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UNDERSTANDING THE LOW MATHEMATICS ACHIEVEMENT OF CHILEAN STUDENTS: A CROSS-NATIONAL ANALYSIS USING TIMSS DATA

Dissertation

by

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Abstract

UNDERSTANDING THE LOW MATHEMATICS ACHIEVEMENT
OF CHILEAN STUDENTS:
A CROSS-NATIONAL ANALYSIS USING TIMSS DATA

Dissertation by María José Ramírez

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The low performance of Chile in the TIMSS 1999 international study of mathematics and science achievement was a great disappointment. To investigate the likely causes for low performance in mathematics, this study 1) compared Chile to three countries and one large school system that had comparable economic conditions but superior mathematics performance, and 2) examined how important characteristics of the Chilean educational system could account for poor student achievement in mathematics. The results show that, compared to South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools, Chilean 8th graders had parents with fewer years of schooling and with fewer educational resources at home. At school, Chilean students were taught by teachers who felt less prepared to teach, and who covered fewer advanced mathematics content in class than teachers in other countries. Analyses using a series of hierarchical linear models show that, in Chile, school assets were unequally distributed across social classes. Schools in socially advantaged areas had more instructional resources and better prepared teachers; these teachers, in turn, emphasized more advanced mathematics content. Schools with their own mathematics curriculum and whose teachers covered more advanced content had significantly higher student

achievement in mathematics. This relationship held true even after controlling statistically for the socio-economic level and type of administration (public/private). Regardless of school characteristics, students who a) expected to graduate from university, b) thought that doing mathematics was not so difficult, and c) thought that their academic performance did not depend on good luck or innate talent, attained significantly higher mathematics achievement.

To Cristóbal

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CHAPTER 1

INTRODUCTION

Compared to other countries with similar economic conditions, the Chilean education system is lagging in terms of educational achievement. Data from the 1999 Trends in International Mathematics and Science Study (TIMSS) show that other countries with similar economic resources manage to perform substantially better than Chile in both mathematics and science. This is the case in South Korea, Malaysia, and the Slovak Republic (Mullis, Martin, Gonzalez, et al., 2000). In other cases, United States districts serving high proportions of low-income students do significantly better than Chile, the Miami-Dade County of Public Schools in Florida being a good example (Mullis, Martin, Gonzalez, et al., 2001).

These jurisdictions are like Chile in various ways. Chile, Malaysia, and the Slovak Republic are all upper middle-income economies according to the World Bank classification (World Bank, 1999). South Korea already reached the status of high-income economy; nevertheless, this country is not so far away from Chile in its economic development. While Miami-Dade County is part of United States – the strongest economy in the world – public schools in this county serve a significant proportion of low-income students.

Despite these similarities in economic level, enormous differences exist in the academic performance of the students in these jurisdictions. While Chile obtained an average score of 392 scale-points in the TIMSS 1999 mathematics test, South Korea scored 587, the Slovak Republic 534, Malaysia 519, and Miami-Dade 421. Considering that this test had an international average of 487 and a standard deviation of 100, these differences are substantial.

The school effectiveness literature refers to several factors that may be helpful to understand why some schools attain higher performance levels than others. Some of the most frequently mentioned factors are: a) the broader social and economic context in which the schools operate, b) the curriculum, c) teacher quality, d) school resources, and e) students' attitudes (Reynolds & Teddlie, 2000). These factors may be also helpful in understanding the achievement gap between Chile and the mentioned jurisdictions.

While Chile shares similar economic indicators with South Korea, Malaysia, the Slovak Republic and Miami-Dade County, it differs from them in other important ways. For instance, as of 2003, only half of the adult population has finished secondary school in Chile (Ministerio de Planificación y Cooperación [MIDEPLAN], 2004). It is well known that parents' education is one of the most powerful predictors of students' academic achievement. Therefore, it is reasonable to hypothesize that the poor educational level of the students' parents is limiting the ability of Chilean students to learn in school. It may be the case that other jurisdictions have a more educated adult population, and that these differences explain the achievement gap between Chile and other jurisdictions.

Among jurisdictions with similar global economic indicators, important social differences may still exist as a consequence of the distribution of the wealth. For example, the distribution of wealth is more uneven in Chile than in the Slovak Republic. Consequently, there may be a greater proportion of poor students in the Chilean schools than in the Slovakian ones. These differences in the students' social background may account for their low academic performance. It is also likely that proportionally more students in Chile attend schools in rural areas than do students in either Miami-Dade or South Korea. Such demographic differences may also partially account for the lower achievement levels observed in Chile.

In 1998, a limited mathematics curriculum was the basis for instruction in Chile (Comisión Nacional para la Modernización de la Educación, 1995; Cox, 1999).[1] The national curriculum was more of a framework for the schools to develop their own curricula than a curriculum itself. Consequently, it provided very little guidance for the mathematics teachers to prepare their classes. Moreover, some important content and skills were not part of the curriculum, and others were not emphasized enough. It may be the case that other jurisdictions had a more demanding mathematics curriculum, or a curriculum that provided more guidance to the teachers to prepare their classes. These differences in the official curriculum could be helpful in understanding the achievement gap between Chile and the other jurisdictions.

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[1] The TIMSS 1999 data collection for Chile and the other southern hemisphere countries took place at the end of 1998.

Beyond the curricular intentions, the curriculum delivered in classes is the one that actually shapes the students' opportunities to learn mathematics. There is accumulated evidence that the same official curriculum may result in different implemented curricula (Mullis, Martin, Gonzalez, et al., 2000, chap. 5). The implemented curriculum may vary in content coverage and cognitive skills emphasized in classes. These differences in the implemented curriculum could contribute to the differences in academic achievement between Chile and other jurisdictions.

Because of the meager specifications of the Chilean curriculum, schools with their own curriculum or program of study, materials and activities may have been in a better position to produce quality learning. It may also be the case that the curriculum delivered in the Chilean classes provided fewer opportunities to learn the relevant mathematics content, compared to the curriculum delivered in other jurisdictions. It may also be the case that the Chilean schools offered fewer additional courses to address the needs of students with different knowledge and skills. These differences in the mathematics curriculum as it is implemented in the schools may be negatively affecting the quality of learning in Chile.

In Chile, teachers are perceived as not having the basic knowledge and skills to bring their students to high academic standards. Their low social status may affect their salary, which may affect their motivation to work, which in turn may affect teaching quality and students' learning rates. The poor academic performance of Chilean students may be related to the low qualifications and preparation to teach of their teachers, relative to the teachers in other countries.

The capacity of the schools to provide quality instruction can be affected by their resources. The TIMSS 1999 discusses important differences in school resources, both within and across the countries (Mullis, Martin, Gonzalez, et al., 2000, chap. 7). These differences may account for the achievement differences between Chile and the other jurisdictions.

It could also be hypothesized that Chilean students differ from their peers in other countries in their attitudes toward mathematics. Chilean students may not like mathematics, or they may not appreciate its importance. The students may have a poorer self-concept of their mathematics knowledge and skills. They may also perceive that their mathematics performance depends more on factors out of their control, such as good luck or innate intelligence, and less on their own effort and motivation to do well. It is also possible that Chilean students have lower expectations for further education (e.g., finishing university) than the students in other jurisdictions. These differences in students' attitudes may account for some of the dispersion in average mathematics achievement among the jurisdictions.

While the achievement differences between Chile and other jurisdictions are large, the variations in students' performance within the country also are substantial. According to the TIMSS 1999 report, the top performing Chilean students (i.e., those at national percentile 95) outperformed the bottom performing ones (i.e., those at national percentile 5) by 280 score points (Mullis, Martin, Gonzalez, et al., 2000, p. 354). In Chile, the top performing students were able to apply basic mathematical knowledge in straightforward situations, while students with the lowest scores were not even able to do basic computations with whole numbers.

There is evidence that the Chilean schools differ in important ways, and it is likely that these differences may account for some of the variation in students' performance. First, the schools differ in the broad social context in which they operate. For instance, its is not the same to attend a school in the elite-paid system or a private-subsidized school as it is to attend a public school. Second, there are variations in the way the curriculum is implemented at the school and classroom level, in the provision of differentiated mathematics instruction, in teacher quality, and in school resources.

There is variation in students' achievement within the Chilean classes and schools. The students attending a school may differ widely in their attitudes toward mathematics. Some students may be highly motivated to do well while others may not. Some may believe that doing well in mathematics is a matter of luck, while others may rely more heavily on their own effort to do well. These differences in students' characteristics may be helpful to understand why students who attend the same classes and schools vary widely in their mathematics performance.

Statement of the Problem

This study aims to understand further why Chile has low mathematics achievement levels relative to other jurisdictions with similar economic conditions. It also aims to understand the achievement differences observed among and within the Chilean schools.

This dissertation study used TIMSS 1999 data from Chile, and from four other countries and districts that have similar levels of economic development, or that serve high proportions of low-income students. The comparison jurisdictions were South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools. The first stage of the study consisted of a comparative analysis between Chile and the four jurisdictions. The comparisons focused on five dimensions: a) schools' community contexts, b) curriculum implementation, c) teacher quality, e) school resources, and f) students' attitudes toward mathematics. Univariate and multivariate analyses of variance were the main statistical techniques used at this stage.

The second stage of the study focused on the Chilean data only. Mathematics achievement was modeled using several indicators of the background dimensions above mentioned as predictors. The achievement outcome was modeled at two levels: the school level and the students-within-school level. Hierarchical linear models were the main statistical technique used.

Research Questions

The research questions that guided the analyses were as follows:

Schools' community contexts:

1. Are the schools' community contexts poorer in Chile than in the comparison jurisdictions? Is there a positive relationship between schools' community contexts and mathematics achievement in Chile?

   Two hypotheses guided the analyses: a) the schools' community contexts are poorer in Chile than in the comparison jurisdictions, b) there is a positive relationship between schools' community context and achievement in Chile.

Curriculum implementation:

2. Is the implemented mathematics curriculum poorer in Chile than in the comparison jurisdictions? Is there a positive relationship between the level of implementation of the mathematics curriculum and achievement in Chile?

   Two hypotheses guided the analyses: a) the implemented mathematics curriculum is poorer in Chile than in the comparison jurisdictions, b) there is a positive relationship between the level of implementation of the mathematics curriculum and achievement in Chile.

Teacher quality:

3. Is teacher quality worse in Chile than in the comparison jurisdictions? Is there a positive relationship between teacher quality and mathematics achievement in Chile?

   Two hypotheses guided the analyses: a) teacher quality is worse in Chile than in the comparison jurisdictions, b) there is a positive relationship between teacher quality and mathematics achievement in Chile.

School resources:

4. Are the Chilean schools more poorly equipped than the schools in the comparison jurisdictions? Is there a negative relationship between resource limitations and mathematics achievement in Chile?

   Two hypotheses guided the analyses: a) the Chilean schools are more poorly equipped than the schools in the comparison jurisdictions, b) there is a negative relationship between resources limitations and mathematics achievement in Chile.

Students' attitudes toward mathematics:

5. Are students' attitudes toward mathematics more negative in Chile than in the comparison jurisdictions? Is there a positive relationship between students' attitudes toward mathematics and achievement in Chile?

   Two hypotheses guided the analyses: a) Chilean students' have more negative attitudes toward mathematics than the students in the comparison jurisdictions, and b) there is a positive relationship between students' attitudes and achievement in Chile.

Importance of the Study

The main purpose of this dissertation study is to contribute to the debate in Chile about how to improve education in general, and mathematics education in particular. In Chile, many proposals have been made to improve the quality of education. Unfortunately, many of these proposals are based on solely theoretical or ideological grounds, and have little to no empirical support.

In Chile, studies using nationally representative samples are scarce, and are almost always limited to the data provided by the national assessment system, SIMCE (*Sistema de Medición de Calidad de la Educación*). This dissertation study involves a comprehensive analysis using the data from an international study. TIMSS collected data on mathematics achievement, and on hundreds of contextual variables pertinent to understanding the academic performance of a country.

Apart from the national report published by the Ministry of Education, there are few publications using the TIMSS dataset in Chile. These publications are usually focused on very specific aspects of the school system, or are restricted to descriptive analyses of the data already presented in the TIMSS reports. It is likely that this dissertation study is the first attempt to analyze and understand many of these background variables. Comparative analyses with other countries/systems are scarce in Chile. This dissertation is probably the first using a comparative approach to further shed light on the reasons underlying the poor mathematics performance of Chilean students.

CHAPTER 2

LITERATURE REVIEW

This chapter is divided into three main sections. The first section, the schooling system in Chile, describes the major characteristics of the educational system that is the focus of this dissertation study. The second section, the schooling system in the comparison jurisdictions, describes the main characteristics of the educational systems that were used as comparison cases in this study. The third section, factors related to mathematics achievement, reviews what the specialized literature says about the relationship between some relevant background variables and mathematics achievement.

The Schooling System in Chile

This section opens with an historical overview of Chile, then focuses on the main characteristics of its educational system: enrollment, school cycles, school governance and finances. The antecedents and main characteristics of the reform efforts of the last decades are provided. The official mathematics curriculum for the 8th grade is described. Since this dissertation used data collected in Chile in 1998, the descriptions offered here aim to portray the state of the Chilean educational system at that time, even though some reforms have since been introduced. This section ends with an overview of the main findings provided by different international studies in which Chile has participated.

Chile is a long and narrow country that lies in the western coast of the South American Cone. Native tribes of gatherers, hunters, and fishers were scattered in its territory when the Spanish conquerors arrived in the 16th century. Centuries of racial mixture with Spanish and other European immigrants have produced a population highly homogeneous in its ethnic background and language (Spanish).

Chile gained its independence from Spain in 1810. It had a long tradition of democratically elected governments, which was broken with Pinochet's coup in 1973. A right wing dictatorship was in power until 1990. A new democratically elected president took office that year, and a center-left coalition has been in the government since. During the last two decades, Chile has witnessed sustained economic growth; this is an upper middle-income economy according to the World Bank classification. At the end of the 1990s, Chile had a population of almost 15 million, 84% of which were urban (World Bank, 1999).

The Chilean educational system expanded substantially during the last decades. Enrollment in preschool education reached 21% in 1990, and rose to 30% in 1998 (MIDEPLAN, 2004). Enrollment in primary schools reached 93% in 1970, 95% in 1982, and 98% in 1992. Enrollment in secondary schools reached 50% in 1970, 65% in 1982, and 80% in 1992 (González, 1999, p. 323). The average number of school years of the economically active population doubled in 20 years, passing from 4.3 years in 1970 to 8.6 years in 1990 (Rodríguez, 1995). As of 2003, half of the adult population had finished secondary school (MIDEPLAN, 2004). Literacy rates increased from 70% in 1940, to 90% in1970, and 95% in 1990 (Rodríguez, 1995).

School cycles and enrollment. In 1998, the Chilean schooling system served a population of slightly more than three million students, in approximately 10,000 schools (Ministerio de Educación [MINEDUC], 2002a). The school cycle is divided into three levels: preschool, primary (grades 1-8) and secondary education (grades 9-12[2]). Secondary education has two tracks: academic and professional-technical. Primary education has been compulsory since 1920; secondary education has been so since 2004.

The majority of Chilean schools (56%) are located in an urban setting; these schools serve almost 90% of the student population. Rural schools are isolated and small; many of them have multi-grade classes, and are managed by three or few teachers. Rural areas frequently have higher levels of poverty, making it more difficult for rural schools to reach the desired educational goals.

Governance and finances. Chile has a centralized educational system, with the majority of policy-related decisions made by the Ministry of Education. The Ministry of Education is the main authority regarding policies, curriculum, and selection of textbooks. It also negotiates the minimum salaries to be earned by school teachers throughout the country with the teachers' union. The Ministry operates through a network of provincial and local (municipal) offices of education (*Departamentos Provinciales de*

[2] Grades 9-12 correspond to "I-IV año de enseñanza media" in Chile.

Educación and *Dirección de Administración de Educación Municipal*), the latter being in more direct contact with the schools.

A market-oriented philosophy underlay the financing and administration of the Chilean schools. In 1981, the military regime implemented a *subsidized system*, with the state paying a fixed amount of money to the schools (indirect vouchers) on the basis of enrollment. The main objective of this policy was to increase the efficiency of the system; that is, to produce the same school quality at lower costs. To what extent this goal was met is not clear due to the lack of good measures of school quality.[3]

During the 1980s, the number of private schools operating in the country grew consistently, and the proportion of students enrolled in the private system increased from around 10% to 40%. Most of these students (around 30%) enrolled in the new *private-subsidized* schools, which receive the same funding as public (municipal) schools, but have a private administration. During the 1990s, private-subsidized schools were allowed to charge fees to the parents; the schools that do so form the *private-subsidized co-financing* system. Public schools are funded by the state only. "By law and in practice, municipal education must guarantee compliance with free, compulsory education as established by the national constitution" (OECD, 2004, p. 68). A third group of schools is the *elite-paid* system. Elite-paid schools have historically served the elite 10% of the population, charge fees well above the voucher value, and do not receive public funding.

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[3] The Chilean national assessment system, SIMCE, was created in 1988 and it only provided relative measures of academic achievement (norm-referenced tests) until the late 1990s.

Currently the educational system is highly segregated by social class: public schools serve the bottom half of the socio-economic distribution, the elite-paid system the top percentages, and the private-subsidized system the rest. Not surprisingly, public schools have consistently attained the poorest results in the national assessment system, followed by the private-subsidized schools. The best performing schools have been, by far, the elite-paid. There has been concern about the negative consequences of the subsidized system. Mella (2003) argued that it has increased the achievement gap between public and private schools, while exacerbating the social class differences among students from different schools.

The privatizations do not seem to have produced higher academic achievement in the schools. There is evidence that public and private schools serving students with the same socio-economic backgrounds attain similar academic performance (McEwan & Carnoy, 2000; Mizala & Romaguera, 2000; Ramírez, 2003).

Regarding school finances, as of 1998, the voucher varied around US$40 per month per student, depending upon factors such as school cycle (i.e., primary, secondary) and context (i.e., rurality, poverty) (González, 1999). Public annual expenditures per student reached US$1,767 in lower secondary (grades 7-8) (OECD/UIS, 2003).

The percentage of the gross national product (GNP) that a country invests in education is an indicator of the country's effort to provide quality instruction. In Chile, public expenditures in education have shown a positive trend during the 1990s, moving from a tiny 2.7% of the GNP in 1991 to a more reasonable 3.6% in 1997 (UNESCO, 1999, p. II 500). Nevertheless, Chile still had the lowest share of its gross national product invested in education when compared to the four jurisdictions. Table 2.1 presents a selection of social and economic indicators for Chile and the comparison jurisdictions.

Data from the national assessment system (SIMCE) showed that, in the year 2000, the mathematics performance of 8th grade students was very similar across the territory. All 13 regions but one had an average performance within one-tenth of a standard deviation from the national average (i.e., 250 ± 5 score points). The region with the highest poverty indices and with the highest proportion of indigenous population in the country (*IX Región*) had the lowest average performance, $M = 237$ (MINEDUC, n.d.-b, p. 22). Boys performed better than girls in the TIMSS 1999 mathematics test, but the difference was not significant (Mullis, Martin, Gonzalez, et al., 2000, chap. 1).

The Chilean schools vary widely in their academic performance and in the social composition of the student body. This is in part the consequence of the economic segregation existing in the school system. Within the same schools, however, students are homogeneous in their social background. Despite sharing the same social class, classmates have very different levels of mathematics knowledge and skills. “While some children are ready to advance in their program of study, others are still trying to grasp the already-taught subject matters” (Ramírez, 2003, p. 20). This evidence suggests that social background conditions the students’ academic performance, but it is far from determining it.

Table 2.1

Selected Social and Educational Indicators for Chile and the Comparison Jurisdictions

Jurisdiction	GNP per capita[1]	GNP PPP per capita[2]	Gini Index[3]	Human development index[4]	Public Expenditure on education as % of GNP[5]	Yearly expenditures per student[6]	Gross enrolment ratio in primary education[7]	Net enrolment ratio in primary education[8]	Adult literacy rate[9]
Chile	4,820	12,240	57.1	0.835	3.6%	1,767	103%	88%	95.7
South Korea	10,550	13,430	31.6	0.878	3.7%	3,208	98%	97%	95.9
Malaysia	4,530	7,730	49.2	0.789	4.9%	1,813	100%	99%	88.7
Slovak Republic	3,680	7,860	25.8	0.842	5.0%	1,811	103%	89%	99.7
Miami-Dade	–	–	–	–	–	6,613	–	–	–
United States	29,080	29,080	40.8	0.935	5.4%	–	100%	94%	–

[1] GNP per capita = Gross National Product per capita, in US dollars. Source: World Bank (1999) World development indicators, p. 12-14.
[2] GNP PPP per capita = Gross National Product Purchasing Power Parity per capita. An international dollar has the same purchasing power over the GNP as a U.S. dollar in the United States. Source: World Bank (1999) World development indicators, p. 12-14.
[3] Gini Index: Measures the extent to which the distribution of income (or consumption) among individuals or households within a country deviates from a perfectly equal distribution. A value of 0 represents perfect equality, a value of 100 perfect inequality. Source: United Nations Development Program.
[4] Human development index. A composite index based on a long and healthy life, knowledge and a decent standard of living. All data from year 2000 with the exception of the Slovak Republic, where data from 2002 is reported. Source: United Nations Development Program.
[5] Source: UNESCO Statistical Yearbook (1999), p. II (500-511).
[6] OECD/UNESCO UIS WEI, 2003. Data for Miami-Dade County Public Schools was estimated by the author based on *Statistical Abstract 2002-03* (Miami-Dade County Public Schools, 2003, p. 34).
[7] Gross Enrolment ratio = Number of pupils enrolled in the given level of education, regardless of age, expressed as a percentage of the population in the relevant official age-group. Primary education = ISCED 1. Source: UNESCO Institute for Statistics.
[8] Net Enrolment ratio = Number of pupils in the official age-group for a given level of education enrolled in that level expressed as a percentage of the total population in that age-group. Primary education = ISCED 1. Source: UNESCO Institute for Statistics.
[9] Adult literacy rate. 2002 census data for Chile, Malaysia, and the Slovak Republic; data for South Korea was estimated. Source: United Nations Development Program.
– Data not available.

Educational Reforms During the 1990s

In Chile, the return of democracy in 1990 brought with it a greater appreciation of the role education could play in both the life of Chileans and the development of the country. Universal enrollment was accomplished for the most part in primary education, and the vast majority of the population was finishing secondary school. However, the school system was perceived as ineffective, inefficient, inequitable, and unable to meet the requirements of a society that was looking forward to overcoming poverty and join a globalized economy.

The newly elected president appointed a special commission to produce a comprehensive report of the state of education. This report, known as the *Informe Brunner* – after its primary author – provided a diagnosis of the educational situation, identified goals for the sector, and suggested strategies to reach them (Comisión Nacional para la Modernización de la Educación, 1995). An appalling picture of the condition of education was depicted; some alarming defects included:

- Students with poor knowledge and skills in language arts (Spanish), mathematics, and science
- Lack of specificity of the curricular frameworks and programs of study: objectives were ambiguous and performance standards nonexistent
- Poor pedagogical skills of the teachers; overemphasis of lecturing and lack of active work by students
- Poor school facilities

- Inefficiencies in the administration of the system
- Low teachers' salaries
- Low investment in education

The Informe Brunner laid out the foundations of a systemic intervention that would take priority in the political agenda of the 1990s. Over time, this intervention came to be known as the *Chilean educational reform*. Its goals were quality and equity in education. Quality was pursued by striving for high standards of academic performance; equity was pursued by providing the technical and material conditions for everyone to reach those standards. The intervention focused on the schools that received funds from the state (public or private-subsidized). Priority was given to the poorest schools in receiving technical and material support (García-Huidobro, 1994). The main areas of intervention of this reform were (García-Huidobro, 1999, 2000; MINEDUC, 1998a):

- New up-to-date curricula for grades 1-12
- Increased instructional time
- Decentralization of pedagogical decisions
- Introduction of information communication technology in all the schools
- New teacher training programs (pre- and in-service)
- Increase in teachers' salaries
- Allocation of more resources for the education sector

The launching of the reform agenda was welcomed enthusiastically from the different social sectors. However, the new curriculum was criticized. In Chile, there has been a constant tension between two opposing visions. On the one side, the Ministry of Education has been attempting to provide a general framework of learning objectives and content to be taught, together with documents aimed to provide a scaffolding to reach the curricular objectives (e.g., programs of study, pedagogical guides, performance standards). On the other side, there are those who advocate for the schools' right to *choose* and produce their own curriculum and programs of study (see Alliende, 2000).

A decade after the launching of this major education intervention, important progress has been made. Between 1990 and 1999, public spending on education increased 2.5 times (MINEDUC, 2000a). All the secondary schools and more than half of the primary schools were supplied with computer labs connected to the Internet (Hepp, 1999). By 1998, around 50% of the subsidized schools (both public and private) were able to increase the number of instructional hours. By 2002, new curricula had been introduced in all grades and content areas (Cox, 1999).

Yet despite the reforms, there is no evidence that students are learning more. Comparable data from the national assessment of SIMCE 1999 and 2002 showed that the 4^{th} graders made no progress in their achievement levels in mathematics, reading, and science (MINEDUC, 2003a). The available data for the 8^{th} grade led to similar conclusions when comparing the assessments from 1997 and 2000 (MINEDUC, 2001).

The assessment results also showed that a considerable gap exist between the goals set by the new curricular frameworks and what the students know and can do. This gap has been clearly identified in all three grades tested by the national assessment – grades 4, 8, and 10 (MINEDUC, 2003a, 2001, 2000b, 2002b). For instance, SIMCE 2000 showed that only 45% of the 8th graders could correctly answer a one-step, straightforward item that required the use of fractions and operations (MINEDUC, 2001, p. 26). Considering that fractions should have been introduced in the 3rd grade (MINEDUC, 1980, 1998b) it is disappointing that five years later more than half of the students were still unable to use them in the simplest of applied contexts.

Two main weaknesses are perceived to threaten reform in Chile. The first relates to the low qualification levels of the teachers. Teachers are perceived as not having the basic knowledge and skills to respond to the demands made by the reform project. There are widespread doubts about their capacity to bring the students to high achievement levels. Likewise, pedagogy is among the university programs that require the lowest scores in the entrance exams.

The second weakness refers to the implementation of the new policies. The feeling is that the new curriculum is not reaching the classrooms. Teachers keep teaching basic mathematics content, put too much emphasis on the memorization of algorithms, and do not stimulate the development of higher order skills. Lecture teaching style dominates instruction, and students have few opportunities for active participation in classes. Some efforts have been made to document the gap existing between the new reformed curriculum and its classroom implementation (MINEDUC, n.d.-a).

The Official Mathematics Curriculum in Chile

Curriculum reform has been at the core of the educational policies in Chile since 1990s. A new curricular framework was published in 1996 and new programs of study for the 8th graders were introduced in 2002.[4] However, in 1998, the year data was collected for this dissertation study, the curriculum in use at the 8th grade was *Planes y Programas de la Educación General Básica* (MINEDUC, 1980). This pre-reform curriculum was introduced during Pinochet's right wing dictatorship, in 1980. It listed the *minimum objectives* to be reached by all the students. The mathematics objectives for the 8th grade were, *de facto*, brought to their minimal expression and were written in just three pages.

During the authoritative regime, a sketchy policy instrument like this was thought "to free" the teachers and schools from the state structures, hence allowing them to make their own decisions regarding interpretation and implementation of the curriculum. These ideas were more clearly expressed in a law passed in 1990, at the very end of the military government. The Constitutional Law of Education (*Ley Orgánica Constitucional de Enseñanza, LOCE*) was largely designed as a tool aimed to prolong the policies initiated

[4] See Cox (1999) and Valverde (2004) for an overview of curricular reforms in Chile.

during the 1980s. The law stated that the Ministry of Education is responsible for providing *frameworks* of fundamental objectives and minimum content.[5]

Based on these frameworks, schools have to develop their *own curriculum* or programs of study. Only the schools that did not do so could adopt the programs of study offered by the Ministry of Education. As of 1998, very few schools had developed their own curriculum, and most of these schools were elite-paid or private-subsidized. Most of the schools (especially the public ones) never had the necessary technical and material resources to do so.

The curricular policies of the 1980s have been the target of important criticism. Espínola, and Gajardo and Andraca (as cited in Cox, 1999) claimed that the increased flexibility and decentralization of the curriculum ended up weakening its implementation. In practice, this policy translated into less instructional time and less content coverage for the schools that worked in impoverished contexts.

The previous paragraphs described the political context and ideology underlying the curricular policy in Chile. In the following paragraphs, the focus turns to the pedagogical dimension of the curriculum and to the specificities of the mathematics curriculum used by the 8th grade students.

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[5] The Constitutional Law of Education (*Ley Orgánica Constitucional de Enseñanza* [LOCE], 1990) defines broad educational goals and minimum skills to be reached by all the students.

The pre-reform curriculum listed the mathematics objectives to be reached by the Chilean students. The structure was simple: one general objective was followed by several specific objectives. For example, the students had to "know and apply the proportionality concept" (general objective), which translated into seven specific objectives, such as "compare two quantities and express them as a ratio," and "recognize a proportion" (MINEDUC, 1980, p. 71).

The Chilean curriculum shared many content areas and skills with the curriculum from other jurisdictions; however, it covered substantially less content and fewer skills. The TIMSS 1999 international report states that only 61% of the content in the TIMSS mathematics test was intended to be taught to Chilean students up through grade 8. This contrasted heavily with the situation in South Korea, Malaysia, and Miami-Dade County Public Schools, where 80% or more of the content was intended to be taught (Mullis, Martin, Gonzalez, et al., 2000, p. 172; Mullis, Martin, Gonzalez, et al., 2001, p. 82).[6]

The mathematics content and skills tested in TIMSS represent what the participating countries considered important to be learned at school up through grade 8. According to the test-curriculum matching analysis performed in TIMSS 1999, the Chilean mathematics curriculum had the lowest overlap with the test: only 58% of the test problems were considered appropriate for the 8th grade students. In contrast, 75% of the problems were considered appropriate by the curriculum in South Korea, 83% by the

[6] Data were not available for the Slovak Republic.

curriculum in Malaysia, and 100% by the curriculum in the Slovak Republic and the United States (Mullis, Martin, Gonzalez, et al., 2000, appendix C). Table 2.2 summarizes some characteristics of the official mathematics curriculum in Chile and the comparison jurisdictions.

Regarding emphasis on approaches and processes, the Chilean curriculum – as well as the curriculum of most of the TIMSS 1999 countries – put a major emphasis on mastering basic skills and on understanding mathematical concepts. However, the Chilean curriculum was among the very few that put little or no emphasis on solving non-routine problems and on assessing student learning (Mullis, Martin, Gonzalez, et al., 2000, p. 163). The official curriculum also failed in promoting the development of important higher order thinking skills. For instance, mathematics reasoning was not part of the curricular intentions (MINEDUC, 1998b). See Table 2.2 for more detailed information on content and processes in the Chilean mathematics curriculum.

The Chilean mathematics curriculum did not address differentiation for students with different abilities or interests, nor did it provide an explicit policy on the use of calculators. The Ministry of Education supported the implementation of the curriculum through mandated textbooks and notes.

Table 2.2

Selected Characteristics of the Official Mathematics Curriculum in Chile and the Comparison Jurisdictions

Jurisdiction	Emphases on approaches and processes[1]: Basic skills	Real-life applications	Solving non-routine problems	Assessing student learning	Percent of TIMSS content appropriate[2]	Percent of TIMSS problems appropriate[3]
Chile	●	○	○	○	61%	58%
South Korea	●	●	◒	◒	80%	75%
Malaysia	●	●	◒	◒	80%	83%
Slovak Republic	–	–	–	–	–	100%
Miami-Dade County Public Schools	●	●	●	●	93%	100%*

[1] Source: TIMSS 1999 International Mathematics Report, chap. 5; and TIMSS 1999 Mathematics Benchmarking Report, chap. 5.

[2] Percent of TIMSS contents included in the official mathematics curricula up to the 8th grade. Source: TIMSS 1999 International Mathematics Report, chap. 5; and TIMSS 1999 Mathematics Benchmarking Report, chap. 5.

[3] Source: Test Curriculum Matching Analysis, TIMSS 1999 International Mathematics Report, appendix C.

* Data from the United States was imputed to Miami-Dade County Public Schools.

– Data not available.

● Major emphasis ◒ Moderate emphasis ○ Minor/ no emphasis

In Chile, there is a system-wide assessment in mathematics (SIMCE), with one grade (4, 8 or 10) tested each year. School level results are highly publicized and monetary awards are distributed (Mullis, Martin, Gonzalez, et al., 2000, chap. 5).

Promotion to the next grade was supposed to be a joint decision between the teacher and school. In practice, students are automatically promoted to the next grade in primary education. Grade retention is practiced in extreme cases only – less than 3% of students were retained in grades 1-8 (MINEDUC, 2002a, pp. 172-173). Grade 12 students take an external exam to apply to the university. Riveros (2004) claimed that over 90% the students taking this exam had *good* or *very good* marks in their school records. This situation raised concern about the pervasive grade inflation existing in the country. It also corroborated the low expectations teachers have for their students, especially toward students come from socially deprived areas (Arancibia, 1994).

Chile in the International Arena

During the 1990s, Chile participated in three international studies in education: UNESCO's Latin American Laboratory of Assessment of the Quality of Education, OECD's Programme for International Student Assessment, and IEA's Trends in International Mathematics and Science Study. By participating in these studies, Chile aimed to know the academic performance of the country relative to other participating countries. Chile also aimed to learn from the experiences of other countries, and to learn about the factors that may be affecting the quality of education.

A brief description of UNESCO's and OECD's studies is offered below, together with a summary of their most important findings for Chile. Because IEA's TIMSS is the main data source for this dissertation study, its goals, design and results are reviewed in more detail.

UNESCO's Latin American Laboratory for Assessment of the Quality of Education

In 1997, UNESCO[7] sponsored the Latin American Laboratory for Assessment of the Quality of Education (*Laboratorio Latinoamericano de Evaluación de la Calidad de la Educación,* LLECE), a study of mathematics and reading skills among 3rd and 4th graders in 13 countries of the continent (UNESCO, 2000a, 2000b). In both subjects and grades, Cuba outperformed all of the other countries, obtaining a median score almost two standard deviations above the international median. At the 4th grade, Chile, Argentina, Brazil, Colombia, and Mexico averaged above the international median in mathematics, forming a cluster of countries behind Cuba. Unfortunately, the significance level of the differences among these countries was not reported, thus making it difficult to draw more meaningful conclusions.

In mathematics, Chile had the highest score gain from the 3rd to the 4th grades. Students from private schools outperformed those in public schools, students from small cities did better than those in "mega-cities" (with more than one million inhabitants), and students from rural areas had lower scores than those in urban settings. This evidence

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[7] UNESCO = United Nations Educational, Scientific and Cultural Organization.

suggests that Chile is in comparatively good shape regarding the quality of its educational system when looking at other Latin-American countries.

OECD's Programme for International Student Assessment

The Programme for International Student Assessment (PISA) is an international assessment project sponsored by the Organisation for Economical Co-operation and Development (OECD). Literacy in reading, mathematics, and science are measured in a 3-year cycle; one of the three subjects is emphasized in each assessment. PISA measures how well 15-year-old students can use their skills and knowledge to answer questions based on real-life situations. Fifteen-year-old students are sampled regardless of the grade in which they are enrolled; however, only students enrolled in school had a chance to participate in the study.

While PISA is targeted at OECD members – the richest countries in the world – some low- and middle-income countries administered PISA 2000, in a data collection effort that took place in 2002 (OECD, 2003). Chile participated in this effort with a nationally representative sample of students at the target age. In this sample, 61% of the 15-year-old students came from the 10th grade (MINEDUC, 2004, p. 224).

Among the 41 countries participating in the assessment, Chile's performance was relatively low in reading, mathematics, and science. Its average score was approximately one standard deviation below the OECD average. In both reading and mathematics, Chile ranked 36th; and in science Chile ranked 35th (OECD, 2003). The Chilean results in mathematics indicated that, on average, the students only mastered the most basic knowledge and skills evaluated by PISA. They could complete one step, straightforward problems that required the routine application of an algorithm to get the solution (MINEDUC, 2004, p. 103).

Among developing nations, there is a substantial proportion of the youth population that does not attend secondary school. The higher this proportion, the more the country's mean achievement reflects the knowledge and skills of an elite group of students rather than of the whole population. For this reason, enrollment rates are important to contextualize the results of international comparisons. Among the Latin American countries participating in PISA, Chile had the highest enrollment rates of the 15-year-old population: 87%. While Argentina had three-fourths of its youth enrolled in the schools (76%), this proportion fell dramatically for Brazil and Mexico, where only one out of two youths were attending the schools (53% and 52%, respectively).[8] In reading, mathematics and science, the mean scores of Chile, Argentina and Mexico did not differ significantly. In contrast, Chile obtained significantly higher scores than Peru (in all three subjects) and Brazil (in mathematics and science) (OECD, 2003).

Both South Korea and the United States had enrollment rates similar or higher than Chile (84% and 99% respectively). In mathematics, South Korea outperformed Chile by one and a half standard deviations (163 score points). The average Chilean students demonstrated knowledge and skills similar to the bottom performing students of

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[8] Author estimation based on *Literacy Skills for the World of Tomorrow: Further Results from PISA 2000* (OECD, 2003), p. 251, Table A3.1, columns 1 and 2.

South Korea. The United States outperformed Chile by one standard deviation (109 score points); and the top-performing students in Chile demonstrated knowledge and skills similar to the average students in the United States.[9]

IEA's Trends in International Mathematics and Science Study

Conducted by the International Association for the Evaluation of Educational Achievement (IEA), the Trends in International Mathematics and Science Study (TIMSS)[10] is a large-scale assessment program designed to study the performance of education systems around the globe. Monitoring trends is an important objective of the study, therefore the assessment is being repeated every four years.

TIMSS 1999 collected information about students' achievement in mathematics and science. The sampled students also answered a questionnaire providing background information. For example, the students were asked about their parents' education and resources at home, their attitudes and beliefs toward mathematics, and their school experiences. The mathematics and science teachers of the sampled students provided background information about themselves, the contents covered in classes, and the pedagogical practices implemented while teaching. Principals from the sampled schools were asked about instructional provisions, school characteristics, and the student population served. Data about the intended mathematics curriculum, evaluation, and

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[9] Malaysia and the Slovak Republic did not participate in PISA 2000.

[10] In the 1995 and 1999 evaluations, TIMSS stood for Third International Mathematics and Science Study.

system-level policies in general, were gathered through a curriculum questionnaire to provide a context to interpret achievement results.

Thirty-eight countries participated in the study in TIMSS 1999. The Benchmarking Study was an additional component of TIMSS, whereby 27 jurisdictions in the United States (13 states and 14 school districts or consortia) took part to assess the standing of their students and education system from an international perspective (Mullis, Martin, Gonzalez, et al., 2001, p. 3). The target grade for most of the participating countries and for all the jurisdictions was the 8th grade.

Major Findings for Chile from TIMSS 1999 Mathematics. The Chilean mathematics performance in TIMSS 1999 was very poor. The average mathematics score was 392 score points, which was almost one standard deviation (100 score points) below the international average (M = 487). Chile ranked 35th among the 38 countries participating in the study, only the Philippines, Morocco, and South Africa obtained lower average scores. Compared to the United States benchmarking participants, the Chilean results were the lowest (Mullis, Martin, Gonzalez, et al., 2000; Mullis, Martin, Gonzalez, et al., 2001). The average mathematics scores for the comparison jurisdictions used in this dissertation study were as follows: South Korea M = 587, the Slovak Republic M = 534, Malaysia M = 519, and Miami-Dade County Public Schools M = 421.

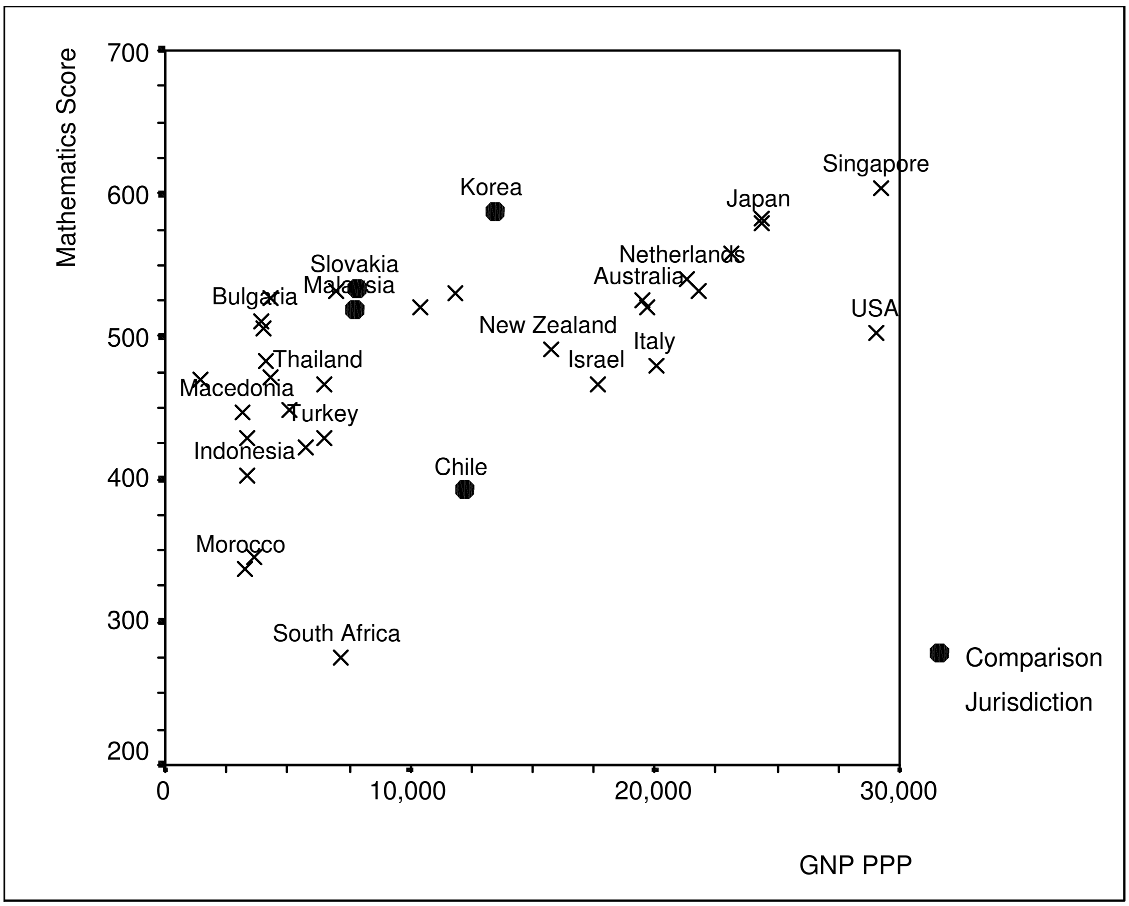
As a national option, Chile also drew a nationally representative sample of 7th grade students and tested them with the same mathematics test used at the 8th grade. Ramírez (2004) reported a significant achievement gain between the two grades (33 score points). This difference was also similar to that observed between Chile and Miami-Dade County Public Schools (392 versus 421 score points). The author estimated that Chilean students were three school years behind the countries performing near the international average in the TIMSS 1999.

The TIMSS 1999 Chilean report (MINEDUC, 2003b) mentions background variables that may account for the lower average performance of the country. For instance, it suggested that Chilean students had fewer resources at home to support their education, that the mathematics curriculum covered fewer content areas than evaluated by the test, that teachers placed too much emphasis on teaching numbers (e.g., whole numbers, decimals), and that teachers did not feel confident teaching mathematics.

Another relevant finding was that the Chilean performance was below expectations given its economic level. As shown in Figure 2.1, there was a positive relationship between mathematics achievement and the wealth of the countries. Nevertheless, countries with similar economic development presented substantial differences in their average achievement. For instance, South Korea scored almost 200 score points higher than Chile, and the Slovak Republic and Malaysia scored more than 100 score points higher than Chile.

TIMSS 1999 showed that Chilean mathematics achievement was low relative to other countries. Moreover, Chile's performance was dramatically low compared to the absolute standards set by the Chilean curriculum. An alarming finding was that only half of the students showed evidence of mastering basic computations (addition, subtraction, rounding) with whole numbers. According to the Chilean curriculum, most of these skills should be mastered in the first cycle of basic education (grades 1-4). Only 15% of the students could apply mathematical concepts in straightforward situations. The low performance of Chilean students was pervasive across the five mathematics content areas evaluated by the test.

Figure 2.1
Mathematics Achievement by the Wealth of the Countries



Note. The figure shows the 38 countries participating in TIMSS 1999. Data for Miami-Dade County Public School was not displayed. Source: TIMSS 1999 dataset.
GNP PPP = Gross national product purchasing power parity as for 1999.

The Schooling System in the Comparison Jurisdictions

This section provides important context information to better understand the schooling systems in South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools. For each jurisdiction, information about enrollment and school cycles, governance and financing, as well as on the official mathematics curriculum is provided.

South Korea

Located on the eastern coast of the Asian continent, Korea has a history of Buddhist and Confucian dynasties. The Chosun dynasty ruled the country beginning in 1392, and the Korean alphabet was introduced during this reign. After five thousand years as a sovereign country, Korea became a Japanese colony in 1905. Independence came with the end of World War II, and with it the dramatic split of the country into North and South Korea (Gwang-Chol Chang, 1995; Se-ho Shin, 1995).

The Korean educational system has a long tradition of formal education. Se-ho Shin (1995) related the following:

> The teaching of Confucianism was dominant in traditional schools before the advent of modern style schools in the late nineteenth century. During the Koryo dynasty and the Chosun period, higher civil officials were selected through a state civil examination system which tested their proficiency in Chinese classics. The

system made the learning of Confucian classics an educational tradition of the elite class. (p. 515)

Western scholars have argued that Confucianism is at the core of the educational success of Asian countries (Paik, 2001; Stevenson & Stigler, 1992). In fact, Confucius (551-479 BC) was mainly a teacher, hence teachers are one of the most respected authorities in these countries. [11] Confucianism promulgates the importance of continuous learning as a way of self-development, which in turn is necessary for social harmony. Children are taught that persistence, effort and hard work are necessary to succeed both in school and in life ("Confucius and Confucianism," 1993).

Despite this tradition of learning, at the time of independence in 1945, only one-fourth of the adult population was literate, and less than 40% of the school-age children attended school (Gwang-Chol Chang, 1995). The history of the two Koreas has followed divergent paths since then. The following paragraphs focus on South Korea only – the comparison jurisdiction used in this dissertation study.

South Korea is a highly homogeneous country both ethnically and linguistically. It has its own unique language (Korean) (Se-ho Shin, 1995, p. 515). At the turn of the millennium, the total population reached 46 million (World Bank, 1999). During the twentieth century, South Korea transformed itself from a feudal society into a highly industrialized nation. By the end of the 1990s, over 83% of its population was urban.

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[11] Korea and other Asian countries celebrates "Teacher's day," which is a sort of Confucius day (Chung Park, Koran Institute of Curriculum and Evaluation [KICE], personal communication, October 26, 2004).

According to the World Bank classification, South Korea is high-income economy (World Bank, 1999). It is, in fact, the wealthiest of the five jurisdictions used for comparison in this dissertation study.

South Korea accomplished lofty educational goals in the decades following its independence. Enrollment in primary school was universal for school age children by 1960. In 1991, the enrollment rate was 100% for primary school, 95% for middle school, 88% for high school, and 38% for higher education (Se-ho Shin, 1995). The present day population is highly educated. One out of four students have a parent who graduated from a university (Mullis, Martin, Gonzalez, et al., 2000, p. 254). The adult literacy rate is 96% and 89% of students attend preschool (World Bank, 1999).

The Schooling System in South Korea

School cycles and enrollment. At the time of the TIMSS 1999 data collection, the Korean educational system served a population of around 9 million of students in approximately 10,000 schools. The school cycle was divided into preschool, primary school (grades 1-6), middle school (grades 7-9), and high school (grades 10-12). High schools were divided into academic and vocational tracks. At the end of the 9th grade, Korean students have to take examinations to enter high school. Usually, students with higher scores follow the academic track and those with lower scores follow the vocational one (Chung Park, Korean Institute of Curriculum and Evaluation [KICE], personal communication, October 12, 2004). In the 12th grade, students take another round of examinations to enter higher education. There is fierce competition for entry into the more prestigious institutions.

In South Korea, education is highly valued as a means of social mobility (Se-ho Shin, 1995). Parents have a strong commitment to their children's education and make huge efforts to support them during the school years. Tutoring and private lessons are widely spread practices that help children prepare for the external exams. Wolf (2002) reported that up to 50% of the middle school students attended tutoring after their regular school hours. Many Korean families are said to spend up to half of their income on private teachers!

Governance and finances. South Korea has a centralized education system, in which the Ministry of Education is responsible for formulating policies, directing subordinate agencies in planning and policy implementation, as well as publishing and approving textbooks. In 1999, yearly expenditures per student reached US$3,208 in middle schools (grades 7-9) (OECD/UIS WEI, 2003). Expenditures in education reached 3.7% of the gross national product (GNP) (UNESCO, 1999, p. II 503). See Table 2.1 on page 17 for detailed information.

The Korean system is highly privatized, with 28% of the students attending private middle schools, and 62% attending private high schools (Se-ho Shin, 1995; Kim, 1997). The Ministry of Education governs both the public and the private system. This situation ensures that the same rules of the game apply to both types of schools. For instance, both type of schools receive public funding, charge a fee to the parents, and use a lottery system to select their students. The only difference is that public schools are administered by the government structures, while private schools are usually under the administration of religious congregations (Park & Park, in press; Chung Park, KICE, personal communication, October 26, 2004).[12]

The Official Mathematics Curriculum in South Korea

The Korean national curriculum is revised periodically – its 6th version was introduced in 1995. In some 170 pages, this document detailed the contents to be taught to the 8th graders and provided examples of the kind of problems students must solve to demonstrate mastery (Ministry of Education South Korea, 1994). The curriculum emphasized the mastering of basic skills, as well as the application of mathematics to real-life problems.

The Korean curriculum covered 80% of the content included in the TIMSS 1999 test, and 75% of the problems in the test were considered appropriate for the 8th grade students (Mullis, Martin, Gonzalez, et al., 2000, chap. 5). The school curriculum was uniform in all of the schools, and principals were responsible for monitoring its implementation at the classroom level (Se-ho Shin, 1995). See Table 2.2 (on page 25) for a comparison of the Korean curriculum with the curriculum of the other jurisdictions examined in this dissertation study.

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[12] These and other regulations governing all publicly funded schools are part of the "Equalization Policy" introduced in 1974 with the aim to reduce the achievement gap among the Korean schools (Park & Park, in press).

In South Korea, the same curriculum was used for all students, but teachers were required to adapt it to accommodate students with different abilities or interests. The curriculum recommended the restricted use of calculators. The implementation of the curriculum was supported through pre-service and in-service teacher education, textbooks, instructional or pedagogical guides, ministry notes or directives, and a system of school inspection or audit. A system-wide assessment in mathematics was in place at grades 4-8, 10 and 11 (Mullis, Martin, Gonzalez, et al., 2000, chap 5). Within each level of school education, the promotion of students from grade to grade was generally automatic (Kim, 1997).

Malaysia

Malaysia has a strategic location in Southeast Asia, which has favored its development as a trade center. Small city-states scattered along the coast flourished since the 11th century, and gradually fell under the dominance of the city-state of Malacca during the 15th century. At that time, Malacca was already known in Europe as a strategic port for the spice trade. Malacca fell under Portuguese dominance in the 16th century. The peninsula was a Portuguese, Dutch, and British colony before getting its independence from Britain in 1957 ("Malaysia," 1993).

The British colonial rule transformed the country socially and economically. Transportation networks and industries prospered. Thousands of Chinese and Indians migrated to work in mining, manufacturing, and rubber estates. A diverse society was thus created. Nowadays Malaysia is a multiracial, multicultural, multireligious, and multilingual country. The main ethnic groups are Malays (some 60% of the population), Chinese (30%), and Indians (10%) (Aziz & Maimunah, 1995; “Malaysia,” 1993).

At the end of the 1990s, the Malaysian population approached 22 million (World Bank, 1999). Malaysia is very rural; however, the urban population has been increasing rapidly: while 42% of the population was urban in 1980, this percentage increased to 55% in 1997. Slightly more than half of the urban population is Chinese. Confucianism is the dominant philosophy/moral in the Chinese communities (Aziz & Maimunah, 1995; “Malaysia,” 1993; World Bank, 1999).

Currently, Malaysia is a federal constitutional monarchy with a nonpolitical head of state, who is elected from among nine state hereditary rulers (“Malaysia,” 1993). This country has witnessed a strong economic boom during the last decades. The World Bank classifies Malaysia as having an upper-middle income economy, which is one of the strongest in Southeast Asia (World Bank, 1999).

Being an extremely diverse country, the creation of a national identity has been one of the primary challenges of the educational system (Aziz & Maimunah, 1995; “Malaysia,” 1993). This is a difficult task because it has proven to be elusive (“Forging a Nation,” 2004):

> Children of different backgrounds do not even mix in schools, thanks to the Chinese and Indian communities’ insistence that children should study in their native language. About 90% of Chinese children attend state-financed Mandarin-

medium schools, while some 70% of young Indians are taught in Tamil. That leaves very few non-Malays studying in the mainstream public schools, where Malay is the main language of instruction.… So from an early age, Malaysians become accustomed to racial segregation. (p. 44)

The Schooling System in Malaysia

Enrollment and school cycles. In 1998, the Malaysian school system served a population of four million students. The school cycle is divided into preschool, primary (grades 1-6), lower secondary (grades 7-9), and upper secondary (grades 10-11). The majority of the population (68%) attends preschool. There has been universal coverage in primary schools since 1988. Coverage in lower secondary schools approaches 90% (Aziz & Maimunah, 1995).

Governance and Finances. The Ministry of Education is the main authority at the federal level, responsible for formulating plans, programs, and projects. At the state level, the state education departments are responsible for the implementation of the federal mandates (Aziz & Maimunah, 1995).

As for 1997, Malaysia expended 4.9% of its gross national product (GNP) in its educational system. While this percentage was not particularly high compared to the other jurisdictions, it is notable that for almost 20 years (from 1975 to 1994) education received over 5% of the GNP, with a peak of 6.6% of the GNP in 1985 (UNESCO, 1999, p. II 504). As shown in Table 2.1 (on page 17), yearly expenditures per student reached US$1,813 in secondary schools (grades 7-11) (OECD/UIS WEI, 2003).

The Official Mathematics Curriculum in Malaysia

The National Curriculum in Malaysia was introduced in 1990. A 60-page document contained the mathematics specifications for the 8th grade. These were divided into 13 learning areas, such as "directed numbers," "square roots, cubes and cube roots," "algebraic expressions II," "circles," and "statistics." Some four pages were devoted to the treatment of each area; the following points were outlined (Ministry of Education Malaysia, 2003):

- Learning objectives, defining what should be taught in mathematical terms (e.g., understand and use the concept of coordinates)
- Suggested teaching and learning activities.
- Learning outcomes, defining what the student should be able to do (e.g., identify the x-axis, y-axis and the origin on a Cartesian plane).
- Points to note and vocabulary

The Malaysian curriculum places major emphasis on the mastering of basic skills, as well as on daily applications of mathematical concepts. The curriculum emphasized problem solving, communication, reasoning, making connections, and application of technology. The importance of affective objectives such as "good moral values" and "patriotism," the development of positive attitudes towards mathematics, and the appreciation of the "importance and the beauty of mathematics" were also strengthened (p. 1-9).

The Malaysian curriculum covered 80% of the content included in the TIMSS 1999 mathematics test, and 83% of its problems were considered appropriate for the 8th grade students (see Table 2.2 on page 25). The same curriculum was used for all students, but teachers were required to adapt it to accommodate students with different abilities and/or interests. Calculators were described as learning aids, however, the curriculum did not contain any recommendations about their use.

The implementation of the curriculum is supported through pre-service and in-service teacher education, textbooks, pedagogical guides, Ministry of Education notes or directives, a system of school inspection or audit. Malaysia has a system of external examinations which is also aimed to support the implementation of the curriculum (H. Yusof and A. Zakaria, Ministry of Education Malaysia, personal communication, November 2, 2004). There is a system of external examinations to decide entry to course tracks (grade 9); certification and end of secondary education (grade 11), and certification of pre-university and entry to university (grade 13). In all publicly funded schools, students are automatically promoted up to grade 9 (Aziz & Maimunah, 1995; Mullis, Martin, Gonzalez, et al., 2000, chap. 5).

Slovak Republic

Only recently established in 1993, the Slovak Republic is a very new country with a long history. The fall of the Soviet block came with the division of Czechoslovakia, and with the adoption of a market economy. The 1990s was a period of profound economic and social transformations. Liberalization of the economy came with pervasive inflation and unemployment. Despite these economic troubles, and thanks to the development of industries and agriculture in the decades following World War II, the people enjoy a high standard of living relative to other Eastern European countries ("Czechoslovakia," 1993; Vantuch, 1995). Nowadays, the Slovak Republic is an upper middle-income economy according to the World Bank classification (World Bank, 1999).

The Slovak Republic is a parliamentary democracy with a one-chamber parliament and a president elected by the parliament. At the end of the 1990s, the total population was 5.4 million (World Bank, 1999). The largest city, Bratislava, has less than half a million inhabitants. For an industrialized country, there is not a particularly high level of urbanization. Many Slovakians live scattered in rural farmlands or in villages in the mountains. In 1997, only 60% of the Slovak population was urban ("Czechoslovakia," 1993; Vantuch, 1995; World Bank, 1999).

Similar to other nations that were part of the socialist block, the Slovak Republic has a strong educational tradition. Universal enrollment in primary education was reached during the 1960s, and enrollment in secondary education reached 94% in 1996 (Vantuch, 1995; World Bank, 1999). The population is highly educated: one out of five students has a parent who graduated from university (Mullis, Martin, Gonzalez, et al., 2000, p. 254). State preschools are available for children three to six year olds, and 76% of the population attends preschool (World Bank, 1999).

Slovak parents are very concerned about their children's education, and they make every effort to ensure quality instruction. Wolf (2002) reported the widespread use of tutoring and private lessons in the country: more than three-fourths of the 8^{th} graders were enrolled in some kind of extra-school-instruction in mathematics!

At the time of the TIMSS 1999 data collection, the morale of Slovak teachers seemed to be very low. During the 1990s, teacher salaries devaluated nine times in real terms (Vantuch, 1995). Only 12% of the students were taught by teachers who thought that society appreciated their work (TIMSS 1999 international database).[13]

The Schooling System in the Slovak Republic

Enrollment and school cycles. At the time of TIMSS 1999 data collection, the school system served a population of almost one million students. The school cycle is divided into preschool, primary education (grades 1-9), and secondary education (grades 10-13). Enrollment is almost universal, with 98% of the students entering secondary education. Secondary schools are divided in gymnasia (academic track), vocational and apprentice. Only 3% of the schools are private (Lukačková, 2002; Matúsová, Berová, & Tothova, 1997).

[13] The percentage of students taught by teachers who felt that society appreciated their work was as follow for the other countries included in this dissertation study: Chile 46%, South Korea 54%, and Malaysia 86%. Data for Miami-Dade County Public Schools were not available (TIMSS 1999 international database).

Governance and finances. In the Slovak Republic, the Ministry of Education was responsible for educational policy and its implementation, legislation and financing. In 1996, school governance was shifted to local state administration. Departments of education at the district level are responsible for primary schools (Lukačková, 2002). In 1999, yearly expenditures per student reached US$1,811 in the lower secondary schools (grades 5-8) (OECD/UIS WEI, 2003). The Slovak Republic makes a relatively strong effort to educate its people: 5% of its gross national product (GNP) goes to the educational budget (UNESCO, 1999, p. II-511). As can be seen in Table 2.1 (on page 17), this was the highest percentage when compared to the other jurisdictions included in this dissertation study.

The Official Mathematics Curriculum in the Slovak Republic

In the Slovak Republic, the official mathematics curriculum specifies the contents and performance standards to be reached by students in grades 1-9 (Balint, 2001). The performance standards for mathematics are divided into four areas: arithmetic, algebra, geometry, and data/statistics. For each area and grade level, the curriculum specifies the content and skills students are expected to master, and provides examples of the type of problems students must be able to solve. The percentage of students that must show proficiency is indicated. According to the Slovak curriculum, all the problems in the TIMSS 1999 test were considered appropriate for the 8th grade students (see Table 2.2 on page 25).

The Slovak mathematics curriculum was used for all students, but teachers were required to adapt it to accommodate students with different abilities or interests. The implementation of the curriculum was supported through pre-service and in-service teacher education, textbooks, ministry notes or directives, and a system of school inspection or audit. At the end of each school year students were evaluated in different content areas and skills. The Ministry of Education set up the criteria for assessing student performance. At grade 8, students took an exam to determine acceptance to secondary school; at grade 12 another exam (*maturita*) was taken for certification purposes and entry to university. The Slovak Republic did not have system-wide assessments in mathematics (Matúsová, Berová, & Tothova, 1997; Mullis, Martin, Gonzalez, et al., 2000, chap. 5; Vantuch, 1995). Students were automatically promoted from grades 1 through 9 (J. Kuraj, Ministry of Education Slovak Republic, personal communication, October 25, 2004).

Miami-Dade County Public Schools

The Miami-Dade County Public Schools comprise a district serving a low middle to low socio-economic area of Florida, the most southeastern state in the United States. Miami-Dade includes the southern half of the city of Miami – including downtown and the keys. The county has an estimated population of two million (Miami-Dade County Public Schools, 2004; U.S. Census Bureau, 2000).

Miami is one of the fastest-growing metropolitan areas in the United States. Half of its inhabitants are foreign-born (U.S. Census Bureau, 2000). Immigration from Cuba and, more recently, from other Caribbean and Latin American countries, have given the city a Hispanic identity. Many students enter the school system after migrating from their country of origin (M. Casares, personal communication, October 10, 2004).

The Miami-Dade County Public Schools make up the fourth largest school district in the United States, with over 360,000 students enrolled in 325 schools. Public schools do not have a good reputation in the city of Miami. In more affluent communities, many parents prefer to enroll their children in private, fee-paying schools (M. Casares, personal communication, October 10, 2004). This fact is important in order to understand the social composition of public schools. In 1999, the percentage of students receiving free or reduced-price meals reached 56%, whereas the percentage classified as limited English proficient was 17%. The student population was 56% Hispanic, 31% African American, 11% White, and 2% Asian and Native American (Thornton & Wongbundhit, 2002).

In the 1994/95 school year, Miami-Dade County Public Schools launched a systemic reform intervention aimed to improve the quality of education. A new competency-based curriculum was implemented, low-track courses were eliminated, an algebra course was required for graduation, and professional development was offered at school sites. Thornton and Wongbundhit (2002) reported significant gains in students' achievement as a result of this comprehensive intervention.

The Schooling System in Miami-Dade County Public Schools

In the United States, education is a state and district responsibility. The district school board has direct jurisdiction over the schools and is responsible for matters related to preschool through secondary curriculum and instruction, educational planning and assessment, student services, and school operations.

In Miami-Dade County, the school cycle is divided into preschool, primary education (grades 1-5), middle school (grades 6-8), and high school (grades 9-12). In the school year of 1998/99, Miami-Dade Public Schools yearly expenditures per student reached US$6,613 in grades 4-8.[14]

The Official Mathematics Curriculum in Miami-Dade County Public Schools

There is no national curriculum in the United States. The states and districts usually develop their own curriculum. The Florida Sunshine State Standards for grades 6-8 in mathematics were introduced in 1996. These standards were expanded to include grade level expectations for the 8th grade. In some 10 pages, these two documents specified the learning objectives to be reached by the 8th graders in five areas: number sense, concepts and operations; measurement; geometry and spatial sense; algebraic thinking; and data analysis and probability.

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[14] Author estimation based on *Miami-Dade County Public Schools Statistical Abstract 2002-03*, pp. 143-144.

The state also developed the Florida Curriculum Framework PreK-12 Sunshine State Standards and Instructional Practices, which is a guide for teachers to help students achieve the state standards. A hundred pages of this document are devoted to operationalize what it means to reach the standards in each grade. For each standard, it provides several benchmarks and sample performance descriptions showing the type of problems students should be able to solve at each level. The Florida's Comprehensive Assessment Test was aligned with the state curriculum, and was administered at grades 5, 8, and 10. Schools not performing well were provided with technical support (Mullis, Martin, Gonzalez, et al., 2001, chap 5).

Beyond the state level policy instruments, the Miami-Dade County Public Schools developed the *Competency-Based Curriculum*, which was aligned with the state standards. This curriculum put a major emphasis on the mastering of basic skills, as well as on the mastering of more advanced processes, like real-life application of mathematical concepts, and solving non-routine problems. Regarding the fit of the curriculum and the TIMSS 1999 mathematics test, 93% of the contents in the test were covered by the curriculum and all its problems were considered appropriate for the 8th grade students (see Table 2.2 on page 25). The curriculum recommended unrestricted use of calculators. Banks of activities, a website, and a CD-ROM with "best practices" were used to support the curriculum implementation (Mullis, Martin, Gonzalez, et al., 2001, chap 5).

Factors Related to Mathematics Achievement

The purpose of this section is to better understand the factors that may affect academic achievement in general, and mathematics achievement specifically. Studies relating mathematics achievement to five major areas are reviewed. These areas are: a) the socio-economic level of the students' families, b) the mathematics curriculum, c) teacher quality, d) school resources, and e) students' attitudes toward mathematics.

Socio-economic Level of the Students' Families

The socio-economic level of the families has shown to be the strongest predictor of academic achievement. Its pervasive effect has been documented in hundreds of studies, the first and most influential being the Coleman Report (Coleman et al., 1966). Students with more educated parents, from more affluent families, and with more resources at home have systematically higher achievement levels than their peers from more disadvantaged homes.

Using 8th grade data from TIMSS 1995, Beaton and O'Dwyer (2002) studied the relationship between socio-economic status and mathematics achievement. They found systematic differences in the social status effect among the schools. For instance, in the United States, socio-economic status accounted for 75% of the mean achievement differences among the schools; in South Korea it accounted for 40%; and in the Slovak Republic it accounted for 24%. Within the classes, though, socio-economic status was not a strong predictor of the achievement differences among classmates; in fact, this variable only accounted for marginal amounts of outcome variance (less than 6% in South Korea, the Slovak Republic and the United States). The authors concluded that "once the students are assigned to a classroom, having highly educated parents at home or having a computer in the home has little further to do with mathematical accomplishment" (p. 229).

Using TIMSS 1999 data from Chile, Ramírez (in press) reported that socio-economic status accounted for most of the achievement spread among the classes from different schools. Yet within the classes, this variable was not a strong predictor of mathematics achievement. These findings were used as evidence of the social segregation occurring in the Chilean schools. The weak effect of socio-economic level within the classes was interpreted as the consequence of the homogeneous social background of classmates. Students seem to be already sorted in the schools based on the socio-economic level of their families. Since students within schools are homogeneous in their socio-economic level, it is likely that the effect of this variable was obscured when measured within the classes.

In Chile, the educational system is highly stratified by social class: public schools serve the poorer families, private-subsidized schools serve the middle-class, and the elite-paid schools serve the richer families. Not surprisingly, the public system has consistently gotten lower scores in standardized achievement tests (MINEDUC, 2001).

In this scenario, it is important to consider the effect of the socio-economic level of the communities served by the schools in order to better understand the achievement differences among the schools. Yet within the Chilean schools, students are homogeneous in their socio-economic background. Hence, this factor cannot account for the large variations in achievement observed within the classes.

In Chile, cultural differences are also reflected in the urban-rural dichotomy. Among schools with similar socio-economic levels, those from urban settings perform better than those from rural areas (Mizala & Romaguera, 2000; Ramírez, 2003). These differences may be a consequence of the schools having more access to technical support and material resources in the city.

Mathematics Curriculum

The curriculum is an important variable in understanding differences in academic performance because it shapes students' opportunities to learn. The curriculum usually states content and skills to be learned, pedagogical approaches, and evaluation practices, as well as other aspects of the learning and instruction process. As shown in previous sections, there was wide variation in the curriculum documents when comparing Chile with the other jurisdictions included in this dissertation study.

In Chile, the national curriculum was in fact a framework that provided very little guidance regarding what to teach and how to teach it. The schools were expected to develop their own curriculum or programs of study based on this framework. Unfortunately, the majority of the schools never had the necessary technical and material resources to do so. Hence, having a school curriculum became an important feature of the Chilean system.

Beyond the official (intended) curriculum, it is the curriculum implemented in classes that more directly shapes students' experiences and opportunities to learn. IEA's studies have developed a conceptual framework to understand the difference between the intended and implemented curriculum in cross-national contexts (see Robitaille, 1993). The discrepancies between the intended and the implemented curriculum arise from the necessary interpretation teachers make of the curricular intentions, and also from the classroom contexts in which they work. For instance, the implemented curriculum may vary depending upon teachers' knowledge of mathematics, the previous knowledge of their students, and/or the availability of instructional resources.

The gap between intended and implemented curriculum is large in Chile. While 8th grade students should be studying geometry and algebra in their mathematics classes, 72% of Chilean students were taught by teachers who emphasized mainly numbers in their classes (e.g., whole numbers, fractions). Among the 38 countries participating in TIMSS 1999, Chile emphasized this content area the most. This emphasis came at the cost of not covering other important content included in the curriculum. For example, while simple algebraic expressions should have been studied beginning in grade 7 according to the Chilean curriculum, only 68% of the students were taught this content by the end of grade 8. In contrast, more than 90% of the students in South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools had an opportunity to learn this content (Mullis, Martin, Gonzalez, et al., 2000, chap. 5; Mullis, Martin, Gonzalez, et al., 2001, chap. 5).

Several studies have shown how opportunities to learn mathematics are related to socio-economic level and to academic achievement (Gau, 1997; Secada 1992; Cueto, Ramírez, León, & Pain, 2003). Students enrolled in schools serving more affluent communities are more likely to be taught greater content in their classes, more likely to have taken algebra courses, and more likely to be taught the content included in achievement tests, when compared to students attending school in less affluent communities. Secada (1992) provided further evidence of how these unequal opportunities to learn were related to race, ethnicity, and social class in the United States. Gau (1997) stated that less affluent students are in a doubly disadvantaged situation. The scarce educational support they get at home is further confounded by the fewer opportunities to learn they have at school.

Because of the way the educational system is structured in Chile, there is serious concern about the unequal distribution of learning opportunities. Private schools (subsidized and elite-paid) satisfy the demands of the upper- and middle-income families. The children of these families benefit from additional educational support at home (e.g., more educated parents), and hence are in a better position to learn at school. On top of that, private schools can charge fees to the parents, thus increasing the school resources and their capacity to provide a quality education. On the contrary, public schools serve the children from the most socially disadvantaged backgrounds. Because public schools are not allowed to charge fees, they usually have less resources and resources of a poorer quality than their private counterparts.

Teacher Quality

It is reasonable to assume that quality teaching requires professionals with formal training in both how to teach (i.e., education) and what to teach (e.g., mathematics). Fennema and Loef (1992) heavily emphasized the importance of content knowledge for effective teaching:

> Since one cannot teach what one does not know, teachers must have in-depth knowledge not only of the specific mathematics they teach, but also of the mathematics that their students are to learn in the future. Only with this intensive knowledge of mathematics can a teacher know how to structure her or his own mathematics teaching so that students continue to learn. (p. 147)

According to the TIMSS 1999, while almost all the Chilean 8^{th} graders were taught by certified teachers, only 78% were taught by teachers having mathematics as their major area of study. This contrasted heavily with the situation in South Korea and the Slovak Republic, where 97% of the students were taught by teachers with a background in mathematics. Despite the high average mathematics achievement of Malaysia in the TIMSS 1999 test, only 72% of its students were taught by teachers with a background in mathematics (Mullis, Martin, Gonzalez, et al., 2000, p. 189). In Miami-Dade County Public Schools, only one-third of the students were taught by teachers who majored in mathematics (TIMSS 1999 Benchmarking database).

Mayer, Mullens, Moore, and Ralph (2000) reviewed studies linking teachers' academics skills (as measured by their entrance examination scores) and their students' scores in achievement tests. They reported that the academic skills of the teachers were positively correlated with their students' achievement scores. This finding should be a concern in Chile considering that pedagogy is among the least selective university programs.

In Chile, teacher training programs have been in crisis for years. They are among the less selective university programs and have a highly bureaucratic profile. The courses use outdated programs of study and lack connection with schools (Ávalos, 1999). Because of these characteristics, the teaching profession does not have a high status. The poor training offered by these programs may explain why Chilean students taught by certified teachers who majored in mathematics attained achievement levels far below expectations in the TIMSS 1999 test.

Beyond teachers' formal studies, another relevant issue for quality teaching is how well prepared the teachers feel to teach different mathematic contents and skills. In this context, preparation to teach is a proxy of teachers' knowledge of mathematics. It is expected that teachers who feel better prepared to teach would have the capability to produce higher achievement levels in their students than teachers who do not feel well prepared. This was in fact the achievement trend for most of the countries in TIMSS 1999.

TIMSS 1999 created an index of "teachers' confidence in preparation to teach mathematics." This index was based on teachers' responses to 12 questions about how well prepared they felt to teach different aspects of mathematics included in the test.

Based on the teachers' index scores, the students were classified in a high, medium, or low index level. In Chile, only 24% of the students were taught by teachers who felt very well prepared (high index level), compared to 87% in the Slovak Republic, 86% in Miami-Dade County Public Schools, 75% in Malaysia, and 48% in South Korea. Chilean students taught by teachers who felt very well prepared attained substantially higher achievement scores than students taught by teachers who did not feel as well prepared (Mullis, Martin, Gonzalez, et al., 2000, p. 192; Mullis, Martin, Gonzalez, et al., 2001, p. 206).

Provasnik and Young (2003) raised the question of whether the most qualified teachers in the United States tended to move to schools with better performing students, leaving disadvantaged students with the worst teachers. To test this hypothesis, the authors studied the relationship between teacher quality and student background characteristics. Indicators of teacher quality were teacher education and self-confidence in teaching specific mathematical skills/competencies, among others. Student background characteristics included parents' education and free/reduced-price lunch eligibility, among others. The authors reported that quality teachers were more likely to be found in desirable teaching jobs: in schools that offer higher salaries, that are well resourced, that do not have large number of students with special learning requirements, and that are not in remote areas.

While these findings are hardly surprising, they have at least two major implications. First, they raise the question of equity in the distribution of opportunities to learn. The more disadvantaged students are taught by the least qualified teachers, hence perpetuating a vicious cycle of poverty: the poorer the students are, the less likely they are to have a highly skilled teacher, and the less likely they are to get the skills that will allow them to overcome poverty. Second, these findings pose a technical problem for the study of teacher effect on academic achievement. Because teacher qualifications and students' background variables are correlated, teacher effect is confounded with other background variables.

School Resources

The capacity of schools to provide quality instruction can be affected by their resources. The TIMSS 1999 report showed that there were important differences in school resources, both across and within the countries; and that these resources were correlated with mathematics performance. An "index of availability of school resources for mathematics instruction" was computed based on schools' average responses to questions about shortages that affect mathematics instruction. Resources were classified into two categories: shortages that affect general capacity to provide instruction (e.g., school buildings and grounds), and shortages that affect mathematics instruction (e.g., calculators, computers). High index levels indicated that both shortages, on average, affected instructional capacity *none* or *a little*. Low levels indicated that both shortages affected instructional capacity *some* or *a lot*. Medium level encompassed all other combinations of responses (Mullis, Martin, Gonzalez, et al., 2000, p. 232; Mullis, Martin, Gonzalez, et al., 2001, p. 254).

Students in better-resourced schools outperformed their peers attending schools where the principal reported that instruction was negatively affected by shortages. In Chile, students in the high index level (22%) had an average mathematics score of 435, while those in the low index level (10%) scored 365.

In South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools, students in better-resourced schools also attained higher achievement than students in schools affected by more shortages. The results for South Korea, Malaysia, and the Slovak Republic differed from Chile in some interesting ways. These three countries had lower proportions of students attending well-resourced schools, compared to Chile. Also, students in the low index level did even better than Chilean students enrolled in well-resourced schools!

A categorical index like the one used in TIMSS 1999 was appropriate for reporting differences in school resources among several countries. However, a continuous measure can probably better capture the real differences in school resources existing in Chile. Because of its increased variance, a continuous variable is also probably better than a categorical variable to model mathematics achievement.

Students' Attitudes Toward Mathematics

In Chile, the debate about how to improve academic achievement usually points to structural factors such as teacher education programs, school resources, or curricula. However, little attention has been given to students' perceptions, such as how much they like mathematics, how important they think it is, how difficult they perceive it is to do well in mathematics, and what factors they believe affect their mathematics performance. By the same token, little is known about students' aspirations for further education: Do Chilean students just want to finish secondary school or do they plan to enter university?

Students' opinions and beliefs regarding mathematics, how much they like and value it, and what they forecast for their own future education can all be understood as different facets of *students' attitudes toward mathematics*. An attitude is an internal disposition to evaluate an object in positive or negative terms. It is accompanied by affective, cognitive, and behavioral responses (for a detailed discussion, see Aiken, 2002). The study of attitudes toward mathematics is justified from at least three standpoints. First, the development of positive attitudes is a goal for many educational systems; they are seen as a requisite for students' academic engagement and to boost learning. Second, attitudes are learned predispositions that reflect the school ethos and the wider social context in which mathematics instruction occurs. As such, attitudes can be influenced by policy interventions. Third, the literature has suggested that there is a positive relationship between favorable attitudes toward mathematics and academic competence.

However, the study of attitudes in the school setting has several complications. Because of the different facets of the attitudinal construct, what is meant by attitudes toward mathematics varies from one study to the other. Moreover, it is common to find studies that do not use the term attitudes, but whose focus lay in one or more of its facets (e.g., academic self-perception, locus of control). The unit of analysis is another complication in the study of attitudes. Relationships that may hold true at the student level may not be of the same nature or strength at the school or classroom level.

From the TIMSS 1995 there is evidence that the majority of 8th graders around the world liked mathematics, thought it was important for them to do well in this subject, thought it was not boring, and did not find it easy (Beaton et al., 1996; Kifer, 2002). In school effectiveness studies, expectations for further education had been reported as a strong predictor of school mean achievement across the countries (Martin, Mullis, Gregory, Hoyle, & Shen, 2000). In South Africa, students with higher self-concepts (i.e., who thought that it was not so difficult to do well in mathematics) and who valued the importance of mathematics, were more likely than their peers with low self-concepts to attain higher mathematics performance (Howie, 2002).

Using data from the Chilean national assessment system, Ramírez (2003) found that 4th graders with more positive attitudes toward their studies (as reported by their parents) attained substantially higher mathematics scores than students with more negative attitudes. By the same token, the more the parents expected their children to study in the university, the higher the child's mathematics performance. Attitudes and educational aspirations were among the very few variables that made a substantial contribution to achievement, after controlling statistically for the effect of the socio-economic level of students' families.

Cueto, Andrade, and León (2003) reported that primary students in Peru liked mathematics, and had a high concept of their self-efficacy in doing mathematics. However, these positive attitudes declined in secondary school, probably as a consequence of the increased difficulty of the mathematics content covered in classes. Students' perception of the utility of mathematics remained high throughout the school years.

In Israel, Nasser and Birenbaum (2004) studied the relationship between mathematics achievement and some learner-related variables, including self-efficacy, beliefs regarding knowledge, and attitudes toward mathematics. The authors conducted their study in two samples of 8^{th} graders: Arabs and Jews. They reported that in both groups the strongest predictor of mathematics achievement was students' beliefs regarding their performance capabilities in mathematics (self-efficacy). The better the students evaluated themselves in doing mathematics, the higher their academic performance.

The authors operationalized attitudes towards mathematics as encompassing how much the students liked mathematics, how difficult they found it, and how important they thought it was. The relationship between mathematics achievement and attitudes was not so clear. They found that attitudes had minor and insignificant effect on the mathematics achievement of Jewish children, while it had a modest but significant effect on the Arabs' achievement. Arab students reporting more positive attitudes toward mathematics attained higher levels of performance than those reporting more negative attitudes.

Interestingly, while the Jewish students outperformed their Arab peers in mathematics, the latter reported more positive attitudes toward this subject.

Directly related with the above findings, Shen and Pedulla (2000) found that more students from lower performing countries reported having more positive attitudes toward mathematics: they found it easier and perceived themselves as more capable of doing well in this subject. These authors interpreted their findings as the consequence of more demanding curricula and higher standards used in high achievement countries, which may lead the students to see mathematics as a harder content area, and themselves as less capable of doing mathematics.

Benham (1995) reviewed studies relating students' self-perceptions and academic achievement. When students believed that their academic performance was the consequence of their own actions (e.g., studying hard, perseverance, motivation) rather than the consequence of factors out of their control (e.g., good luck, innate ability), they had better academic performance. In the literature, the former are said to have an internal locus of control, while the latter have an external one. Stemler (2001) provided further evidence of the importance of the students developing an internal locus of control. From an analysis of 4th grade TIMSS 1995 data from 14 countries, he concluded, "effective schools tend to have a student body who is able to see a connection between hard work, ability, and achievement, and are less likely to attribute achievement to factors such as luck" (p. 145).

CHAPTER 3

METHODOLOGY

This chapter documents the main technical aspects of this dissertation study. First, it presents the criteria used to select the comparison jurisdictions, and describes the TIMSS 1999 sample design and implementation. Second, it offers a description of the mathematics test and background questionnaires. Third, the focus turns to the exploratory analyses carried out to define which background variables to use, how to summarize them, and how to deal with missing data. The fourth section, data analysis, provides detailed information about the statistical techniques used in both the comparative and the national analyses of the Chilean data.

Comparison Jurisdictions

Selection Criteria

The TIMSS 1999 (Gonzalez & Miles, 2001) and the Benchmarking Study (TIMSS 1999 Benchmarking Database) datasets served as the main sources of information for this study. From the 38 countries participating in TIMSS 1999, four were selected for this dissertation study. These were Chile, South Korea, Malaysia, and the Slovak Republic. TIMSS 1999 also included an ambitious benchmarking component by the United States involving 13 states and 14 school districts. One of these districts, the Miami-Dade County Public Schools, was also included in this study. While Chile was the focus of the study, the other four jurisdictions served as a basis for comparison for the

Chilean data. The comparison jurisdictions were selected based on the following criteria (Table 3.1):

- Their economic situation was similar to Chile's
- They tested the same grade as Chile (grade 8)
- They sampled students with an equivalent average age to Chile (14 years)
- They outperformed Chile on TIMSS 1999 [15]

As discussed in Chapter 2, each of these jurisdictions shared Chile's background characteristics. They were middle-income economies, were in the high/upper-middle level of the human development index, and their education systems had universal coverage. Table 3.1 provides further information about Chile and the four comparison jurisdictions in regards to their participation in TIMSS 1999.

[15] It could have been interesting to include in this study a jurisdiction with a lower average performance than Chile. But of the three countries with average scores lower than Chile – Morocco, the Philippines, and South Africa – none met the criteria of sampling the same target grade, and same students' average age than Chile. While Morocco and the Philippines tested the 7^{th} grade, in South Africa the 8^{th} grade students were one year older than the Chilean ones (15.5 year old). All the United States jurisdictions performed better than Chile in the TIMSS 1999 mathematics test.

Table 3.1
Characteristics of Students' Samples and Average Mathematics Achievement

Jurisdiction	TIMSS 1999 math score (Std. error)	Target grade	Average age
Chile	392 (4.4)	8	14.4
South Korea	587** (2.0)	8	14.4
Malaysia	519** (4.4)	8	14.4
Slovak Republic	534** (4.0)	8	14.3
Miami-Dade County Public Schools	421* (9.4)	8	14.3

Pairwise comparison significantly higher than Chile at level * $p < .05$ and ** $p < .01$.
Sources: TIMSS 1999 international Mathematics Report and TIMSS 1999 Mathematics Benchmarking Report.

Sampling Design and Implementation

As is the case with all TIMSS assessments, to participate in TIMSS 1999 all of the education systems had to comply with stringent sampling policies. TIMSS 1999 collected achievement and background information from nationally representative samples of students, as well as background information about their schools and teachers. The TIMSS 1999 international target population was defined as all students enrolled in the upper of the two adjacent grades that contained the largest proportion of 13-year-olds at the time of testing. This was the 8^{th} grade in most of the countries (Foy & Joncas, 2000a, 2000b).

TIMSS 1999 used a *two-stage stratified sample design* to sample from the target population. In the first stage, a sample of schools was selected using the *probability-proportional-to-size* (PPS) method. In the second stage, entire mathematics classes were randomly selected from the target grade in each sampled school. The sampling guidelines required the countries to sample around 150 schools. The participants in the benchmarking study were required to sample 25 schools (Foy & Joncas, 2001; Fowler, Rizzo & Rust, 2001). Chile, Malaysia, and the Slovak Republic sampled one entire class per school, whereas South Korea and Miami-Dade sampled students from different 8th grade classes. Table 3.2 presents information about sample implementation in the five jurisdictions included in this dissertation study.

Table 3.2
Sample Implementation

Jurisdiction	8th grade student population	Sampled schools	Sampled 8th grade students	Percent of sampled students that participated
Chile	238,894	185	5,907	96%
South Korea	635,080	150	6,114	100%
Malaysia	378,762	150	5,577	99%
Slovak Republic	76,790	145	3,497	94%
Miami-Dade County Public Schools	24,485	25	1,356	91%

In all the countries, data were collected at the end of the school year. For Chile – the only southern hemisphere jurisdiction included in this dissertation – this was November 1998. For South Korea, Malaysia, the Slovak Republic, and Miami-Dade – the northern hemisphere jurisdictions – data were collected between February and June 1999. Detailed information about the sampling procedures and other technical aspects of the assessment can be found in the TIMSS 1999 Technical Reports (Martin, Gregory & Stemler, 2000; and Martin, Gregory, O'Connor & Stemler, 2001).

As a consequence of the TIMSS 1999 sample design, each Chilean school was represented by one class, so achievement differences among the schools could not be distinguished from achievement differences among the classes from the same schools. For this reason, schools and classes are referred to as the school/class level or unit in this dissertation study. As described in a later section, this study modeled the average achievement of the Chilean schools/classes in an attempt to understand better their mathematics scores.

Instruments

The TIMSS 1999 Mathematics Test

The TIMSS 1999 mathematics assessment framework contained two main dimensions: *content* and *performance expectations* (Mullis, Martin, Smith, et al., 2001). There were five content areas: fractions and number sense; measurement; algebra; geometry; and data representation, analysis and probability. The performance expectations included five cognitive skills: knowing, using routine procedures, using complex procedures, investigating and solving problems, communicating and reasoning.

The TIMSS 1999 test was the product of a collaborative effort involving mathematics educators and specialists from all around the world. Every effort was made to ensure that the test represented the curricula of the participating countries and that the problems in the test exhibited no bias towards or against particular countries. The national research coordinators of the participating countries reviewed all of the problems.

The problems were extensively reviewed for accuracy, clarity, classification according to the framework, format, and number of score points (Garden & Smith, 2000; Mullis & Martin, 2000).

The mathematics test consisted of 162 problems. Multiple-choice problems made up three-fourths of the items and were each worth one point. One-fourth of the problems were in a free-response format, requiring the students to write their answers and provide explanations. These problems were each worth one or two points. The problems were distributed across eight booklets according to a matrix sampling design with students responding to one booklet only. This matrix sampling design maximized the content and skills that could be evaluated by the assessment in the time available (Garden & Smith, 2000).

Problems were assigned to booklets so that each booklet contained some mathematics items.[16] This, in conjunction with item response theory (IRT) scaling, allowed students to be given a mathematics score regardless of the booklet answered. Because each student only answered a subset of the mathematics problems included in the test, there was more uncertainty associated with each student scores. Assuming that there is a random distribution of plausible scores associated with each student average score, TIMSS draws five random scores from that distribution. The TIMSS dataset

[16] Test booklets contained both mathematics and science problems.

provides five "plausible values" for each student. These scores are appropriate for making inferences about the student population (Yamamoto & Kulick, 2000).

Trained scorers from each country scored the students' responses using a two-digit rubric. The first digit indicated correctness level and the associated score points, and the second digit was a diagnostic score to track types of approaches, common errors, etc. The average inter-rater reliability was 99% for the first digit, and 96% for the first and second digit combined (Garden & Smith, 2000; Mullis, Martin, Gonzalez, et al., 2000, appendix A).

The reliability of the test was estimated using the *internal consistency* approach. The median Kuder-Richardson Formula 20 (KR20) for all the countries was ρ_{KR20} = 0.89. For the jurisdictions in this study, it was as follows: Chile ρ_{KR20} = 0.83, South Korea ρ_{KR20} = 0.91, Malaysia ρ_{KR20} = 0.90, the Slovak Republic ρ_{KR20} = 0.89, and Miami-Dade County of Public Schools ρ_{KR20} = 0.86 (Mullis, Martin, Gonzalez, et al., 2000, appendix A; Mullis, Martin, Gonzalez, et al., 2001, appendix A).

The TIMSS 1999 Background Questionnaires

The purpose of the TIMSS questionnaires was to provide a context to help in better understanding the students' mathematics performance. The questionnaires were prepared through a collaborative effort by an international team of experts, and extensively reviewed by the national research coordinators of the participating countries.

Four background questionnaires were developed to collect information at different levels of the system. The student questionnaire sought information about home characteristics, attitudes, and school experiences. The teacher questionnaires (one for the mathematics teacher and another for the science teacher) gathered information about preparation to teach, contents covered in classes, and instructional approaches. The school questionnaire focused on school staffing and facilities, curriculum, and instructional arrangements. The curriculum questionnaire addressed issues of curriculum design and policies (Mullis, Martin & Stemler, 2000).

Most of the items in the questionnaires used a four-point Likert scale format (e.g., *strongly agree*, *agree*, *disagree*, and *strongly disagree*). The exception was the curriculum questionnaire – one per country – where respondents were asked to write explanations about the schooling system and mathematics curriculum in their jurisdictions.

Exploratory Analyses

Data Screening

A crucial step in this dissertation study was the selection of the background variables that would be used to understand better the achievement differences between Chile and the comparison jurisdictions, as well as the achievement differences within Chile. Bearing in mind the research questions of this study, all the TIMSS 1999 questionnaires were reviewed extensively for questions that could be used as indicators of the constructs of interest. Once a preliminary set of items was selected, a standard checking procedure was implemented to verify the availability of the data in all five jurisdictions[17], response rates, and the plausibility of the data.

Univariate statistics were computed for each variable of interest (e.g., means and modes, ranges and variances). Outliers and skewed distributions were identified. Some variables were recoded to reflect better the distribution of responses among the available options. Categories were sometimes combined to avoid missing data. For instance, the original six response options of students' educational expectations were recoded into three categories. The first category, "finish secondary school or less" (1 point), encompassed *some secondary school* and *finish secondary school*. The second category, "Some vocational/technical or some university" (2 points) encompassed *some vocational/technical education after secondary school*, *some university*, *I don't know* (6% of total cases), and also the missing responses (20% of total cases). The last category, *finish university* (3 points), was kept in its original form. This procedure was equivalent to use mean imputation to replace missing and *I don't know* values.

The bivariate association between the variables was investigated together with their relationship with mathematics achievement. Some variables were reverse scored so that the scale direction made more sense conceptually.

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[17] Jurisdictions could omit/adapt items in the questionnaires that were not considered appropriate for their population.

Background Variables

Table 3.3 presents the background variables used in this study. The variables were grouped in dimensions or blocks that reflected the broad conceptual categories addressed in the research questions. The blocks were: a) schools' community contexts, b) implemented mathematics curriculum, c) teacher quality, d) school resources, e) type of school, f) students' attitudes toward mathematics, and g) students' family background.

In total, 17 variables (single- and multiple-item indicators) were used to measure the different facets of these dimensions. For each variable, the table provides information about the source question(s) in the TIMSS 1999 questionnaires, category options and score points. In the case of multiple-item indicators, a brief explanation of how these derived variables were computed is also provided. Detailed information about the computation of multiple-item indicators is provided in the following section.

The background variables presented in the table below were further transformed to fit the needs of different statistical analyses. The nature of these transformations is explained together with the corresponding analyses.

Table 3.3
Detailed Information About Background Variables

Variable	Description
	SCHOOLS' COMMUNITY CONTEXTS
Socio-economic level of the school community	Index score computed by averaging the score points associated with the responses to father and mother education, number of books at home, and possessions at home (as reported by the students). All items were given equal weight and were aggregated at the school/class level.
	How far in the school did your father and mother go? (SQ_7) Response options: Some primary or did not go to school (0 point) Finished primary school (1 points) Some secondary school (2 points) Finished secondary school (3 points) Some vocational/technical education after secondary school (4 points) Some university (5 points) Finished university (6 points) *About how many books are there in your home?* (SQ_10) Response options: None or very few (0 point) Enough to fill one shelf (1 points) Enough to fill one bookcase (2 points) Enough to fill two bookcases (3 points) Enough to fill three or more bookcases (4 points) *Do you have any of these items at your home?* (SQ_11a-l) 1. calculator 2. computer 3. study desk/table 4. dictionary Response options: *No* (0 point) – *Yes* (1 point)
Urban/rural	*In what type of community is your school located?* (SCQ_1) Category options: Away from city center (0 point) – Closer to city center (1 point)

Note. SCQ = Schools' questionnaire, SQ = Students' questionnaire. Item numbers match the general version of the questionnaires.

Table 3.3

Detailed Information About Background Variables (cont.)

Variable	Description
	IMPLEMENTED MATHEMATICS CURRICULUM
Content coverage (advanced) *	Index score computed across 20 questions by averaging the score points associated with each response option. Topics were grouped in 4 content areas (measurement; geometry; algebra; and data representation, analysis and probability). Score points were weighted proportional to the number of mathematics problems from the advanced content areas in the TIMSS mathematics test. *The following list includes the main topics addressed by the TIMSS mathematics test. Check the response that describes when students in your mathematics class have been taught each topic* (list of 20 topics) (TQMB_13b13-c24, e27-f34) Response options: Taught before this year (1 point) Taught 1-5 periods this year (1 point) Taught more than 5 periods this year (2 points) Not yet taught (0 point) I do not know (0.5 points)
Content coverage (general)*	Same as advanced index but including 14 additional questions about fractions, number sense, and probability topics. Score points were weighted proportional to the number of mathematics problems from each content area in the TIMSS mathematics test. (TQMB_13a1-f34)
Subject emphasis	*What subject matter do you emphasize most in your mathematics class?* (TQMB_2) Category options: Basic content (whole numbers, fractions, decimals, percentages) (0 point) – Advanced content (geometry, algebra, or a combination of them with other subjects) (1 point)
Additional mathematics courses	*Schools sometimes organize instruction differently for students with different abilities and interests in mathematics. Which of the following does your school do for students in the 8th grade?* (SCQ_20a-d) 1. Remedial mathematics is offered 2. Enrichment mathematics is offered Category options: None (0 point) – Either remedial or enrichment (1 point) – Both remedial and enrichment (2 points)
School curriculum	*Does your school have its own written statement of curriculum content to be taught for mathematics?* (SCQ_10a) Response options: *No* (0 point) – *Yes* (1 point)
Instructional materials	*Has your school developed instructional activities or learning materials to address the curriculum taught in your school?* (SCQ_11a) Response options: *No* (0 point) – *Yes* (1 point)

Note. SQ = Students' questionnaire, SCQ = Schools' questionnaire, TQM = Mathematics teachers' questionnaire (part A or B). Item numbers match the general version of the questionnaires.

* The advanced content coverage index was used for the international comparisons only. Since this measure did not have enough variability in Chile, the general index was used for the national analyses.

Table 3.3
Detailed Information About Background Variables (cont.)

Variable	Description
	TEACHER QUALITY
Teacher qualification	Index score computed across 4 questions by averaging the score points associated with each response category. Equal weight was given to each question.
	What is the highest level of formal education you have completed? (TQMA_15) Response options: Did not complete secondary school (0 point) – Secondary only (1 point) – Bachelor or equivalent (2 points) – Master or Doctorate (3 points) *Do you have a teacher training certificate?* (TQMA_16a) Response options: *No* (0 point) – *Yes* (1 point) *While studying to obtain your teacher training certificate, what was your major or main area of study?* (TQMA_17a,c,e,f) 1. Mathematics 2. Mathematics education Response options: *No* (0 point) – *Yes* (1 point) *If you have a master's degree, what was your major or main area of study?* (TQMA_18a,c,e,f) 1. Mathematics 2. Mathematics education Response options: *No* (0 point) – *Yes* (1 point)
Preparation to teach	Index score computed across 12 questions by averaging the score points associated with each response option.
	How well prepared do you feel you are to teach (TQMA_14a-l) 1. Fractions, decimals and percentages 2. Ratios and proportions 3. Measurement – units, instruments, accuracy 4. Perimeter, area, and volume 5. Geometric figures – definitions and properties 6. Geometric figures – symmetry, motions, and transformations, congruence and similarity 7. Coordinate symmetry 8. Algebraic representation 9. Evaluate and perform operations on algebraic expressions 10. Solving linear equations and inequalities 11. Representation and interpretation of data in graphs, charts, and tables *12.* Simple probabilities – understanding and calculations Response options: *Not well prepared* (0 point) – *Somewhat prepared* (1 point) – *Very well prepared* (2 points)

Note. SQ = Students' questionnaire, SCQ = Schools' questionnaire, TQM = Mathematics teachers' questionnaire (part A or B). Item numbers match the general version of the questionnaires.

Table 3.3

Detailed Information About Background Variables (cont.)

Variable	Description
	SCHOOL RESOURCES
Limitations in school resources	Index score computed across 11 questions by averaging the score points associated with each response option. *Is your school's capacity to provide instruction affected by a shortage or inadequacy of any of the following* (SCQ_12a-e,g-k,r). 1. Instructional materials (e.g., textbooks) 2. Budget for supplies (e.g., paper, pencils) 3. School buildings and grounds 4. Heating/cooling and lighting systems 5. Instructional space (e.g., classrooms) 6. Computers for mathematics instruction 7. Computer software for mathematics instruction 8. Calculators for mathematics instruction 9. Library materials relevant to mathematics instruction 10. Audio-visual resources for mathematics instruction 11. Teachers qualified to teach mathematics Response options: *None* (0 point) – *A little* (1 point) – *Some* (2 points) – *A lot* (3 points)
	SCHOOL ADMINISTRATION
School administration	School administration (MINEDUC) Category options: Public/municipal (0 point) – Private (elite-paid or private-subsidized) (1 point)

Note. SQ = Students' questionnaire, SCQ = Schools' questionnaire, TQM = Mathematics teachers' questionnaire (part A or B). Item numbers match the general version of the Student Questionnaire. MINEDUC = Data provided by Ministry of Education, Chile.

Table 3.3

Detailed Information About Background Variables (cont.)

Variable	Description
	STUDENTS' ATTITUDES TOWARD MATHEMATICS
Liking mathematics	Index score computed across 4 questions by averaging the score points associated with each response option. *How much do you like mathematics?* (SQ_21a) Response options: *Dislike a Lot* (0 point) – *Dislike* (1 point) – *Like* (2 points) – *Llike a Lot* (3 points) *I enjoy learning mathematics.* (SQ_24a) *I would like a job that involved using mathematics.* (SQ_24e) *Mathematics is boring.*[r] (SQ_24b)
Importance of mathematics*	Index score computed across 4 questions by averaging the score points associated with each response option. *I think it is important to do well in mathematics at school.* (SQ_15b) *Mathematics is important to everyone's life.* (SQ_24d) *I need to do well in mathematics to get into the secondary school or university I prefer.* (SQ_25c) *I need to do well in mathematics to please myself.* (SQ_25d)
Difficulty of doing mathematics	Index score computed across 5 questions by averaging the score points associated with each response option. *I usually do well in mathematics.* [r] (SQ_16a) *Mathematics is an easy subject.* [r] (SQ_24c) *I would like mathematics much more if it were not so difficult.* (SQ_17a) *Although I do my best, mathematics is more difficult for me than for many of my classmates.* (SQ_17b) *Sometimes, when I do not understand a new topic in mathematics initially, I know that I will never really understand.* (SQ_17d)
Importance of luck & innate talent in doing mathematics	Index score computed across 4 questions by averaging the score points associated with each response option. *To do well in mathematics at school you need good luck.* (SQ_18b) *To do well in mathematics at school you need lots of innate talent.* (SQ_18a) *Nobody can be good in every subject, and I am just not talented for mathematics.* (SQ_17c) *Mathematics is not one of my strengths.* (SQ_17e)
Educational expectations	*How far in school do you expect to go?* (SQ_8) Response options: Finish secondary school or less (0 point) – Some vocational/technical, some university, or don't know (1 point) – Finish university (2 points)

Note. Unless otherwise indicated, all the questions had a 4-point Likert-format scale with response options *Strongly Disagree* (0 point), *Disagree* (1 point), *Agree* (2 points), and *Strongly Agree* (3 points).
SQ = Students' questionnaire. Item numbers match the general version of the questionnaire.
[r] Reversed scored scale.
* For the national analyses, the variable "Importance of Mathematics" was dichotomized so that 1 = *Strongly agree* to all four statements, and 0 = any other combination of responses. This transformation was implemented considering the highly skewed distribution of this index in Chile.

Table 3.3
Detailed Information About Background Variables (cont.)

Variable	Description
	STUDENTS' FAMILY BACKGROUND
Socio-economic level of the students	Index score computed by averaging the score points associated with the responses to father and mother education, number of books at home, and possessions at home (as reported by the students). All items were given equal weight and were aggregated at the school/class level.
	How far in the school did your father and mother go? (SQ_7) Response options: Some primary or did not go to school (0 point) Finished primary school (1 point) Some secondary school (2 points) Finished secondary school (3 points) Some vocational/technical education after secondary school (4 points) Some university (5 points) Finished university (6 points) *About how many books are there in your home?* (SQ_10) Response options: None or very few (0 point) Enough to fill one shelf (1 point) Enough to fill one bookcase (2 points) Enough to fill two bookcases (3 points) Enough to fill three or more bookcases (4 points) *Do you have any of these items at your home?* (SQ_11a-l) 1. calculator 2. computer 3. study desk/table 4. dictionary Response options: *No* (0 point) – *Yes* (1 point)

Note. SQ = Students' questionnaire. Item numbers match the general version of the questionnaire.

Computation of Multiple-Item Indicators

The TIMSS 1999 questionnaires included sets of questions related to the same underlying construct. Whenever possible, these questions were combined to form *indices*. Indices present several conceptual and measurement advantages that make them preferable to single-item indicators. They are better suited to represent complex constructs difficult to capture in a single item, have greater reliability and discriminating power, allow for data reduction, and maximize the amount of valid cases (see DeVellis, 1991; Spector, 1992; Sullivan & Feldman 1979).

A somewhat different procedure was used to compute different types of indices. The TIMSS 1999 dataset included some 40 variables that could be used to measure different facets of students' attitudes toward mathematics. Principal component was used to identify the items that measured common underlying constructs (i.e., they loaded in the same underlying factor). Reliability analysis was used to assess the strength of the association among the items.

In other cases, there were just two or three items available to measure the construct of interest. Chi-square and Spearman's rank order correlation were used to measure the association between pair of variables before combining them. Finally, in some cases the source items were not expected to covary; these indices were more cumulative in nature. A good example is the offering of additional mathematics courses. In the Chilean schools, it was frequent to observe that neither remedial nor enrichment courses were available, or that the schools offered only remedial courses. The schools that offered enrichment courses only did so if remedial courses were available.

In general, index scores were computed by averaging the score points associated with the response options of the selected questions. All the source variables were scaled so that more points corresponded to higher levels of the attribute being measured. In most of the cases the source variables were given equal weight to compute the index score. In general, two-thirds of the component variables had to have valid data for an index to be computed.

Preliminary analyses showed that, in Chile, almost 50% of the students had missing data for one or more of the variables shown in Table 3.3. The missing data posed a major problem at the school/class level, since all the students enrolled in those schools/classes were missing that information after disaggregating the data at the student level. Missing data also posed a major problem for the hierarchical linear modeling of mathematics achievement (see next section), because the available software does not accept missing data at level 2 (the school/class level). Since it was reasonable to presume that the data was not missing at random, losing cases with missing data was likely to introduce *bias* into the parameter estimates.

Combining variables into indices drastically diminished the amount of missing data. In general, an index score was computed for each case provided that the number of variables with missing values was less than one-third. If an index score could not be computed, then conditional mean imputation was used to impute data to replace missing values. This procedure was also used to impute data on the single-item indicators that were used in the statistical analyses.

Using conditional mean imputation, a separate regression model was specified for each variable with missing data. The regression model was chosen to reflect the type of data: a linear model was used for continuous data, logistic regression for binary data, and multinomial logit for categorical data. The regression models were estimated beginning with the variables with the least missing data, and proceeding next with the variables with more missing data. Predicted scores and predicted groups were then used to replace the missing data (see Allison, 2001). This procedure was performed independently for each of the five jurisdictions.

Variables with too many missing data, or for which the predictive models did not seem to be accurate enough, were not imputed. In fact, during the preliminary analyses, only the variables with a reasonably high response rate were kept for further analysis. By the same token, schools/classes with too many missing data were dropped from the analyses, as well as the students enrolled in those schools/classes. In Chile, three schools/classes and their students were dropped from all the analyses. As a consequence, 182 out of 185 (98%) schools/classes were analyzed from the Chilean dataset. In Chile, the proportion of students with valid data (after imputation) varied around 98%, depending on the analysis.

In Miami-Dade County Public Schools, missing data were a more critical issue. In this jurisdiction, data from the School Questionnaire was available for only 20 out of the 25 schools (80% of the sampled schools). As a consequence, the comparative analyses were run with a restricted sample. Caution is recommended in interpreting the data from this district.

Chapter 4 provides the percentage of valid cases for each separate analysis (see Tables 4.1-4.5 and Figures 4.1-4.4). In general, these percentages were very high, with almost all the analyses having over 90% of valid cases across the five jurisdictions. The modeling of mathematics achievement in Chile included over 97% of the original sample of students.

Data Analysis

Comparative Analysis of the Schooling Systems

Univariate Analyses

The first phase of this study compared the Chilean educational system with the systems in South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools. As stated in the research questions, the aim was to learn to what extent the Chilean educational system differed from the comparison jurisdictions in regards to five dimensions:

1. Schools' community context
2. Implemented mathematics curriculum
3. Teacher quality
4. School resources
5. Students' attitudes toward mathematics

Within each dimension, several background variables were analyzed using Chile as the reference group. In practice, this implied standardizing the variables and centering them so that Chile had a mean equal to zero and a standard deviation equal to one ($M = 0$, $SD = 1$). Means and standard errors were computed using the jackknife repeated replication (JRR) method. This method provides approximately unbiased estimates of the sampling errors by taking into account the complex sampling design used in TIMSS 1999 (i.e., it avoids the assumption of simple random sampling). The JACKGEN macro provided in the TIMSS 1999 database computes means and standard errors using the jackknife repeated replication method. Confidence intervals around the mean were computed to test the significant level of differences.

These univariate comparative analyses were weighted with TOTWGT, one of the weighting variables provided in the TIMSS 1999 database. TOTWGT takes into account the differential probability of the students being selected in the sample, and reproduces the number of cases in the target population of each jurisdiction. Therefore, statistical analyses with TOTWGT provide information about the target population of interest, rather than about the sampled students. The students were always the unit of analysis, even when schools/classes variables were under scrutiny.

Multivariate Analyses

Theory suggests that socio-economic level, the nature of the implemented curriculum, teacher quality, and school resources are not independent of one another (see Chapter 2). These background factors are expected to covary. For this reason, it is desirable to include them together in a single analysis. Multivariate analysis of variance (MANOVA) was run with this purpose.

MANOVA tested how different Chile was from the comparison jurisdictions on a combination of variables taken together. Only the most relevant variables (as shown in the univariate analyses) were used as input for this analysis. These variables were: students' socio-economic level, content coverage (advanced), preparation to teach, and importance of luck and innate talent. First, an omnibus analysis was run to see if there were overall differences between the jurisdictions on the combined set of variables. Then, planned comparison was used to contrast Chile against the four jurisdictions combined (Chile versus others).

All the analyses were weighted to account for the differential probability of the students being selected in the sample. As indicated before, sample sizes varied widely from one jurisdiction to the other. In this particular analysis, it was desirable to have all five jurisdictions contributing equally to the final statistics, no matter what their sample size was. Because of this reason, the analyses were weighted with SENWGT, a weighting variable provided in the TIMSS 1999 dataset. Within each jurisdiction, the sum of SENWGT is 500, no matter what the actual sample size was. This weight is recommended when international estimates are sought and you do not want them to be affected by differential sample sizes, i.e., all countries are weighted equally. The analyses were run using the SPSS MANOVA codes. The students were the unit of analysis, even though schools/classes variables were under scrutiny.

Modeling Mathematics Achievement in Chile

The second phase of this study aimed to discover if the background variables already identified were related to mathematics achievement in Chile. Mathematics achievement was modeled at the school/class level, and at the student-within-class level using a hierarchical linear models.

As a result of the TIMSS 1999 sampling design, students were nested within schools/classes (clusters). Therefore, students from the same schools/classes were expected to be more alike than students randomly sampled from the whole population of 8th graders. This was because these students shared more common experiences (e.g., same teacher, school resources) than students randomly drawn from different classes and schools.

Considering the clustered structure of the TIMSS 1999 data set, a multilevel approach was adopted in this study. Multilevel modeling presents several advantages, both conceptual and technical, over ordinary least squares (OLS) regression. Hierarchical linear models (HLM) explicitly recognize the presence of hierarchical units of analysis and allow modeling them simultaneously, in interrelated sub-models (Hox, 2002; Heck & Thomas, 2000; Raudenbush & Bryk, 2002).

The Hierarchical Linear Models

This dissertation study stated several hypotheses about the relationship between background variables and mathematics achievement in Chile. These hypotheses were tested using a *two-level random intercept model.* At the school/class level, the mean mathematics score of the schools/classes were modeled using community, curriculum, teacher, and school variables. At the students-within-class level, students' mathematics scores served as the outcome and students' characteristics as the predictors.

Before modeling mathematics achievement, it was important to know the proportion of achievement variance at the school/class level, and the proportion at the students-within-class level. The proportion of outcome variance at the school/class level set the upper-limit that could be explained by the models of mathematics achievement at the school/class level. By the same token, the proportion of outcome variance at the students-within-class level set the upper-limit that could be explained by the models of mathematics achievement at the students-within-class level.

The between schools/classes (unconditional) model was the preliminary step before modeling mathematics achievement. Then, five schools/classes (conditional) models were tested to evaluate the partial contribution of different sets of predictor variables. Lastly, two students-within-class models were used to test the partial effect of students' attitudes on achievement. Detailed explanations of these models are provided below.

The between schools/classes model. This model estimated the ratio of school/class mean variance to the total achievement variance. This model is similar to a one-way analysis of variance because the variation in the dependent variable (mathematics achievement) is partitioned into two components: between schools/classes and students-within-classes. No predictors were entered at the school/class level, nor at the students-within-class level (Equations 1 and 2 respectively).

$$y_{ij} = \beta_{0j} + r_{ij} \qquad (1)$$

$$\beta_{0j} = \gamma_{00} + u_{oj} \qquad (2)$$

Where:

y_{ij} = Mathematics score of student *i* in school/class *j*

β_{0j} = Mean mathematics score for school/class *j* (intercept)

γ_{00} = Grand mean mathematics score

r_{ij} = Random error associated with student *i* in school/class *j*

u_{0j} = Random error associated with school/class *j*

The ratio of the school/class mean variance to the total achievement variance was computed as follows (Equation 3):

$$\hat{\rho} = \frac{\hat{\tau}_{00}}{\hat{\tau}_{00} + \hat{\sigma}_2} \qquad (3)$$

Where:

$\hat{\tau}_{00}$ = Variance of the school/class means around the grand mean (between-group variability)

$\hat{\sigma}^2$ = Variance of the students-within-school/class (within-group variability)

The school/class models. Five models of mathematics achievement were tested at the school/class level. The models were inclusive, with each one encompassing additional blocks of predictor variables. The blocks matched the grouping categories already presented in Table 3.3: the implemented mathematics curriculum, teacher quality, school resources, school community context, and school administration. Using inclusive models allowed estimating the proportion of additional outcome variance accounted for by the successive models.

The use of the models was an attempt to see the effect of educational variables first, without considering the effect of socio-economic level. The indicators of curriculum implementation were entered first, in Model 1. This was because the implemented curriculum more directly conditions students' opportunities to learn mathematics. Teacher quality indicators were entered second, in Model 2. This was because quality teachers are a necessary but not sufficient condition to produce quality learning. A good teacher also needs a good curriculum to boost achievement. Schools resources affect instruction in a more indirect way; hence this measure was included in a third model. The broader socio-economic context in which the school operates is a given condition, beyond the control of the school. The community socio-economic level was included in Model 4. Model 5 was restricted to the variables that had a more consistently significant effect. All these steps are summarized below:

- Model 1 used five variables measuring the implemented mathematics curriculum.
- Model 2 encompassed the previous model, plus two variables measuring teacher quality.
- Model 3 encompassed the previous model, plus a variable measuring limitations in school resources.
- Model 4 encompassed the previous model, plus two variables measuring schools' community contexts.
- Model 5 was restricted to the variables that had a significant partial effect on the outcome, conditional on the average socio-economic level of the community served by the school. This model also included a variable measuring the type of school administration (public/private).

An additional model using only the socio-economic index was also tested. This sixth model allowed estimating how much additional variance was accounted for by Model 5, compared to a model that used the socio-economic index as predictor.

Equation 4 presents the general formula for the school/class sub-models:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(comm_j) + \gamma_{02}(curr_j) + \gamma_{03}(teach_j) + \gamma_{04}(school_j) + u_{oj} \quad (4)$$

Where:

β_{0j} = Mean mathematics score for school/class *j* (intercept)

$comm_j$ = Value of a "schools' community contexts" variable for school/class *j*

$curr_j$ = Value of an "implemented mathematics curriculum" variable for school/class j

$teach_j$ = Value of a "teacher quality" variable for school/class j

$school_j$ = Value of "limitation in school resources" for school/class j

γ_{00} = Grand mean mathematics score

γ_{01} = Partial effect of the "schools' community contexts" variable

γ_{02} = Partial effect of the "implemented mathematics curriculum" variable

γ_{03} = Partial effect of the "teacher quality" variable

γ_{04} = Partial effect of the "limitations in school resources" variable

u_{0j} = Random error associated with school/class j

The students-within-school/class models. At the students-within-school/class level, one sub-model, including five attitude variables, was tested: liking mathematics, importance of mathematics, difficulty of doing well in mathematics, importance of luck and innate talent in doing mathematics, and educational expectations. Since all of the variables tapped one construct (i.e., attitudes toward mathematics), no successive blocks of variables were used. Instead, the five predictors were entered at once, as shown in Equation 5:

$$y_{ij} = \beta_{0j} + \beta_1(LIKE_{ij}) + \beta_2(IMP_{ij}) + \beta_3(DIFF_{ij}) + \beta_4(LUCK_{ij}) + \beta_5(EDEX_{ij}) + r_{ij} \quad (5)$$

Where:

β_{0j} = Mean mathematics score for school/class *j* (intercept)

$\beta_1 \ldots \beta_5$ = Partial regression coefficients for five predictor variables

$LIKE_{ij} \ldots EDEX_{ij}$ = Predictor values for student *i* in school/class *j* (group-mean centered)

LIKE	= Liking mathematics
IMP	= Importance of mathematics
DIFF	= Difficulty in doing mathematics
LUCK	= Importance of luck and innate talent in doing mathematics
EDEX	= Educational expectations

r_{ij} = Random error associated with student *i* in school/class *j*

A second students-within-school/class sub-model was run to find out if the partial effect of the attitudes variables was affected by the students' socio-economic level.

In the hierarchical linear analyses, all predictors other than dummy variables were standardized to facilitate the interpretation of results. At the students-within-class level, the predictors were group-mean centered. This allowed for the study of the relationship between attitudes and mathematics achievement within the schools/classes.

Mathematics achievement is represented in the TIMSS 1999 database by five "plausible values" for each student. The five plausible values were entered in the plausible value function of the HLM 5.02 software (Raudenbush, Bryk, & Congdon, 2000). The models were run using restricted maximum likelihood. This method was chosen because it introduces less bias in the parameter estimates than maximum likelihood (Hox, 2002, p. 38). Robust standard errors were reported because they are less dependent on the normality assumptions (Hox, 2002, p. 201). All of the analyses were weighted by HOUWGT to account for the differential probability of the students being selected in the sample. This weighting variable reproduced the country sample size and was provided in the TIMSS 1999 dataset.

CHAPTER 4

RESULTS

This chapter answers the research questions of this dissertation study in two main steps. First, key characteristics of the Chilean educational systems were compared to the characteristics existing in the four comparison jurisdictions. Second, the relationship between these characteristics and mathematics achievement in Chile was further examined.

Comparative Analysis of the Schooling Systems

This section compares some key characteristics of the Chilean educational system with the characteristics of the educational systems in the four jurisdictions. The analyses focused on: a) schools' community contexts, b) implemented mathematics curriculum, c) teacher quality, d) school resources, and e) students' attitudes toward mathematics.

How Different Was Chile from the Comparison Jurisdictions in Schools' Community Contexts?

Despite the fact that Chile shares a somewhat similar level of economic development with South Korea, Malaysia, the Slovak Republic, and Miami-Dade County, it was hypothesized that Chilean students came from a social background that was more disadvantaged. This hypothesis was tested using background data from the students who provided information about their parents' education, availability of educational resources at home (calculator, computer, study desk/table, and dictionary), and the number of books they had at home. This information was summarized in a socio-economic index.

The socio-economic index was standardized so that Chile had a mean equal to zero and a standard deviation equal to the unit ($M = 0$, $SD = 1$). The jurisdiction means were recomputed in standard deviation scores from the Chilean mean. As shown in Table 4.1, Chile had the lowest score in the socio-economic index when compared to the four jurisdictions. South Korea, the Slovak Republic and Miami-Dade County Public Schools scored three-fourths of a standard deviation above Chile. Chilean 8^{th} graders had a socio-economic index significantly lower than the students across the four jurisdictions ($p < .005$, one-tailed test). While Chilean students also scored significantly lower than the Malaysian students in the socio-economic index the gap was considerably smaller.

Table 4.1
Descriptive Statistics for Socio-Economic Level and Mathematics Achievement

	Socio-economic level			Mathematics achievement
	M (SE)	*SD*	% Variation among schools*	*M* (SE)
Chile	0.00 (0.05)	1.00	45%	392 (4.5)
South Korea	0.72 (0.02)	0.85	16%	587 (2.0)
Malaysia	0.14 (0.04)	0.88	33%	520 (4.2)
Slovak Republic	0.73 (0.03)	0.74	26%	534 (3.9)
Miami-Dade County Public Schools	0.72 (0.07)	0.87	13%	421 (9.5)

Note. Valid cases across the five jurisdictions = 99.6%. Analysis weighted by TOTWGT.
* Computed as the ratio of sum of squares between to sum of squares total (SS_b / SS_t).

At the country level (i.e., excluding Miami-Dade County), the socio-economic index correlated with average mathematics achievement. Higher performing South Korea and the Slovak Republic also had the higher socio-economic index, whereas middle performing Malaysia had a lower index level. Chile had both the lowest index level and the lowest average mathematics achievement.

In Table 4.1, the standard deviation column indicates how much the students from each jurisdiction differed in their socio-economic status. Chilean students had the highest socio-economic spread (*SD* = 1.00) while the Slovakian the least (*SD* = 0.74). These results indicate that, on average, Chilean students were more heterogeneous in their socio-economic backgrounds than students from other jurisdictions.

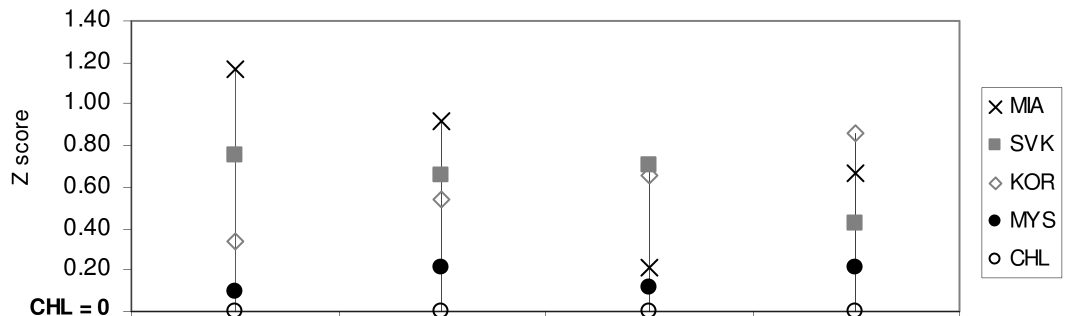
Table 4.1 also shows the socio-economic dispersion among the schools for each jurisdiction. The higher the percentage of index variance among the schools, the higher the levels of socio-economic segregation in that educational system. Countrywise, Chile had the highest proportion of index variance among the schools (45%), followed by Malaysia (33%), the Slovak Republic (26%), and South Korea (16%). It is interesting to note that, among the countries, the proportion of index variance among the schools was inversely correlated with average mathematics achievement. South Korea, the highest performing jurisdiction, had the least economic segregation in the school system. Chile, the lowest performing jurisdiction, had the most.

Miami-Dade County Public Schools had the least socio-economic variation among the schools. There is evidence that the United States has one of the most economically segregated educational systems in the world (Beaton & O'Dwyer, 2002), and Miami-Dade has a large percentage of students (59%) from low-income families – based on the percentage of students eligible to receive free or reduced-price lunch (Thornton & Wongbundhit, 2002).

Furthermore Figure 4.1 breaks down the socio-economic index in its source variables, which were also standardized and centered on the Chilean mean, so that in Chile $M = 0$ and $SD = 1$. The y-axis indicates deviations (in standard scores) from the Chilean mean. Results indicate that Chilean students differed from the students in other jurisdictions by having less educated parents (both father and mother), fewer books, and fewer educational resources at home. In all four measures, the Chilean mean was significantly lower than the mean of the four jurisdictions combined ($p < .005$, one-tailed test).

The source variable that differed the most from the Chilean average was the level of education reached by the students' mothers. In Miami-Dade County, the average educational level of mothers was more than a standard deviation above the Chilean mean, whereas in the Slovak Republic it reached three-fourths of a standard deviation. While Chilean students were more like their peers in Malaysia regarding their mothers' education, substantial differences still arose. In fact, while 37% of Chilean students reported that their mothers at least finished secondary school, this proportion reached 50% in Malaysia.[18]

Figure 4.1
Differences in Socio-Economic Indicators
Between Chile and the Comparison Jurisdictions



	Mother education	Father education	Books at home	Educational resources at home
MIA	1.17	0.92	0.21	0.67
SVK	0.76	0.65	0.71	0.43
KOR	0.34	0.54	0.65	0.86
MYS	0.10	0.22	0.12	0.21
CHL	0.00	0.00	0.00	0.00

Note. CHL = Chile (*M* = 0, *SD* = 1), MYS = Malaysia, SVK = Slovak Republic, KOR = South Korea, MIA = Miami-Dade County Public Schools. Valid cases by column: 80%, 76%, 99%, and 99%. Analysis weighted with TOTWGT.

These results confirm the hypothesis that, despite sharing similar global indicators in economic development, Chile has a serious disadvantage in comparison to the other four jurisdictions used in this study. The cultural capital of the students' families was substantially lesser in Chile than in South Korea, Malaysia, the Slovak Republic, and Miami-Dade County. Most notably, Chilean students' parents had considerably fewer years of schooling than parents in other jurisdictions. This is an important finding since,

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[18] Percentages based on all valid responses other than *I don't know*.

among all the background variables collected by TIMSS 1999, mothers' and fathers' education were probably the strongest predictors of students' mathematics achievement.

South Korea, the Slovak Republic, and the United States had universal coverage of primary education in the 1960s; Malaysia did so in the 1980s. In Chile, only a tiny elite attended the school in the 1960s, and universal coverage was reached in the 1990s. These results emphasize the importance of raising the educational level of Chile's future generations. Steps are being taken to respond to Chilean educational deficits. Access to education has been rising steadily during the last decades. A 2004 government report stated that over 90% of the young were enrolled in school (MIDEPLAN, 2004). It is likely that greater access to education and increased years of schooling will have a long lasting ripple effect in future families of the current high school students. However, this positive trend will only show up in some 20 more years.

Beyond the socio-economic level, the community contexts in which the schools operate may differ in their urban/rural location. Schools in urban settings are more likely to have access to technical and material resources, therefore it is important to know if the schools in Chile differed from the schools in the other jurisdictions in regard to this. In Chile, 80% of the students attended a school *close to the center of a town/city* or *on the outskirts of a town/city*. In South Korea and Miami-Dade County Public Schools, more students were enrolled in urban schools (88% and 100%, respectively). In Malaysia and the Slovak Republic, substantially fewer students were enrolled in this type of school (59% and 67%, respectively). This result shows that Chile did not stand apart from the other jurisdictions in the urbanization of its schools. This finding does not support the hypothesis that the Chilean schools were less urban than the schools in the other jurisdictions.

How Different Was Chile from the Comparison Jurisdictions in the Implementation of the Mathematics Curriculum?

The mathematics curriculum (as it is implemented in the schools) influences the opportunities students have to learn different content and skills. In this dissertation study it was hypothesized that Chilean schools had poorer strategies to implement the official mathematics curriculum when compared to the schools in other jurisdictions. It was also hypothesized that Chilean students had fewer opportunities to learn the most advanced mathematics content assessed in the TIMSS 1999 test when compared to the students across the other jurisdictions. Five measures of curriculum implementation were used to test these hypotheses:

1. The schools having their own written statement of the mathematics content to be taught (other than the national or regional curriculum guides).
2. The schools having developed instructional activities or learning materials to address the mathematics curriculum.
3. Index of content coverage (advanced), based on four content areas assessed in the TIMSS 1999 mathematics test (measurement; geometry; algebra; and data representation, analysis and probability).

4. Emphasis on subject areas: basic content (whole numbers, fractions, decimals, percentages) versus advanced content (geometry, algebra, or a combination of them with other subjects).

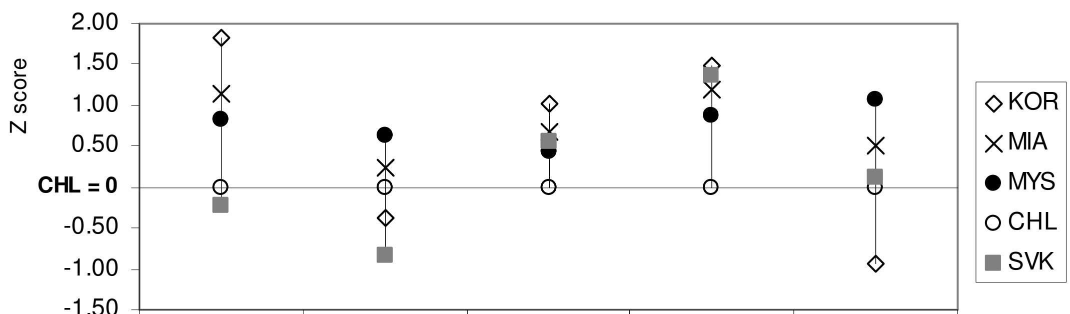
5. The schools providing additional mathematics courses to address the needs of students with different levels of knowledge and skills – remedial and/or enrichment courses

Figure 4.2 shows how the four comparison jurisdictions differed from Chile in each one of these measures. Here again, deviations from zero (the Chilean mean) were standardized so that they could be interpreted in the context of the Chilean distribution. Results indicate that Chile was lagging in terms of the implementation of the mathematics curriculum.

Chilean schools differed from the comparison jurisdictions in their development of curricular guides, materials and activities to support the teaching of mathematics. In Chile, 16% of the students were enrolled in schools with their own mathematics curriculum. Despite having more detailed and demanding official curricula than Chile, in three jurisdictions this proportion was substantially higher: South Korea (66%), Miami-Dade County Public Schools (59%), and Malaysia (47%). The Slovak Republic was the exception, with only 8% of the students enrolled in schools that had their own mathematics curriculum. However, as noted previously, the Slovak Republic has a very detailed national curriculum used for all students.

Figure 4.2

Differences in the Implemented Mathematics Curriculum
Between Chile and the Comparison Jurisdictions



	School with own math curriculum	School with own math materials	Content coverage (advanced)	Emphasis on advanced contents	Additional math courses
KOR	1.82	-0.38	1.01	1.50	-0.93
MIA	1.16	0.24	0.69	1.20	0.50
MYS	0.83	0.63	0.44	0.88	1.08
CHL	0.00	0.00	0.00	0.00	0.00
SVK	-0.24	-0.85	0.55	1.36	0.12

Note. CHL = Chile (*M* = 0, *SD* = 1), MYS = Malaysia, SVK = Slovak Republic, KOR = South Korea, MIA = Miami-Dade County Public Schools. Overall response rates by column: 88%, 94%, 95%, 94%, and 99%. Analysis weighted with TOTWGT.

Regarding the development of instructional materials and activities by the schools, findings varied. Sixty eight percent of Chilean students attended schools that had their own materials/activities. This proportion was substantially higher in Malaysia and Miami-Dade County Public Schools (98% and 80%, respectively) and lower in South Korea and the Slovak Republic (51% and 29%, respectively).

Chilean 8th graders were taught significantly less content than the students across the four jurisdictions, as shown by the index of advanced content coverage ($p < .005$, one-tailed test). It is notable that South Korea scored one standard deviation above Chile in this index.

The gap in the type of mathematics taught could also be seen in the content most emphasized by the teachers in their mathematics classes. In Chile, 73% of the students were taught by teachers who emphasized “mainly numbers.” In the comparison jurisdictions, this proportion was substantially smaller: 6% in South Korea, 12% in the Slovak Republic, 19% in Miami-Dade County Public Schools, and 33% in Malaysia.

From these analyses it is clear that Chilean teachers were not teaching the mathematical content deemed important by the international community. While some of these content were not part of the Chilean curriculum (e.g., rounding), others were not covered despite being part of it (e.g., symmetry and transformations). The lack of rigor and detail in the Chilean curriculum is partly to blame for this poor coverage. The inability of the Chilean schools to produce their own mathematics curriculum and instructional resources probably further contributed to the disparity in students' opportunities to learn mathematics.

Finally, the implemented mathematics curriculum was also evaluated by the opportunities the students had to take remedial and/or enrichment mathematics courses in their schools. In Chile, 28% of the students attended a school offering both remedial and enrichment mathematics, compared to 87% in Malaysia, 45% in Miami-Dade Public Schools, and 30% in the Slovak Republic. Only in South Korea there were fewer students than in Chile enrolled in schools that offered both courses (12%).

It is interesting to note the vast differences existing in the provision of additional mathematics courses in Chile. While 83% of the students were enrolled in schools offering remedial mathematics, only 29% were in schools offering enrichment courses. This is probably so because the learning needs of low-achievement students are given priority over the needs of their high-achievement mates in the Chilean schools.

It seems that Chilean students have few opportunities to learn advanced mathematics content. Teachers barely cover this material in their regular classes, and advanced mathematics courses are not offered in most of the schools. It is likely that the higher performing students of each school are not exposed to challenging enough classes. This situation deserves more attention from educational authorities, since previous research has shown that students in the same classes cover a wide spread of mathematics knowledge and skills (Ramírez, 2003).

It is notable that South Korea, the highest performing jurisdiction, outperformed the other jurisdictions in three out of five measures of curriculum implementation. These measures were: coverage of advanced mathematics content, emphasis on advanced contents, and schools having developed their own curriculum. This evidence supports the notion that a positive relationship exists between curriculum implementation and mathematics performance.

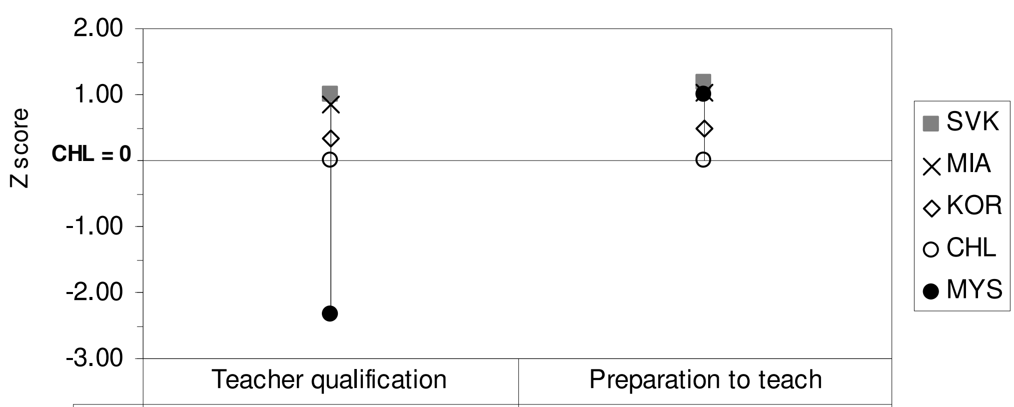
How Different Was Chile from the Comparison Jurisdictions in Teacher Quality?

In this dissertation study, it was hypothesized that Chilean students were taught by less qualified mathematics teachers than the students in the comparison jurisdictions. To test this hypothesis, an index of teacher qualification was computed by combining information from teachers' educational level, training certificate, and mathematics major.

As shown in Figure 4.3, the students in Chile were taught by less qualified teachers than the students across Miami-Dade County Public Schools, the Slovak Republic, and South Korea ($p < .005$, one-tailed test). While just 1% of the students in Chile had a teacher with a master or Ph.D. degree, this percentage increased to 15% in South Korea, 56% in Miami-Dade County Public Schools, and 97% in the Slovak Republic. In practice, Slovak teachers must have a graduate university diploma to teach (J. Kuraj, Ministry of Education Slovak Republic, personal communication, October 25, 2004). Teachers usually get their first degree in a subject area (e.g., mathematics) and then complete a master or Ph.D. in education (Vantuch, 1995).

Chilean students were taught by more qualified teachers than Malaysian students ($p < .005$, one-tailed test). This difference was largely because 19% of the Malaysian students were taught by teachers with a diploma from a technical/vocational institution. In Chile, teachers were required to have a university degree to teach; therefore almost all students (98%) were taught by teachers with a university degree.

Figure 4.3
Differences in Teacher Quality
Between Chile and the Comparison Jurisdictions



	Teacher qualification	Preparation to teach
SVK	1.00	1.18
MIA	0.86	1.02
KOR	0.34	0.49
CHL	0.00	0.00
MYS	-2.34	1.00

Note. CHL = Chile (*M* = 0, *SD* = 1), MYS = Malaysia, SVK = Slovak Republic, KOR = South Korea, MIA = Miami-Dade County Public Schools. Overall response rates by column: 99% and 99%. Analysis weighted with TOTWGT.

These findings partially support the hypothesis that Chilean students were taught by less qualified teachers than students in the comparison jurisdictions. It is unclear whether the demands of the degree required to teach in Chile were equivalent to those of Malaysia. The vocational/technical title obtained by teachers in Malaysia may in fact be superior than the training obtained in Chilean universities. For comparison purposes it would be helpful to have data on the quality and demands of the training programs instead of only having the degree title.

The relationship between average mathematics achievement and teacher qualification was not clear. Miami-Dade County teachers were among the most qualified and yet their students' mathematics performance was very poor. In contrast, South Korea had the highest mathematics scores of the jurisdictions but its teachers did not have the highest qualifications.

Another facet of teacher quality is teachers' preparation to teach a range of mathematics content. In this dissertation study it was hypothesized that teachers were less prepared to teach mathematics in Chile. This hypothesis was tested using an index of preparation to teach. Teachers evaluated how prepared they felt in a list of mathematics content. The response options were *not well prepared* = 0 point, *somewhat prepared* = 1 point, and *very well prepared* = 2 points.

The average index score in Chile was $M = 1.32$. This value indicates that Chilean 8^{th} graders were taught by teachers who felt *somewhat prepared* to instruct relevant mathematics content. In contrast, the students in the four comparison jurisdictions were taught by teachers who felt significantly better prepared to teach the contents ($M = 1.67$, $p < .005$, one-tailed test). The average index score for each jurisdiction was: the Slovak Republic $M = 1.88$, Miami-Dade County Public Schools $M = 1.80$, Malaysia $M = 1.79$, and South Korea $M = 1.56$. The data supports the hypothesis that Chilean students were taught by teachers that were less prepared than students in the comparison jurisdictions. Figure 4.3 shows the relative standing of Chile in teacher preparation, after standardizing and centering the index score in the Chilean mean.

The relationship between the index of teachers' preparation to teach and average mathematics achievement was at times contradictory. Teachers in the top performing

South Korea did not feel better prepared to teach than the teachers in the bottom performing Miami-Dade County Public Schools. This counter-intuitive finding may be the result of Korean teachers evaluating their ability to teach the extremely demanding mathematics curriculum that South Korea uses. An additional explanation is that the responses given in a self-report survey like TIMSS may be influenced by cultural differences. It seems that Asian respondents tend to under-rate their knowledge and skills, whereas more westernized respondents tend to over-rate them.

How Different Was Chile from the Comparison Jurisdictions in School Resources?

Shortages and inadequacies in school resources may affect instruction, and this in turn may affect students' mathematics achievement. In this dissertation study it was hypothesized that more students in Chile were enrolled in schools whose capacity to provide instruction was affected by scarcity of resources. This hypothesis was tested using an index of limitation of school resources. This index was based on the school principals' perceptions of the extent to which shortages or inadequacies in a list of 11 resources (e.g., library, computers) affected the schools' capacity to provide instruction. The response options were *none* = 0 point, *a little* =1 point, *some* = 2 points, and *a lot* = 3 points. [19]

[19] The percentage of valid cases for the index of school resources was 99% (across all five jurisdictions).

In Chile, the average index score was M = 1.20, which was near *a little*. This result suggests that limitations in resources had a minor effect on the capacity of the Chilean schools to provide instruction. Three jurisdictions reported significantly more resource limitations than Chile ($p < .05$). These were Malaysia, M = 1.29; the Slovak Republic, M = 1.33; and South Korea, M = 1.51. Miami-Dade County Public Schools had principals that reported fewer limitations, M = 1.15; the difference between Chile and Miami-Dade County was not significant.

These findings do not support the hypothesis that Chilean schools may be affected by more resource limitations than the schools in the comparison jurisdictions. To the contrary, Chilean schools seem to have more resources than schools in the other jurisdictions, with the exception of Miami-Dade County Public Schools.

In interpreting these results, it is important to bear in mind that the index of limitations of school resources is a subjective measure based on the principals' perceptions instead of on the objective physical conditions of the schools. This is a limitation since the principals' perceptions are probably affected by their own expectations of what the school resources should be. In fact, it is in South Korea where the principals perceived the most limitations due to scarce/inadequate resources. This stringent evaluation is likely the result of the high standards that characterize the Asian culture, rather than the actual school conditions.

To understand Chile's positive evaluation regarding school resources one needs to take into consideration the time and context. It is possible that the positive evaluation of school resources was a response to the reform efforts that have taken place during the last decade. Many Chilean schools have recently benefited from the construction of new buildings and libraries, expansion of grounds, and addition of computers. Principals may still be astonished with the improved conditions of their schools, and tend to be optimistic and generous in their evaluations.

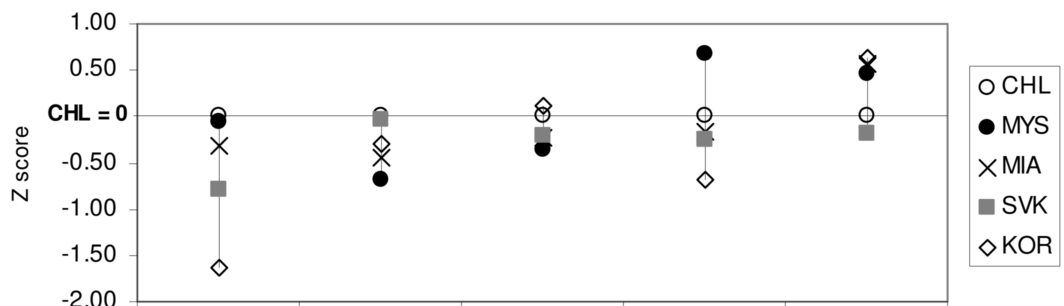
How Different Was Chile from the Comparison Jurisdictions in Students' Attitudes Toward Mathematics?

In this dissertation study, it was hypothesized that Chilean students had more negative attitudes toward mathematics than students in the comparison jurisdictions. To test this hypothesis, this study used five indicators of students' attitudes toward mathematics. Each indicator was aimed to target a different facet of the attitude construct. These indicators were:

1. Importance of mathematics
2. Importance of luck and innate talent in doing mathematics
3. Difficulty in doing mathematics
4. Liking mathematics
5. Educational expectations

The five measures were standardized and centered so that in Chile $M = 0$ and $SD = 1$. As shown in Figure 4.4, Chilean 8th graders reported that mathematics were more important for them in comparison to students from the other four jurisdictions ($p < .01$, two-tailed test).

Figure 4.4
Differences in Students' Attitudes Toward Mathematics
Between Chile and the Comparison Jurisdictions



	Importance of math	Importance of luck and talent	Difficulty of doing math	Liking math	Educational expectations
CHL	0.00	0.00	0.00	0.00	0.00
MYS	-0.05	-0.69	-0.35	0.68	0.46
MIA	-0.31	-0.45	-0.22	-0.16	0.58
SVK	-0.80	-0.04	-0.21	-0.24	-0.19
KOR	-1.63	-0.29	0.11	-0.68	0.63

Note. CHL = Chile (*M* = 0, *SD* = 1), MYS = Malaysia, MIA = Miami-Dade County Public Schools, SVK = Slovak Republic, KOR = South Korea. Overall response rates by column: 100%, 99%, 100%, 99%, and 100%. Analysis weighted with TOTWGT.

South Korea, the jurisdiction with the highest performance in mathematics, had the lowest value in the index of importance of mathematics. The low relative standing of this country should not be interpreted as Korean students not valuing mathematics. On average, Korean students *agreed* to all the questions about importance of mathematics. However, students in the other jurisdictions were more likely to *strongly agree* with the same questions.

A measurement problem may be obscuring the "real" perceived importance of mathematics in Chile. It seems that in low performing countries students tend to over-report the value of mathematics. Little is known about this phenomenon, but one plausible reason is that these students tend to compensate their "failure" in the achievement tests by answering in a socially desirable way to the questionnaires. Shen and Pedulla (2000) reported a similar phenomenon in their analysis of students' attitudes in several countries.

As expected, Chilean students reported stronger beliefs in the importance of luck and innate talent in doing mathematics when compared to students across other four jurisdictions ($p < .01$, two-tailed test). There is a strong body of research showing that students that place more emphasis on factors that are outside their reach (e.g., luck, innate intelligence) have lower academic performance than those who place more emphasis on factors such as effort and motivation (Benham, 1995). Effective teacher feedback is considered a key variable for promoting stronger beliefs in the importance of effort and motivation. The pervasive grade inflation existing in Chile (see Riveros, 2004) is probably concealing serious failures in teachers' feedback. Perhaps fewer teachers in Chile were providing effective feedback to their students in comparison to teachers in the four jurisdictions.

Students in Chile reported that mathematics were more difficult for them than students in Malaysia, Miami-Dade County Public Schools, and the Slovak Republic ($p < .003$, two-tailed test). However, it was in South Korea, the highest performing jurisdiction, where the students reported that mathematics were the hardest. Korean students scored significantly higher than Chilean students on the index of difficulty in doing mathematics ($p < .05$). This is probably the consequence of the highly demanding curriculum of South Korea.

In Chile, three-fourths of the students endorsed the statements “I like mathematics” and “I enjoy learning mathematics.” Chilean students had significantly higher scores in the liking mathematics index when compared to the students across South Korea, the Slovak Republic, and Miami-Dade County Public Schools ($p < .003$, two-tailed test). However, Chilean students scored significantly lower than Malaysian students in this index ($p < .003$, two-tailed test). This was an unexpected finding. This dissertation study hypothesized that the low mathematics performance of Chilean students was due, at least in part, to the students not liking the subject matter. More specifically, it was hypothesized that Chilean students liked mathematics less than students in the other four comparison jurisdictions.

In Chile, 43% of the 8^{th} graders planned to graduate from a university; another 40% planned to study in a vocational/technical institution after secondary school. These were very high expectations for a country where only half of the adults have finished secondary school (MIDEPLAN, 2004). Nevertheless, students’ expectations in Chile were significantly lower than across South Korea, Miami-Dade County Public Schools, and Malaysia ($p < .003$, two-tailed test). Only students in the Slovak Republic reported significantly lower educational expectations than students in Chile ($p < .05$, two-tailed test). These results partially support the hypothesis that Chilean students may have lower expectations for further education, compared to students in the other jurisdictions.

Summarizing, it is unclear whether Chilean students had more negative attitudes toward mathematics when compared to the students in other jurisdictions. While some facets of the attitudes construct confirm the research hypothesis, others clearly do not.

How Different Was Chile from the Comparison Jurisdictions in a Combination of Background Variables Taken Together?

In the previous section, separate comparative analyses were presented for five dimensions related to mathematics achievement. These were: a) the socio-economic level of the students' families, b) the mathematics curriculum as it was implemented in the schools, c) teacher quality, d) school resources, and e) students' attitudes toward mathematics. The variables used as indicators of these dimensions were expected to covary. For instance, higher socio-economic levels are usually associated with more qualified and better prepared teachers, more school resources, and with students' that have more positive attitudes. Since these background variables are not always independent of one another, this section considered them together.

This section addresses the following question: Is the combination of background variables different for Chile than for the comparison jurisdictions? It was hypothesized that the answer would be yes. Only a subset of the variables already examined was selected for the combined analyses. Criteria for selecting these variables were that they must represent different dimensions of the educational process, and that they had shown significant differences among the jurisdictions in the previous analyses. The four selected variables were: a) students' socio-economic index, b) teachers' report on coverage of advanced mathematics content, c) teachers' report on preparation to teach, and d) students' perceptions of the importance of luck and innate talent in doing mathematics.

The first step of the combined analysis explored if the selected variables had the expected inter-relationships. Within each jurisdiction, Pearson's correlations were computed for each pair of variables; and then the pairwise *r*s were averaged (Table 4.2). Against expectations, the average correlations were low. The strongest correlation was between socio-economic level and importance of luck and innate talent ($r = -.198$). In all cases the direction of the correlations were according to expectations: higher socio-economic level was associated with increased content coverage, teacher who felt better prepared to teach, and students who relied less on luck and innate talent.

Table 4.2
Pooled Within-Jurisdictions Correlations for Four Background Variables (N = 2,219)

Variable	1	2	3	4
1. Socio-economic level	--			
2. Content coverage (advanced)	.024	--		
3. Preparation to teach	.077	.115	--	
4. Importance of luck and innate talent	-.198	-.035	-.029	--

Note. Valid cases across all five jurisdictions = 88%. Analysis weighted with SENWGT.

The low correlation among these variables was an unexpected finding. These correlations should be interpreted with caution. Some variables were continuous, while others categorical; some variables were measured at the school/class level, while others at student-level. Correlations between school/class means and individual variables are constricted.

As a follow up, a multivariate analysis of variance (MANOVA) was used to estimate to which extent the four variables combined varied as a function of the jurisdictions (see upper-half of Table 4.3). The omnibus test showed that there were significant differences among the jurisdictions in the combined set of variables, $F(16, 6755) = 96$, $p < .0005$. The univariate analyses revealed that there were significant differences in all four variables depending on the jurisdiction ($p < .0005$). These associations were not very strong, with the proportion of variance accounted for the jurisdictions ranging from $\eta^2 = .26$ (teachers' preparation) to $\eta^2 = .08$ (students' beliefs in luck and innate talent).

A multivariate test was performed comparing Chilean students with the students of the other four jurisdictions. As shown in the bottom-half of Table 4.3, the results indicated that the combined variables differed significantly between Chile and the four jurisdictions taken together, $F(4, 2214) = 24$, $p < .0005$. Univariate statistics showed that there were significant differences between Chilean students and students across the comparison jurisdictions for all variables under analysis ($p < .004$). The strength of the associations were not strong, with the proportion of variance accounted for by the grouping ranging from $\eta^2 = .18$ (teachers' preparation) to $\eta^2 = .03$ (students' beliefs in luck and innate talent).

Table 4.3

Multivariate and Univariate Results

	Wilk's	df	MS	*F*	*p*
Omnibus analysis					
Multivariate test	.53	16/6755		96.19	<.0005
Univariate tests					
Socio-economic level		4/2214	64.94	76.26	<.0005
Content coverage (advanced)		4/2214	14.21	79.01	<.0005
Preparation to teach		4/2214	24.68	204.27	<.0005
Importance of luck and innate talent		4/2214	17.14	49.91	<.0005
Planned comparison: Chile versus the four jurisdictions combined					
Multivariate test	.96	4/2214		23.87	<.0005
Univariate tests					
Socio-economic level		1/2217	29.93	31.37	<.0005
Content coverage (advanced)		1/2217	2.00	9.81	.002
Preparation to teach		1/2217	11.35	70.90	<.0005
Importance of luck and innate talent		1/2217	3.32	8.91	.003

Note. Valid cases across all five jurisdictions = 88%. Analysis weighted with SENWGT.

Modeling Mathematics Achievement in Chile

In this section, the aim is to understand the relationship between the background variables and mathematics achievement in Chile. Mathematics achievement was modeled at two levels: the school/class level and the students-within-schools/classes level. These levels matched the cluster design of the TIMSS sampling. Before modeling achievement, however, the distribution of the achievement scores within and among the schools/classes was examined.

In TIMSS 1999, Chile had a mean mathematics score of M = 395 and a standard deviation of SD = 84.[20] This implied that 95% of the students got between 230 and 560 score points on the mathematics test. The partition of the achievement variance revealed that 39% of the differences in mathematics scores were among the schools/classes. Schools/classes in Chile seemed to differ more than in the comparison jurisdictions. For TIMSS 1995, Beaton and O'Dwyer (2002) reported that 27% of the achievement spread was among the schools/classes in the Slovak Republic, and just 6% in South Korea. While Malaysia and Miami-Dade County did not participate in TIMSS 1995, the authors reported that 51% of the achievement spread was among the schools/classes in the United States.

In Chile, the educational system is highly segregated by social class. Results indicate that students from more affluent communities were clustered together in higher performing schools and students from socially disadvantaged backgrounds were clustered in lower performing schools. In fact, 43% of the socio-economic variance was among schools/classes. Socio-economic level was the strongest predictor of mathematics achievement. This variable alone accounted for 69% of achievement dispersion among the schools/classes.

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[20] These numbers do not exactly replicate the ones in the TIMSS 1999 international report because of differences in the number of valid cases.

Among the schools/classes, the differences in average mathematics scores were substantial: the lowest performing school/class had an M = 298 scale points and the highest performing had an M = 613 scale points. The differences were so large that the achievement distributions of these two schools/classes did not overlap. The maximum score in the bottom performing school was Max = 402 scale points, the minimum score in the top performing one was Min = 512 scale points.

What Factors Accounted for the Differences in Mean Mathematics Achievement Among the Schools/Classes?

The research questions of this dissertation study asked about the relationship between background variables important for learning and mathematics achievement in Chile. This section addresses these questions by modeling mathematics achievement at the school/class level. Six hierarchical models were tested (Table 4.4). These were primarily cumulative models that added successive sets of explanatory variables. Each new set of variables focused on a different dimension of the school context: the implemented mathematics curriculum, teacher quality, school resources, schools' community contexts, and school administration.

The following paragraphs present the rationale underlying each model, with a justification of the variables used to predict achievement. The hypotheses that guided the analyses are stated, and the statistical results are presented and interpreted.

Table 4.4

Models of Mathematics Achievement at the School/Class Level ($N_j = 182$)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Among schools/classes variance accounted for by model (R^2)	30%	30%	34%	72%	72%	69%
Reliability	.95	.95	.94	.87	.87	.88
	B (SE)	*B (SE)*	*B (SE)*	*B (SE)*	*B (SE)*	*B (SE)*
Mean mathematics score	388 (8.8)	363 (6.7)	367 (6.6)	382 (5.3)	385 (3.2)	391 (2.7)
IMPLEMENTED MATHEMATICS CURRICULUM						
School curriculum (0 = no, 1 = yes)	67.8** (11.5)	67.5** (11.7)	61.9** (11.3)	23.1** (7.9)	22.1* (8.8)	
School materials/activities (0 = no, 1 = yes)	19.5** (7.3)	18.8* (7.4)	17.2* (7.1)	2.5 (5.0)		
Content coverage (general)^z	5.1 (4.0)	5.2 (4.0)	5.3 (3.9)	4.5* (2.2)	4.8* (2.3)	
Subject emphasis (0 = basic, 1 = advanced)	15.0 (8.7)	13.5 (8.9)	10.6 (8.8)	3.5 (5.9)		
Additional math courses^z	-0.3 (3.8)	-0.3 (3.8)	-1.6 (3.7)	1.5 (2.4)		
TEACHER QUALITY						
Teacher qualification^z		1.9 (4.0)	2.0 (3.8)	-0.6 (2.3)		
Preparation to teach^z		2.5 (3.6)	1.0 (3.6)	-5.1 (2.7)		
SCHOOL RESOURCES						
Limitations in school resources^z			-11.9** (3.7)	-0.5 (2.4)		
SCHOOLS' COMMUNITY CONTEXT						
Socio-economic level^z				39.5** (3.5)	38.2** (3.1)	44.1** (2.8)
Urban level (0 = rural, 1 = urban)				4.1 (5.1)		
SCHOOL ADMINISTRATION						
School administration (0 = public, 1 = private)					6.7 (5.9)	

Note. Hierarchical linear models with random intercepts weighted with HOUWGT.
Method: Restricted maximum likelihood with robust standard errors.
Valid cases = 98% of the schools/classes sample. $^{**}p < .01$. $^{*}p < .05$.
^{z} Standardized variable.

Model 1: The implemented mathematics curriculum. Curriculum-related variables can be considered the foundation for the delivery of quality instruction. For example, curriculum documents are often the primary method of conveying the material to be taught to teachers. As described in Chapter 3, the Chilean mathematics curriculum, distributed by the Ministry of Education, provided a framework for the schools to develop their own curriculum (i.e., program of study) instead of a detailed set of learning goals. Therefore, the official curriculum did not specify the mathematics objectives in a useful way for schools and classroom teachers. Moreover, there were no official documents providing instructional materials and activities to help the schools and teachers reach these objectives. Since schools had the responsibility of developing their own detailed objectives and making decisions about their instructional materials, great variation was expected in the way the schools implemented the official curriculum. It was expected that a greater coverage of TIMSS mathematics content topics in the implemented curriculum would be associated with higher mathematics achievement. Due to these assumptions, priority was given to the inclusion of variables measuring the implemented curriculum in the first model tested in this study.

Model 1 analyzed the relationship between mathematics achievement and five curriculum-related variables: school curriculum (dummy variable), school instructional materials/activities (dummy variable), coverage of mathematics content, subject emphasis (dummy variable), and provision of additional mathematics courses.

This study hypothesized that schools that had their own curriculum and instructional materials/activities would attain higher mathematics scores than schools that did not. The content coverage variable measured the "depth and breadth" with which the teachers covered the mathematics content topics assessed by TIMSS 1999. It was hypothesized that increased content coverage would lead to increased mathematics performance. In teaching mathematics, some teachers emphasized "mainly numbers," while others emphasized more advanced areas like algebra and geometry. This study hypothesized that increased emphasis on advanced content areas would be associated with higher mathematics achievement. There is a wide range of mathematics knowledge and skills among students in the same schools/classes. In this dissertation study it was hypothesized that schools providing additional mathematics courses (i.e., remedial, enrichment) to address the needs of students with different performance levels would attain higher mathematics scores than schools that did not.

In Model 1, the characteristics of the implemented mathematics curriculum accounted for 30% of the achievement variance among the schools/classes. Of the five indicators of curriculum implementation, two were highly significant. These were the schools/classes that had their own mathematics curriculum ($p < .0005$), and the schools/classes that had their own instructional materials/activities ($p < .009$). These results confirm the hypothesis that teachers in schools that had developed their own mathematics curriculum, as well as instructional materials and activities, would be in a better position to implement effective mathematics instruction.

It appears that having a detailed curriculum and adequate instructional materials go a long way toward ensuring content coverage. Content coverage and subject emphasis both were significant predictors when entered alone in the equation ($p < .049$; not shown in Table 4.4), but were not significant predictors of achievement when combined with schools having their own curriculum and instructional materials. Thus, their lack of significance in Model 1 must be interpreted as the consequence of their inter-correlation with school curriculum and instructional materials. In schools having their own curriculum and instructional materials, teachers were likely to cover more mathematics content topics and to emphasize more advanced topics.

Contrary to expectations, the provision of additional mathematics courses was not a significant predictor of mathematics achievement. This was in fact the case in all models tested in this dissertation study. More information about the nature of these courses is needed to interpret this finding.

Model 2: Teacher quality. Since teachers have the responsibility of delivering the mathematics curriculum at the classroom level, they play a key role in mediating between the curricular policies and the students' learning processes. Because research has shown that teacher quality and achievement are positively related (Mayer et al., 2000; Mullis, Martin, Gonzalez, et al., 2000), there is concern in Chile about how well prepared teachers are to fulfill their role.

In Model 2, indicators of teacher quality were combined with the implemented curriculum variables. The new indicators were:

1. Teacher qualification. This variable measured a) how far teachers advanced in their formal education; b) if they had a teacher certificate; and c) if they majored in mathematics in their undergraduate and/or graduate programs.

2. Teacher preparation. This variable measured how well prepared the teachers felt to teach different mathematics content.

In this study it was hypothesized that the more qualified teachers and the teachers who felt better prepared to teach a variety of mathematics content topics would have students with higher mathematics achievement.

The percentage of variance accounted for by Model 2 remained the same as the previous model (30%). In combination with the curriculum-related variables, neither of the teacher quality variables made a significant contribution to explaining variation in achievement. School curriculum and school materials/activities remained the only significant predictors of achievement ($p < .012$).

Nevertheless, it should be emphasized that teacher preparation was a significant predictor of achievement when analyzed alone ($p = .044$, not shown in Table 4.4). However, when school curriculum, school materials/activities, and content coverage were included with teacher preparation, the contribution of this variable was negligible. It appears that better prepared teachers were more likely to work in schools that had their own math curriculum and materials/activities; these teachers were also more likely to cover more mathematics content in classes.

In this dissertation study, it was expected that higher-qualified teachers would have higher-achieving students in mathematics. However, a closer look at the data showed that all teachers in Chile had basically the same qualification level – a bachelor university degree with a teacher-training certificate. The lack of variance in teacher qualification level probably explains its lack of significance in explaining between-school variation in mathematics achievement.

Model 3: School resources. The provision of quality mathematics instruction can be facilitated by availability of school resources, such as instructional space, libraries and computers. Shortages or inadequacies of these resources may affect the school capacity to provide quality instruction (Mullis, Martin, Gonzalez, et al., 2000). In Chile, where schools are organized into different systems, it was expected that this variable could have a substantial impact on achievement. School resources are unevenly distributed between the public and private systems, with the private systems having more resources.

Because some schools have more resources than others, the third model encompassed the curriculum and the teacher variables, plus a variable measuring the extent to which limitations in resources affected the schools' capacity to provide instruction. It was hypothesized that limitations in school resources would have a negative partial effect on the achievement outcome.

Model 3 accounted for 34% of the achievement variance among the schools/classes, i.e., four percentage points more than the previous models. According to the given hypothesis, limitations of school resources had a negative effect on achievement, having controlled statistically for the effect of the other predictors in the model (b = -11.9, p = .002). School curriculum and school materials/activities remained significant ($p < .016$), while the other predictors in the equation did not.

Model 4: Schools' community contexts. All previous models looked at achievement in relation to school-related variables, without taking into account the effect of socio-economic level. However, it is well known that mathematics achievement is strongly related to the socio-economic level of the communities served by the schools (Beaton & O'Dwyer, 2002; Coleman et al., 1966; Ramírez, 2003). The importance of socio-economic level in Chile could be even greater considering that the school systems are strongly segregated by social class (Mella, 2003).

Beyond the socio-economic level, the urban/rural status of schools may also affect their capacity to provide quality instruction. Rural schools usually work in more socially deprived contexts and are more isolated than urban schools. In Chile, rural schools have lower academic achievement than urban schools serving communities with the same socio-economic background (Mizala & Romaguera, 2000; Ramírez, 2003).

Because of the well-documented importance of socio-economic level, Model 4 tested the simultaneous effect of two school community variables – socio-economic level and urban/rural status of the school – together with the previously described indicators of the implemented curriculum, teacher quality, and limitations of school resources. This model accounted for 72% of the mean achievement differences among the schools/classes, which was more than double the amount accounted for in the previous model. The partial regression coefficient of socio-economic index was positive and highly significant ($b = 39.5$, $p < .0005$). This result vividly illustrates the consequences of having Chile's school systems so closely aligned with socio-economic status.

The urban/rural status of the school community was not a significant predictor of achievement, when analyzed together with socio-economic level and other predictors in the equation ($p = .42$). This was most likely because more affluent schools tend to be located in urban areas and poorer schools in rural areas.

Schools having their own mathematics curriculum remained a significant predictor in Model 4 ($p = .004$). However, in combination with stronger socio-economic indicators, schools having their own instructional materials/activities and adequate resources had less explanatory power. Instead, greater content coverage emerged as having a significant effect on mathematics achievement ($p = .04$). With the structure of the Chilean system so closely aligned with socio-economic status, it could be easy to overlook the importance of teaching an effective curriculum. Yet, in each subsequent analysis, the importance of this factor is apparent.

Model 5: School administration. Model 5 evaluated the combined effect of the four most powerful predictors: school administration (public/private), school socio-economic level, schools having their own curriculum, and extent of content coverage. These variables accounted for 72% of the variance between schools/classes in mathematics achievement – the same proportion than the previous model.

As explained previously, schools in Chile are organized and administered by different systems that are directly associated with socio-economic background. The public schools tend to serve the students from the lower end of the socio-economic distribution, while private schools (private-subsidized and elite-paid) serve the students from the middle and upper end of the distribution. Thus, it was important to examine the effect of school administration (public/private) in combination with socio-economic level and curriculum variables to see if type of school system, in and of itself, explained any variation in mathematics achievement.

It also was interesting to examine the impact of curriculum and content coverage in relation to the type of school administration and socio-economic level. It would seem that the schools in the private system would be more likely to be able to afford to produce their own curriculum and facilitate greater classroom coverage of mathematics content, while the schools in the public system may have had to struggle with the less specific national curriculum.

Among the variables included in Model 5, as anticipated, socio-economic level was the strongest predictor of mathematics achievement (b = 38.2, $p < .0005$). However, school curriculum and content coverage also had significant effects on mathematics achievement ($p = .012$ and $p = .034$, respectively). The model predicted that a school with its own curriculum would score 22 score points higher than a similar school without its own curriculum, holding constant the other variables in the model. This was a substantial difference considering that the achievement gap between 7^{th} and 8^{th} graders in Chile was 33 score points (Ramírez, 2004).

Finally, an additional model was built to examine how much added variance was accounted for by the fifth model, in comparison to a model that only used socio-economic level as a predictor. The socio-economic level of the school community accounted for 69% of the between-school/class variance in mathematics achievement (Model 6 in Table 4.4), almost the same percentage (72%) that was accounted for by the model that evaluated the combined effect of school administration, school curriculum, content coverage, and socio-economic level. This finding suggests that, in Chile, school assets are distributed along socio-economic lines. Schools working in socially advantaged backgrounds are more likely to have their own curriculum and their teachers are more likely to have covered more mathematical content in their classes.

What Factors Accounted for the Differences in Mathematics Achievement Among Classmates?

All the models presented in the previous section attempted to explain the achievement variance at the school/class level. They used predictors that were constant for all students within a school/class. As a consequence, these models were not designed to account for the achievement dispersion that was within the schools/classes.

Results indicate that, in Chile, 61% of the achievement variance was within the schools/classes. Classmates covered a wide range of achievement scores. In a typical middle-performing school/class, mathematics scores approximately ranged from 250 to 524 score points. On average, the schools/classes had an achievement range of 274 score points. This average was equivalent to slightly more than three standard deviations in the national achievement distribution. This implies that students who could apply their knowledge and skills to solve mathematical problems and students who could not even do basic computations with whole numbers, shared the same schools/classes.

This section aims to further understand the achievement differences among classmates in the same schools/classes. Since students' attitudes toward mathematics are expected to vary among classmates, they were used as predictors of mathematics achievement at the students-within-schools/classes level. In this dissertation study it was hypothesized that students with more positive attitudes toward mathematics had higher mathematics scores.

Chilean students reported very positive attitudes toward mathematics. Practically all (99%) endorsed the statement (*agreed* or *strongly agreed*) "it is important to do well in mathematics," and 73% reported liking this subject area. Considering the poor average performance of Chile in the TIMSS 1999 test, it was surprising that 41% of the students reported that "mathematics is an easy subject," while up to 77% endorsed the statement "I usually do well in mathematics." Half of the students (51%) reported that "to do well in mathematics you need good luck," and 43% aspired to "finish university." As mentioned in the comparative results section, students may have answered in a socially desirable way to some of these statements.

As explained in Chapter 3, most of these source variables were combined into indicators that measured different facets of the attitude construct. Five indicators were used as predictors in the achievement models: a) liking mathematics, b) importance of mathematics, c) difficulty in doing mathematics, d) importance of luck and innate talent in doing mathematics, and e) educational expectations.

Table 4.5 presents the predictive models at the students-within-schools/classes level. Model 1 used the five attitudes variables, and accounted for 22% of the within schools/classes achievement variance. The results only provided partial support for the hypothesis that students' attitudes toward mathematics were positively related to mathematics achievement. Only three of the five predictors had a significant partial association with the outcome.

According to expectations, students reporting that mathematics were more difficult for them had significantly lower mathematics scores than their classmates, conditional on the other variables in the model (b = -21.7, p < .0005). This finding is consistent with those reported by Howie (2002) in South Africa and by Nasser and Birenbaum (2004) in Israel.

Table 4.5
Models of Mathematics Achievement at the Students-Within-Schools/Classes Level (N = 5,702)

	Model 1		Model 2	
	R^2	$R_{xx'}$	R^2	$R_{xx'}$
	22.3%	.96	22.4%	.96
Variables	*B*	(*SE*)	*B*	(*SE*)
Mean mathematics score (intercept)	391	(4.2)	391	(4.2)
Liking mathematics	-0.9	(2.9)	-0.9	(2.9)
Importance of mathematics	-0.1	(1.3)	-0.2	(1.4)
Difficulty in doing mathematics	-21.7**	(1.7)	-21.6**	(1.7)
Importance of luck and innate talent	-11.1**	(1.9)	-11.0**	(1.9)
Educational expectations	10.1**	(1.2)	9.9**	(1.3)
Socio-economic level			1.3	(3.1)

Note. All the predictors were standardized and group-mean centered. Method: Restricted maximum likelihood with robust standard errors. Analysis weighted with HOUWGT. Valid cases = 97% of the student sample. **p < .0005.

Also according to expectations, students reporting a stronger belief in luck and innate talent also attained significantly lower scores than their classmates, net the effect of the other variables in the model (b = -11.1, p < .0005). This result is consistent with the literature on locus of control and with previous studies using the TIMSS data (Benham, 1995; Stemler, 2001).

There was a positive partial association between students' educational expectations and the outcome, hence students who expected to go further in their formal education (e.g., finish university) attained higher mathematics scores than their classmates with lower expectations (b = 10.1, $p < .0005$). Again, this finding was consistent with previous studies of educational attainment (Martin, Mullis, Gregory, et al., 2000).

In Chile, liking mathematics and the importance of mathematics were not significant predictors of mathematics achievement, once the other variables in the model were held constant ($p > .77$). This was an unexpected finding that did not support the results of previous studies (Howie, 2002). The lack of significance of these indices may be better understood bearing in mind the tendency of Chilean students to report very positive feelings toward mathematics, resulting in the low variability of these predictors.

Model 2 was used to test the partial effect of the students' socio-economic level on achievement, when analyzed together with the attitudes variables. The same predictors reported as significant in the first model were also significant in Model 2. These were difficulty of doing mathematics, importance of luck and innate talent, and educational expectations. Results also indicate that classmates with a more advantaged socio-economic background did not attain higher mathematics scores than their classmates with more disadvantaged backgrounds, after controlling statistically for the other variables in the model ($p = .68$). This finding is consistent with previous studies that show that once students are allocated to classes and schools, their cultural background is not a significant predictor of academic performance (Beaton & O'Dwyer, 2002).

Summary of Findings

This dissertation study found that Chilean students had a more socially disadvantaged background than the students in South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools. Chilean schools were also more economically segregated than the schools in the comparison countries. Chilean students were taught significantly fewer advanced mathematics topics than the students across the four comparison jurisdictions. While most of the Chilean students were taught by teachers who emphasized "mainly numbers," less than one-third of the students in the other jurisdictions were taught by teachers doing so. Chilean students were also taught by teachers who felt less prepared to teach a variety of mathematics topics, when compared to the students across the four jurisdictions. These findings confirm the hypotheses of this study.

However, other results ran against the stated hypotheses. Chile did not stand apart from the other jurisdictions in schools' having their own curriculum, schools' having their own instructional resources, schools' offering additional mathematics courses, school resources, and teacher qualifications. Chilean students did not have more negative attitudes toward mathematics, when compared to the students across the other jurisdictions.

To study impact of important education variables in relation to mathematics achievement in Chile, several predictive models were tested using hierarchical linear models. At the school/class level, a model that included school-related indicators (implemented mathematics curriculum, teacher quality, and school resources) and schools' community variables (socio-economic level and urban/rural location) accounted for 72% of the achievement variance. Another model that only included a socio-economic variable accounted for 69% of the achievement variance among the schools. This finding suggests that, in Chile, school assets are unevenly distributed. Schools serving more affluent communities were more likely to have their own curriculum, better prepared teachers, and better instructional resources, when compared to schools working in more socially deprived contexts.

Because school and community factors were closely interwoven, their unique effect on the achievement outcome could not be isolated. Nevertheless, two school-related variables were shown to have a significant partial effect on the outcome: school curriculum and content coverage. This result suggests that schools having their own mathematics curriculum and whose teachers covered more content attained significantly higher mathematics scores than schools without their own curriculum and whose teachers covered less content in classes. This achievement gap holds true when comparing schools having the same type of administration (public/private) and working in similar social contexts.

At the students-within-school/class level, students' expectations for further education, perceived difficulty of doing mathematics, and beliefs in luck and innate talent were significant predictors of mathematics performance. Liking and the importance of mathematics were not associated with achievement. This was mainly the consequence of almost all the Chilean students reporting that they liked mathematics and found this subject important.

CHAPTER 5

CONCLUSIONS

This chapter begins with an overview of the problem under investigation, followed by a statement of the main purposes of this dissertation study. Next, central findings are presented. Results are discussed and policy implications for the Chilean education system are raised.

The TIMSS 1999 test revealed that the mathematics knowledge and skills of Chilean 8th graders were far below than expected. Only half of the students showed evidence of mastering basic computations with whole numbers, and just 15% could apply mathematical concepts in straightforward situations. The highest performing students scored similarly to the average students in South Korea, Malaysia, and the Slovak Republic (Mullis, Martin, Gonzalez, et al., 2000, chap. 1). Chilean students lagged a whole school year behind when compared to the students in Miami-Dade County Public Schools (see Ramírez, 2004).

This dissertation study aimed to understand better why Chile was lagging behind in educational achievement when compared to other countries with similar economic conditions, or when compared to United States districts serving high proportions of low-income students. Mathematics achievement and background characteristics of the Chilean students were compared to similar data from South Korea, Malaysia, the Slovak Republic, and Miami-Dade County. This dissertation study also aimed to better understand how important characteristics of the Chilean educational system could account for poor student achievement in mathematics.

The results of this study suggest that commonly used economic indicators (e.g., gross national product) veil important differences in the cultural capital of the nations. Chilean students come from a more disadvantaged social background than the students in South Korea, Malaysia, the Slovak Republic, and Miami-Dade County. Chilean students have fewer educational resources at home (e.g., books, computer, study desk), and their parents have less education than those in the comparison jurisdictions. For instance, while slightly more than one-third of the Chilean students reported that their mothers finished secondary school, this proportion reached 50% in Malaysia. In South Korea, the Slovak Republic and Miami-Dade County, parents have even more years of education than parents in Malaysia. The low cultural capital of the Chilean families seems to be accounting for an important proportion of the achievement differences between Chile and the comparison jurisdictions.

Chile only expanded its educational system recently. As a consequence, Chilean families have a poor cultural capital. Chile reached almost universal enrollment in primary education during the 1990s. In South Korea, the Slovak Republic, and the United States, this goal was accomplished during the 1950-60s. It seems that Chile needs to overcome the educational deficits of the previous generation.

Because of the poor educational level of the Chilean population students' parents are not in a position to provide strong educational support at home. Nevertheless, parental support at home is important for the students to learn at school (Reynolds & Teddlie, 2000). Chile needs to find viable ways to maximize parental involvement. One way to do that may be to provide parents with more and better information about their child's school. For instance, parents may receive school reports with national and local norms, and with the percentage of students reaching proficiency levels.

Parental involvement may also be increased by providing parents with reports of how their children are doing in the school according to the curricular objectives. The pervasive grade inflation existing in Chile is probably playing against parental involvement. As noted by Stevenson and Stigler (1992), when parents are (wrongly) told that their child is doing well in the school, this creates a sense of satisfaction that becomes an obstacle for improving education. Setting clear performance standards and more rigorous evaluation criteria in the classrooms may indirectly contribute to engage Chilean parents in their children education.

The socio-economic level of the students' families (which takes into account parents' education) is strongly related to mathematics performance in Chile. Schools serving socially advantaged communities show substantially higher mathematics scores than schools working in socially deprived areas. This achievement gap is, in part, the outcome of the differential educational resources students have at home. A student would be in a better position to learn at school if he/she has literate parents who can help with the schoolwork, and if he/she has books and a computer at home.

However, the achievement gap among Chilean schools is also impacted by the unequal distribution of school assets between high- and low-income schools. This study found that schools in more affluent communities are more likely to have more and better instructional resources and also more likely to hire better prepared teachers. These teachers, in turn, are more likely to emphasize advanced mathematics topics. Schools serving affluent communities are also more likely to develop their own curriculum or program of study, instructional materials, and activities; these are important resources since the national curriculum provided little guidance on the subject of what to teach and how to teach it. These findings are consistent with previous studies reporting the unequal distribution of school resources (and opportunities to learn) among schools, and the correlation between school resources and socio-economic level. As stated by Gau (1997), low-income students' disadvantaged situation is compounded as they receive less educational support at home and have fewer opportunities to learn at their local schools. To provide low- and middle-income students with access to quality education is a pending task in Chile.

Another relevant finding of this dissertation study is that Chile has the most economically segregated educational system, when compared to South Korea, Malaysia, and the Slovak Republic. Chilean students vary widely in their socio-economic levels, and this variance is clearly structured in the school system. In general terms, public schools serve the lower-class, private-subsidized schools serve the middle-class, and the elite-paid schools serve the upper-class. While economic segregation in the school system is a common phenomenon around the world (Beaton & O'Dwyer, 2002), none of the comparison countries have the degree of segregation observed in Chile.

South Korea offers an interesting example of a highly privatized school system that has no economic segregation. In this country, one-third of the schools are private but funded by the state (similar to the private-subsidized schools in Chile). Both public and private schools demonstrate very advanced (and very similar) academic performance. The motto behind this success seems to be that the same rules of the game apply for all the schools that receive public funds, no matter if public or private. For instance, Korean students are assigned at *random* to a school in their residential area, regardless if it is public or private. Korean parents have to pay a fee from grade 7 onward in all state funded schools. The only difference between public and private schools is that the former are administered by the local government and the latter are administered by religious congregations.

In this study, special attention was given to the mathematics curriculum and the role it played in explaining the poor performance of Chilean students. At the time of the TIMSS 1999 data collection, the official curriculum in Chile had no more than three pages. This document listed the mathematics objectives to be reached by Chilean 8th graders. The curriculum was deficient; it was the least specific when compared to the curriculum of the other jurisdictions, and covered the least content and cognitive skills.

The idea behind this limited curriculum was that the schools would use it by adding their own curricular proposals or programs of study. The Chilean curriculum was more of a framework for schools to develop their own curriculum, than a curriculum in itself. In practice, only a small group of schools developed their own curriculum (around 16%); most of these schools were from the elite-paid and private-subsidized systems. Public schools, which served a more socially deprived population, lacked the necessary resources to develop their own curriculum.

It seems that having a school curriculum was necessary to operationalize the curricular mandates. Not surprisingly, schools having their own curriculum performed significantly better than the schools that did not. The achievement gap between the former and the latter was equivalent to two-thirds of a school year. This difference held true after controlling statistically for the schools' socio-economic level and type of administration (public/private).

Nowadays, Chilean schools have a more rigorous and detailed national curriculum than in 1998, when data was collected for this dissertation study. The new curriculum may serve as a leading force to improve other important areas of the educational system. By providing clearer performance standards, the new curriculum should better support teachers in choosing what to teach, in preparing their classes, and in grading their students' performance. The Ministry of Education should closely monitor the extent in which the new curriculum is changing teaching practices.

The new curriculum could be used to boost teacher-training programs. Universities should prepare future teachers in how to teach the reformed curriculum. A teacher certification exam may be used to ensure that the future teachers master the new curriculum, and that they are prepared to teach the advanced mathematics knowledge and skills stated in it.

Beyond the official curriculum, it is the curriculum delivered in classes that actually shapes students' opportunities to learn mathematics. In Chile, the gap between the official curriculum and the "delivered" one is substantial. While 8^{th} grade students should be studying geometry and algebra, most of them study basic mathematics content in their classes (Mullis et al., 2000, chap. 5). An important finding of this dissertation study is that Chilean students have significantly fewer opportunities to learn advanced mathematics content, when compared to the students across South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools.

The lack of rigor and detail of the pre-reform curriculum is partly to blame for this poor content coverage. However, it is possible that Chilean teachers do not introduce new content because of the already poor mathematics skills of their students. While slowing down to match the skills of students may be appropriate, it is necessary to highlight the tradeoffs of this approach. It seems that Chilean students are not provided with enough opportunities to learn the advanced mathematics content stated in the national curriculum. The advanced mathematic content is what standardized tests regularly assess.

Another factor that may be contributing to the poor coverage of mathematics content is that Chilean teachers do not feel prepared to teach it. If teachers teach what they barely know, the quality of instruction will suffer. Chilean students are taught by teachers who report feeling *somewhat prepared* to teach a variety of mathematics content – including algebraic representations, coordinate geometry, and data analysis. In South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools, students are taught by teachers who feel significantly better prepared to teach mathematics. This situation urges the Chilean authorities to pay more attention to pre- and in-service teacher preparation programs.

Chilean teachers report substantial variation in the amount of mathematics content covered in their classes. This dissertation study found that there is a positive relationship between content coverage and mathematics performance. This relationship holds true after controlling statistically for schools' socio-economic level and type of administration (public/private). This finding is consistent with previous studies reporting a positive relationship between students' opportunities to learn and mathematics achievement (Gau, 1997; Secada, 1992).

Because the analyses presented in this cross-sectional study are correlational in nature, the association between variables should not be interpreted as definite causal effects. Correlations may suggest a causal relationship but, ultimately, further research is required to establish cause and effect. Hence, causal interpretations should be interpreted with prudence.

Self-report surveys like TIMSS are useful to study the opinions and beliefs of students, their teachers and principals. However, these instruments also have limitations that the reader needs to be aware of. Some students may answer in a socially desirable way to some questions, or may have a tendency to *agree* with every single statement in a questionnaire. It seems that these tendencies are somewhat stronger in countries with low academic achievement like Chile. Another limitation is that respondents from different cultures tend to answer in somewhat different ways to the same questions. For instance, Korean students seemed to be very strict to evaluate their mathematics skills, whereas Chilean respondents seemed to be more lenient in evaluating themselves. Similarly, Chilean principals were very generous in evaluating their school resources; this was probably because their schools have recently benefited from increased resources. In contrast, Korean principals seemed to have higher expectations about what the school resources should be.

In Chile, the debate about how to improve academic achievement usually points to structural factors such as school resources, the curriculum, or teacher quality. Little attention has been given to students' characteristics such as how much they like mathematics, how do they perceive themselves doing mathematics (self-perception), and what factors they believe affect their mathematics performance.

The findings of this study show that Chilean students' attitudes toward mathematics are very positive. Practically all of them think it is important to do well in this area, and three-fourths report liking mathematics. These are good strengths for learning and instruction. Unfortunately, Chilean students seem to have an extremely high and distorted self-perception of their knowledge and skills. Despite their low academic performance, 77% report that "I usually do well in mathematics," and 41% think that "mathematics is an easy subject."

Mathematics difficulty and self-perception in doing mathematics are probably a function of the difficulty level of the contents covered in classes. Students might perceive mathematics as an easy subject because they see variations of the same (basic) content during the school year. Another plausible explanation is that students think that they do well in mathematics simply because they get good grades in this subject. Grade inflation and poor academic expectations are a pervasive problem in Chilean schools (Arancibia, 1994; Riveros, 2004).

Chilean students have stronger beliefs in the importance of luck and innate intelligence, when compared to students across South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools. A relevant finding was that, in Chile, students who rely more on luck and innate intelligence attained significantly lower mathematics scores than their classmates who gave less importance to these factors. This result is consistent with the locus of control theory, which states that the more the students rely on factors out of their control (e.g., luck, innate talent), as opposed to more controllable factors (e.g., effort, motivation), the lower their academic performance (Benham, 1995). In contrast, Korean and Malaysian students are embedded in Confucian ideas of effort and perseverance and therefore are less likely to emphasize the importance of good luck and innate intelligence in doing well in mathematics.

In Chile, only the elite class has access to higher education. Nevertheless, an impressive 43% of the students aspire to a university degree. Chilean students who plan to finish university attain significantly higher mathematics scores than students who do not plan to do so. This finding is consistent with previous studies of academic achievement (Martin, Mullis, Gregory, et al., 2000).

Educational systems are extremely complex social organizations. They respond to social goals, and are shaped by historical and present circumstances. This dissertation study does not pretend to encompass all this complexity. Many important dimensions of school systems were not considered in the analyses presented here (e.g., classroom practices, school climate). This dissertation study focused on a subset of variables relevant for the analysis of mathematics performance. It is hoped that the findings reported will be useful in understanding the poor academic performance of Chilean students. It is also hoped that these findings will be useful to inform the debate in Chile about how to improve mathematics education.

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