

Comparing the Relationships between Mathematics Achievement
and Student Characteristics in Canada and Hong Kong through HLM

by

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ABSTRACT

This study investigates and compares the effects of student characteristics- socioeconomic status, sex, family structure and immigration background- on 15-year-old mathematics achievement in Canada and Hong Kong through HLM. Using PISA data in 2003, the results showed that 20% and 49% of the variance in mathematics achievement was accounted for by schools in Canada and Hong Kong, respectively. All student-level variables were significant in Canada model except family structure whereas only sex and immigration background were significant in Hong Kong model. At school level, the significant school aggregate variables had much larger effects on school average mathematics achievement in Hong Kong than those in Canada. The findings suggest that school composition has an effect on mathematics achievement over and above that of individual characteristics.

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CHAPTER ONE: INTRODUCTION

Overview

Academic achievement is an important indicator for students' educational attainment. Among all subjects, mathematics has an important influence on real life as well as on future employment, career choices and professional performance. This is especially true in the age of technology, since mathematics is related to logical thinking and scientific foundations (Meece, Parsons, Kaczala, Goff, & Futterman, 1982). It is, therefore, important to identify factors that affect mathematics achievement in order to provide educators and policy-makers with information that can be used to enhance learning and accountability.

Students' performance is determined by multiple factors. Eccles (1993) suggested that family characteristics, such as socioeconomic status (SES) and ethnicity, and individual characteristics such as sex and intelligence, are related to children's achievement. Different student background may lead to diversified educational attainment (Teachman, 1987).

For individual characteristics, sex is an important but controversial factor associated with mathematics achievement (Friedman, 1989). The findings on sex differences in mathematics achievement are inconclusive and ambiguous, ranging from being

nonsignificant (e.g., Callahan & Clements, 1984), to favoring boys (e.g., Manger & Eikeland, 1998) or favoring girls (e.g., Tsai & Walberg, 1983). These inconsistencies might be the result of differences in the age of the population, the selected population (e.g., gifted or general), prior mathematics background, area or topic (geometry, algebra, reasoning, computation etc) (e.g., Benbow & Stanley, 1980; Fennema & Sherman, 1977; Geary, 1994; Ma, 1995) or other factors.

In addition to individual student characteristics, the family traits can be related to achievement. Family is the place children are born into, where their intellectual, cognitive, and mental development are shaped (Coleman, 1988; Spaeth, 1976), where they start learning before school and where they usually live before attending college. Furthermore, learning outcome is the outward presentation of ability across time rather than at a specific time point. Therefore, family background can be one of the key factors determining children's future educational attainment (Boocock, 1972). Family affects individuals in many ways, for example, by passing on certain features, such as SES, race, immigrant status, and religion, to the child through the family membership or by how the family is structured and how the family members interact (Boocock, 1972). An important finding in the Equality of Educational Opportunity Survey, which emphasized that more of the variability in achievement is attributed to the child (e.g., family and social

background) than to school, was that

schools bring little influence to bear on a child's achievement that is independent of his background and general social context; and that this very lack of an independent effect means that the inequalities imposed on children by their home, neighborhood, and peer environment are carried along to become the inequalities with which they confront adult life at the end of school (Coleman, Campbell, Hobson, McPartland, Mood, Weinfield, & York, 1966, p.325).

Among measures of family characteristics, SES is an influential predictor of achievement verified by countless studies (Boocock, 1972). Despite the wide variation of the magnitude of this relationship, high SES has a consistently positive impact on academic achievement regardless of the SES measures used (Boocock, 1972; Sirin, 2005; White, 1982). A considerable body of literature gives evidence to the fact that family instability has a persisting adverse effect on children's educational performance (e.g., Garfinkel & McLanhan, 1986; Krein & Beller, 1988). Children from nonintact families have a significant academic lag and are less likely to finish high school or to attend college than those from intact families (e.g., Astone & McLanahan, 1991; Downey, 1994; Entwisle & Alexander, 1992; Pong & Ju, 2000). In addition, students' immigrant or generation status is an essential factor in explaining their differential academic

performance, especially in countries with large immigrant populations. However, a convergent consensus about whether assimilation is positively associated with children's educational attainment has not been reached (Kao & Tienda, 1995).

Purpose

The purpose of this study is to investigate the student- and school-level variables of mathematics achievement for 15-year-old students focused on student characteristics (SES, family structure, immigrant status, and sex) across different cultures. The countries of interest in this study are Canada and Hong Kong-China, since both countries have similar backgrounds- high overall mathematics achievement, a large immigrant population, and are former British colonies- each representing western and eastern cultures. Hierarchical linear modeling (HLM) will be used to analyze the large-scale and multilevel structure dataset conducted by the Program for International Student Assessment (PISA) in 41 participating countries in 2003.

Research Questions

This study will explore the following questions:

1. What are the overall across-school means in mathematics achievement and proportions of variance that can be attributed to schools for Canada and Hong Kong, respectively?

2. What are the proportions of variation in mathematics achievement accounted for by SES at the student level in Canada and Hong Kong, respectively?
3. How much variability in mathematics achievement can be further explained by student characteristics (sex, family structure, and immigrant status) in Canada and Hong Kong, respectively?
4. Do the school-level variables- school mean SES, proportion of girls, proportion of non-nuclear families, and proportion of non-native students- explain differences in school mean mathematics achievement and influence the gradient of student factors in Canada and Hong Kong, respectively?

CHAPTER TWO: LITERATURE REVIEW

Sex and Mathematics Achievement

Sex difference in mathematics has been a long-developed and controversial topic. Many important findings which are cited in this study have been established from 1970s to 1990s. It is long believed that males surpass females in mathematics achievement (Maccoby & Jacklin, 1974). However, this is not universally true since sex difference in mathematics achievement can be confounded by many factors (Fennema & Sherman, 1977) and therefore cannot be generalized easily.

Factors of Sex-Mathematics Relationships

Age

Although it is difficult to derive a convergent explanation for sex difference in mathematics achievement, there is some agreement that this gap increases with age (Fennema & Sherman, 1978). Accumulated evidence showed that sex differences in mathematics achievement generally are not noticeable in early school years (e.g., Armstrong, 1981; Fridman, 1989; Hyde, Fennema, & Lamon, 1990; Peterson & Fennema, 1985). Maccoby and Jacklin (1974) pointed out that boys and girls were generally equal in learning quantitative concepts and mastering in mathematics before adolescent, but when differences were observed, they usually favored boys.

However, boys began to surpass girls in mathematics ability and spatial visualization during intermediate school years (i.e., early adolescence) (e.g., Ma, 1995; Macobby & Jacklin, 1974) but the findings were mixed (Friedman, 1989; Ma, 1995). For example, Tsai and Walberg (1983) found a slight but significant difference in mathematics favoring 13-year-old female students from data in 1977-1978 National Assessment of Educational Progress (NAEP). Sex differences in eighth-grade mathematics were not significant after conditioning students' cognitive skills, attitudes towards mathematics and mathematics background (Sherman, 1980) whereas those in ninth-grade mathematics were favored males after conditioning curriculum and the amount of mathematics instructions (Hilton & Berglund, 1974). These studies confirmed that male superiority in mathematics abilities was not consistently significant until high school (Ma, 1995; Peterson & Fennema, 1985).

Numerous studies showed that substantial male advantage in mathematics aptitude and achievement emerged by the end of high school (e.g., Aiken, 1986; Armstrong, 1981). High school boys outperform girls in mathematics achievement even with spatial abilities, differential mathematics course-taking, high school grades, and attitudes towards mathematics controlled (Ethington & Wolfe, 1984). However, Nowell and Hedge (1998) investigated on seven representative samples from American twelfth grader students and

the NAEP long term data from 1960 to 1994 and concluded that the size of the male-female gap has decreased over the years.

Gifted samples

Male-female gaps in mathematics were found to be smallest and favored female in samples of the general population, enlarged in selective samples and were the greatest in gifted samples in a meta-analysis of 100 studies (Hyde, Fennema, & Lamon, 1990).

Benbow and Stanley (1982) investigated nearly 2000 seventh- and eighth-graders who participated in the Study of Mathematically Precocious Youth (SMPY) with similar formal mathematics instruction between 1972 and 1974 and who also wrote mathematics test in Scholastic Aptitude Test (SAT-M) 5 years later. They found the greatest sex difference favoring males occurred at the upper end of the mathematics score distribution. Among those who achieved above 660 on SAT-M, boys outnumbered girls by fourteen to one. Other studies also discovered the male domination among the high mathematics achievers (e.g., Fan & Chen, 1997; Fox & Cohn, 1980).

Content area

Males and females differ in specific abilities (Aiken, 1986). In general, females excel in numerical computation and verbal fluency whereas males excel in mathematics reasoning and visuospatial ability (Geary, 1994; Maccoby, 1966; Minton & Schneider,

1980), which is supported by a substantial body of literature (e.g., Benbow & Stanley, 1980; Fennema, 1974; Hyde, Fennema, & Lamon, 1990). For example, Marshall (1984) concluded that sixth-grade boys outperformed girls in mathematical reasoning (e.g., story problems) and girls outperformed boys in mathematics fundamentals (e.g., computations). More specifically, it is concluded from numerous studies that boys surpass girls in measurement, geometry, spatial geometry, analytic geometry, trigonometry, and application whereas girls surpass boys in computation, set operation and symbolic relation (Ethington, 1990; Leahey & Guo, 2001; Ma, 1995).

Large-scale studies

Large samples are more representative of population parameters than those of small sizes, especially when they also meet the random requirement (Dowdy, Wearden, & Chilko, 2004). Male advantage in mathematics achievement is often seen in large-scale studies (Armstrong, 1981). For example, significant sex differences favoring 13-year-old boys existed in nearly all of the 12 participating countries from the International Project for the Evaluation of Educational Achievement (IEA) (Husen, 1967). Additionally, in PISA 2000 mathematics assessment based on a relatively small number of items, 15-year-old boys, on average, outperformed girls by 11 points across 43 participating countries (OECD, 2003a). Sex differences in mathematics achievement significantly

avored males in 15 countries and favored females in only 1 country. However, there are still inconsistent findings. For example, the Third International Mathematics and Science Study (TIMSS) 2003 indicated there were no significant sex differences in the overall mathematics achievement across 46 participating countries at both the fourth and eighth grades (Mullis, Martin, Gonzalez, & Chrostowski, 2004).

It is difficult to offer a simple explanation for sex differences in mathematics achievement that includes all the factors. However, there is an analogous nature-nurture argument, as in psychology, in the sources which explain the sex differences in mathematics (Aiken, 1986; Friedman, 1989; Klein, 2004; Maccoby & Jacklin, 1974; Minton & Schneider, 1980; Willms & Kerr, 1987). Genetic disposition decides whether a person belongs to a higher math-achieved group or lower math-achieved group whereas environmental factors (e.g., expectation effects) decide a person's location in that particular group (Stafford, 1972).

Sources of Sex Differences in Mathematics

Biological factors

Genetic disposition. "Biological endowment lays the foundation for the development of our abilities" (Minton & Schneider, 1980, p.279), which partly accounts for the sex differences in mathematics abilities. Female-male differences in hormone and

cerebral lateralization might be essential determinants of mathematics performance (Aiken, 1986). Geschwind and Behan (1982) proposed that testosterone hampers the development of the left hemisphere and hence strengthens the development of the right hemisphere, which is associated with numerical and spatial tasks (Aiken, 1986; Garner, 1983). Moreover, Witelson (1976) investigated from 200 children from age 6 to 13 and discovered that boys had greater and earlier development of the right hemisphere than girls.

Several studies lend support to this hypothesis. For example, Fox and Cohn (1980) found a considerable male advantage in the mean SAT-M score as well as at the upper end of the distribution emerged as early as grade seven and Geary (1994) also discovered a male-female gap in mathematics problem solving occurred at the first grade, which might result from a genetic factor. Furthermore, Benbow and Stanley (1980, 1982) suggested that a substantial male superiority in mathematics reasoning lasting for several years was better predicted by male-female difference in reasoning ability itself rather than environmental factors because this superiority already existed before differential mathematics course taking took place and attitudes toward mathematics was weakly related to mathematics achievement in this gifted sample. However, Benbow (1988) later admitted that along with biological factors, male-female gap in mathematics is also

environmentally induced.

Spatial visualization. Spatial visualization is “the ability to visually manipulate images without the aid of verbal mediation” (Petersen, 1976, p.524). Several researchers proposed that spatial ability is an essential predictor of mathematics performance and is positively associated with mathematics (Aiken, 1986; Bock, & Kolakowski, 1973; Burnett, Lane, & Dratt, 1979; Maccoby & Jacklin, 1974; Sherman, 1967; Stafford, 1972). Females tend to have lower visual abilities than males (Ethington & Wolfle, 1984; Maccoby & Jacklin, 1974; Sherman, 1967). From these two arguments, sex differences in mathematics achievement can be partly attributed to spatial ability (Sherman, 1967). Several studies lend credence to Sherman’s conclusion (e.g., Burnett, Lane, & Dratt, 1979; Kaufmann & Helstrup, 1985). Nevertheless, Armstrong’s (1981) findings did not support that male’s high mathematics achievement was related to their higher spatial abilities. In this study, female superiority in computation and spatial visualization was observed at seventh-grade but disappeared at twelfth-grade. Males outperformed females in problem solving, but were equivalent in spatial visualization by the end of high school.

Researchers also have investigated if the effect of spatial ability on mathematics achievement differs by sex. Fennema and Sherman (1977) concluded that spatial ability and verbal ability had nearly equivalent correlation (about .5) with mathematics

achievement for both genders. In other words, the relationship between spatial ability and mathematics achievement does not vary with sex. However, Friedman (1995) and Tartre (1990) discovered that female's higher mathematics achievement can be predicted by greater spatial ability but it did not apply to males whereas Connor and Serbin (1985) had the opposite findings.

Social/psychological factors

Differential mathematics course taking. Ethington and Wolfle (1984) concluded from a national longitudinal data that differences in student characteristics (e.g., SES and intelligence), ability, attitudes toward mathematics, grades, and exposure to mathematics accounted for a substantial proportion of sex differences in mathematics. Among these variables, exposure to mathematics had the most contribution to the sex differences in mathematics. A lot more males enroll mathematics courses than females after these courses becomes elective, which explains the emergence of the male advantage in mathematics beginning in high school and the enlargement during the high school (Fennema & Sherman, 1977; Wolleat, Pedro, Becker, & Fennema, 1980).

Several researchers agreed that male-female gap in mathematics can be largely explained by differential coursework (Fennema & Sherman, 1977; Pallas & Alexander, 1983). In particular, the study of Pallas and Alexander (1983) showed that 60% of the

male-female gap favoring boys in SAT-M score was reduced by conditioning sex differences in mathematics course-taking. However, Hilton and Burglund (1974) conducted a longitudinal study on a national sample starting from fifth to eleventh grade. Sex differences in mathematics achievement were not significant in fifth grade, but favored boys and increased with age later in grade seventh, ninth, and eleventh even after controlling for curriculum and amount of the mathematics instruction.

Attitudes. Some researchers (Luchins, 1979; Michaels, 1978) argued that attitudes towards mathematics may contribute more to mathematics achievement than biological factors. Positive attitudes toward mathematics might be attributed to early success experiences (Gebhard, 1948). Males and females are significantly different in attributing their success in mathematics, which may result in female's lack of confidence and perseverance in mathematics (Tocci & Engelhard, 1991; Wolleat, Becker, Pedro, & Fennema, 1980). Lower confidence in mathematics ability was seen in girls than in boys and mathematics was considered a male-domain in later elementary years (Boswell, 1985; Fennema & Sherman, 1978; Swim, 1994). In addition, boys had higher interest in mathematics and perceived mathematics more useful than girls, both of which contributed to the sex inequality in mathematics achievement (Castambis, 1994; Fennema & Sherman, 1977; Sherman, 1980). These negative attitudes led to the enlarging sex

differences in taking advanced mathematics courses from tenth grade onward, which translated into enlarging sex differences in mathematics achievement (Ai, 2002; Fennema & Sherman, 1977).

Family Structure and Achievement

Coleman's Financial, Human, and Social Capitals

Coleman (1988) proposed that family background is composed of at least three components, which is commonly accepted by the contemporary sociologists and psychologists (Astone & McLanahan, 1991; Entwisle & Astone, 1994), and as such has been adopted by many researchers (e.g., Bradley & Corwyn, 2002; Entwisle & Astone, 1994; Sirin, 2005). First, financial capital refers to material resources and is often measured by household wealth, income, or possessions. Wealth is considered to be a better measure of financial resources than income because income can vary substantially within occupation and is not frequently consistent with educational attainment (Haug, 1977; Leberatos, Link, & Kelsey, 1988). Along with wealth and income, home possessions have also been identified as a useful alternative of family background (e.g., Coleman, 1988; Entwisle & Astone, 1994; Yang & Gustafsson, 2004) due to its higher response rate than traditional SES indicators (Wardle, Robb, & Johnson, 2002).

The second dimension, human capital, refers to the characteristics possessed by

parents to foster children's learning through influencing the cognitive environment. It is usually measured by parental education. However, financial and human capital only account for part of the family effect on children's educational attainment although they manifest the fundamental limitations and opportunities related to a family's resource base (Teachman, Paasch, & Carver, 1996). Lastly, social capital consists of two components: social networks and parental involvement. Social networks refer to the access to interpersonal interactions and adult-child relationships within the family, as measured by the number of parents present at home, a simple indicator of family structure (Teachman, Paasch, & Carver, 1996), and the number of siblings. It also refers to parents' involvement in their children's lives (Israel, Beaulien, & Hartless, 2001). Social capital within the family provides children with an access to the adult's human capital through an adult's presence at home and the care provided to the child. This implies that without a close adult-child relationship in the family (social capital), the adult's human capital and financial capital are not explicitly beneficial for the child (Coleman, 1988).

Relationship between Family structure and Achievement

Family disruption is one of the critical crises in contemporary society due to the rapid increase rate and high proportion in the population (Hetherington, Cox, & Cox, 1978). According to the Census in 2001, Canada had about 8.3 million families and 1.3

million were single-parent (about 16%) (Statistics Canada, 2001). Nonintact families can be largely classified into single-parent families and stepfamilies. Both types of families can be considered similar in that children from these families only live with one biological parent and the adverse effects on educational outcomes are roughly equivalent if SES is held constant (Astone & McLanahan, 1991; Ginther & Pollak, 2004; McLanahan & Sandefur, 1994). Furthermore, prior research has verified that children's behavioral, emotional, and academic problems occurred at the same rate in both types of families (Zill, 1988). Most research findings about single-parent families are related to single-mother families due to the substantial proportion in single-parent families that are headed by females (Downey, 1994). For example, about 81% of single-parent families in Canada are female-headed in 2001 Census (Statistics Canada, 2001).

How Family Disruption Affects Achievement

Numerous studies have shown that children from nonintact families perform less well academically than those from intact families (e.g., Mulky, Crain, & Harrington, 1982; Pong, Dronkers, & Hampden-Thompson, 2003). Two hypotheses are used to explain how parent-absence affects children's educational attainment: the economic deprivation and the family stress hypotheses (Gohm, Oishi, Darlington, & Diener, 1998; McLanahan, 1985).

Economic deprivation hypothesis. Parents provide a home environment that facilitates children's learning, drive, and orientation with material and nonmaterial resources (Teachman, 1987), which mostly depend on the family's financial condition (Downey, 1994). Compared with two-parent families, single-parent families possess fewer resources, particularly in investing time and money on children's education and parent-child interaction (Downey, 1994; Krein & Beller, 1988). Coleman (1988) proposed that a structural deficiency due to the absence of one parent results in lower level of social capital that children need. Accumulated evidence has echoed his theory that parent-child interaction (i.e., social capital within the family), which is related to the number of parents at home and has a positive effect on children's scholastic performance, decides if the advantages from parents' financial and human capital can be transmitted to the child (e.g., Astone & McLanahan, 1991; Downey, 1994; Pong, 1997). In particular, single-mother families have the highest poverty rate among demographic groups no matter how poverty is measured due to their lower education and lower earning abilities, inadequate child support from noncustodial fathers, and deficient benefits from public welfare program (Downey, 1994; Garfinkel & McLanahan, 1986).

Two arguments explain why economic deprivation might result in children's low educational attainment (McLanahan, 1985). First, supervision is a crucial factor

predicting children's academic performance (Colletta, 1979). Parents of nonintact families are more likely to work due to financial necessity. Therefore, they have lower educational expectations about their children and less supervision on children's school work and social activities than those of intact families, which translate into children's lower achievement or the exhibition of early dropout of school (Astone & McLanahan, 1991; Pong & Ju, 2000). Second, economic needs propel children to undertake adult responsibilities, which influences their individual attainment. Children from single-parent families tended to work and to look after their siblings, which might lead to early disengagement from school (Colletta, 1979). They were more likely to leave school prematurely due to family survival rather than poor achievement or behavioral problems (McLanahan, 1985).

Family stress hypothesis. Family disruption affects the socialization process in the following ways. First, parents' marital disruption is extremely stressful for children due to the fear of loss of the attachments with parents (Hess & Camara, 1979). Following a divorce, the short-lived inconsistent parenting or negative psychological impacts (e.g., anger and loss) on children might occur (Hetherington, 1981). All these adverse impacts might weaken the internalization of parental values and role models (Hess & Camara, 1979; Sandefur, McLanahan, & Wojtkiewicz, 1992). Second, the negative effects on

children's achievement decrease with time after marital disruption (McLanahan, 1985). That is, the stress is most severe for recent disruption, since mother and children experience multiple transitions in roles and status after marital disruption (Garfinkel & McLanahan, 1986; Hetherington, 1981). The common changes are in residence (usually from richer to poorer neighborhoods) and in employment, which might lead to the loss of important social networks and support as well as the decrease in parent-child interaction, respectively (Garfinkel & McLanahan, 1986; Pong, 1997). Changing schools is usually the consequence of moving and highly related to academic failure (Teachman, Paash, & Carver, 1996). The distress and inconsistency of marital disruption absorb the children's time and emotions, interfere with their normal development and influence their academic achievement (Hess & Camara, 1979).

SES and Achievement

Definition of SES

SES originates from social stratification, which is ranking people to different hierarchical strata based on different values that a society defines or attributes (Haug, 1977). Weber (1946) proposed a widely accepted definition that social stratification consists of three dimensions: class, status, and party (or power). Class is often referred to as economics, while status and party are referred to as one's prestige ranked by others in

the community and political power, respectively (Brinkerhoff & White, 1985; Eshleman & Cashion, 1983). Most SES measures have been operationalized by American sociologists according to Weber's conceptualization of SES as three separate but intercorrelated domains (Liberatos, Link, & Kelsey, 1988). In addition, Muller and Parcel (1984) defined SES as "a social system in which individuals, families, or groups are ranked on certain hierarchies or dimensions according to their access to or control over valued commodities such as wealth, power, and status" (p.14).

Conventional SES indicators

Parental income, parental education, and parental occupation are the conventionally used variables to measure family SES because they represent the domains of class and status of social standing in Weber's conceptualization (Haug, 1977; Leberatos, Link, & Kelsey, 1988). Of these three indicators, income is considered to be the most sensitive and volatile (Entwisle & Astone, 1994; Hauser, 1994; McLoyd, 1998) due to its high non-response rate (usually 15%), which weakens its ability to delineate the general economic condition (Entwisle & Astone, 1994). Education is the most stable of the three indicators since it is usually established at an early age and is less likely to change over time (Sirin, 2005). Occupation is frequently ranked in two ways. First is prestige, which is societal perception of a particular occupations' level of prestige. Second is educational

qualifications and financial payoffs (Haug, 1977). Therefore, education is sometimes viewed as an indicator of income and occupation, although better education does not imply higher level occupation and income (Liberatos, Link, & Kelsey, 1988).

It is unquestionable that using multiple indicators is better than one single indicator to measure SES (White, 1982) due to the multi-dimensional nature of SES (Leberatos, Link, & Kelsey, 1988; Yang, 2004). However, there is no consensus about using the multiple indicators individually or combined (Schulz, 2006). Some researchers recommended measuring SES with individual indicators so that the associated effects can be clearly differentiated (Campbell & Parker, 1983; DeGarmo, Forgatch, & Martinez, 1999; Entwisle & Astone, 1994; Hauser, 1972). On the other hand, others suggested the use of composite SES measure because using individual indicators may have the problems of multicollinearity as well as interpretation of the findings (Campbell & Parker, 1983). In addition, Schulz (2006) found that the index of economic, social and cultural status (ESCS) used by PISA as a composite indicator of SES explained more variance in reading achievement 2003 than the three individual SES indicators (parental occupation, parental education, and home possessions) in most participating countries. Despite the controversies about how to measure SES, Entwisle and Astone (1994) concluded that the best SES measure for a study is determined by the nature of the study such as the target

population, research design, the role of SES in the study, and the research purpose (Hauser, 1994; Leberatos, Link, & Kelsey, 1988). Furthermore, White (1982) pointed out that the utility of SES is determined by the validity of that specific measure of SES and /or the magnitude of the relationship between SES and the outcome variable.

Relationship between SES and Achievement

Faced with such a dynamic and multi-dimensional construct as SES, it is difficult to give a universal operational definition that includes all relevant aspects of family characteristics for different cultures or different studies. Therefore, it leads to the wide range of variation in the strength of the SES-achievement relationship (White, 1982). Sirin (2005) conducted a meta-analysis of 207 studies published between 1990 and 2000. The results showed that the SES-achievement correlation ranged from .005 to .77. Variation may result from different sources: different types of SES measures, sources of SES data, unit of analysis, range of SES variables, achievement measures, student grade level, minority status, school location (Sirin, 2005), structure of culture (Laosa, 1981), and design of data collection (Entwisle & Astone, 1994).

Immigrant Status and Achievement

Immigrant children's educational attainment becomes an important issue as the immigrant population grows rapidly. In Canada, for instance, the proportion of

foreign-born population was 12.2% before 1991 and increased to 18.4% from 1991 to 2001 (Statistics Canada, 2001). About 95% of the population in Hong Kong is composed of Chinese (Census and Statistics Department of Hong Kong, 2006). That is, the immigrant ethnicity in Canada is more diversified than that in Hong Kong. Whether immigrant children's scholastic attainment increases with assimilation (or generational status) is still debatable (Kao & Tienda, 1995).

Park (1950) proposed that there are four phases as an ethnic group assimilates into a dominant culture: "contact, competition, accommodation and eventual assimilation" (p.150) where accommodation and assimilation were defined as

Accommodation... a process of adjustment, that is, an organization of social relations and attitudes to present to reduce conflict, to control competition, and to maintain a basis of security in the social order for persons and groups of divergent interests and types to carry on together their varied life activities.

Assimilation is a process of interpenetration and fusion in which persons and groups acquire the memories, sentiments, and attitudes of other persons or groups, and, by sharing their experience and history, are incorporated with them in a common cultural life (Park & Burgess, 1969, P. 735).

Students are categorized into three groups by PISA based on the country of birth of

students and their parents: (a) non-native (who were foreign-born with foreign-born parents), (b) first-generation (who were native-born with foreign-born parents), and (c) native (who were native-born or who had at least one native-born parent). Two hypotheses were proposed for the effects of generational status on academic achievement (Gans, 1992; Warner & Srole, 1945; Zsembik & Llanes, 1996): straight-line assimilation and segmented assimilation.

Relationship between Immigrant Status and Achievement

Straight-line (Classic) assimilation hypothesis

Straight-line hypothesis states that the conflicts due to cultural, language, and social differences arise inevitably as immigrant group assimilate into the dominant culture and negatively affect immigrant children, especially recent immigrants (Gans, 1992; Kao & Tienda, 1995; Rong & Grant, 1992; Warner & Srole, 1945; Zsembik & Llanes, 1996). Therefore, this hypothesis predicts that educational attainment of immigrant children increases with generational status (or assimilation) (Kao & Tienda, 1995; Zsembik & Llanes, 1996). The years of schooling of Hispanic Americans and the high school completion rate of Mexican Americans showed a rising tendency in educational attainment over generations (Rong & Grant, 1992; Zsembik & Llanes, 1996). Furthermore, foreign-born immigrant students had a higher high school dropout rate than

did first-generation and native peers and this dropout rate appeared to decline with length of residence in America (White & Kaufman, 1997). These findings lend credence to this hypothesis.

Segmented assimilation hypothesis

Segmented assimilation hypothesis considers the process of assimilation into the dominant culture not unidirectional, but rather depends on the form that immigrant groups adapt and the degree that the social contexts accept (Rumbaut, 1994; Zsembik & Llanes, 1996). Many researchers agreed that, in general, students of immigrant families (i.e., foreign-born or first-generation) performed better than their native counterparts (Fuligni, 1997; Kao & Tienda, 1995; Rong & Grant, 1992; Zsembik & Llane, 1996). But the patterns between the educational attainment and generational status were different among race and ethnic groups. Students of immigrant families had similar (e.g., Hispanic and black) or higher (Asian) academic achievement than their native counterparts in US (Kao & Tienda, 1995). In particular, although small achievement differences existed between foreign-born and first-generation students, the academic achievement and college completion rate peaked in the Asian- and Mexican-American first-generation students, respectively, and declined in the next generation (Kao & Tienda, 1995; Zsembik & Llane, 1996). Moreover, the achievement of both Asian and non-Hispanic white groups

was highest in first-generation students, but that of Asian group remained even in the next generation whereas that of non-Hispanic white group decreased for subsequent generations (Rong & Grant, 1992).

School Contexts and Achievement

Environments in which individuals grow up shape their behaviors and values (Yang & Gustafsson, 2004). In addition, peers have an increasing influence on adolescents' behavior, attitudes, and educational performance (Bankston & Caldas, 1998; Coleman et al., 1966). School is a place where adolescents' backgrounds have reciprocal effects on one another (Bankston, 1995; Coleman, 1961). If school contexts are social environments composed of students' backgrounds, then, following Coleman's arguments, the social environment of each school is made up of the family background predominated in that school (Bankston & Caldas, 1998; Coleman, 1961, 1966). Therefore, the school context variables associated with student family backgrounds, such as school SES, proportion of nonintact families and proportion of foreign-born students, may have strong effects on students' educational performance in addition to individual family background (Bankston & Caldas, 1998; Entwisle & Alexander, 1992; Pong, 1997).

Summary of Chapter Two

This chapter reviews all the factors related to students' academic achievement in this

study. Family disruption and high SES have been shown to have consistently negative and positive effect on children's achievement, respectively. Sex effect on mathematics depends on many factors and therefore cannot be generalized whereas the effect of immigrant status on achievement also depends on race and ethnicity and cannot be generalized.

CHAPTER THREE: METHODOLOGY

Overview of PISA

The objective of PISA is to measure 15-year-old students' capacities to apply their knowledge and skills to real-life situations rather than simply their mastery over a particular school curriculum. PISA encompasses four assessment domains- reading, mathematics, science, and problem solving- and is conducted every three years, with a major domain and others as minor domains. The primary testing subject domain was reading in 2000, mathematics in 2003, science in 2006, and back to reading in 2009. The mathematics assessment 2003 was administered in 30 Organization for Economic Co-operation and Development (OECD) countries and 11 non-OECD countries. The findings allow for comparing the trends of students' educational performance across countries.

Sampling

The PISA target population was composed of approximately 23 million students aged from 15 years 3 months to 16 years 2 months at the time of assessment and enrolled full time or part time in any educational program in 41 participating countries in 2003. A two-stage stratified sampling was employed by PISA (Willms & Smith, 2005). At first stage, schools were selected systematically with probabilities proportional to their sizes

whereas a fixed number of students were drawn from these schools at the second stage. For those sampled schools with more than 35 students in total, 35 students were randomly selected with equal probability. For schools with fewer than 35 students, all of the students were included. The sampling plan for each country needed to be approved by PISA to ensure the same procedures conducted in all countries. The sampling criteria require a minimum of 85 percent participation rate across schools and 80 percent within schools (OECD, 2005a). In total, the final sample size was 276,165. PISA's sampling design and sufficient sample size for each country (a minimum of approximately 4,500 students sampled from at least 150 schools) allow for making valid comparisons across countries. The samples in this study include 27,953 students from 1,087 schools in Canada and 4,478 students from 145 schools in Hong Kong.

Instruments

The mathematics assessment included a written session of 2 hours with 85 test items equally distributed in three formats: multiple-choice, short-answer, and extend-response. The content covers four areas: quantity, space and shape, change and relationships, and uncertainty. The student questionnaire consists of the items on student characteristics, home background, educational career, school/classroom climate, learning behavior and self-related cognitions in the area of the major domain. The school questionnaire

collected data from the school principal on the school characteristics and learning environment.

An international assessment often has translation errors in the test versions due to cultural or curricular differences that might lead to biased interpretations of the test items. To improve the translation equivalence and to ensure high quality standards in the translated assessment materials, PISA adopted strict verification procedures which included offering two (English and French) parallel source versions of the instruments and suggesting that each country use a double translation from two different languages as well as reconcile them into one national version, preparing commonly-used translation notes, providing detailed guidelines for translation and adaptation, training essential staff from national team and assigning and training a group of international verifiers with professional and proficient training in translation to examine the national versions versus the source versions (OECD, 2005a).

Variables

Mathematical Literacy Assessment

The mathematics scores of all students were converted into the scale with an average of 500 and a standard deviation of 100 in PISA. From these scores, six proficiency levels have been defined and specified (OECD, 2005a).

The dependent variable in HLM is the mathematics performance which is reported as five plausible values chosen for each student in PISA. HLM (Byrk & Raudenbush, 1992), also called multilevel model (Goldstein, 1995), allows for estimating both the effects of group-level variables on group mean (e.g., school mean score) and on the slopes of the individual characteristics to predict outcome variable (Willms & Smith, 2005). Furthermore, HLM can also include in the analysis of plausible values as well as sampling weights. Plausible values are the possible scores based on a student's ability that are derived from a one-parameter item response theory (IRT) analysis (OECD, 2002, 2005b; Willms & Smith, 2005). PISA adopts a rotated-booklet design to test students on the major assessment domain. That is, each student is scored according to the fractional test items that they were randomly assigned. Based on this score and the measurement error associated with the test, a posterior distribution estimating the possible scores that the student might have if given a full test can be generated. Five plausible values (PV1math-PV5math) of mathematics scores rather than one being selected from this posterior distribution for each assessed student is to facilitate unbiased estimation of group statistics and their standard errors (NAEP, 2006). The final estimates in HLM are the average results from the five analyses with final student weights taken into account (Mislevy, Johnson, & Muraki, 1992). The purpose of assigning different weights to

students is to give appropriate estimates of sampling error, to make valid estimates and inferences, and to avoid or reduce the biases due to the unequal selection probabilities in the two-stage stratified sampling in PISA (OECD, 2005a; Willms & Smith, 2005). The final reliability of the PISA scales in mathematics assessment is .92 (OECD, 2005a).

Student Characteristics Variables

There were 16 questionnaire items pertaining to students' family background including parents' occupation, parents' education, and home possessions (personal, computer, cultural, and educational), family structure (adult presence at home), and immigrant background (place of birth) (see Appendix A). It is important to examine the construct validity for student background measures. PISA used Structural Equation Modelling (SEM) to verify theoretically anticipated dimensions and to re-identify the dimensional structure as needed (OECD, 2005a). In addition, the requirement for confirmatory factor analysis (CFA) is a theoretical model of item dimensionality, which can be tested on the collected data (Kaplan, 2000).

ESCS

The index of economic, social and cultural status (ESCS) is the SES measure of PISA and is operationalized as a composite of parental occupation, parental education, and family wealth with home possessions as a proxy to wealth due to no direct income or

wealth measure in PISA questionnaires. The student ESCS scores, standardized to have a PISA mean 0 and standard deviation 1, are derived from the factor loadings (ranging from 0.65 to 0.85) of a principal component analysis for the three ESCS components- the Highest International Socio-Economic Index of occupational status (HISEI), the Highest International Standard Classification of Education (HISCED) converted into years of schooling (PARED), and home possessions (the number of books at home as well as home educational and cultural possessions)- with approximately equal contributions. The reliability estimates (Cronbach's alpha) of the ESCS scale for Canada, Hong Kong, and overall OECD sample were .62, .64, and .69, respectively (OECD, 2005a), which moderately supported the cross-national validity of the ESCS index.

In order to attain international comparabilities for occupation, 2-step transformations were applied to the response first converted into 4-digit ISCO (International Standard Classification of Occupations) codes (ILO, 1990) and then converted into ISEI (International Socio-Economic Index of Occupational Status) index (Ganzeboom, de Graaf & Treiman, 1992). The HISEI indicates to the highest ISEI of either the father or the mother, which ranges from 0 to 100. Higher ISEI scores imply higher level of occupational status.

A similar conversion procedure was applied to the highest level of education

between the two parents, which were coded by ISCED (International Standard Classification of Education). HISCED refers to the highest ISCED between the two parents and has six ordinal categories: 0 for no education; 1 for the completion of primary education (ISCED level 1); 2 for the completion of lower secondary education (ISCED level 2); 3 for the completion of vocational/ pre-vocational upper secondary education (ISCED level 3B or 3C); 4 for the completion of upper secondary education and/or non-tertiary post-secondary (ISCED level 4); 5 for qualifications in vocational tertiary (ISCED 5B); and 6 for completion of tertiary-type A and advanced research programs (ISCED level 5A, 6). HISCED was converted into years of schooling in PISA.

PISA included 13 items of home possessions (e.g., desk, computer, books, a dishwasher) as well as 3 country-specific items due to the cultural differences. Home possessions were classified into two categories. First, educational possessions include a dictionary, a quiet place for study, and a calculator. Second, classic cultural possessions include classic literature, books of poetry, and works of art. Both variables were coded through IRT scaling with positive values indicating higher levels of educational or cultural resources.

Family Structure

Through the inquiry into adult's presence at home, PISA classified students' family

structure into four categories: single-parent family (living with one of the following: mother, father, female guardian, or male guardian), nuclear family (living with both parents), mixed family (living with a father and a guardian, a mother and a guardian, or two guardians) and others. For comparisons in this study, single-parent, mixed families and others are grouped as non-nuclear families.

Immigrant Status

Native status is defined by PISA as strictly relating to the country of birth of students and their parents. PISA did not intend for this variable to encompass aboriginal people in Canada. The immigration information a student provided indicated the countries where the student and his/her parents were born in order to classify students into three categories- native students (those who were native-born or who had at least one native-born parent), first-generation students (those who were native-born with foreign-born parents), and non-native students (these students as well as their parents were all foreign-born). For comparisons in this study, first-generation and native students are grouped together versus non-native students.

Data Analysis

HLM 6.0 (SSI Inc., Lincolnwood IL) and SPSS 13.0 (SPSS Inc., Chicago IL) are used to analyze hierarchically structure data and to conduct preliminary data analysis in

this study, respectively. Student-level variables include three dichotomous dummy variables- sex (female 1, male 0), non-nuclear (nuclear 0, other groups 1), non-native (native and first-generation 0, non-native 1), and one continuous variable-ESCS (standardized with PISA mean 0 and standard deviation 1). School-level variables are the aggregated student-level variables for each school, which are proportion of girls, proportion of non-nuclear families, proportion of non-native students, and school mean SES.

HLMs for Canada and Hong Kong

Null Models

The first step is to construct a null model for Canada and Hong Kong in order to estimate the proportion of variance in the outcome measure that can be attributed to level 2- the schools.

$$\text{Student level: } \text{Math}_{ij} = \beta_{0j} + r_{ij}$$

$$\text{School level: } \beta_{0j} = \gamma_{00} + u_{0j}$$

where Math_{ij} is the mathematics score for student i in school j ;

β_{0j} is the average mathematics score in school j ;

r_{ij} is the error of using mean math score in school j to predict the

mathematics achievement of student i in school j ;

γ_{00} is the grand (overall, across-school) mean of mathematics scores;

u_{0j} is the error of using grand mean math score to predict the average

math score in school j .

The outputs of null models demonstrate (1) whether the school mean math scores (β_{0j}) vary across schools; (2) the proportion of total variance explained in school level (i.e., intraclass correlation ρ); and (3) the grand means of mathematics scores (γ_{00}) in Canada and Hong Kong, which answer the first research question.

Random Coefficient Models

The second step is to include SES first into the student-level model in order to estimate the effect of SES. The HLM is as follows.

$$\text{Student level: } \text{Math}_{ij} = \beta_{0j} + \beta_{1j}(\text{SES})_{ij} + r_{ij}$$

$$\text{School level: } \beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

where β_{1j} is the slope for SES in school j ;

γ_{10} is the across-school slope average.

The second research question- the proportion of variance explained by adding SES into the student-level- can be derived from the difference of the variance within school between this model and that of null model. Furthermore, whether the slopes for

SES (β_{1j}) vary across schools can also be examined.

Similarly, the variance within school can be further reduced by adding three dichotomous dummy variables- non-nuclear, non-native, and sex- in student level in addition to SES, which answers the third research question- the variability in mathematics achievement that can be further explained by these three variables. The HLM model is as follows.

$$\begin{aligned} \text{Student level: } \mathit{Math}_{ij} = & \beta_{0j} + \beta_{1j}(\mathit{SES})_{ij} + \beta_{2j}(\mathit{Non-nuclear})_{ij} \\ & + \beta_{3j}(\mathit{Non-native})_{ij} + \beta_{4j}(\mathit{Sex})_{ij} + r_{ij} \end{aligned}$$

$$\text{School level : } \beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

$$\beta_{4j} = \gamma_{40} + u_{4j}$$

where Non-nuclear, Non-native, Sex are dichotomous dummy variables;

β_{2j} to β_{4j} are mean differences between the mathematics achievement

of the 0 and 1 groups in the dichotomous student-level variables;

γ_{10} to γ_{40} are the across-school slope averages;

u_{1j} to u_{4j} are the errors to the intercept and level-1 gradients associated with

school j .

Intercepts- and Slopes-as-Outcomes Model

The intercepts- and slopes-as-outcomes model allows us to model the variability of the regression coefficients (both intercepts and slopes) (Raudenbush & Bryk, 2002).

$$\text{Student level: } Math_{ij} = \beta_{0j} + \beta_{1j}(SES)_{ij} + \beta_{2j}(Non - nuclear)_{ij} \\ + \beta_{3j}(Non - native)_{ij} + \beta_{4j}(Sex)_{ij} + r_{ij}$$

$$\text{School level: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{school SES}) + \gamma_{02}(\text{proportion of non - nuclear}) \\ + \gamma_{03}(\text{proportion of nonnative}) + \gamma_{04}(\text{proportion of girls}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{school SES}) + \gamma_{12}(\text{proportion of non - nuclear}) \\ + \gamma_{13}(\text{proportion of nonnative}) + \gamma_{14}(\text{proportion of girls}) + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(\text{school SES}) + \gamma_{22}(\text{proportion of non - nuclear}) \\ + \gamma_{23}(\text{proportion of nonnative}) + \gamma_{24}(\text{proportion of girls}) + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + \gamma_{31}(\text{school SES}) + \gamma_{32}(\text{proportion of non - nuclear}) \\ + \gamma_{33}(\text{proportion of nonnative}) + \gamma_{34}(\text{proportion of girls}) + u_{3j}$$

$$\beta_{4j} = \gamma_{40} + \gamma_{41}(\text{school SES}) + \gamma_{42}(\text{proportion of non - nuclear}) \\ + \gamma_{43}(\text{proportion of nonnative}) + \gamma_{44}(\text{proportion of girls}) + u_{4j}$$

School-level variables with non-significant coefficients and the student-level

variables with non-significant intercepts and negligible error variances are removed from

the model and rerun the HLM to acquire the final model. The results of $\gamma_{01}, \dots, \gamma_{04}$ and $\gamma_{11}, \dots, \gamma_{44}$ demonstrate which school-level variables explain school mean mathematics achievement and which school-level variables influence the gradients of student factors on mathematics achievement, respectively, which answers the last research question. This study will compare the different results of HLM in Canada and Hong Kong in next chapter.

Summary of Chapter Three

This chapter describes the participants, sampling method, instrument, variables and analytic models used in this study. It also outlines the preliminary data analyses. The interpretations and comparisons of the results between Canadian and Hong Kong will be discussed in the following chapters.

CHAPTER FOUR: RESULTS

Preliminary Data Analyses

The Sample

The Canadian sample consisted of 27,593 students from 1,087 schools and the Hong Kong sample consisted of 4,478 students from 145 schools. The number as well as the proportion of missing data is shown in Table 1. Canada sample had more missing values than Hong Kong. About 6% occurred in the non-native variable in Canada, which was still relatively low. Therefore, listwise deletion is used for the missing data in this study.

Table 1

Missing data in Canada and Hong Kong

Variables	Canada	Hong Kong
SES	1363(4.8%)	30(.6%)
Sex	736(2.6%)	0(0%)
Non-nuclear	1477(5.3%)	27(.6%)
Non-native	1696(6.1%)	85(1.9%)

Descriptive Statistics

The descriptive statistics for the variables at student level (Table 2) and school level (Table 3) provide a basic understanding of the tendency and characteristics about the data.

As to outliers, there are no data exceedingly large or small from the maximum and minimum for all the variables in both countries.

Mathematics Achievement

The descriptive statistics (skewness and kurtosis shown in Table 2) and histograms (Figure 1 and Figure 2) both indicate that five plausible values of mathematics achievement are roughly normally distributed for both countries. Canada and Hong Kong, both with means above OECD average of 500, are two high mathematics performing countries. But Hong Kong overall surpasses Canada in mathematics by about 24 points (about 0.25 standard deviation).

Student- and School-level Predictors

On average, Canadian students had considerably higher SES (.35) than Hong Kong students (-.75) (as shown in Table 2). The difference (1.1) was about 1.3 standard deviations. Both samples had equal proportion (.5) for different genders. At student level, the proportion of students from non-nuclear families (.31) in Canada was slightly higher than that (.25) in Hong Kong. Furthermore, the proportion of non-native students in Canada (.06) was lower than that of Hong Kong (.19). There is a slight difference in the means between the student- and school-level variables might be due to the unequal sample sizes for each school and the unweighted mean calculation.

Table 2

Descriptive Statistics for Student-level variables

Country	Variable	Mean	SD	Min	Max	Skew -ness	Kurtosis
Canada	PV1math	521.66	88.04	160.34	859.28	-0.06	-0.17
	PV2math	521.16	87.47	83.14	866.83	-0.07	-0.13
	PV3math	521.57	87.56	123.96	856.47	-0.06	-0.14
	PV4math	521.26	87.95	119.75	853.28	-0.08	-0.14
	PV5math	521.45	87.94	191.03	844.48	-0.06	-0.14
	SES	0.35	0.84	-3.59	2.42	-0.04	-0.36
	Female	0.50	0.50	0.00	1.00	-	-
	Non-nuclear	0.30	0.46	0.00	1.00	-	-
	Non-native	0.05	0.23	0.00	1.00	-	-
Hong Kong	PV1math	555.02	98.06	95.61	881.09	-0.46	0.31
	PV2math	555.28	96.83	159.87	870.96	-0.41	0.14
	PV3math	556.83	97.46	174.20	877.19	-0.39	0.12
	PV4math	556.00	97.01	95.61	878.75	-0.42	0.19
	PV5math	556.18	97.90	159.87	893.78	-0.39	0.18
	SES	-0.75	0.82	-3.45	2.19	0.24	0.22
	Female	0.50	0.50	0.00	1.00	-	-
	Non-nuclear	0.25	0.43	0.00	1.00	-	-
	Non-native	0.19	0.39	0.00	1.00	-	-

Table 3

Descriptive Statistics for School-level variables

Country	Variables	Mean	SD	Min	Max
Canada	School SES	0.32	0.43	-1.49	1.72
	proportion of girls	0.50	0.15	0.00	1.00
	proportion of non-nuclear	0.31	0.16	0.00	1.00
	proportion of non-native	0.06	0.13	0.00	1.00
Hong Kong	School SES	-0.76	0.41	-1.59	0.86
	proportion of girls	0.50	0.26	0.00	1.00
	proportion of non-nuclear	0.25	0.10	0.00	0.52
	proportion of non-native	0.19	0.11	0.00	0.55

Comparing Canada and Hong Kong through HLM 45

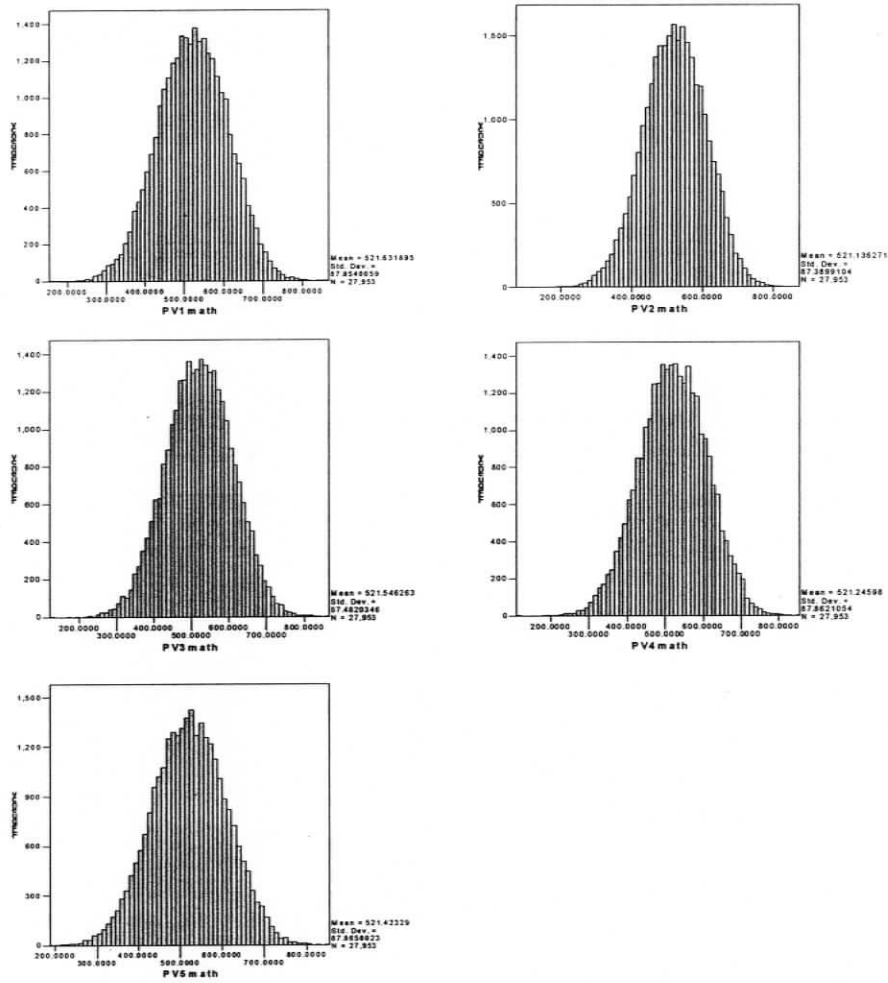


Figure 1. Histograms of the five plausible values of math scores for Canada

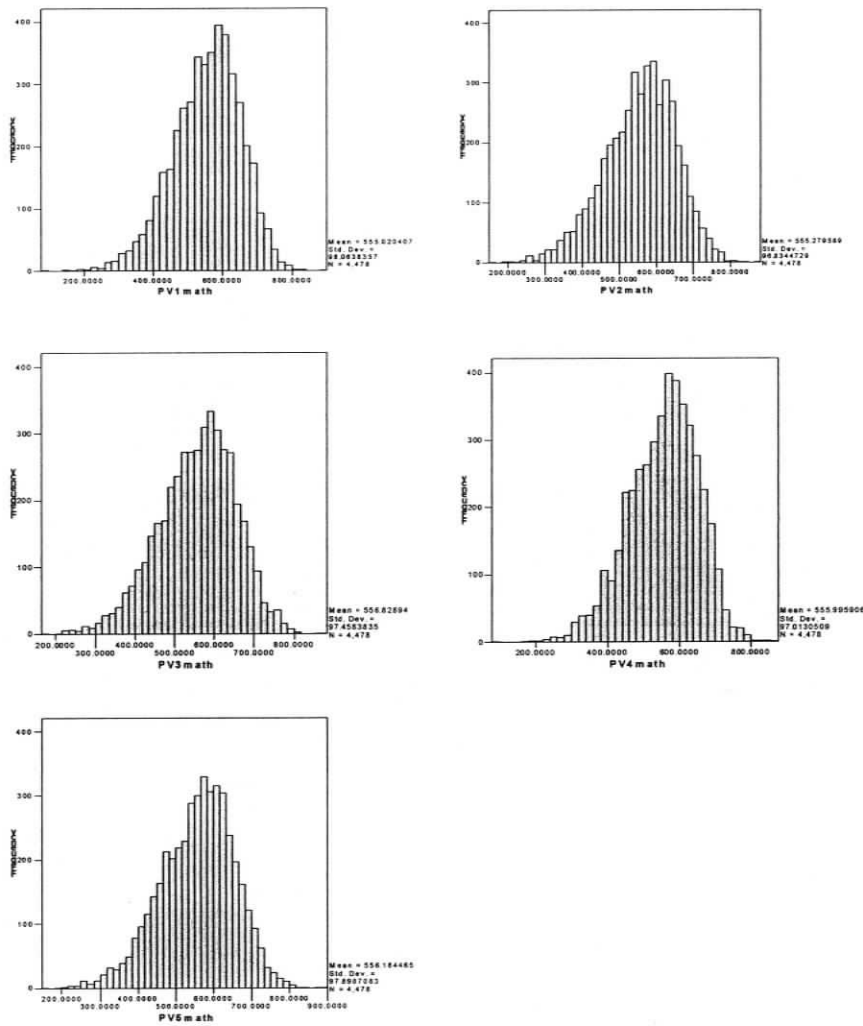


Figure 2. Histograms of the five plausible values of math scores for Hong Kong

Correlations

The correlations between mathematics achievement and SES for Canada and Hong Kong are presented in Table 4 and 5, respectively. Since the means and distributions of the five plausible variables are roughly equivalent, only PV1math is used for the calculation of correlation. The correlations between mathematics achievement and SES at student level indicate that SES has a significantly positive effect on mathematics

achievement in both countries and Canada has a higher SES-math (.33) correlation than Hong Kong (.26).

Table 4-7 show the pairwise correlations between PV1math and the predictors at two levels for Canada and Hong Kong. From the correlations, there is no serious multicollinearity among the variables.

At student level, the correlation between SES and individual mathematics achievement is significantly positive in both countries. The correlations between sex (female) and mathematics and between coming from non-nuclear and mathematics are significantly negative in both countries. The correlation between being non-native and individual mathematics achievement is significantly negative in Hong Kong but positive (non-significant) in Canada.

At school level, the proportion of non-nuclear families in the school is significantly and negatively correlated with mathematics achievement and school SES in both Canada and Hong Kong. It implies that schools with higher concentration of students from non-nuclear families tend to have lower mathematics achievement and lower average SES. In addition, the proportion of non-native students has a significantly positive but low correlation with mathematics achievement and school mean SES in Canada, but a significantly negative correlation with mathematics achievement and school mean SES in

Hong Kong. It indicates that schools with higher proportion of non-native students are associated with higher mathematics achievement and school SES in Canada but lower mathematics achievement and school SES in Hong Kong.

Table 4
Correlations between Student-level Variables for Canada

	1	2	3	4	5
1. PV1math	1				
2. SES	.33**	1			
3. Sex (Female)	-.04**	.01	1		
4. Non-nuclear	-.14**	-.15**	.01	1	
5. Non-native	.01	.07**	-.01	-.00	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 5
Correlations between Student-level Variables for Hong Kong

	1	2	3	4	5
1. PV1math	1				
2. SES	.26**	1			
3. Sex (Female)	-.05**	.02	1		
4. Non-nuclear	-.09**	-.00	-.02	1	
5. Non-native	-.17**	-.22**	.02	-.05**	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 6
Correlations between School-level Variables for Canada

	1	2	3	4	5
1. PV1math	1				
2. School SES	.58**	1			
3. proportion of girls	.13**	.01	1		
4. proportion of non-nuclear	-.42**	-.25**	-.09**	1	
5. proportion of non-native	.09**	.23**	-.02	.02	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 7
Correlations between School-level Variables for Hong Kong

	1	2	3	4	5
1. PV1math	1				
2. School SES	.64**	1			
3. proportion of girls	.09	.11	1		
4. proportion of non-nuclear	-.54**	-.24**	-.12	1	
5. proportion of non-native	-.38**	-.39**	-.07	.04	1

** Correlation is significant at the 0.01 level (2-tailed).

Results from HLM

The results of the HLM models in Canada and Hong Kong are presented in Tables 8-11. The final estimates in HLM are the average results from analysis of the five plausible values with final student weights taken into account (Mislevy, Johnson, & Muraki, 1992). Replicate weights, which were in PISA 2003 dataset, are not used in this study since they do not considerably affect the results (Willms & Smith, 2005). The final model is derived by removing the school-level variables with non-significant coefficients and the student-level variables with non-significant intercepts and negligible error variances and then rerunning HLM. Only the values of the significant fixed effects and random effects are presented in the tables.

Null Models

The null model is unconditioned in that no student or school level variables are entered in the model. However, schools are modeled to vary in terms of average

mathematics performance.

$$\text{Student level: } \text{Math}_{ij} = \beta_{0j} + r_{ij}$$

$$\text{School level: } \beta_{0j} = \gamma_{00} + u_{0j}$$

Table 8

Output of the Null Models for Canada and Hong Kong

Level	Fixed Effect	Canada	Hong Kong
		Coefficient	Coefficient
School	Intercept, γ_{00}	531.33	548.01
	Random Effect	Variance Component	Variance Component
Student	R	5728.75	5174.70
School	U_0	1445.94	4946.99
	Intraclass correlation ρ	0.20	0.49

Table 8 shows that the school average mathematics scores (β_{0j}) significantly vary across schools in both Canada and Hong Kong (i.e., significant random effect on the school intercept). The intercept (γ_{00}) for Hong Kong (548) is about 17 points higher than that (531) for Canada. Furthermore, the intraclass correlation (ρ) is the proportion of variance in mathematics achievement that can be explained by schools, which is also considered as an index of school homogeneity (Kreft & Leeuw, 1998). About 20% and 49% of the variance in mathematics achievement can be attributed to schools in Canada and Hong Kong, respectively. It implies that, on average, Canadian schools are much more homogeneous in mathematics performance than those in Hong Kong.

Random Coefficient Models Including SES

In order to estimate the effects of SES, the random coefficient model is to include SES first into the student-level model.

$$\text{Student level: } \text{Math}_{ij} = \beta_{0j} + \beta_{1j}(\text{SES})_{ij} + r_{ij}$$

$$\text{School level: } \beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

Table 9

Output of the Random Coefficient Models Including SES for Canada & Hong Kong

Level	Fixed Effect	Canada Coefficient	Hong Kong Coefficient
Student	SES, γ_{10}	27.64	6.20
School	Intercept, γ_{00}	522.50	553.10
	Random Effect	Variance Component	Variance Component
Student	R	5074.69	5126.81
School	U_0	1009.17	4683.93
School	SES slope, U_1	119.19	NS
Student	explained variance	0.11	0.01

NS= Non-significant

Table 9 shows that the results of the models with SES included at student level for both countries. At student level, students' mathematics achievement increases 27.64 points in Canada and 6.2 points in Hong Kong as their SES increases 1 unit. The proportion of within-school variance in mathematics achievement accounted for by SES is about 11% in Canada, but only about 1% in Hong Kong.

At school level, the intercepts (γ_{00}), which indicates the overall school mean

mathematics scores after conditioning SES, for Canada and Hong Kong are 522.50 and 553.10, respectively. There is significant variation in school mean mathematics scores (β_{0j}) in both Canada and Hong Kong. On average, the slopes for SES are statistically homogeneous across schools in Hong Kong (i.e., nonsignificant variance of SES gradient), but vary significantly across schools in Canada.

Random Coefficient Models Including All Student-level Predictors

In addition to SES, three other dichotomous variables- non-nuclear, non-native, and sex- are added to the student-level model in order to investigate the variability in mathematics achievement that can be further explained by these three variables.

$$\begin{aligned} \text{Student level: } \text{Math}_{ij} = & \beta_{0j} + \beta_{1j}(\text{SES})_{ij} + \beta_{2j}(\text{Non} - \text{nuclear})_{ij} \\ & + \beta_{3j}(\text{Non} - \text{native})_{ij} + \beta_{4j}(\text{Sex})_{ij} + r_{ij} \end{aligned}$$

$$\text{School level : } \beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

$$\beta_{4j} = \gamma_{40} + u_{4j}$$

Table 10 shows the results of the models including SES, sex, non-nuclear, and non-native as student-level predictors in Canada and Hong Kong. At student level, all

variables are significant in Canada and only sex and non-native are significant in Hong Kong. One unit increase in student's SES predicts a higher mathematics score by 26.72 points in Canada after other variables are fixed. However, SES becomes nonsignificant in Hong Kong model after including three other student-level predictors. Female students, on average, are predicted to achieve lower in mathematics than male students in Canada and Hong Kong by 12.92 points and 16.12 points, respectively, as other variables are held constant. Students from non-nuclear families in Canada are associated with lower mathematics scores than their counterparts from nuclear families by 14 points after controlling for other variables. Being a non-native student predicts a lower mathematics score than a native student in Canada and Hong Kong by 12.13 points and 24.77 points, respectively, given other variables are fixed. By adding three predictors besides SES at student level further reduces 4% and 3% of the within-school variance in mathematics achievement in Canada and Hong Kong, respectively.

At school level, the intercepts γ_{00} (the conditioned overall school mean mathematics scores) for Canada and Hong Kong are 536.06 and 560.88, respectively. Furthermore, there is a significant variation in school means (β_{0j}) (i.e., the error variance is significant) in both Canada and Hong Kong. SES slopes, sex slopes, non-nuclear slopes, and non-native slopes vary significantly among schools in Canada whereas only non-native

slopes vary significantly among schools in Hong Kong.

Table 10

Output of the Random Coefficient Models Including Student-level Variables for Canada & Hong Kong

Level	Fixed Effect	Canada Coefficient	Hong Kong Coefficient
Student	SES, γ_{10}	26.72	NS
	Sex(female), γ_{20}	-12.92	-16.12
	Non-nuclear, γ_{30}	-14.00	NS
	Non-native, γ_{40}	-12.13	-24.77
School	Intercept, γ_{00}	536.06	560.88
	Random Effect	Variance Component	Variance Component
Student	R	4822.72	4928.07
School	U_0	1168.78	5161.18
School	SES slope, U_1	125.65	NS
	Sex slope, U_2	193.39	NS
	Non-nuclear slope, U_3	471.11	NS
	Non-native slope, U_4	293.80	428.70
	further reduced within –school variance	0.04	0.03

NS= Non-significant

Intercepts- and Slopes-as-Outcomes Models

The intercepts- and slopes-as-outcomes model allows us to model the variability of the regression coefficients (both intercepts and slopes) (Raudenbush & Bryk, 2002).

$$\text{Student level: } \text{Math}_{ij} = \beta_{0j} + \beta_{1j}(\text{SES})_{ij} + \beta_{2j}(\text{Non - nuclear})_{ij} \\ + \beta_{3j}(\text{Non - native})_{ij} + \beta_{4j}(\text{Sex})_{ij} + r_{ij}$$

$$\text{School level: } \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{school SES}) + \gamma_{02}(\text{proportion of non - nuclear}) \\ + \gamma_{03}(\text{proportion of nonnative}) + \gamma_{04}(\text{proportion of girls}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{school SES}) + \gamma_{12}(\text{proportion of non-nuclear}) \\ + \gamma_{13}(\text{proportion of nonnative}) + \gamma_{14}(\text{proportion of girls}) + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(\text{school SES}) + \gamma_{22}(\text{proportion of non-nuclear}) \\ + \gamma_{23}(\text{proportion of nonnative}) + \gamma_{24}(\text{proportion of girls}) + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + \gamma_{31}(\text{school SES}) + \gamma_{32}(\text{proportion of non-nuclear}) \\ + \gamma_{33}(\text{proportion of nonnative}) + \gamma_{34}(\text{proportion of girls}) + u_{3j}$$

$$\beta_{4j} = \gamma_{40} + \gamma_{41}(\text{school SES}) + \gamma_{42}(\text{proportion of non-nuclear}) \\ + \gamma_{43}(\text{proportion of nonnative}) + \gamma_{44}(\text{proportion of girls}) + u_{4j}$$

Table 11 lists the output of the final models for Canada and Hong Kong. At student level, all student-level variables except non-nuclear are significant in Canada whereas all except SES and non-nuclear are significant in Hong Kong. One unit increase in SES predicts 24.63 points higher in mathematics achievement in Canada but stays level in Hong Kong after controlling for other variables. Female students are predicted to score lower than male students by 13.55 points and 41.14 points in Canada and Hong Kong, respectively, with other variables being fixed. Being a native student has an advantage in mathematics than a non-native student by 12.82 points and 48.99 points, respectively, in Canada and Hong Kong as other variables are held constant.

Table 11
Output of Final Models for Canada and Hong Kong

Level	Fixed Effect	Canada Coefficient	Hong Kong Coefficient	
Student	SES, γ_{10}	24.63	NS	
	Sex (female), γ_{20}	-13.55	-41.14	
	Non-nuclear, γ_{30}	NS	NS	
	Non-native, γ_{40}	-12.82	-48.99	
School	Intercept, β_{0j}	Intercept, γ_{00}	524.28	740.99
		School SES, γ_{01}	29.49	76.77
		% of girls, γ_{02}	31.81	NS
		% of non-nuclear, γ_{03}	-54.06	-364.04
		% of non-native, γ_{04}	NS	-135.05
	Sex slope	% of non-nuclear, γ_{21}	*	95.08
	Non-nuclear slope	% of non-nuclear, γ_{31}	-40.04	*
	Non-native slope	% of non-native, γ_{41}	*	106.86
	Random Effect	Variance Component	Variance Component	
Student	R	4807.18	4956.06	
School	U_0	932.85	1789.64	
	SES slope, U_1	120.68	NS	
	Sex slope, U_2	217.31	NS	
	Non-nuclear slope, U_3	431.41	NS	
	Non-native slope, U_4	361.54	NS	

NS=Non-significant

*=Not applicable

At school level, the intercepts γ_{00} (the conditioned overall school mean mathematics scores) are 524.28 and 740.99 in Canada and Hong Kong, respectively. The school average mathematics scores (β_{0j}) vary significantly across schools both in Canada and Hong Kong (i.e., significant random effects for β_{0j}). As the proportion of girls increases 1 unit, the school average mathematic score goes up by 31.81 points in Canada and stay

level in Hong Kong while conditioning other variables. That is, 10% increase in the proportion of girls in a school raises the school average score by 3.18 points in Canadian schools. One unit increase (meaning a shift from 0% to 100%) in the proportion of students from non-nuclear families associates with 54.06 points and 364.04 points decrease in school average mathematics scores in Canada and Hong Kong, respectively as other variables are fixed. That is, schools with 10% increase in non-nuclear families are associated with decrease of 5.4 points and 36.4 points in school mean math scores in Canada and Hong Kong, respectively. One unit increase in the proportion of non-native students does not seem to influence the school average mathematics performance in Canada but lower that in Hong Kong by 135.05 points (i.e., 10% increase in the proportion of non-native students predicts 13.5 points lower in school mean score) given other variables are constant.

The SES slopes differ significantly from school to school in Canada, but are statistically equivalent in Hong Kong. The increase in the proportion of students from non-nuclear families flattens the sex slope in Hong Kong. This means that the male-female gap in mathematics becomes smaller in the schools with higher concentration of non-nuclear families in Hong Kong. The sex slopes vary significantly across schools in Canada, but they seem to be more homogeneous in Hong Kong after

controlling for the proportion of non-nuclear families. Both the averages of the non-nuclear slopes for Canada and Hong Kong are approximately 0 at the student level while conditioning other variables. As the proportion of non-nuclear families increases, the non-nuclear slopes become steeper in Canada. That is, more students from non-nuclear families enlarge the mathematics gap between students from nuclear and non-nuclear families in Canadian schools. The non-nuclear family slopes in Canada are significantly different across schools even after conditioning the proportion of non-nuclear families whereas those in Hong Kong are statistically equal. The increase in the proportion of non-native students flattens the non-native slopes in Hong Kong. It implies that the mathematics differences between native and non-native students reduce in schools with higher percentage of non-native students in Hong Kong. There is a significant school variation in the non-native slopes in Canada but no significant school variation in those in Hong Kong with the proportion of non-native students being fixed.

Compared with null model, the final model of Canada reduces about 16% of the estimated within-school variance in mathematics achievement whereas that of Hong Kong only reduces 4%. School-level variables in the Canadian model and Hong Kong model account for about 35% and 64% of the estimated between-school variance, respectively.

Comparisons between Two Countries

Similarities

Both countries have the following similarities. First, the directions of the coefficients of the significant variables in both countries are similar. Second, being a female student and a non-native student are significantly and negatively related to mathematics achievement while controlling for other variables. Third, coming from a non-nuclear family does not seem to significantly influence individual mathematics achievement if other variables are held constant. Fourth, school mean SES and the proportion of students from non-nuclear families have significantly positive and negative contribution to school average mathematics performance, respectively. Fifth, school mean mathematics scores (β_{0j}) vary significantly across schools even after conditioning the listed variables.

Differences

First, the magnitude of the coefficients for all the significant variables in both countries at student- and school-level is stronger in Hong Kong than that in Canada. Second, individual SES, when conditioned by sex, family structure, and immigrant status, is significantly and positively associated with mathematics achievement in Canada, but nonsignificant in Hong Kong. Third, proportion of girls is significantly and positively related to school mean mathematics score in Canada, but not in Hong Kong. Fourth, the

proportion of non-native students has a significantly detrimental impact on school average mathematics performance in Hong Kong, but not in Canada. Fifth, all of the four slopes- SES, sex, non-nuclear, and non-native- are heterogeneous across schools in Canada, but statistically homogeneous in Hong Kong.

CHAPTER FIVE: DISCUSSION AND CONCLUSION

This study investigated and compared the hierarchical relationships between mathematics achievement and student characteristic variables (SES, sex, family structure, and immigration background) as well as school aggregate variables (school SES, proportion of girls, proportion of non-nuclear families, and proportion of non-native students) in Canada and Hong Kong. Interpretations, comparisons and conclusions will be discussed in this chapter. The findings of this study provide policy-makers and parents with the information to inform educational practice and accountability.

Limitations

There are several limitations for this study. First, the findings are correlational. Based on the secondary dataset and the nature of HLM, the results in this study show correlational rather than causal relationship. Second, student characteristic variables and aggregate school variables in this study only account for part of the variance in mathematics achievement. Since students' mathematics achievement depends on multiple factors, there is still a large proportion of unexplained variance in students' mathematics achievement. Third, this study only compares the differences in the coefficients of student characteristics at student- and school-level on mathematics achievement between Canada and Hong Kong. Statistical inferences of the differences are not made.

Future Research

First, the results in this study are limited to the 15-year-old samples in Canada and Hong Kong. Future research could further investigate the relationship between mathematics achievement and student characteristics on different age groups to check if there is any pattern in this relationship across age. Second, only Canada and Hong Kong are compared in the relationship between mathematics and student characteristics. Further research could extend the comparison to multiple countries in order to have a better understanding of how student characteristics influence their mathematics achievement at student level and at school level across countries.

Policy Implications

The major implication of this study for educators and policy makers is that the aggregated variables of student characteristics play an important role in students' mathematics achievement in addition to their individual characteristics. Three recommendations are provided to promote the quality and equality (i.e. to elevate and flatten the slopes) in mathematics performance in Canada and Hong Kong based on current study's findings. The first is for schools to provide non-native students with a specialized curriculum or supplementary instructions (OECD, 2004). This suggestion could increase the equity in mathematics performance within the school by offering more

differentiated learning opportunities to students (OECD, 2004).

The second recommendation is for educational practices to increase the finance and resource allocation for schools with lower mean SES (Yang 2003), which has a significantly positive effect on school average mathematics achievement for both countries in this study. These schools tend to be associated with lower teacher morale and aspirations, less discipline, and fewer material resources (Willms, 1992). Better financial support allows schools to recruit qualified teachers, improve physical facilities, and promote parent-school interactions, which all facilitate students' learning, and thereby boosts the school overall mathematics achievement (Yang, 2003).

The last recommendation is for schools to build teacher-parent relations and interparental relations (Pong, 1998) since the proportion of non-nuclear families and the proportion of non-native students have been shown in this study to be significantly and negatively related to school overall mathematics performance. Pong (1998) showed that children's mathematics achievement increased with the number of parental acquaintances in schools that had more than half students from single-parent families. Coleman (1990) also proposed that increased social capital of the community can considerably compensate for decreased social capital within certain families. For instance, children from single-parent families have similar educational attainment to their counterparts from

two-parent families if the schools are in communities with extensive social capital.

Therefore, it is important for parents to keep contact with teachers and other parents especially for single parents and non-native parents since they can exchange their experiences with teachers and other parents, gain information about schools, communities, and children's peers, and parents of their children's friends can serve as surrogate parents when parents are busy (Pong, 1998).

Discussion

Hong Kong has a higher overall mathematics performance than Canada in PISA 2003. The intra-class correlation in Hong Kong (49%) is almost 2.5 times as that in Canada (20%). That is, the effects of school characteristics on variation in students' mathematics achievement are much stronger in Hong Kong than in Canada. One possible explanation for this gap is the different educational systems in these two countries. In Hong Kong, ability grouping is very common at school level (schools are classified into 5 bands) and the admission criteria for particular schools are based on academic achievement (Biggs, 1996). Furthermore, in the school questionnaire of PISA 2003, most principals reported the determinant for school admission in Hong Kong is students' prior academic achievement whereas that in Canada is their community of residence (OECD, 2004).

Consistent with prior research, SES is significantly and positively associated with mathematics achievement at student level in both countries. The positive impact of SES on mathematics achievement is smaller in Hong Kong than that in Canada. The inclusion of SES explains 11% of the within-school variance in mathematics achievement in Canada, but only 1% in Hong Kong. This difference might be due to different cultural values of education. Compared with western parents, Chinese parents have higher valuation of education and emphasize the needs for educational success more regardless of their SES since education predicts future occupation and income (Liberatos, Link, & Kelsey, 1988; Sue & Okazaki, 1990).

Adding three other student characteristic variables to the model, SES effect on mathematics decreases slightly in Canada, but disappears in Hong Kong. Only 4% of the within-school variance in mathematics can be further explained by these three variables (sex, family structure, and immigrant status) in Canada and 3% in Hong Kong.

Non-native students are predicted to have significantly lower mathematics performance than native students in both countries, which might be partly attributed to the grouping of native students in this study. First-generation students outperformed the other two groups (native and non-native) in both countries. In order to know how foreign-born status relates to mathematics performance, first-generation students are grouped with native

students. The magnitude of this negative coefficient is larger in Hong Kong than in Canada possibly because education strongly affects income and status in Hong Kong (McLelland, 1991). For example, the lifetime pay of a manual worker can be earned by a high school teacher in 15 years and by a professor in 5 years in Hong Kong (Chiu & Ho, 2006). In British Columbia Canada, the average hourly pay for a university professor (about \$32.24) is about 4 times as that for a worker with minimum pay (\$8) (Service Canada, 2005). That is, the 20-year pay of a worker can be earned by a professor in 5 years in Canada. It showed that the income differences between educational levels in Hong Kong are larger in those in Canada. Therefore, parents in Hong Kong make arrangements for children's schooling from kindergarten in order to increase their chance to attend good universities which assure the best job opportunities (Chiu & Ho, 2006). Non-native students whose parents are also non-native are more likely to fall behind native students due to the gap in curriculum and the adaptation in schooling.

The effects of all the significant variables in both countries at school level are stronger in Hong Kong than those in Canada. One underlying factor might be more variance can be attributed to schools in Hong Kong ($\rho = .49$) than in Canada ($\rho = .20$). Therefore, the influences of school traits on the differences in students' mathematics achievement are much greater in Hong Kong than in Canada. Consistent with previous

studies, schools with higher proportions of students from high SES family background may provide more effective learning environments and therefore promote the overall academic performance (Willms, 1992). Higher proportion of girls significantly increases the school average mathematics achievement in Canada since it may lead to a more study-oriented culture, which might promote male students' achievement and thereby raise the overall mathematics performance (Houtte, 2004).

The proportion of students from non-nuclear families in a school has a significantly negative impact on school average mathematics achievement in both Canada and Hong Kong. It has been shown that family disruption which leads to non-nuclear family structure lowers a child's academic performance (e.g. McLanahan, 1985). Aside from these children, their schoolmates might also underperform due to the school compositional effects of family instability (Bankston & Caldas, 1998; Pong, 1997). This might be related to two factors. The first is the economic deprivation hypothesis for students from non-nuclear families (McLanahan, 1985). Schools with higher proportion of students from non-nuclear families are more likely to have parents with lower SES and therefore lower the school mean SES (Pong, 1997). These schools tend to be related to lower teacher morale and aspirations, less discipline, and fewer material resources (Willms, 1992). Second, parents' social networks might be associated with children's

achievement (Pong, 1997). Parents of non-nuclear families might have less time to interact with teachers and other parents to learn more about children's performance and life outside the family and about parenting. These two factors might subsequently influence academic performance of the children.

The proportion of students from non-nuclear families has a more detrimental effect on school average mathematics achievement in Hong Kong than in Canada. There are three possible reasons for this. The first is the counteraction of the negative effects from family disruption by the national family and welfare policies (Pong, Dronkers, & Hampden-Thompson, 2003). Canada has better family and welfare policies which allocate resources equally between nuclear and non-nuclear families than Hong Kong. Therefore, the negative effect of family disruption on academic performance might be reduced in Canada in comparison to Hong Kong. The second is the cultural difference in perception of family disruption. In China, the interest, completeness, and reputation of the family have a high priority and should be considered before individual needs (Locke, 1992). Therefore, cultural pressure is placed on one's behavior that will not embarrass his/her family and cause them to lose face (Locke, 1992). Family disruption used to be considered disgraceful in Chinese society. Although the situation has changed, the influence of the perception still remains. This means that the children from non-nuclear

families not only directly experience family disruption but also face the pressure and negative perception from the society, which might in turn negatively affect their academic outcomes. The third is the intra-class correlation coefficient. Much more variation in mathematics achievement can be accounted for by schools in Hong Kong than those in Canada. This means that the effects of school traits on variation in students' mathematics achievement are much greater in Hong Kong than in Canada. Based on these factors, the school context effect of family disruption on achievement might be aggravated in Hong Kong than in Canada.

Higher proportion of non-native students within a school is associated with significantly lower overall school average mathematics achievement in Hong Kong whereas it does not significantly influence Canadian overall school average mathematics achievement given other variables are fixed. It might be because the school correlates have more effects on variation in students' mathematics achievement in Hong Kong than in Canada. Another possible reason is the mathematics achievement gap between native and non-native students in Canada is not as large as that in Hong Kong.

Conclusion

In general, Hong Kong has higher mathematics performance than Canada. Much more variance in mathematics achievement can be attributed to schools in Hong Kong

than those in Canada. SES accounts for only 1% of the within-school variance in mathematics achievement in Hong Kong but 11% in Canada. In addition, the three other variables only further explain 3% of the variance in Hong Kong and 4% in Canada.

At student level, SES, sex and immigrant status are significant in predicting mathematics achievement in Canada whereas sex and immigrant status are significant in predicting mathematics achievement in Hong Kong. That is, being female and being non-native are significantly and negatively related to 15-year-old students' mathematics achievement in both countries and higher SES predicts higher individual mathematics achievement only in Canada.

At school level, school mean SES, proportion of girls, and proportion of non-nuclear students are significant correlates for school average mathematics scores in Canada while school mean SES, proportion of non-nuclear students and proportion of non-native students are significant correlates for school average mathematics score in Hong Kong. In other words, high school SES is beneficial for school average mathematics performance and prevalence of non-nuclear families is detrimental for school overall mathematics performance for both countries. Higher proportion of girls promotes school overall mathematics performance in Canada whereas higher proportion of non-native students lowers school overall mathematics performance in Hong Kong after controlling for other

variables.

To conclude, the directions of the coefficients for those variables significant in both countries are similar at student level as well as school level, but the magnitude of the coefficients is stronger in Hong Kong than that in Canada. That is, student characteristics variables significant in both countries at student level and at school level have more effects on mathematics achievement in Hong Kong than in Canada. School mean SES is significantly and positively related to school overall mathematics achievement. Of the three aggregate dichotomous variables, prevalence of students from non-nuclear families has the largest impact on school average mathematics performance. School variations in the slopes of the student characteristic variables can be explained by school aggregate variables in Hong Kong but not in Canada.

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APPENDIX A
Items Descriptors

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Please write in the job title.

ST10	What does your father do in his main job? (e.g., teach high school students, builds houses, manages a sales teams) Please use a sentence to describe the kind of work he does or did in that job.
Recode	Recoding of ISCO codes into SEI results in scores for the Mother's occupational status (BMMJ) and Father's occupational status(BFMJ). The Highest Occupational Level of Parents (HISEI) corresponds to the highest SEI score of both parents or to the only available parent's SEI score. Higher scores of SEI indicate higher level of occupational status.

Educational Level of Parents

ST11	Which of the following did your mother complete at school? (a) ISCED level 3A (b) ISCED level 3B, 3C (c) ISCED level 2 (d) ISCED level 1 (e) None of the above
ST12	Does your mother have any of the following qualifications? Pleas tick as many boxes as apply (a) ISCED 5A, 6 (b) ISCED 5B (c) ISCED 4
ST13	Which of the following did your father complete at school? (a) ISCED level 3A (b) ISCED level 3B, 3C (c) ISCED level 2 (d) ISCED level 1 (e) None of the above
ST14	Does your father have any of the following qualifications? Pleas tick as many boxes as apply (a) ISCED 5A, 6 (b) ISCED 5B (c) ISCED 4
Recode	Indices are constructed by taking always the highest level for each father or mother and have the following categories: (1) None, (2) ISCED 1 (primary education), (3) ISCED 2 (lower secondary), (4) ISCED Level 3B or 3C (vocational/pre-vocational upper secondary), (5) ISCED 3A (upper secondary) and/or ISCED 4 (non-tertiary post-secondary), (6) ISCED 5B (vocational tertiary), (7) ISCED 5A, 6 (theoretically oriented tertiary and post-graduate). Indices with these categories will be provided for mother (MISCED) and father (FISCED) of the student. Highest Level of Parents (HISCED) corresponds to the higher ISCED level of both parents.

 Immigration Background

ST15a	In what country were you and your parents born? Please tick one answer per column).	You	Mother	Father
	Country of test			
	Country A			
	Country B			
	Country C			
	Other country			
ST15b	If you were not born in the country of test, how old were you when you arrived in the country of test? _____ years (If you were less than 12 months old, please write 0)			
Recode	The index on immigrant background (IMMIG) was already used in PISA 2000 has the following categories: (1) 'native' students (those students born in the country of assessment or who had at least one parent born in the country), (2) 'first-generation' students (those born in the country of assessment but whose parent(s) were born in another country, and (3) 'non-native' students (those students born outside the country of assessment and whose parents were also born in another country). Students with missing responses for either the student or for both parents, or for all three questions are given missing values.			

 Home Possessions

ST17	Which of the following do you have in your home? Please tick as many boxes as apply. (a) A desk to study at (b) A room of your own (c) A quiet place to study (d) A computer you can use for school work (e) Educational software (f) A link to the internet (g) Your own calculator (h) Classic literature (e.g., Shakespeare) (i) Books of poetry (j) Works of art (e.g., paintings) (k) Books to help with your school work (l) A dictionary (m) A dishwasher (n) Country-specific item 1 (o) Country-specific item 2 (p) Country-specific item 3			
ST18	How many of these do you have at your home? Please tick only one box in each row.			
	None	One	Two	Three or more
	(a) (Cellular) phone			
	(b) Television			

None One Two Three or more

(c) Computer

(d) Motor Car

(e) Bathroom

ST19

How many books are there in your home? There are usually about 40 books per meter of shelving. Do not include magazines, newspapers, or your schoolbooks.

(a) 0-10 books (b) 11-25 books (c) 26-100 books (d) 101-200 books

(e) 201-500 books (f) More than 500 books

Recode

ESCS (Economic, Social, and Cultural Status) is determined by the following variables: (1) the highest international socio-economic index of occupational status of the father or mother; (2) the highest level of education of the father or mother converted into years of schooling (for the conversion of levels of education into years of schooling see Table A1.1 in OECD, 2004); and (3) the number of books at home as well as access to home educational and cultural resources, obtained by asking students whether they had at their home: a desk to study at, a room of their own, a quiet place to study, a computer they can use for school, books to help with their school work, and a dictionary.

The ESCS is composed of parental occupational status, parental education and wealth. The student ESCS scores are factor scores derived from a Principal Component Analysis which are standardized to have an OECD mean of zero and a standard deviation of one. The patterns of factor loading were very similar across countries, with all three components contributing to a similar extent to the index. For the occupational component, the average factor loading was 0.81, ranging from 0.72 to 0.86 across countries. For the educational component, the average factor loading was 0.80, ranging from 0.70 to 0.87 across countries. For the wealth component, the average factor loading was 0.76, ranging from 0.65 to 0.80 across countries. The reliability of the index ranged from 0.56 to 0.77. These results support the cross-national validity of the ESCS index.
