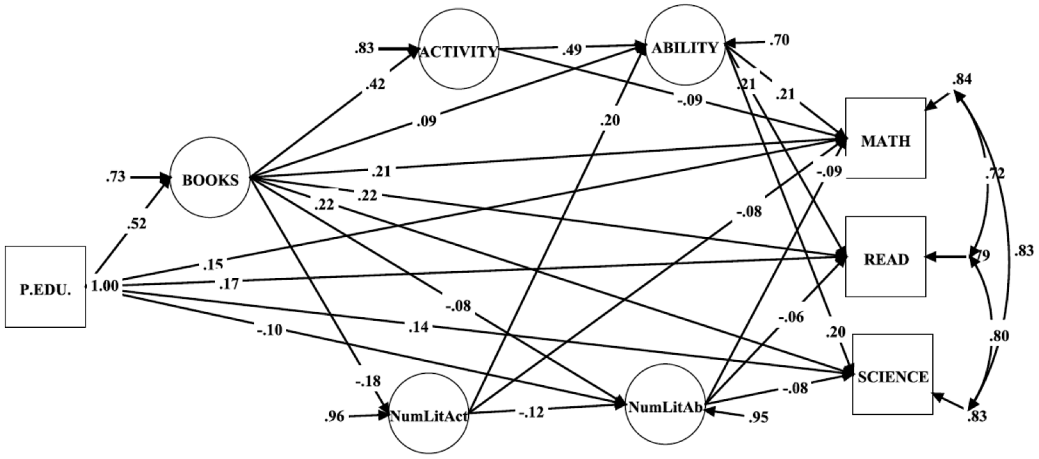
GENDER The total effects of Gender were -.06, -.01, and .17 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .03, and .06. Girls thus outperformed boys in reading by a wide margin, while boys had higher achievement in mathematics. For girls, literacy activities were more emphasized than numeracy activities, which had a positive indirect effect on achievement in all three domains via Ability. However, this emphasis also had a negative direct effect on mathematics achievement for girls.



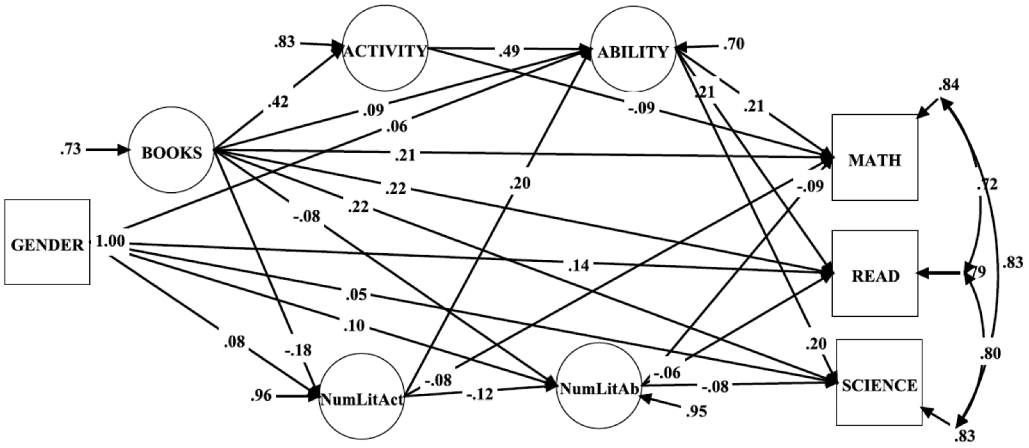
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.25: Georgia

PARENTAL EDUCATION The total effects of Parental Education were .28, .29, and .31 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .13, .14, and .14. The indirect effects were to a very large extent mediated via Books and via the Main Path. The number of books in the home also was associated with a relatively stronger emphasis on numeracy activities than literacy activities, which had a positive effect on mathematics achievement and negative effects on achievement in all three domains via Ability. Similar effects of Books were mediated via NumLitAb.



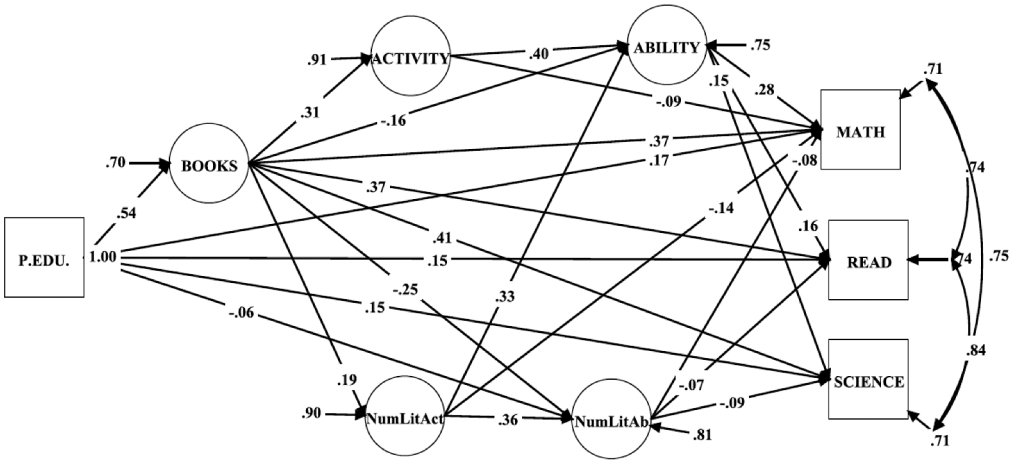
GENDER The total effects of Gender were .04, .06, and .15 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .00, .01, and .01. Girls thus outperformed boys in all three domains of achievement, and particularly so for reading. For girls, there was a relatively stronger emphasis on literacy activities than numeracy activities, which influenced achievement in all three domains positively, via Ability. This pattern of activities also was negatively related to mathematics achievement. Girls also were assessed higher in literacy skills than in numeracy skills, which was negatively related to achievement.



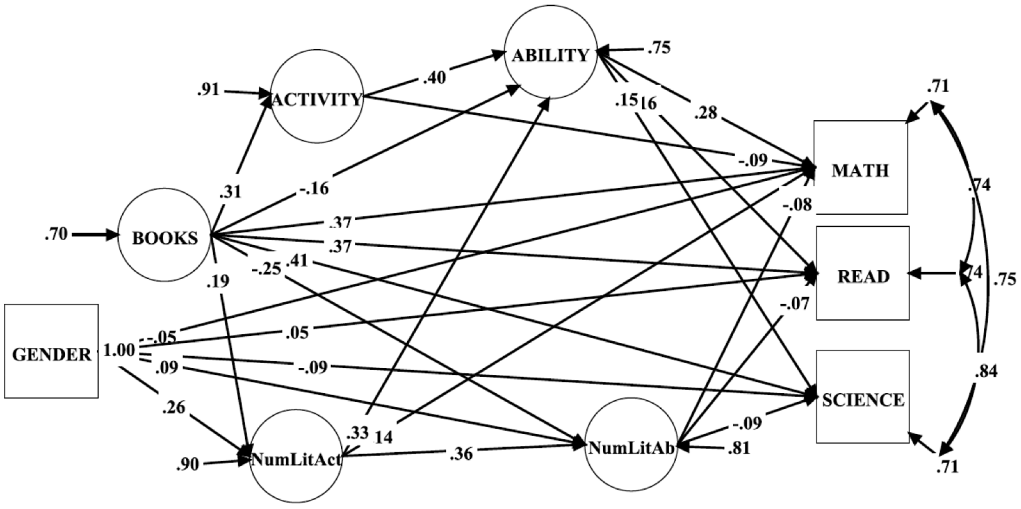
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.26: Germany

PARENTAL EDUCATION The total effects of Parental Education were .36, .38, and .36 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .19, .23, and .21. The total indirect effect was, to a large extent, mediated via Books and via the Main Path. The number of books in the home also was associated with a relatively stronger emphasis on literacy activities than numeracy activities, which indirectly affected achievement positively via Ability. To some extent the effect of Parental Education was mediated via the balance of the assessment of literacy and numeracy skills, as well as more highly educated parents tending to assess numeracy skills higher, both directly and mediated via Books.



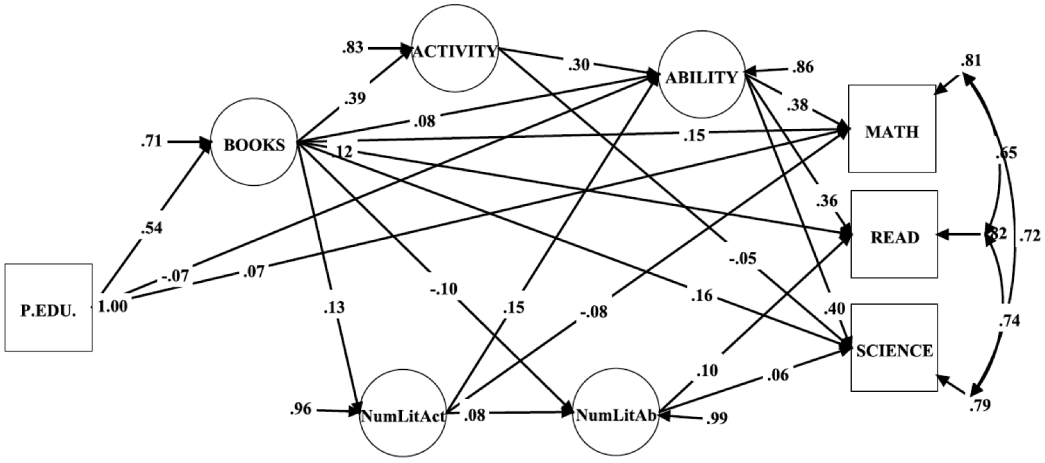
GENDER The total effects of Gender were -.07, -.09, and .06 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were -.02, .00, and .01. Girls thus outperformed boys in reading, while boys had higher achievement in mathematics and science. For girls, there was a stronger emphasis on literacy activities than numeracy activities, which had a positive effect on achievement, via Ability. However, this imbalance also was negatively related to mathematics achievement. Girls also were assessed as having stronger literacy skills than numeracy skills, which was negatively related to achievement.



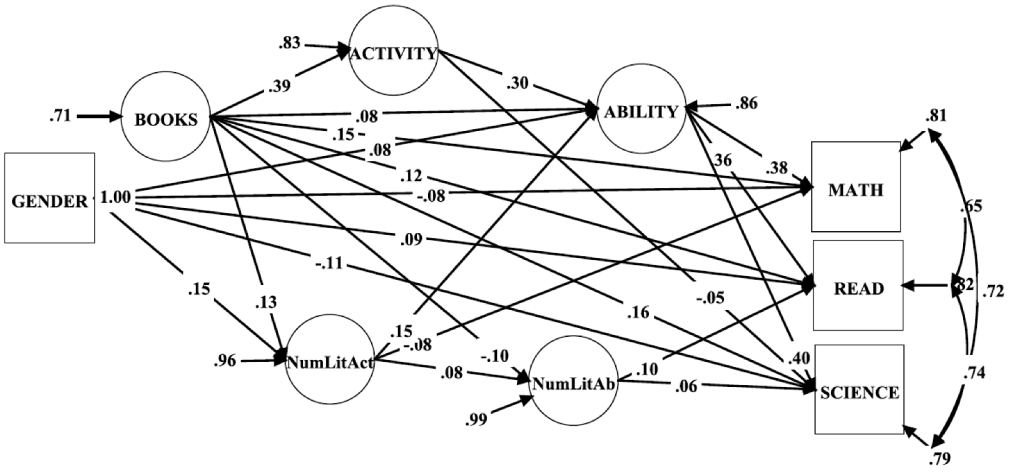
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.27: Hong Kong SAR

PARENTAL EDUCATION The total effects of Parental Education were .16, .15, and .12 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .09, .10, and .08. Thus, there was only a small total effect of Parental Education on the three achievement measures, and particularly so for reading. However, the total indirect effect accounted for a considerable part of the total effect. Indirect effects went via the Main Path and via Books.



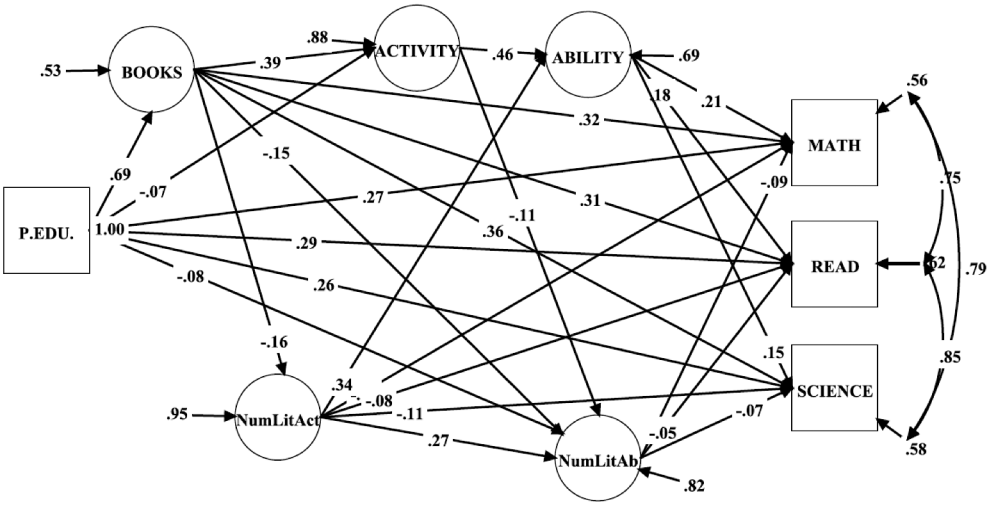
GENDER The total effects of Gender were -.05, -.07, and .13 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .04, and .04. Girls thus outperformed boys in reading, while boys had higher achievement in mathematics and science. For girls, there was a stronger emphasis on literacy activities than numeracy activities, which had a positive indirect on achievement in all domains via Ability. Girls also were assessed somewhat higher on Ability than were boys.



SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.28: Hungary

PARENTAL EDUCATION The total effects of Parental Education were .55, .55, and .53 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .28, .29, and .24. There was thus a substantial total effect of Parental Education on the three achievement measures, and the total indirect effect accounted for a considerable part of the total effect. Indirect effects went via the Main Path and via Books. Parents with a higher level of education tended to assess numeracy skills higher than literacy skills, which had a positive effect on achievement in all three domains. Similar effects of Parental Education on both NumLitAct and NumLitAb were mediated via Books.



GENDER The total effects of Gender were -.03, -.03, and .10 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were -.02, -.01, and .00. Girls thus outperformed boys in reading, while boys had higher achievement in mathematics and science. For girls, there was more of an emphasis on literacy activities than numeracy activities. This was associated with a positive indirect effect on achievement in all three domains via Ability, at the same time as there were negative effects on achievement, and particularly so in mathematics and science.

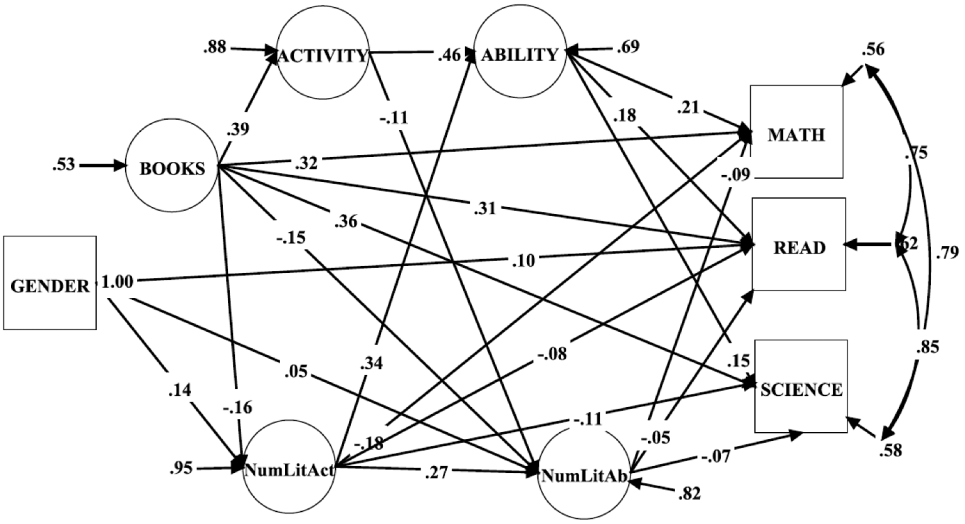
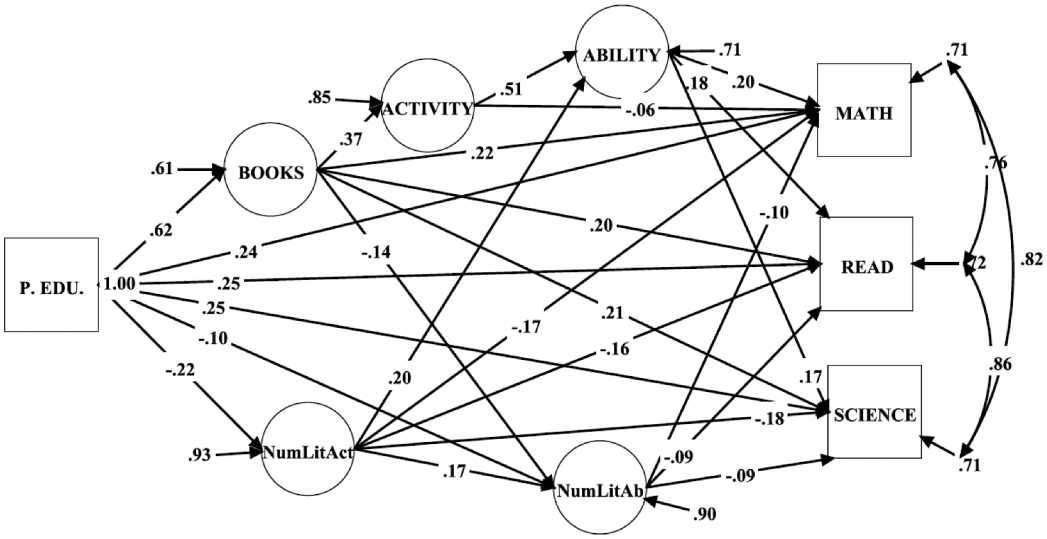
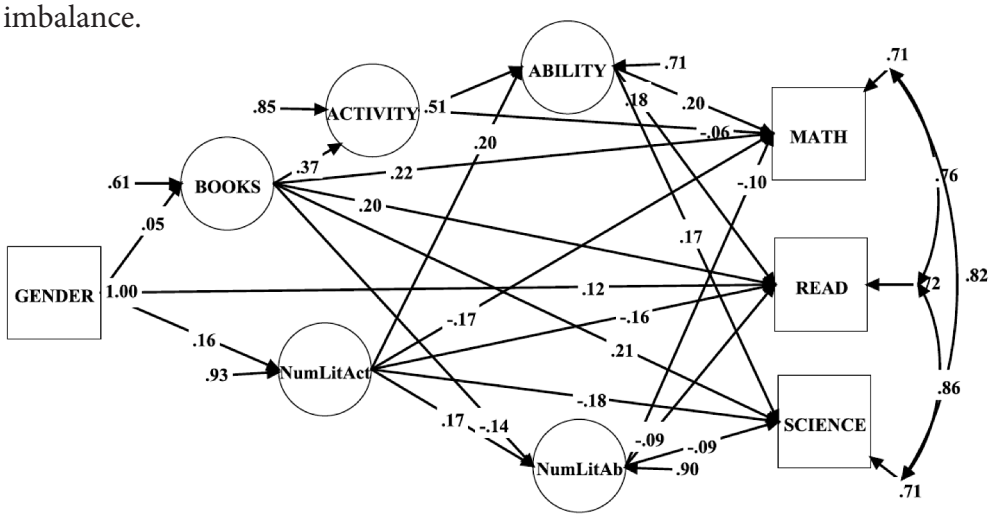


Exhibit 4.29: Iran, Islamic Republic of

PARENTAL EDUCATION The total effects of Parental Education were .44, .45, and .43 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .19, .20, and .18. Indirect effects went particularly via the Main Path and via Books. Parents with a higher level of education tended to place higher emphasis on numeracy activities than on literacy activities, which had a negative effect on achievement in all three domains via Ability. However, there also was a positive direct effect on mathematics achievement. Parental Education and Books also both were associated with assessing numeracy skills higher than literacy skills, which was positively associated with achievement.



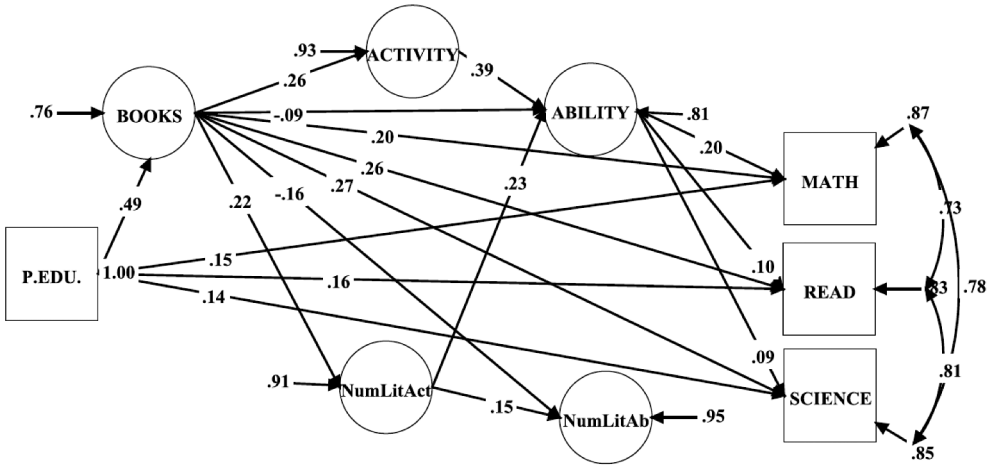
GENDER The total effects of Gender were -.02, -.03, and .11 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were -.01, -.01, and -.01. There was a small positive indirect effect via the Main Path on achievement for girls in all domains. For girls, there was a stronger emphasis on literacy activities than on numeracy activities, and via Ability this had a positive effect on achievement in all domains. However, there also were strong negative direct effects on achievement in all three domains of this imbalance.



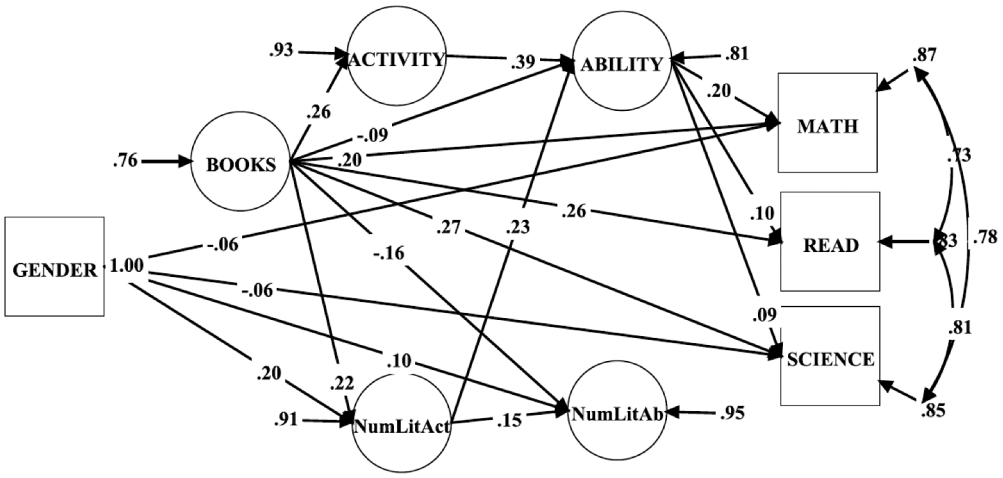
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.30: Italy

PARENTAL EDUCATION The total effects of Parental Education were .24, .28, and .30 for Mathematics, science, and reading, respectively, and the corresponding total indirect effects were .09, .14, and .14. The indirect effects went via the Main Path, and there was also an effect of Books such that, with more books in the home, there was a stronger emphasis on literacy activities than on numeracy activities. This literacy emphasis had a positive effect on achievement in all three domains, which was mediated via Ability.



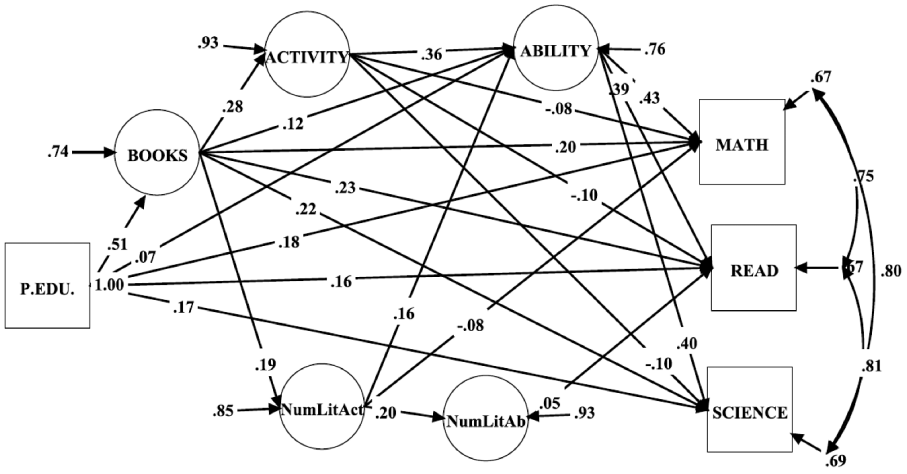
GENDER The total effects of Gender were -.06, -.05, and .03 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .00, .01, and .02. For girls, there was more of an emphasis on literacy than on numeracy activities, which had an indirect effect on achievement via Ability.



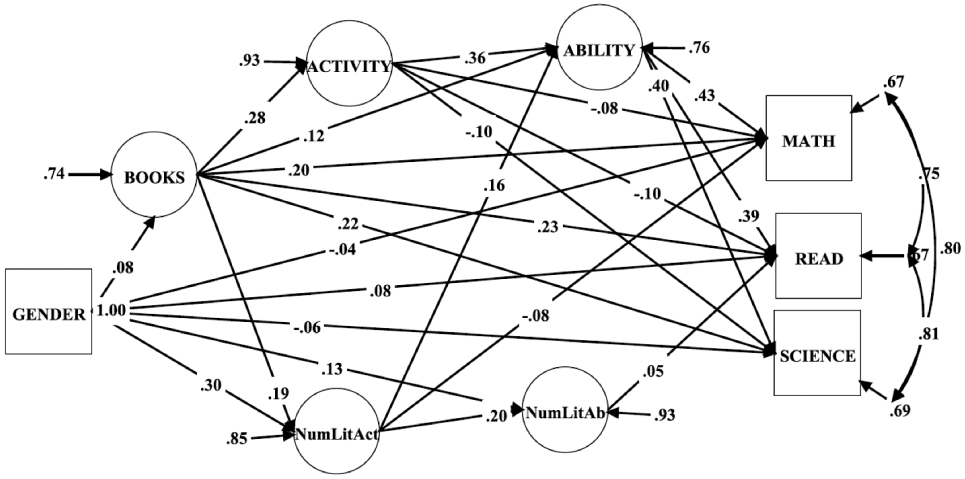
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.31: Lithuania

PARENTAL EDUCATION The total effects of Parental Education were .36, .35, and .35 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .17, .18, and .19. Indirect effects went via the Main Path and via Books. The number of books in the home also was related to a stronger emphasis on literacy activities than on numeracy activities, which had an indirect effect on achievement via Ability. There also was an indirect effect of Parental Education on achievement via Ability.



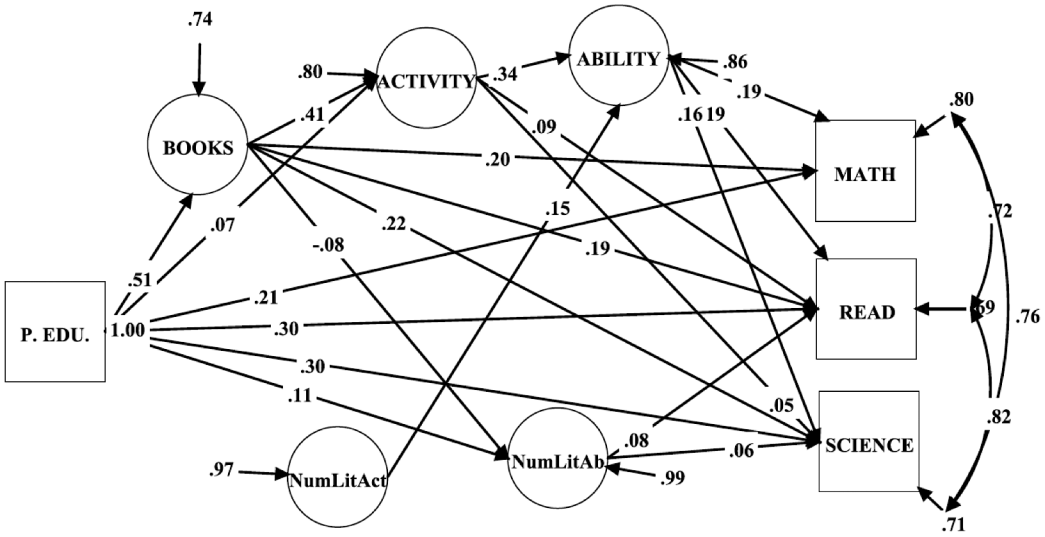
GENDER The total effects of Gender were -.01, -.01, and .15 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .04, .06, and .07. Girls thus had a considerably higher level of achievement than boys in reading. This pattern of gender differences was partially mediated via a stronger emphasis on literacy activities than on numeracy activities, which had an indirect effect on achievement via Ability. In addition to the direct effect of Gender, there was an indirect effect on NumLitAct via Books in the same direction. There also was an effect of Gender via the Main Path on achievement in all domains, and an effect on reading achievement via NumLitAb.



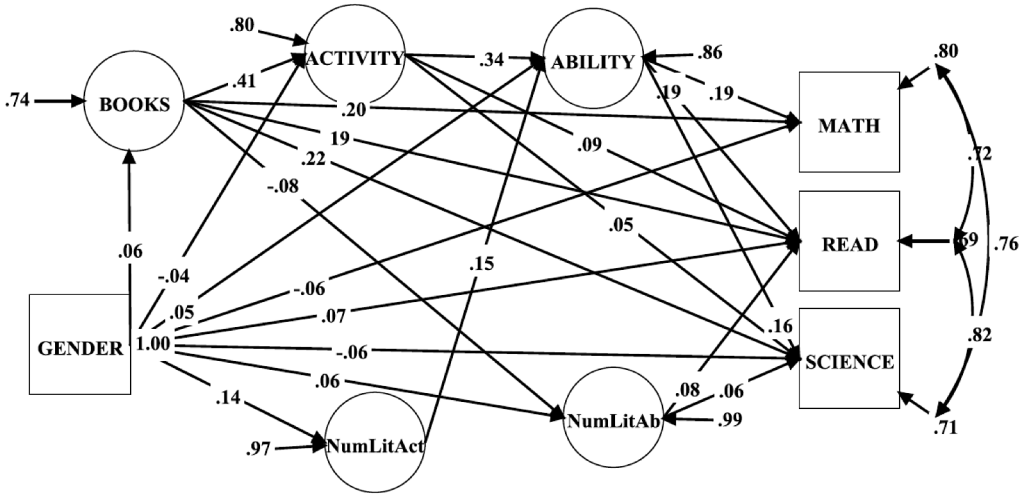
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.32: Malta

PARENTAL EDUCATION The total effects of Parental Education were .34, .45, and .44 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .13, .15, and .15. There was thus a very strong total effect of Parental Education on reading and science achievement and a strong effect on mathematics achievement. The total indirect effect accounted for about one-third of the total effect. Indirect effects went particularly via the Main Path and via Books. There also was an effect of Books, such that the variable was related to a higher level of assessed numeracy skills than literacy skills, which in turn had positive effects on science and reading achievement.



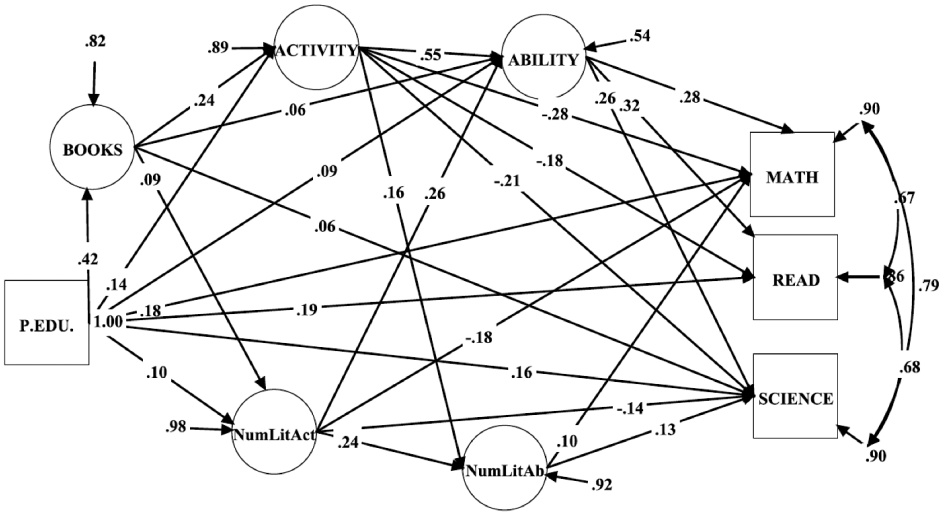
GENDER The total effects of Gender were -.04, -.04, and .10 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .02, .02, and .02. The indirect effects were partially mediated via the Main Path and via Books. For girls, there also was a stronger emphasis on literacy activities than on numeracy activities, which had a positive effect on achievement, which was mediated via Ability.



SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.33: Morocco

PARENTAL EDUCATION The total effects of Parental Education were .19, .19, and .24 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .00, .03, and .05. The indirect effects went in particular via the Main Path and also via Ability, on which there were effects of Parental Education and Books. Higher levels of Parental Education and Books also were associated with a stronger emphasis on literacy activities than on numeracy activities, which influenced achievement positively in all domains via Ability, but which also had negative direct effects on mathematics and science achievement. A higher level of Activity was associated with a higher assessment of literacy skills than numeracy skills, which had positive effects on mathematics and science achievement.



GENDER The total effects of Gender were .03, .04, and .13 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .01, and .01. Girls thus had a higher level of achievement than boys in reading, and to a smaller extent in mathematics and science. A somewhat higher level of Activity was reported for girls than for boys, which influenced achievement positively via Ability. Activity had negative direct effects on achievement in all three domains, and positive indirect effects on mathematics and science via NumLitAb.

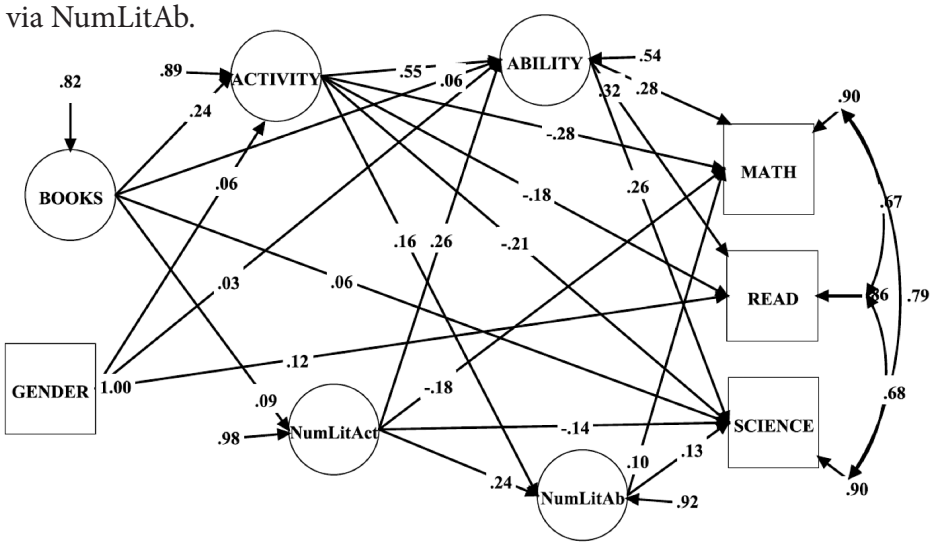
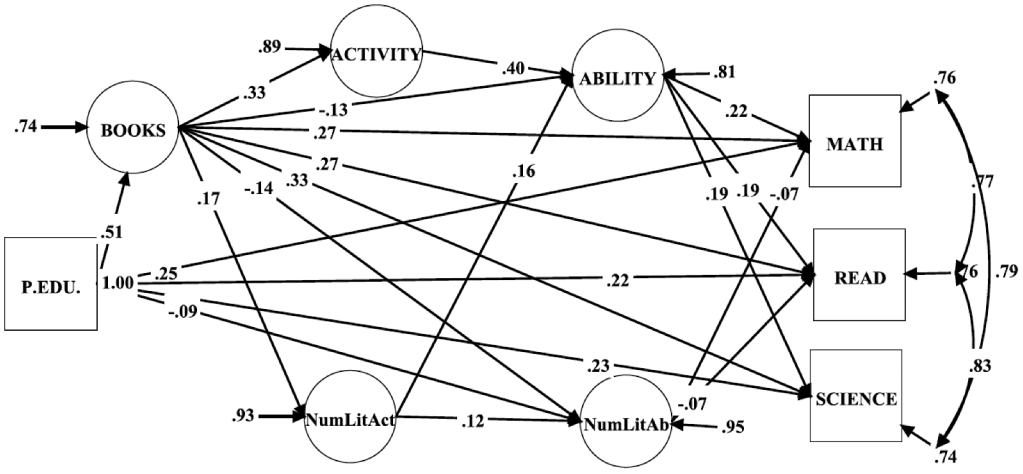
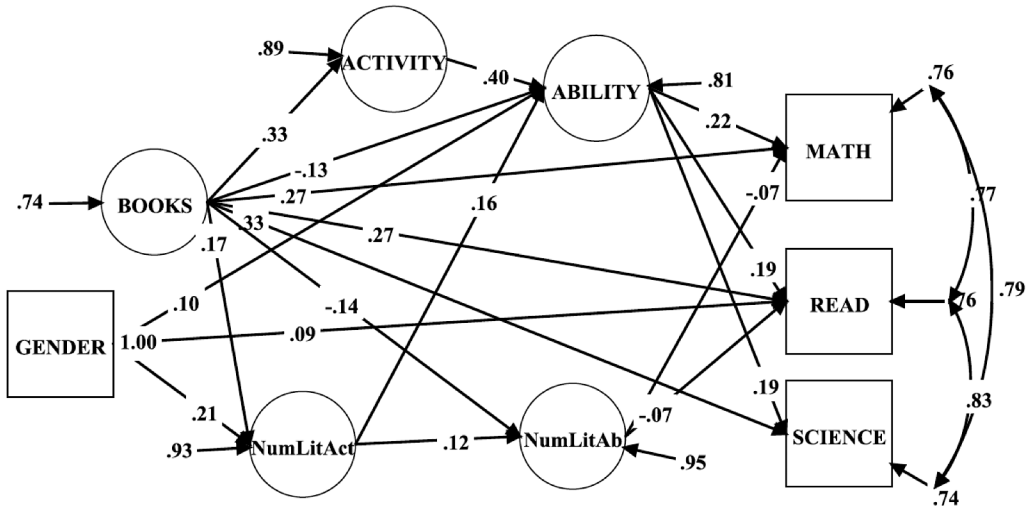


Exhibit 4.34: Northern Ireland

PARENTAL EDUCATION The total effects of Parental Education were .38, .39, and .36 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .13, .16, and .14. The indirect effects of Parental Education were mediated via the Main Path and via Books. In families with a larger number of books, greater emphasis was placed on literacy activities than on numeracy activities, which had a positive indirect effect on achievement via Ability. In such families, numeracy skills also were assessed higher than literacy skills, which was associated with a higher level of achievement in mathematics and reading.



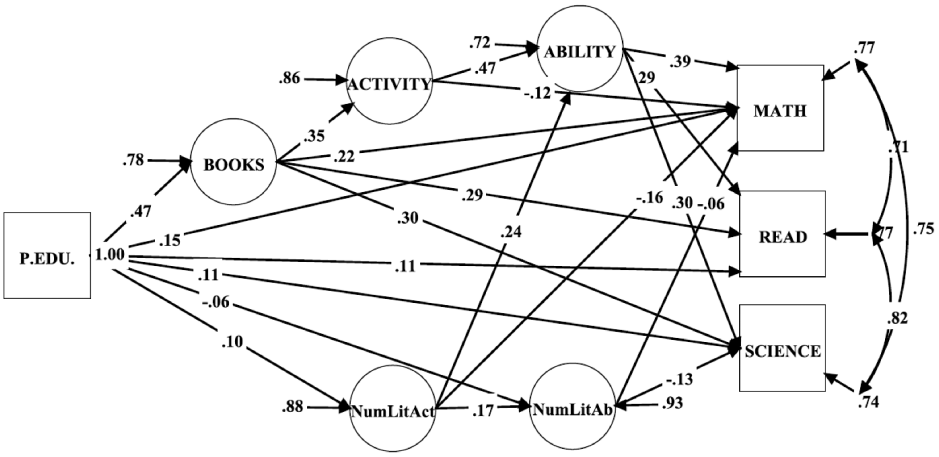
GENDER The total effects of Gender were .02, .02, and .13 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .04, and .04. Girls thus outperformed boys in reading. The effect of Gender was partially mediated via Ability. Furthermore, for girls, there was more emphasis on literacy activities than on numeracy activities, which had positive indirect effects on achievement via Ability.



SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.35: Norway

PARENTAL EDUCATION The total effects of Parental Education were .25, .28, and .26 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .10, .17, and .16. Compared to other countries there was thus a relatively weak total effect of Parental Education on reading, mathematics, and science achievement, and a rather large part of the total effect was indirect. The indirect effects were due to the Main Path and to mediation via Books. Higher Parental Education also was associated with a stronger emphasis on literacy activities than on numeracy activities, which in turn influenced achievement positively via Ability. It also was associated with higher assessed literacy skills than numeracy skills, which had negative direct effects on mathematics and science achievement.



GENDER The total effects of Gender were -.04, -.01, and .13 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .00, .03, and .06. Girls thus had a higher level of achievement than boys in reading, while boys had a somewhat higher level of achievement in mathematics. The indirect effect on reading was partially due to the fact that, for girls, there was a stronger emphasis on literacy activity than on numeracy activity. This affected achievement positively via Ability and it also had a negative direct effect on mathematics achievement. Girls also were assessed as having better literacy skills than numeracy skills, which was negatively related to mathematics and science achievement.

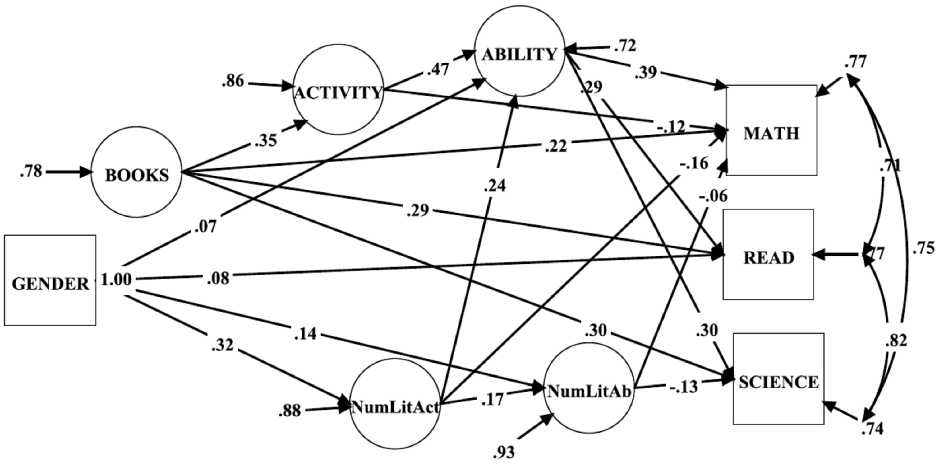
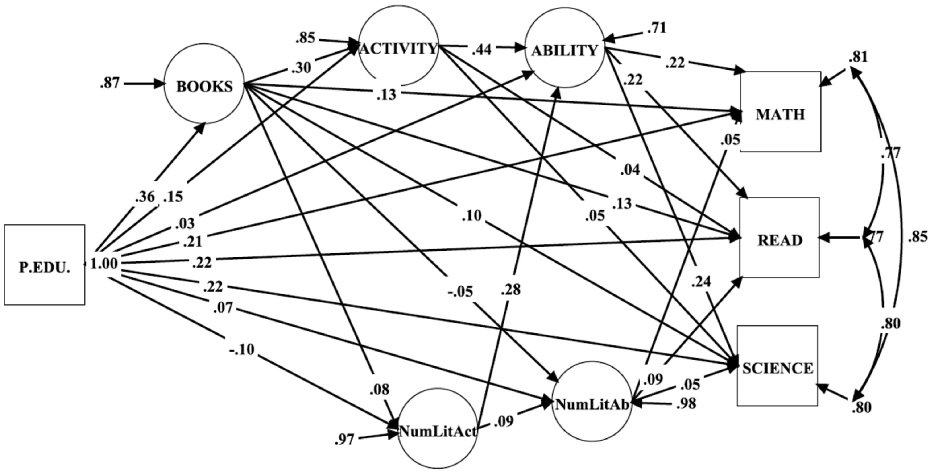
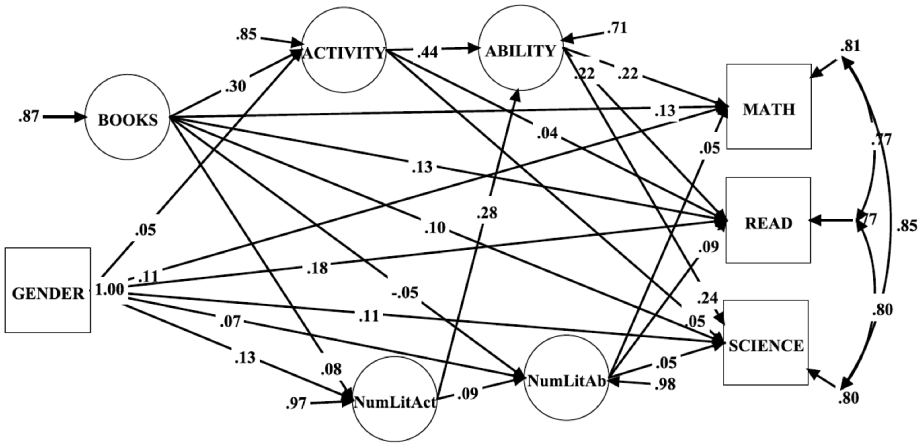


Exhibit 4.36: Oman

PARENTAL EDUCATION The total effects of Parental Education were .30, .31, and .32 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .09, .08, and .09. The indirect effects were mediated via the Main Path and via Books. There also was a direct effect of Parental Education on Activity. For higher levels of Parental Education, there was a relatively stronger emphasis on numeracy than on literacy activities, which indirectly influenced achievement in all domains negatively via Ability. However, there also were positive indirect effects of Parental Education via Books, which was associated with more literacy activity than numeracy activity. Parents with a higher level of education also tended to assess literacy skills higher than numeracy skill, which was positively related to achievement in all three domains.

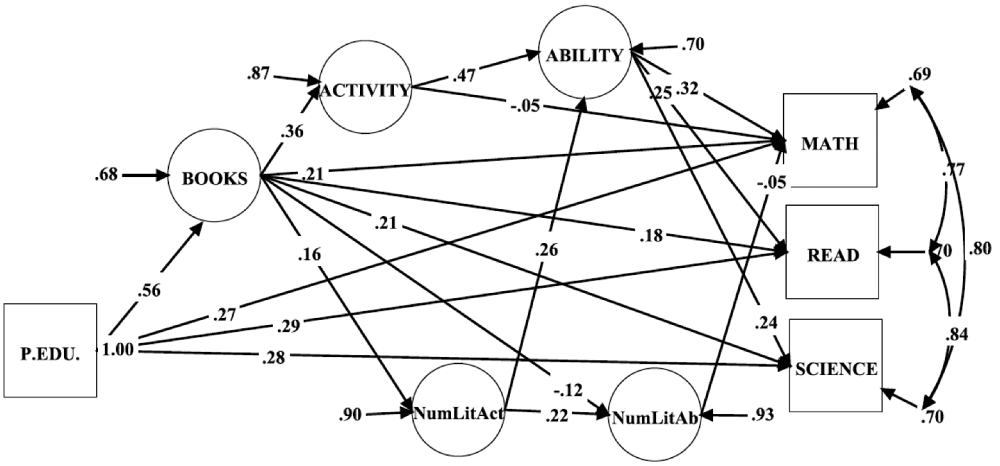


GENDER The total effects of Gender were .13, .14, and .20 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .02, .02, and .03. Girls thus had a considerably higher level of achievement than boys in reading, and they also outperformed boys in mathematics and science. The indirect effects were small for all three outcomes. For girls, there was a relatively stronger emphasis on literacy than numeracy activities, which influenced achievement in all domains via Ability. Girls also were assessed relatively higher in literacy skills than numeracy skills, which influenced achievement in all three domains.



SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

PARENTAL EDUCATION The total effects of Parental Education were .43, .44, and .43 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .15, .16, and .14. The indirect effects were mediated via the Main Path and via Books. In homes with many books, there also was a tendency to place relatively more emphasis on literacy than on numeracy activity. This had a positive effect on Ability, which in turn influenced achievement in all three domains.



GENDER The total effects of Gender were -.06, -.02, and .11 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .02, .04, and .04. Girls thus had a considerably higher level of achievement than boys in reading, while boys outperformed girls in mathematics and science. The indirect effects occurred mainly because for girls there was relatively more emphasis on literacy than on numeracy activities, which influenced Ability positively, and which in turn had a positive effect on achievement in all three domains.

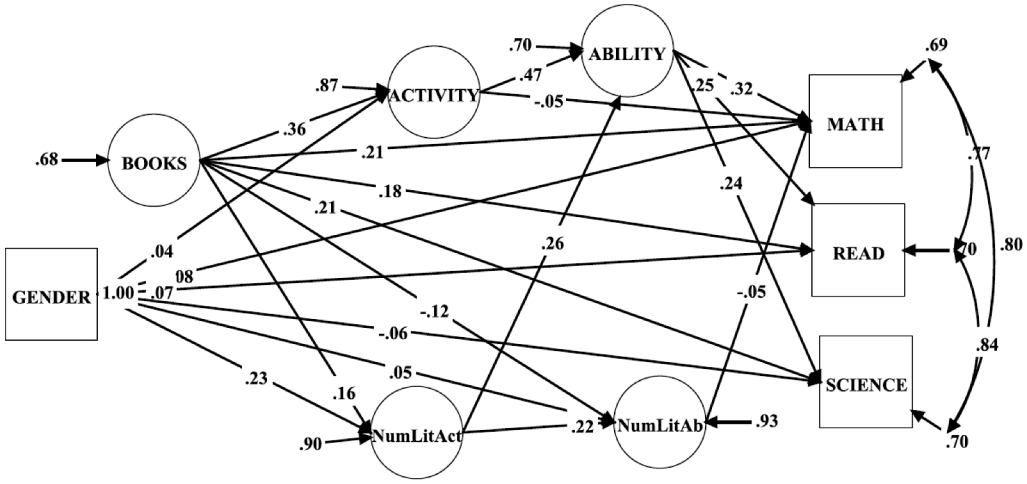
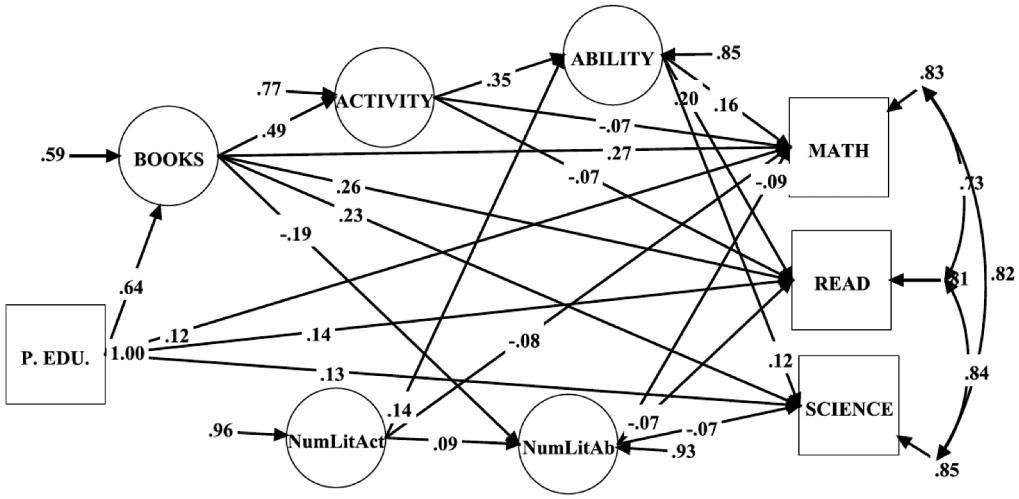
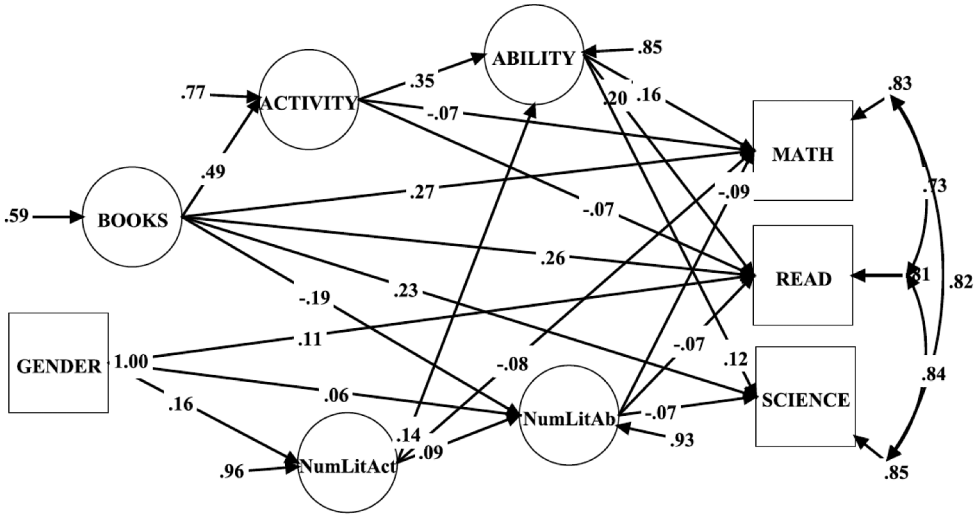


Exhibit 4.38: Portugal

PARENTAL EDUCATION The total effects of Parental Education were .30, .30, and .31 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .18, .17, and .18. The relatively substantial indirect effects went via the Main Path and via Books. There also was a weak effect via Books, because homes with many books tended to assess numeracy skills higher than literacy skills, which in turn had a positive effect on mathematics and science performance.



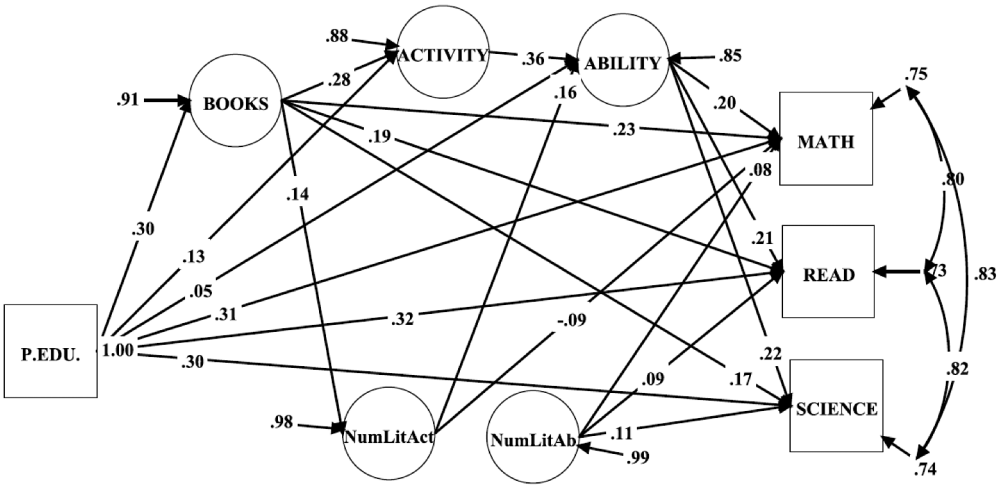
GENDER The total effects of Gender were -.04, -.03, and .11 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were -.01, .00, and .00. Girls thus had a considerably higher level of achievement than boys in reading, while boys had a higher level of achievement than girls in mathematics and science. There was an indirect effect via the pattern of activities, with more emphasis on literacy than on numeracy activities for girls. This indirectly affected achievement positively via an effect on Ability. There also was a small indirect effect via the pattern of assessed skills, with girls having relatively higher assessed literacy skills than numeracy skills, which had negative effects on achievement in mathematics and reading.



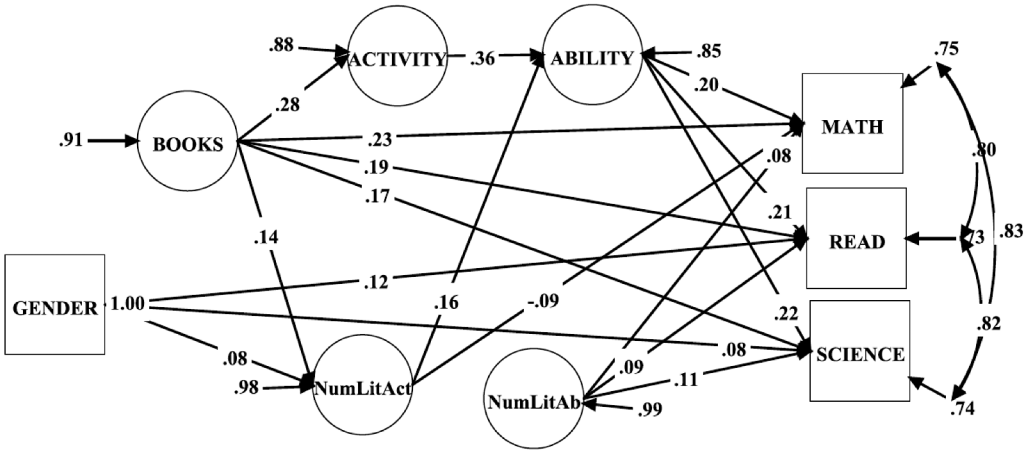
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.39: Qatar

PARENTAL EDUCATION The total effects of Parental Education were .39, .38, and .40 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .09, .08, and .08. The indirect effects were mediated via the Main Path and via Books. In homes with a larger number of books, there was a relatively greater emphasis on literacy than on numeracy activities, which had a positive effect on achievement in all three domains via Ability, along with a negative direct effect on mathematics achievement.



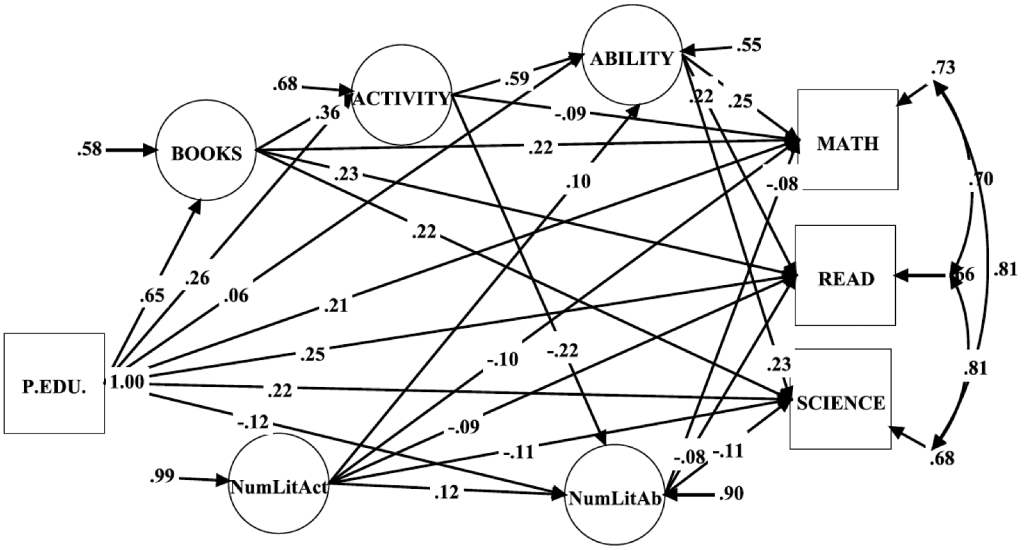
GENDER The total effects of Gender were .06, .11, and .14 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .02, and .02. Girls thus had a considerably higher level of achievement than boys in reading and they also outperformed boys in mathematics and science. There was a small mediating effect via the pattern of activities, with a stronger emphasis on literacy than on numeracy activities for girls. This had a negative direct effect on mathematics achievement, and also a positive effect on Ability, which in turn had positive effects on achievement in all three domains.



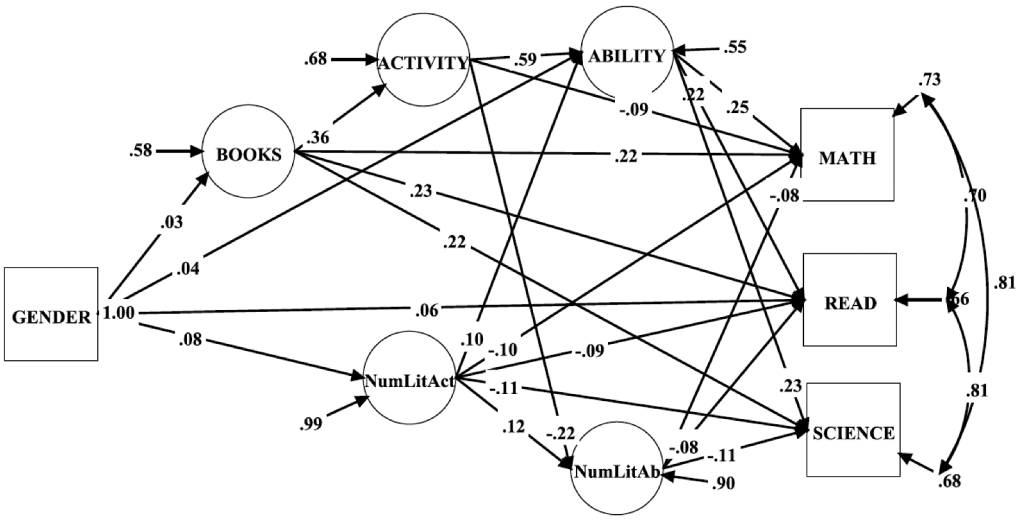
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.40: Romania

PARENTAL EDUCATION The total effects of Parental Education were .43, .47, and .49 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .22, .24, and .24. Thus, there were large total effects of Parental Education on mathematics, science, and reading achievement, and the total indirect effects also were substantial. The indirect effects were mediated via the Main Path and via Books. There also was a direct effect on Activity of Parental Education. In homes with a high level of activity, numeracy skills were assessed higher than literacy skills, which caused positive indirect effects of Activity on achievement in all three domains.



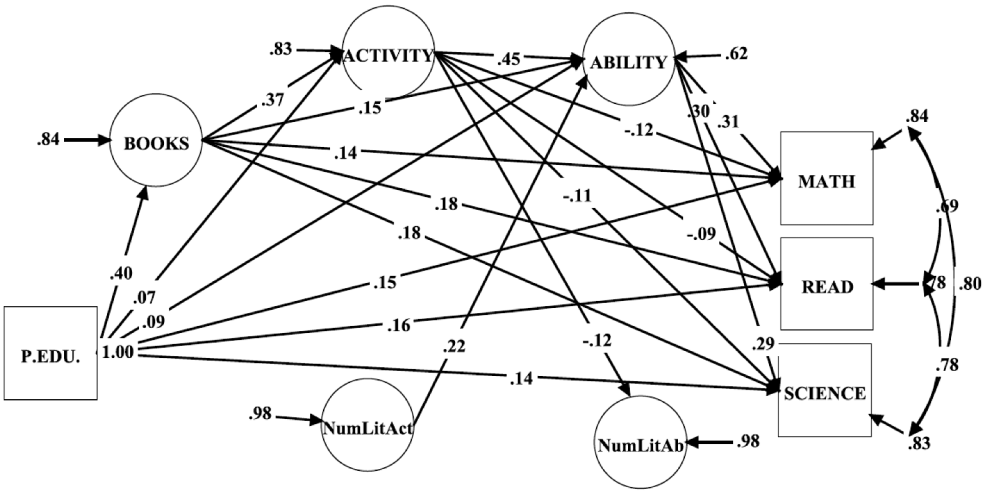
GENDER The total effects of Gender were -.02, -.01, and .08 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .01, and .02. The small indirect effect was partially mediated via Books and via Ability. For girls, there also was a stronger emphasis on literacy than on numeracy activity, which had a positive indirect effect on achievement via Ability, but also negative direct effects in all three domains.



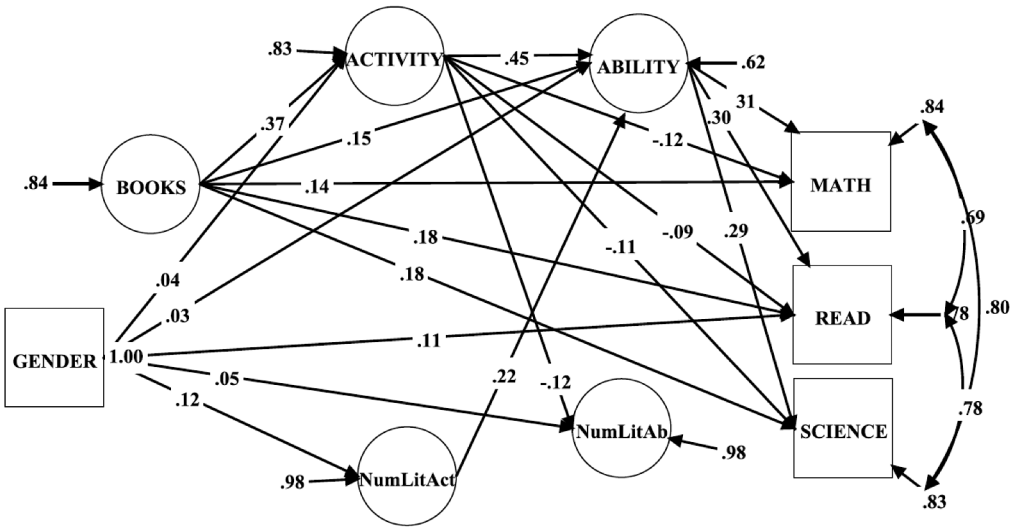
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.41: The Russian Federation

PARENTAL EDUCATION The total effects of Parental Education were .27, .27, and .29 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .11, .13, and .13. The indirect effects were primarily mediated via the Main Path and via Books. There also was an effect of Parental Education on Ability, which had a positive effect on achievement in all three domains.



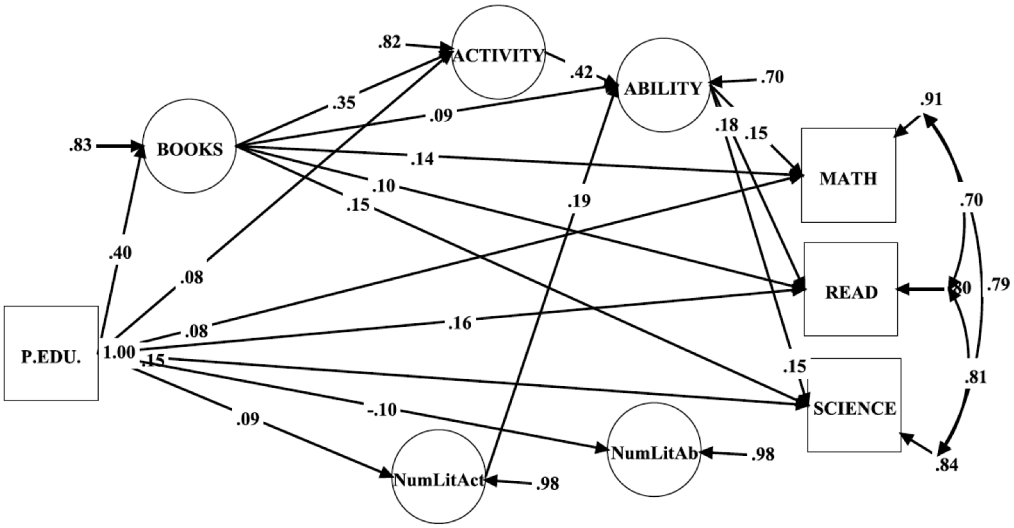
GENDER The total effects of Gender were .01, -.01, and .14 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .02, .02, and .03. Girls thus outperformed boys in reading. A part of the indirect effects was mediated via Activity and Ability. For girls, there also was more emphasis on literacy activities than on numeracy activities, which had a positive impact on achievement via Ability.



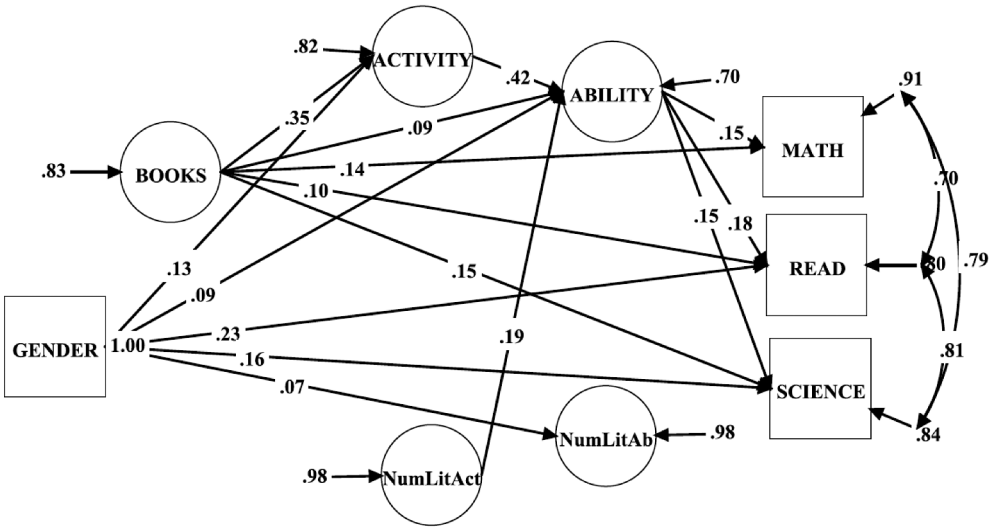
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.42: Saudi Arabia

PARENTAL EDUCATION The total effects of Parental Education were .18, .25, and .24 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .09, .10, and .09. The indirect effects were primarily mediated via the Main Path and via Books. There also was greater emphasis on literacy activities than numeracy activities in homes with higher Parental Education, which influenced achievement in all three domains via was Ability.

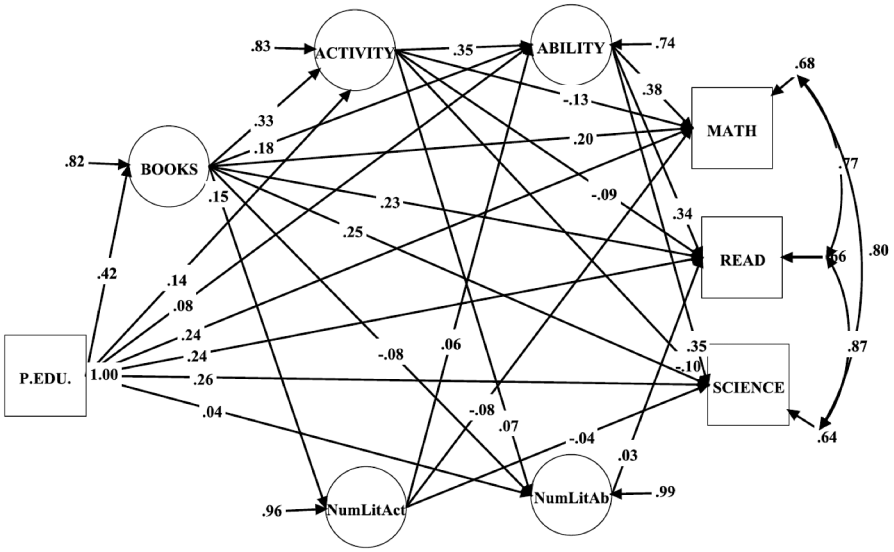


GENDER The total effects of Gender were .06, .20, and .27 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .04, .04, and .04. Girls thus outperformed boys in all three domains, but particularly so in reading and science. For girls, there was a higher level of Activity and higher level of Ability, which was positively related to achievement in all three domains.



SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

PARENTAL EDUCATION The total effects of Parental Education were .39, .44, and .41 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .15, .17, and .17. The indirect effects were mainly mediated via the Main Path and via Books. There also was an effect of Books on the balance of activities, such that in homes with many books there was greater emphasis on literacy activities than on numeracy activities. This had a weak effect on Ability, which influenced achievement in all three domains positively.



GENDER The total effects of Gender were .02, -.03, and .10 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .04, and .04. Girls thus outperformed boys in reading, while boys had a somewhat higher level of achievement in science. The indirect effects were partially mediated via the Main Path and via Ability. For girls, there also was more of an emphasis on literacy activities than numeracy activities, which had a positive effect on achievement via Ability, and a negative direct effect on mathematics achievement. Girls also had somewhat higher assessed literacy skills than numeracy skills, which had a direct effect on reading achievement.

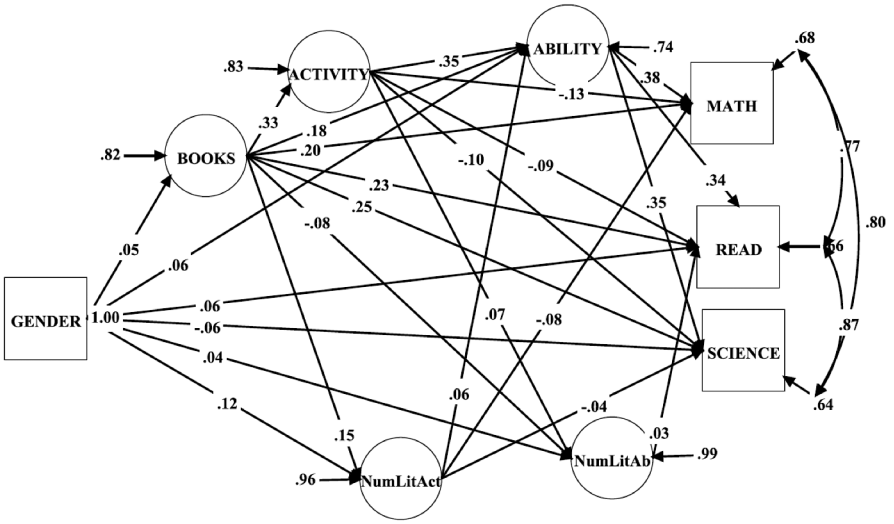
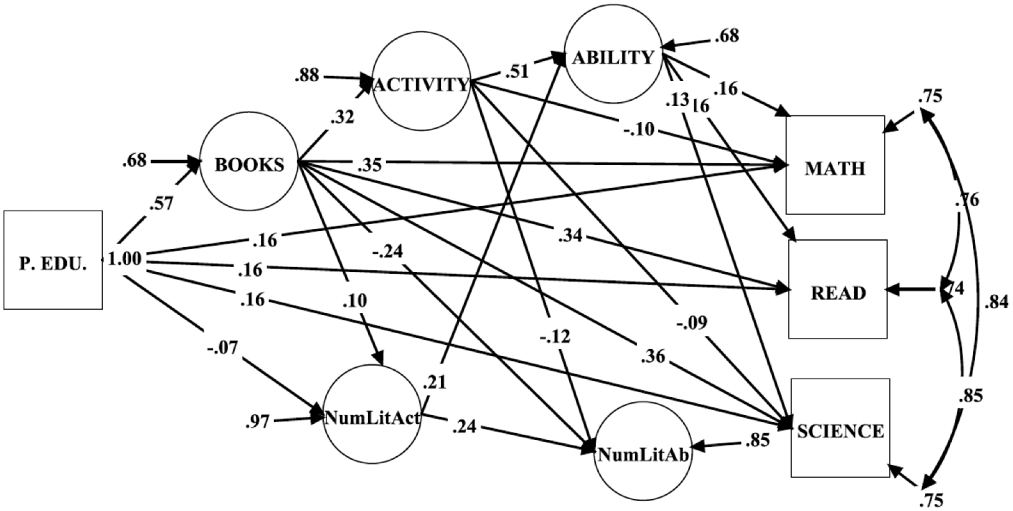
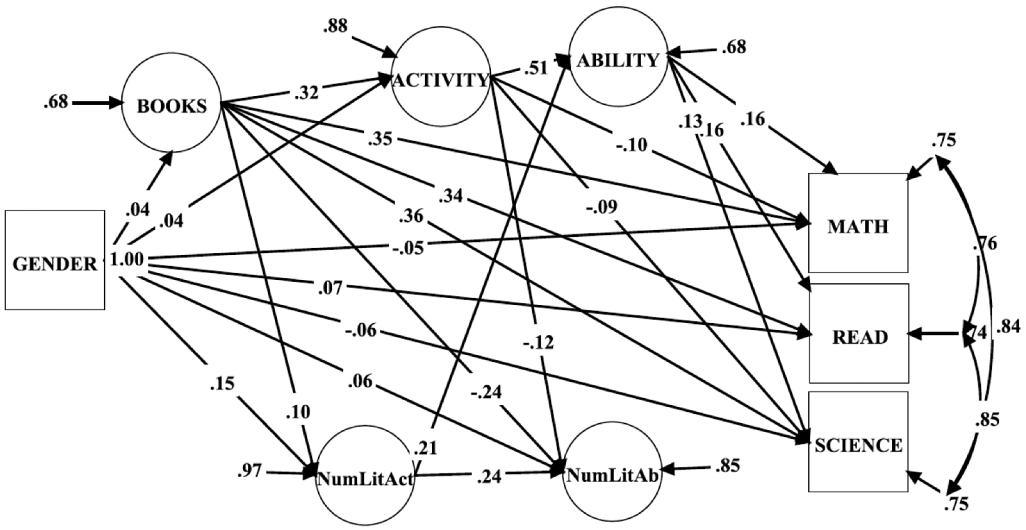


Exhibit 4.44: The Slovak Republic

PARENTAL EDUCATION The total effects of Parental Education were .37, .38, and .38 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .21, .21, and .21. The indirect effects were mediated via the Main Path and via Books. For homes with a high level of parental education, there was more emphasis on numeracy activities than on literacy activities, which had a weak negative effect on achievement via Ability.



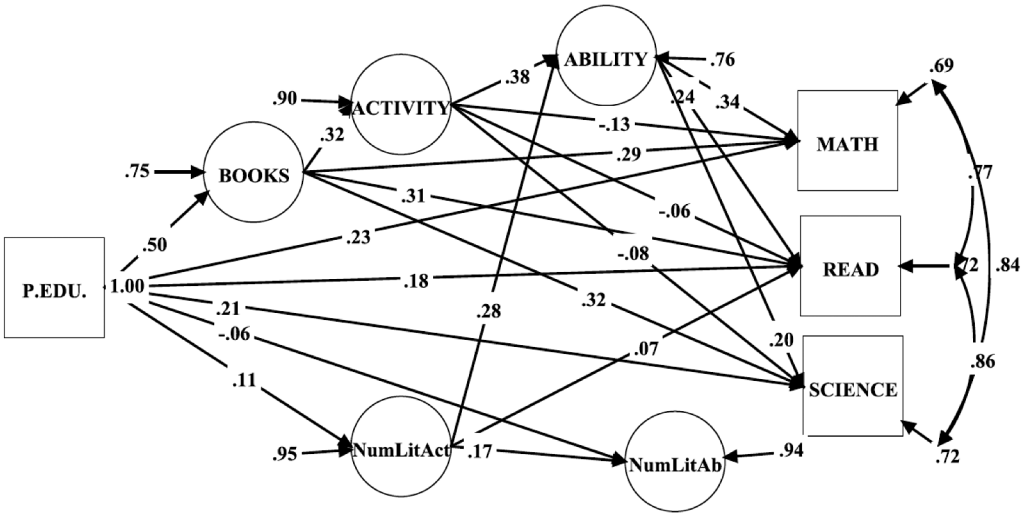
GENDER The total effects of Gender were -.05, -.05, and .08 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .00, .01, and .01. The weak indirect effects were mediated the Main Path and via Activity. There also was an indirect effect via Books. For girls, there also was more of an emphasis on literacy activities than numeracy activities. This had a positive effect on achievement, which was mediated via Ability.



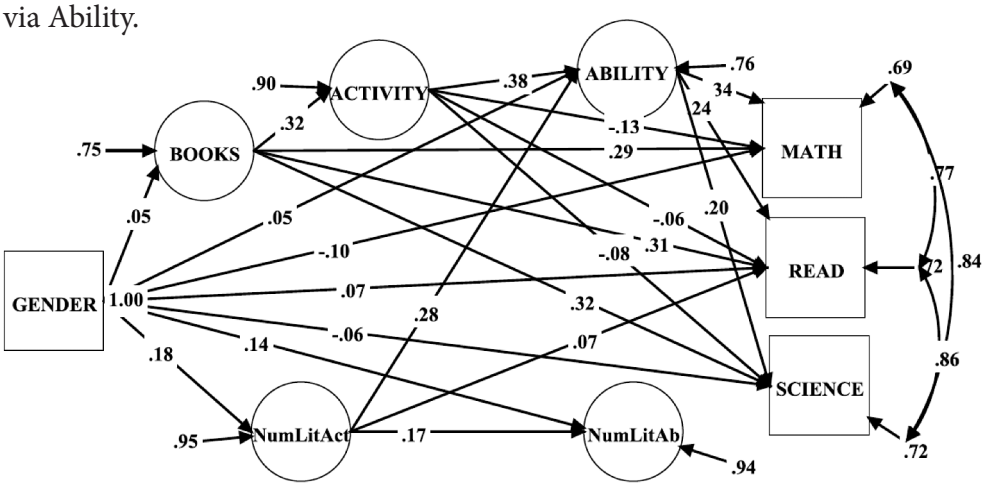
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.45: Slovenia

PARENTAL EDUCATION The total effects of Parental Education were .38, .39, and .35 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .15, .17, and .17. The indirect effects were mediated via the Main Path and via Books. In homes with more highly educated parents, there was more emphasis on literacy activities than on numeracy activities. This had a positive indirect effect on achievement, which was mediated via Ability.



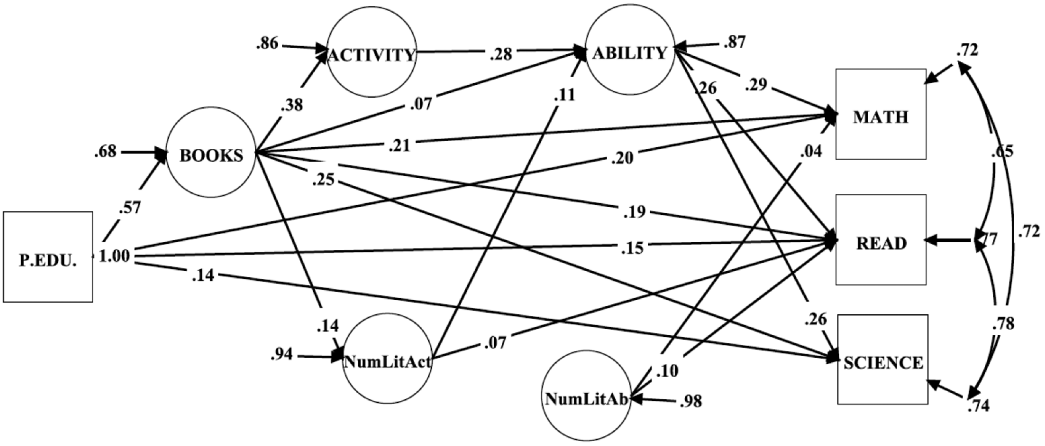
GENDER The total effects of Gender were -.06, -.02, and .12 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .04, .05, and .06. Girls thus outperformed boys in reading, while boys had a higher level of achievement in mathematics. The indirect effects were mediated via the Main Path and via Ability. There also was an indirect effect via Books. For girls, there was more emphasis on literacy activities than numeracy activities, which had a positive indirect effect on achievement in all domains via Ability.



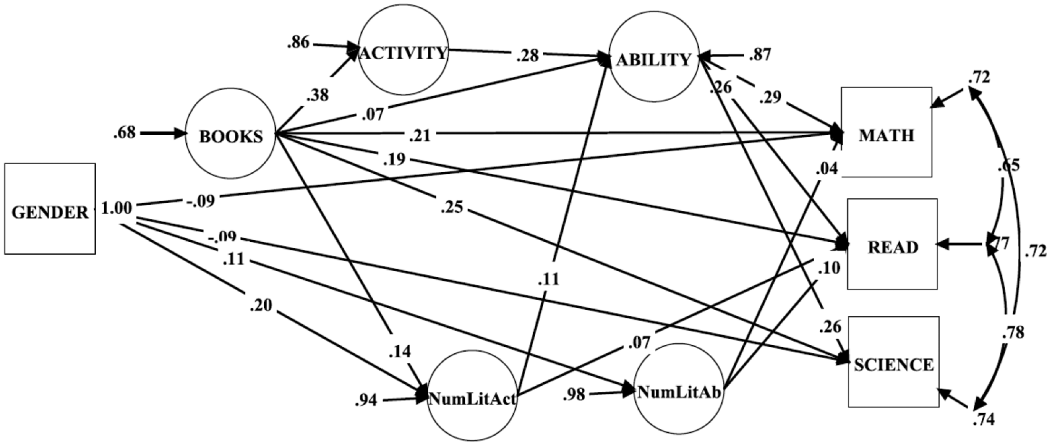
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.46: Spain

PARENTAL EDUCATION The total effects of Parental Education were .37, .33, and .31 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .17, .19, and .16. The indirect effects were mediated via the Main Path and via Books. In homes with a larger number of books, there was greater emphasis on literacy activities than numeracy activities, which had a positive effect on achievement in all domains via Ability.



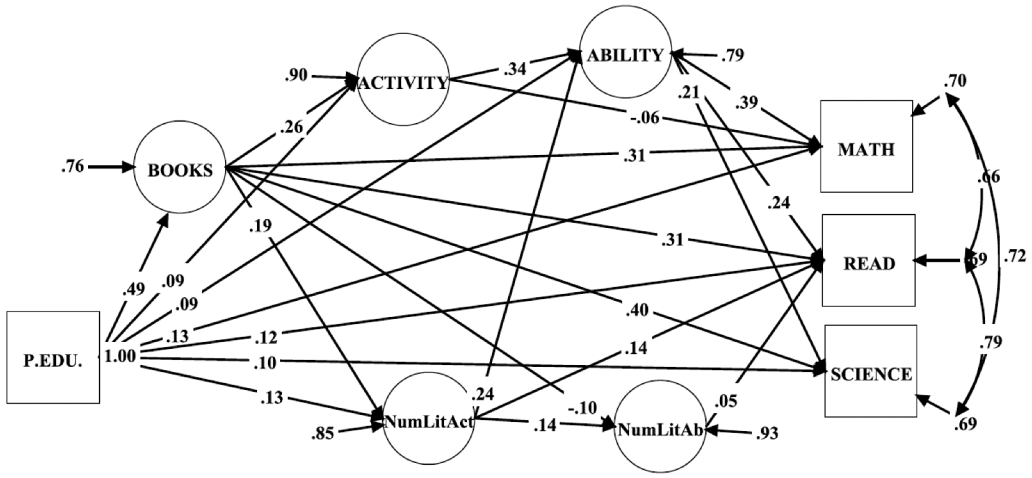
GENDER The total effects of Gender were -.08, -.07, and .03 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .02, and .03. Boys thus outperformed girls in mathematics and science, while girls had a somewhat higher level of achievement in reading. For girls, there was more emphasis on literacy than on numeracy activities, which had a positive indirect effect on achievement in all three domains via Ability, along with a positive direct effect on reading achievement. Girls also were assessed higher on literacy skills than on numeracy skills, which had a positive effect on reading achievement in particular.



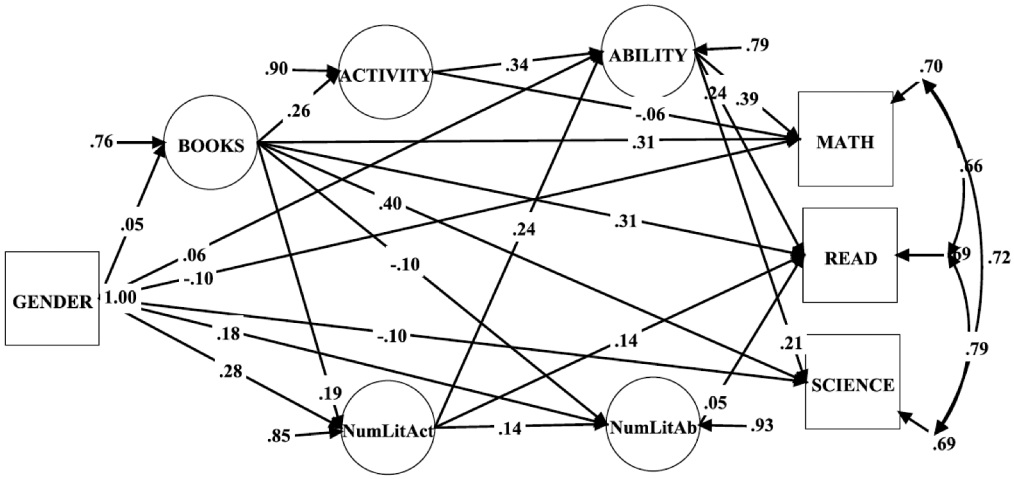
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.47: Sweden

PARENTAL EDUCATION The total effects of Parental Education were .32, .34, and .34 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .20, .25, and .22. The indirect effects were mediated via the Main Path and via Books. Both for homes with more books and more highly educated parents there was more literacy activity than numeracy activity. This had a positive indirect effect on achievement in all three domains, which was mediated via Ability, and there also was a positive direct effect on reading achievement.



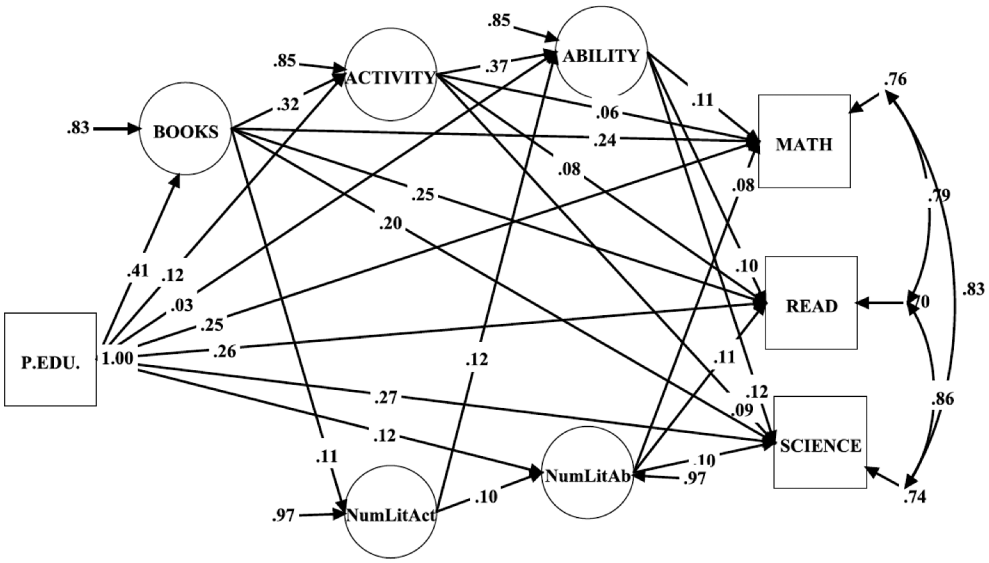
GENDER The total effects of Gender were -.05, -.03, and .11 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .05, .08, and .10. Girls thus outperformed boys in reading, while boys had a higher level of achievement in mathematics and science. Weak indirect effects of Gender were mediated via Books and via Ability. For girls, there also was more emphasis on literacy activities than on numeracy activities, which had a positive indirect effect on achievement via Ability, and there was also a positive direct effect on reading achievement. Girls also were more highly assessed on literacy skills than on numeracy skills, which was associated with a higher level of reading achievement.



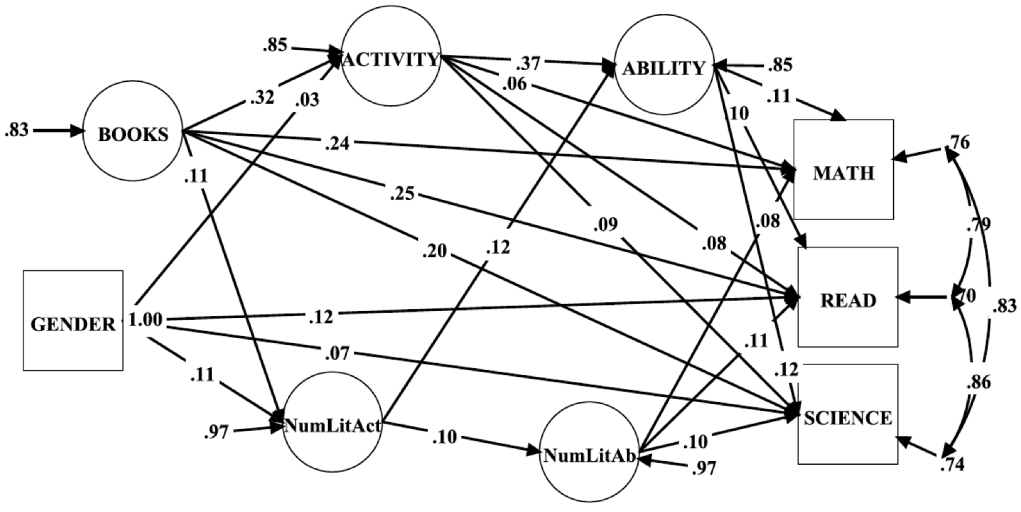
SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

Exhibit 4.48: United Arab Emirates

PARENTAL EDUCATION The total effects of Parental Education were .39, .40, and .42 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .14, .13, and .15. The indirect effects were mediated via the Main Path and via Books. Homes with many books also tended to put more emphasis on literacy activities than numeracy activities, which indirectly had a positive effect on achievement via Ability. Parents with a higher level of education tended to assess literacy skills higher than numeracy skills, which also was positively related to achievement in all three domains.

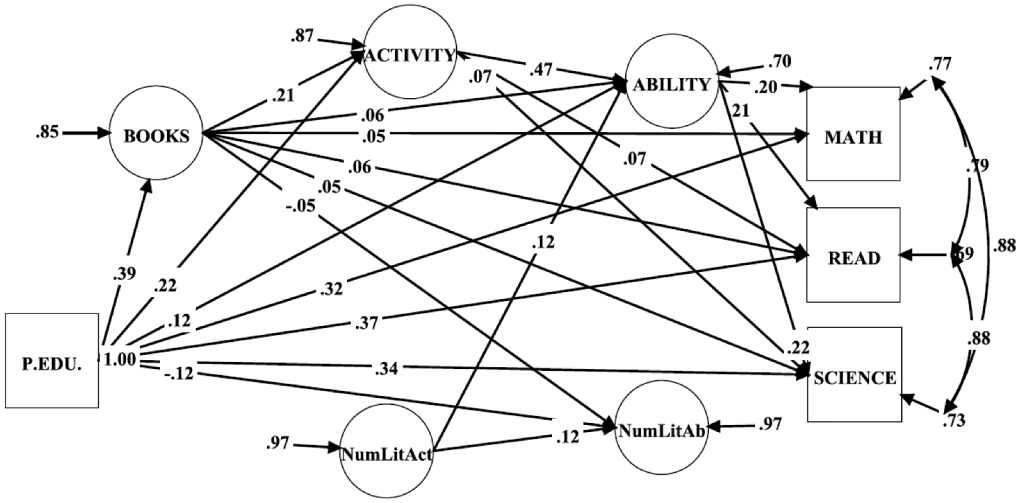


GENDER The total effects of Gender were .04, .09, and .14 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .01, .02, and .02. Girls thus outperformed boys in all three domains, and particularly so in reading and science. For girls, there was more emphasis on literacy activity than numeracy activity which indirectly influenced achievement positively via Ability. For students who had more of literacy than numeracy activities, literacy skills also were assessed higher than numeracy skills, which also had positive effects on achievement in all three domains.

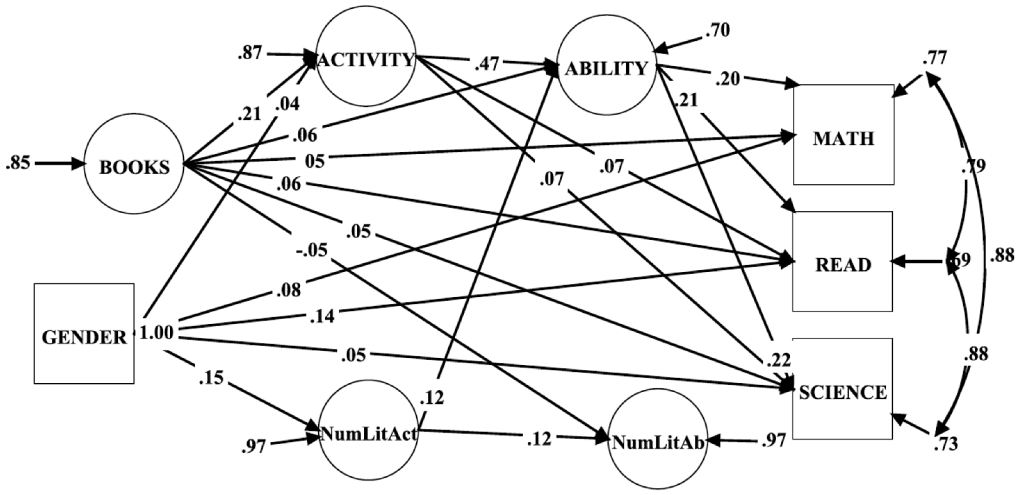


SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

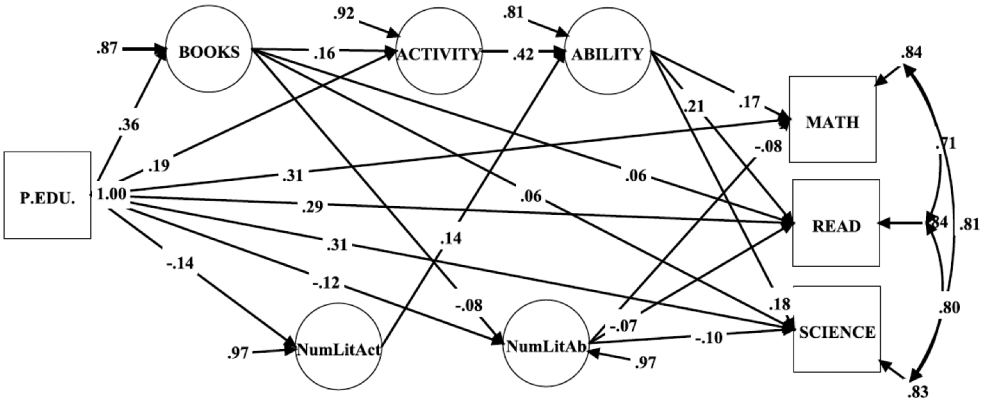
PARENTAL EDUCATION The total effects of Parental Education were .41, .45, and .48 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .09, .10, and .10. A part of the indirect effect was mediated via the Main Path, but there also was a relatively strong direct effect of Parental Education on Activity, and also a smaller direct effect of Parental Education on Ability.



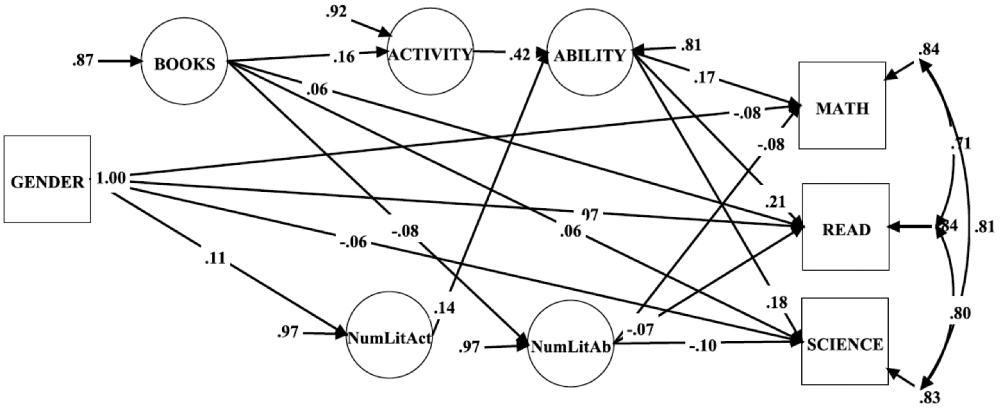
GENDER The total effects of Gender were .10, .06, and .15 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .02, .02, and .01. Thus, girls outperformed boys in all three domains. Most of the effect of Gender was direct. However, for girls there was more emphasis on literacy activity than on numeracy activity, which had a positive effect on achievement in all three domains via Ability.



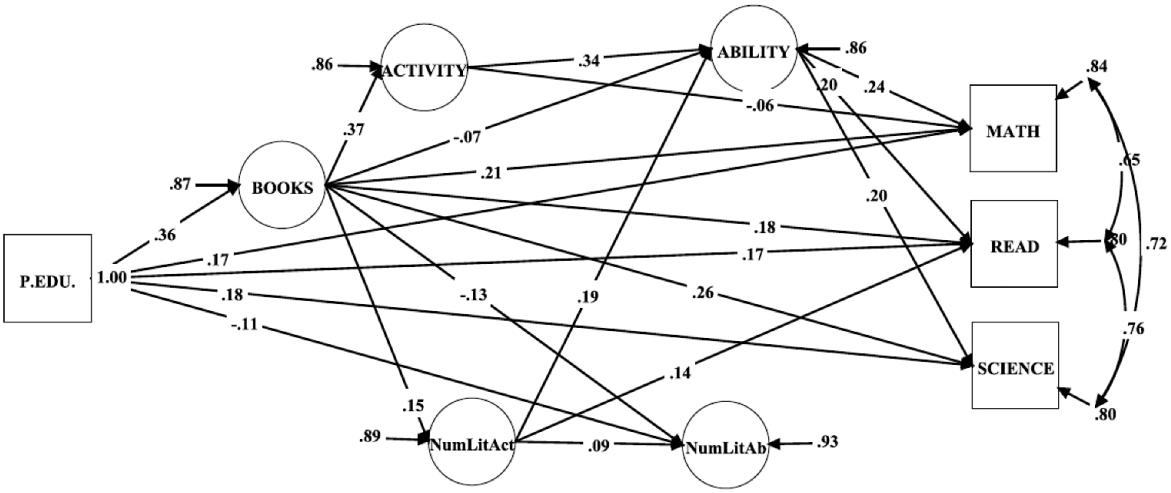
PARENTAL EDUCATION The total effects of Parental Education were .34, .36, and .34 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .05, and .05. The total indirect effect thus accounted for only a small part of the total effect. Small indirect effects went via the Main Path and via Books. To a small extent, the effect of Parental Education was mediated via the balance of the activities and assessment of literacy and numeracy skills, as well as more highly educated parents tending to emphasize numeracy activities more and to assess numeracy skills higher.



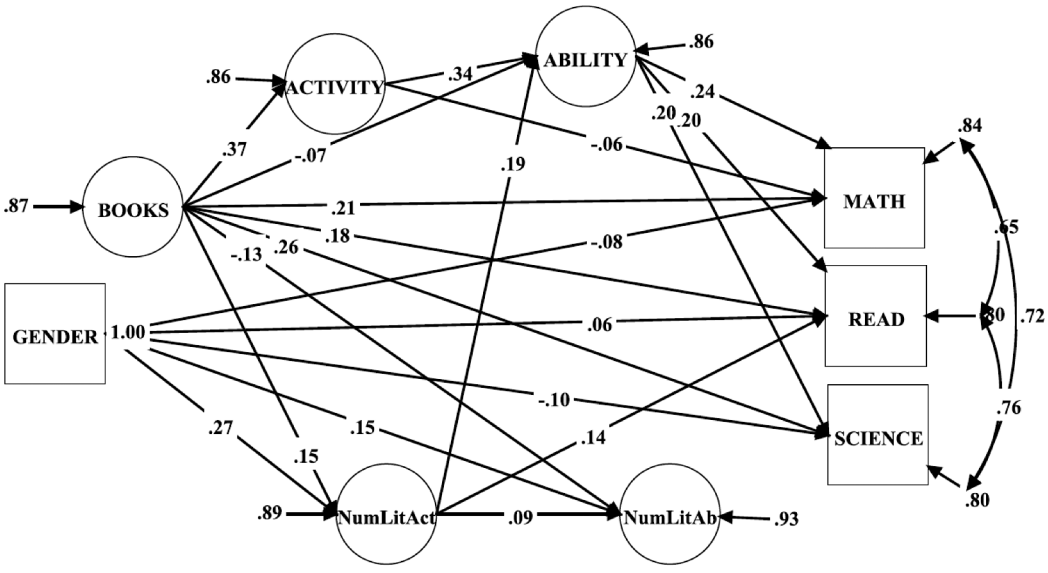
GENDER The total effects of Gender were -.08, -.06, and .07 for mathematics, science, and reading, respectively, and the total indirect effects were all close to 0. Girls thus outperformed boys in reading, while boys had higher achievement in mathematics and science. However, no significant indirect effects were identified. There was, however, a tendency for girls to have more emphasis on literacy activities than on numeracy activities, which influenced achievement in all three domains positively via Ability.



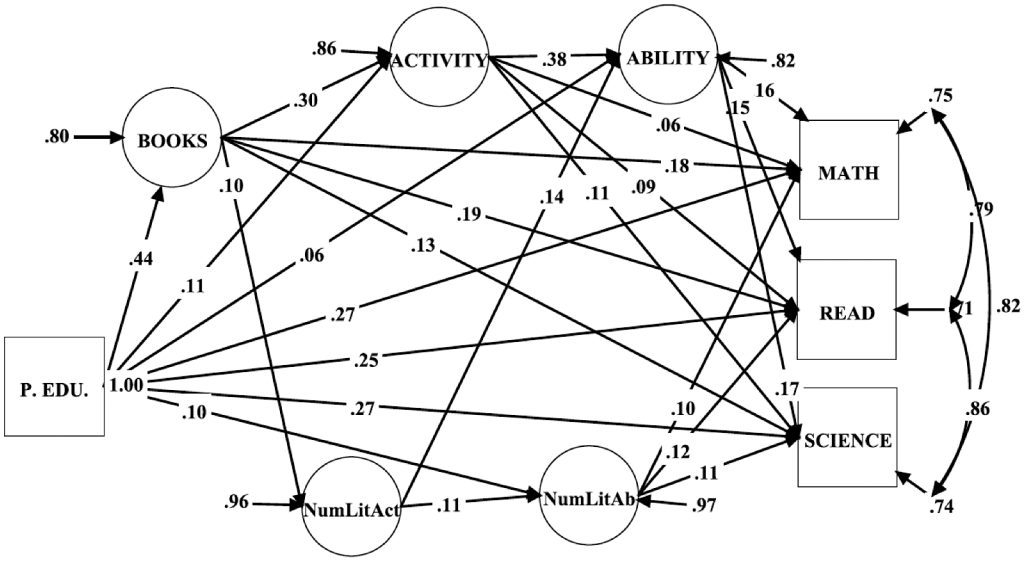
PARENTAL EDUCATION The total effects of Parental Education were .40, .39, and .40 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .13, .12, and .15. The indirect effects were mediated via the Main Path and via Books. In families with a larger number of books, there was greater emphasis on literacy than numeracy activities, which had positive indirect effects on achievement via Ability, and there also was a positive direct effect on reading achievement.



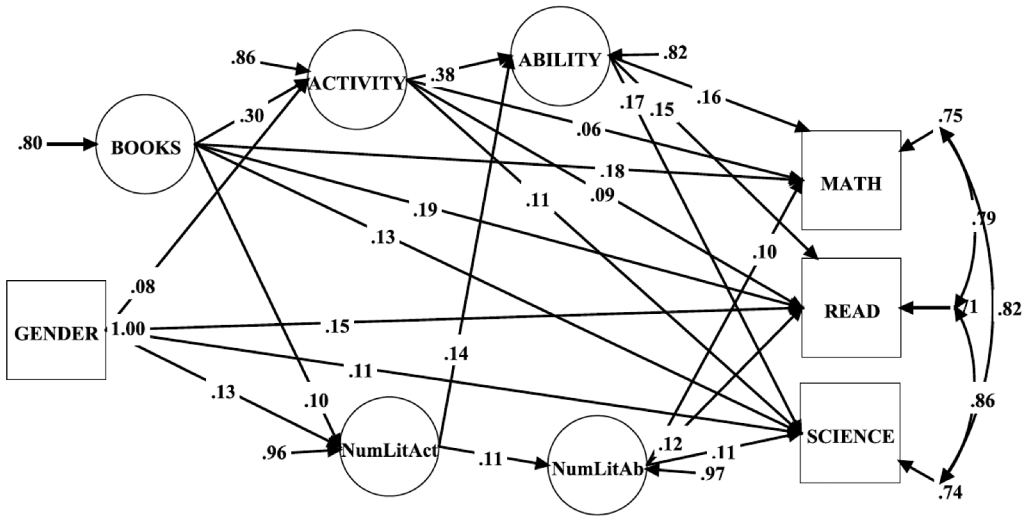
GENDER The total effects of Gender were .08, .14, and .19 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .03, and .03. Girls thus outperformed boys in all three domains, and particularly so in reading and science. For girls, there was more emphasis on literacy activities than on numeracy activities, which had positive indirect effects on all domains of achievement via Ability, and also a positive direct effect on reading achievement.



PARENTAL EDUCATION The total effects of Parental Education were .40, .39, and .40 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .13, .12, and .15. The indirect effects were mediated via the Main Path and via Books. In families with a larger number of books, more emphasis was placed on literacy activities than on numeracy activities, which had a positive indirect effect on achievement via Ability. Parents with a higher level of education also assessed literacy skills higher than numeracy skills, which influenced achievement in all three domains.

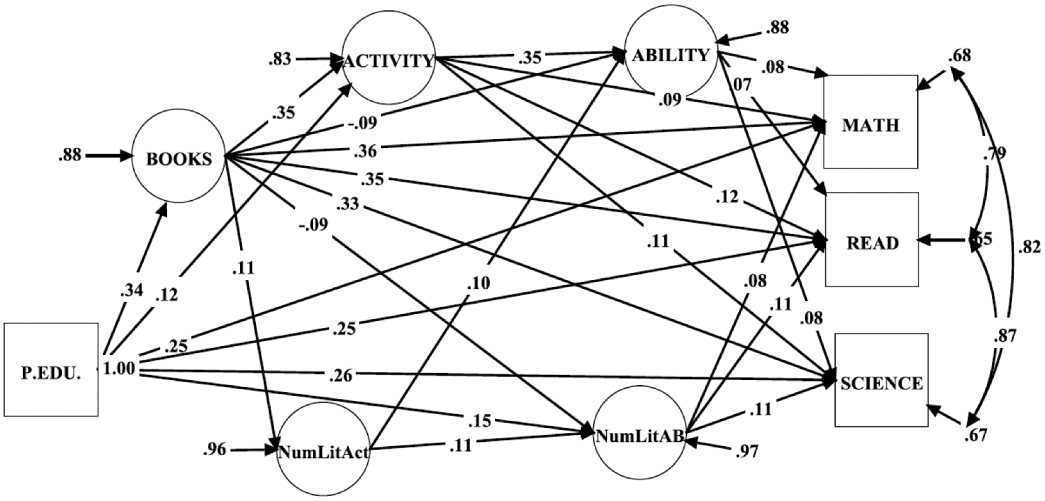


GENDER The total effects of Gender were .08, .14, and .19 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .03, and .03. Girls thus outperformed boys in all three domains, and particularly so in reading. The indirect effects of Gender were mediated via Activity and via Ability. For girls, there was a stronger emphasis on literacy activities than on numeracy activities, which had a positive indirect effect on achievement via Ability.

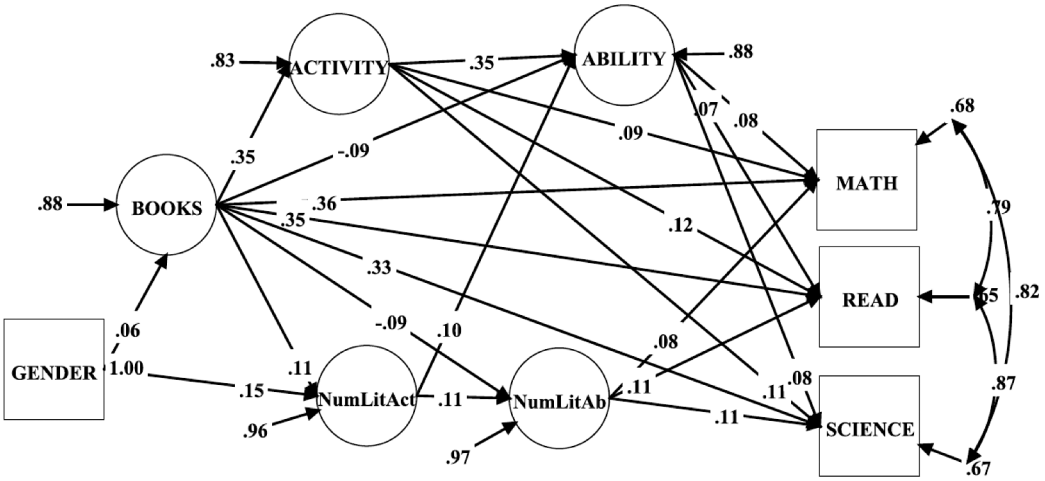


SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

PARENTAL EDUCATION The total effects of Parental Education were .41, .42, and .42 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .16, .16, and .17. Indirect effects were mediated via the Main Path and via Books. In homes with many books, more emphasis was placed on literacy activities than numeracy activities, which had an indirect effect on achievement in all domains via Ability. Parents with a higher level of education also assessed literacy skills higher than numeracy skills, which was associated with a higher level of achievement in all three domains.



GENDER The total effects of Gender were -.01, .02, and .07 for mathematics, science, and reading, respectively, and the corresponding total indirect effects were .03, .04, and .04. Girls thus outperformed boys in reading. Indirect effects were mediated via the Main Path and via Books. For girls, more emphasis was placed on literacy activities than on numeracy activities; this had an indirect effect on achievement via Ability, and via a higher assessment of literacy skills than numeracy skills.



SOURCE: IEA's Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study – TIMSS and PIRLS 2011

References

Aiken, L.R. (1972). Language factors in learning mathematics. *Review of Educational Research, 42*, 359–385.

Anders, Y., Rossbach, H.-G., Weinert, S., Ebert, S., Kuger, S., Lehrl, S., & von Maurice, J. (2012). Home and preschool learning environments and their relations to the development of early numeracy skills. *Early Childhood Research Quarterly, 27*, 231–244.

Baker, D.P. & Jones, D.P. (1993). Creating gender equality: Cross-national gender stratification and mathematical performance. *Sociology of Education*, *66*, 91–103.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Barone, C. (2006). Cultural capital, ambition and the explanation of inequalities in learning outcomes: a comparative analysis. *Sociology*, *40*(6), 1039–1058.

Bernstein, B. (1971). Social class, language and socialization. In B. Bernstein (Ed.), *Class, codes and control.* London: Routledge & Kegan Paul.

Brooks-Gunn, J., Klebanov, P., & Duncan, D. (1996). Ethnic differences in children's intelligence test scores: Role of economic deprivation, home environment, and maternal characteristics. *Child Development, 67*, 396–408.

Brown, T.A. (2006) *Confirmatory factor analysis for applied research*. New York, NY: Guilford Press.

Bourdieu, P. & Passeron, J.-C. (1977). *Reproduction in education, society and culture.* Beverly Hills: Sage.

Davis-Kean, P.E. (2005). The influence of parent education and family income on child achievement: the indirect role of parental expectations and the home environment. *Journal of Family Psychology*, *19*(2), 294–304.

De Graaf, N.D., De Graaf, P.M., & Kraaykamp, G. (2000). Parental cultural capital and educational attainment in the Netherlands: A refinement of the cultural capital perspective. *Sociology of Education*, *73*, 92–111.

Diezman, C. & Yelland, N. (2000). Developing mathematical literacy in the early childhood years. In N.J. Yelland (Ed.), *Promoting meaningful learning*. Washington, DC: National Association for the Education of Young Children.

Doig, B., McCrae, B., & Rowe, K. (2003). *A good start to numeracy. Effective numeracy strategies from research and practice in early childhood*. Camberwell, Victoria: Australian Council for Educational Research.

Duncan, G., Brooks-Gunn, J., & Klebanov, P. (1994). Economic deprivation and early child development. *Child Development*, *65*, 296–318.

Eccles, J.S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, *18*, 585–610.

Else-Quest, N.M., Hyde, J.S., & Linn, M.C. (2010). Cross-national patterns of gender differences in mathematics achievement, attitudes, & affect: A meta-analysis. *Psychological Bulletin*, *136*, 103–127.

Ewers-Rogers, J. & Cowan, R. (1996). Children as apprentices to number. *Early Childhood Development and Care*, *125*, 15–25.

Farkas, G. & Beron, K. (2004). The detailed age trajectory of oral vocabulary knowledge: Differences by class and race. *Social Science Research*, *33*, 464–497.

Gustafsson, J.-E. (2002). Measurement from a hierarchical point of view. In H. I. Braun, D.N. Jackson & D.E. Wiley (Eds.), *The role of constructs in psychological and educational measurement* (pp. 73-95). London: Lawrence Erlbaum Associates, Publishers.

Gustafsson, J.-E. & Balke, G. (1993). General and specific abilities as predictors of school achievement. *Multivariate Behavioral Research, 28*(4), 407–434.

Gustafsson, J.-E. & Åberg-Bengtsson, L. (2010). Unidimensionality and interpretability of psychological instruments. In S.E. Embretson (Ed.), *Measuring psychological constructs: Advances in model-based approaches*. Washington: American Psychological Association.

Hart, B. & Risley, R.T. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Brookes.

Hecht, S.A., Burgess, S.R., Torgesen, J.K., Wagner, R.K., & Rashotte, C.A. (2000). Explaining social class differences in growth of reading skills from beginning kindergarten through fourth-grade: The role of phonological awareness, rate of access, and print knowledge. *Reading and Writing: An Interdisciplinary Journal, 12*, 99–127.

Hyde, J.S. (2005). The gender similarities hypothesis. *American Psychologist*, *60*, 581–592.

Jordan, G.E., Snow, C.E., & Porsche, M.V. (2000). Project EASE: The effect of a family literacy project on kindergarten students' early literacy skills. *Reading Research Quarterly, 35*, 524-546.

Lyster, S.-A.H. (2002). The effects of morphological versus phonological awareness training in kindergarten on reading development. *Reading and Writing: An Interdisciplinary Journal, 15*, 261-294.

Martin, M. O., Mullis, I. V. S., Foy, P., & Arora, A. (2012). Creating and interpreting the TIMSS and PIRLS 2011 context questionnaire scales. In M.O. Martin & I.V.S. Mullis (Eds.), *Methods and Procedures in TIMSS and PIRLS 2011*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College. Retrieved from http://timssandpirls.bc.edu/methods/pdf/TP11_Context_Q_Scales.pdf

Ming Chui, M. & McBride-Chang, C. (2006). Gender, context, and reading: A comparison of students in 43 countries. *Scientific Studies of Reading*, 10(4), 331–62.

Mullis, I.V.S., Martin, M.O., Fierros, E.G., Goldberg, A.L., & Stemler, S.E. (2000). *Gender differences in achievement: IEA's third international mathematics and science study*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I.V.S., Martin M.O., Gonzalez E.J., & Kennedy, A.M. (2003). *PIRLS 2001 international report: IEA's study of reading literacy achievement in primary schools in 35 countries*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I.V.S., Martin M.O., Kennedy A.M., & Foy, P. (2007). *PIRLS 2006 international report: IEA's progress in international reading literacy study in primary schools in 40 countries*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I.V.S., Martin M.O., Foy, P., & Drucker, K.T. (2012). *PIRLS 2011 international results in reading*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Muthén, L.K. & Muthén, B.O. (1998-2012). *Mplus user's guide*. Seventh Edition. Los Angeles, CA: Muthén & Muthén.

Myrberg, E. & Rosén, M. (2009). Direct and indirect effects of parents' education on reading achievement among third graders in Sweden. *British Journal of Educational Psychology, 79*, 695–711.

National Early Literacy Panel. (2008). *Developing early literacy: Report of the national early literacy panel.* Washington, DC: National Institute for Literacy. Retrieved from http://lincs.ed.gov/publications/pdf/NELPReport09.pdf

Noble, K.G., McCandless, B.D., & Farah, M.J. (2007). Socioeconomic gradients predict individual differences in neurocognitive development. *Developmental Science*, *10*, 464–480.

Park, H. (2008) Home literacy environments and children's reading performance: a comparative study of 25 countries. *Educational Research and Evaluation; An international Journal of Theory and Practice, 14*(6), 489-505.

Raz, I.S. & Bryant, P. (1990). Social background, phonological awareness and children's reading. *British Journal of Developmental Psychology, 8*, 209–225.

Reise, S.P. (2012). The rediscovery of bifactor measurement models. *Multivariate Behavioral Research*, *47*(5), 667–696.

Sénéchal, M. & LeFevre, J.A. (2002). Parental involvement in the development of children's reading skill: A five-year longitudinal study. *Child Development, 73*, 445–460.

Sirin, S.R. (2005). Socioeconomic status and academic achievement: A Meta-analytic review of research 1990-2000. *Review of Educational Research, 75*(3), 417–45.

Snow, C.E., Burns, M.S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children*. Washington, DC: National Academy Press.

Spelke, E.S. (2005). Sex differences in intrinsic aptitude for mathematics and science? *American Psychologist, 60*, 950–958.

Tabors, P.O., Snow, C.E., & Dickinson, D.K. (2001). Homes and schools together: Supporting language and literacy development. In D.K. Dickinson & P.O. Tabors (Eds.), *Beginning literacy with language: Young children learning at home and in school* (pp. 313–334). Baltimore: Brookes.

White, K.R. (1982). The relation between socio-economic status and academic achievement. *Psychological Bulletin, 91*(3), 461–481.

Yang, Y. (2003). *Measuring socio-economic status and its effects on individual and collective levels: A cross-country comparison*. Gothenburg: Gothenburg Studies in Educational Sciences, Acta Universitatis Gothoburgensis.

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