

A Multilevel Analysis of Mathematics Literacy in Canada and Japan: The Effects of Sex Differences, Teacher Support, and the School Learning Environment

by

Anita Ram
B.Sc., University of Waterloo, 2004

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ABSTRACT

In this study, the effects of student and school level variables on the mathematics achievement of 15 year old students in Canada and Japan were investigated. Participants included 27, 953 students from Canada and 4, 707 students from Japan. The student level variables used in this analysis included student sex, perceived teacher support, and socioeconomic status, and the school level variables included principals' perceptions of both student and teacher morale and commitment, and student and teacher related factors affecting school climate. Hierarchical linear modeling was used to analyze data from the Programme for International Student Assessment 2003. The proportion of variance in mathematics scores attributable to schools was 20% in Canada and 54% in Japan. In both countries, higher ratings by principals on both student commitment and morale, and student-related factors affecting school climate were linked to higher mathematics achievement. Implications for educators and suggestions for future research are discussed.

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Chapter One: Introduction

A Multilevel Analysis of Mathematics Literacy in Canada and Japan: The Effects of Sex Differences, Teacher Support, and the School Learning Environment

Adolescence is a period of great change (Tartre & Fennema 1995), and for most a point of transition with respect to general developmental changes and a new school environment (Wentzel, 1998). This phase most typically accompanies adolescents distancing themselves from parents (Connolly, Hatchette, & McMaster, 1998) as they seek autonomy (Chen, 2005). Adolescents desire to be respected and make their own decisions, but they also require a sense of structure within which to make decisions (Klem & Connell, 2004). Adolescents need a clear understanding of what is expected of them from adults and that these expectations are fair. They also need to know that not meeting those expectations is associated with consistent and predictable consequences; thus, being able to express autonomy within a safe environment.

Students' cognitive abilities, development, and affective and psychological well being are all influenced by students' experiences in school (Deci & Ryan, 1985). Students spend about 15,000 hours in schools in their first two decades of development (Deci, Vallerand, Pelletier, & Ryan, 1991). This suggests that schools have a significant impact on the course of students' lives (Goh, 2006). Teachers and schools may play an influential role in a students' academic career as teacher support is positively linked to mathematics achievement (Midgley, Feldlaufer, & Eccles, 1989); a decline or lack of teacher support may lead to a decrease in students' mathematics achievement. This study will be examining the influence of sex differences, teacher support, socio-economic

status, and factors relating to school climate on mathematics achievement in both Canada and Japan.

Students interact frequently with teachers and peers during the course of a school day, and the quality of these relationships help to determine whether these sources of support are significant in influencing students' academic endeavours (Chen, 2005). In other words, students who perceive their teachers to be supportive may be motivated to do well simply because they experience less distress and negative affect when presented with academic and social challenges at school (Wentzel, 1997). Good relationships can help to decrease one's levels of stress, while poor relationships can increase it (Haynes, Emmons, Ben-Avie, 1997).

"Success in school is a critical component of the ability to participate fully in contemporary society" (Connolly et. al, 1998, p. 1). Students spend a considerable amount of time in the classroom with teachers who sometimes serve as confidants, mentors, and friends (Lynch & Cicchetti, 1992). Many studies have been devoted to the understanding of support characteristics that maximize academic achievement such as the support of, parents, teachers, and peers (Chen, 2005; Domagala-Zysk, 2006; Rosenfeld, Richman, & Bowen, 2000). More specifically, teacher support in the classroom has shown to have a positive effect on student's academic success (Klem & Connell, 2004). Teacher support not only influences students' school performance (Chen, 2005), but also encourages students at risk of failing, to stay in school (Battstitch, Solomon, Watson, & Schaps, 1997; Croninger & Lee, 2001; Will, 2001; Yeung & McInerny, 1999).

Creating an environment where teachers nurture, stimulate, and challenge students can help to reduce academic failure among at-risk students by having students

persist through school (Will, 2001). Class attendance is consistently a predictor of a students' grade point average (GPA). Teacher support can have a significant association to students' GPA (Will, 2001), and an effect on minimizing students' absence from school in grades 7 and 8 (Yeung and McInerney, 1999). As well, a safe learning environment, and a smooth transition from middle school can be beneficial (Will, 2001) as the structure of middle school (e.g. different teachers for each subject) may impede the formation of close relationships with teachers (Reddy, Rhodes, & Mulhull, 2003).

The transition to a new school environment may be accompanied by a change in school organization that occurs when students move from smaller elementary schools to larger middle or junior high schools. For example, this may result in a shift from extended close contact with one teacher to shorter less personalized classes with many teachers. Students may begin to perceive that teachers no longer care about them, which can lead to decreased opportunities to establish meaningful relationships with peers (Eccles & Midgley, 1989 as cited in Wentzel, 1998); students' relationships with teachers might also undergo changes in nature and significance during early adolescence (Goodenow, 1993). As a result, interpersonal relationships that provide students with a sense of belongingness can be powerful motivators of children's interest in school (Deci, 1992). In other words, a students' sense of being accepted, valued, included, and encouraged, by teachers and peers in the academic classroom setting can lead to the feeling of being an important part of the life and activity in the classroom (Goodenow, 1993).

More than simple perceived liking or warmth, a sense of belonging also involves support and respect for personal autonomy and for the student as an individual

(Goodenow, 1993). Supportive classroom environments foster fuller development of a student's positive self-image and enhance self-concept (Cooper & Simonds, 2003). When students are free of disruptive anxiety, fear, anger, or depression, they are more likely to make desirable cognitive and affective gains. The teacher has the ability to create within his or her classroom a unique environment in which they can connect with their students, raise their self-esteem, win their cooperation, and instil in them the ideal values of society (Nakamura, 1999). From this, we can assert that the teacher has, at the beginning of the year, the opportunity to control and shape the classroom into one that promotes wellness. Students may be empowered by being given opportunities to express themselves. Being sensitive to the needs of each student is one of the greatest means to help students reach their full potential.

Support in the classroom, from teachers, may compensate for inadequate support from parents as perceived by students (Chen, 2005). More specifically, a direct link exists between teacher and parent perceived support and adolescents' school performance (Chen, 2005). Teachers have significantly positive effects on interest, academic self-esteem, and GPA; even greater than the effects of other factors such as personal expectancy, parents, and peers (Yeung & McInerney, 1999). The research shows that the classroom teacher in the class setting has a level of impact that is not matched by parents and peers (Klem & Connell, 2004). Moreover, academic achievement is influential in shaping student's future outcomes (Chen, 2005) and thus the teacher is very important in this process. In the absence of explicit communication of expectations by the teacher, it is important to acknowledge that implicit communication is present (Bandura, 1986; Grusec & Goodnow, 1994). Students may learn and adopt many of the beliefs and goals the adult

(i.e. teacher) would like them to achieve through observational learning. Therefore, Wentzel (2002) exclaims that students may be motivated to achieve positive social and academic outcomes at school because of teacher modeling and through the use of specific care giving strategies (e.g. warmth, absence of conflict, open communication) (Birch & Ladd, 1996). It may be essential for teachers to model for their students through daily practices how to create and maintain good relations with their parents and peers (Domagala-Zysk, 2006) to create a network of support that would benefit more than just the student.

Differences between Sex and Gender

While sex and gender are often considered interchangeable, they actually refer to two distinct concepts (Figure 1) (Reeder, 2005). Sex refers to one's biological status as male or female, as determined by chromosomes and secondary sex characteristics (Reeder, 2005). Gender, however, refers to the behaviors and traits that society considers masculine and feminine.

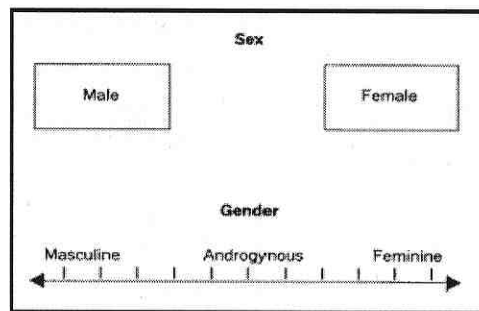


Figure 1: Sex versus Gender. Reeder (2005)

In Western culture, stereotypically masculine traits include aggressiveness, independence, and self-reliance (Bem, 1974). Such traits typically are considered independent and task oriented. Stereotypically feminine traits include being helpful, warm, and sincere. These traits tend to reflect a relationship orientation. Biological sex is

relatively fixed, while gender is fluid and varies in degree (Reeder, 2005). It is recognized that the biological differences between males and females are not dichotomous; however, this figure models the contrast between the relative inflexibility of sex in comparison to the variability of gender. In other words, not all men are alike and not all women are alike (Reeder, 2005).

Some researchers, like Halpern (2000), believe that sex differences refer to both biological and psychosocial aspects of the differences between males and females, and that these two aspects are closely tied together in Western society. Given that biological manifestations are confounded with psychosocial variables, discrepancies found between males and females are often difficult to discern. It is not always obvious whether they are due to biological differences or the psychosocial differences.

In some literature, researchers may express the term gender differences when they are referring to sex differences, because some argue that this topic is a trivial matter of semantics (Kim & Nafziger, 2002). It is difficult to examine both sex and gender independently, especially when individuals may be categorized by sex overall and results may be interpreted in terms of the lifestyles of men and women, or the interaction of sex with other social factors (Cheshire, 2002). In this study, sex differences will be examined, which relate to biological differences. These differences are addressed with the understanding that they may be closely tied to psychosocial aspects in Canada and Japan.

It is important to examine sex differences to further clarify mixed findings, and contribute to the body of literature supporting that sex differences do exist. Sex differences in academic achievement have been studied extensively over the past few decades (Kianian, 1996). In some studies, females have higher grades than males (Leahey

& Guo, 2001; Marsh & Yeung, 1998; Will, 2001; Wentzel, 2002), while in other studies this is not the case; either gender differences do not exist (Kianian, 1996; Lachance & Mazzocco, 2005) or males outperform females (Goldstein, Haldane, & Mitchell, 1990). In terms of teacher support, girls may react differently to teacher support than boys. For instance, girls may show greater concern than boys about asking their teacher questions (Newman & Schwager, 1993). The cause may be underlying socialization differences as adolescent girls may express greater interest in school than boys (Wentzel, 1991; 1997). Consequently, further research is essential in this area in order to clarify and contribute to research findings in this area.

Comparative Educational Research

In general terms, comparative education research refers to inspecting two or more educational processes with the purpose of determining how they are alike and how they are different (Thomas, 1990). Processes in this sense refer to any act associated with learning and teaching. Research includes analyzing two ways of teaching a single mathematics lesson or inspecting several education systems in different countries; these all qualify as engaging in comparative education research. Many times educators intentionally go abroad to examine schooling practices internationally to discover profitable procedures that would be used in their home country. More generally, comparisons can help one to understand, extend their insights, and sharpen their perspectives. It helps one to answer such questions as: Does this relationship hold in another country or another cultural setting? Comparative educational research does not come without some difficulties (Theisen & Adams, 1990). No person is free of the cultural value system of which they are a part. For instance, Japanese students who

studied outside of Japan found it difficult, upon their return, to adjust to differences in dealing with peers and teachers and facets of school life (Hess & Azuma, 1991), demonstrating that there may be implicit differences between two cultures that may not be obvious to an individual rooted in one culture.

In some cases, educational concepts may not have equivalent meanings across social or cultural groups. For example, the word college has definitions that include “a degree-granting institution of higher education,” “a secondary-level school,” and “a loose collection of faculty with similar academic concerns.” (p. 279) One may be limited in their range of perspectives by their experience and training; however it is important to identify an acceptable level of equivalence across institutions being studied and that variables chosen to describe a relationship do not distort the meaning of what is being measured and as a result what is inferred (Theisen, 1984 as cited in Theisen & Adams, 1990).

Purpose

The purpose of this study is to comparatively examine the effects of sex, student perceived teacher support, socioeconomic status (SES), and factors related to the school climate on the mathematics achievement of 15-year old students. The data was provided by the Programme for International Student Assessment (PISA) and analyses were conducted on data from both Canada and Japan. Analyzing national large scale data can aid in developing an understanding of a nation by describing areas of strengths and weaknesses, and as a result helping educators to better understand and monitor students' progress in learning. For instance, Canada and Japan achieve similarly on PISA 2003 mathematics assessment, yet show differences in the level of perceived teacher support

(Thompson, Creswell, & De Bortoli, 2004). This may be a result of the cultural and socialization differences. Students from Canada and Japan may equally be supported in their academic endeavours, but from different sources (e.g. teachers and parents) (Hess & Azuma, 1991).

Hierarchical linear modeling (HLM) was used to examine these variables which allow data to be analyzed on two levels. The first level pertains to student variables and the second level pertains to school variables. Few researchers have examined these variables in a hierarchical structure. Naturally, students exist within hierarchies of classrooms, schools, districts, provinces, and countries (Osborne, 2000). When examining results in this manner, students tend to be more similar in terms of sharing the same environment and experiences, than students randomly sampled from the whole population. As a result, this idea is central to this research and is intended to take into account the impact of student and school hierarchies on students' mathematics achievement.

Research Questions

1. Do sex differences exist in mathematics achievement?
2. Is there a relationship between student perceived teacher support and mathematics achievement?
3. Are there significant relationships between mathematics achievement and socioeconomic status, and mathematics achievement and principals' perceptions of the school climate?
4. What are the differences in findings between Canada and Japan?

Chapter Two: Literature Review

Sex differences have been the topic of interest and research for many years and have been furthered by advances in brain imaging and by a new understanding of the mutual relationships between biology and environment (Halpern, 2000). Gaulin (1995), who studied the spatial abilities in two species of rodents, (polygamous and monogamous voles), argued that the polygamous species showed sex differences in spatial abilities over the monogamous species as a result of the need for males to roam farther to find multiple mates. After examining the hippocampus of voles, Gaulin (1995) was able to conclude that this part of the brain that underlies spatial cognition was larger for males of the polygamous species but not for the monogamous species. Although it is argued that differences in neuroanatomy are strong support for the adaptive modification of the brain (Sherry, Jacobs, & Gaulin, 1992), more research is needed to determine whether sex differences in spatial abilities are correlated with whether a species is monogamous or polygamous (Halpern, 2000). These occurrences lead to such questions as: Are these cognitive differences between the sexes responsible for males dominating career fields requiring strong spatial and mathematical abilities? If so, are these cognitive differences due primarily to biology or environment?

The Evolutionary Perspective

Sex differences may trace as far back as the division of labour in earlier human societies of hunting and gathering. Males were predominantly the hunters and, as a result, were hypothesized to require better spatial skills than women whose main role was to gather food (Halpern, 2000). Ultimately, the evolutionary perspective proposes that, due to male's primary occupation of hunting in previous societies, they evolved to be

genetically superior in spatial ability (Halpern, 2000). In contrast, females, who were primarily gatherers, had to remember the location of edible plants from season to season (Halpern, 2000). Similarly, Silverman and Eals (1992) found women to have better results in tasks requiring memory for location, and found men to be better at tasks involving mental transformations of spatial displays. However, spatial skills were also necessary for gatherers who travelled long distances for food and who weaved baskets for efficient gather (Halpern, 2000). Weaving baskets is considered a complex spatial skill and there were many hunter-gatherer societies where women hunted.

Another researcher (Geary, 1996) described both primary and secondary cognitive skills. For instance, primary skills are those shaped by evolutionary pressures consistent across cultures and in children's play, and secondary skills are those that did not evolve from hunter-gatherer societies like reading and spelling (Geary, 1996). With respect to mathematics skills, Geary (1996) found there only to be sex differences in secondary cognitive skills, but he reported no differences in primary mathematics ability, such as counting and comparing quantity.

The Psychobiosocial Perspective

An individual is predisposed to learn some behaviours or concepts more easily than others, and this is partly influenced by prior learning experiences and partly by interest and expectancy (Halpern, 2000). Consequently, all behaviour results from the joint action of biological, psychological, and social influences (Halpern, 2000). Some studies have shown that, on average, girls do not score as high as boys on mathematics tests, especially those involving higher level cognitive tasks (Leder, 1990). Ideally, everyone should have the same opportunity to learn and achieve in mathematics. In many

cases, females are under-represented in advanced mathematics courses, college majors and careers that involve mathematics (Armstrong, 1985). This leads us to ask the question; are males socialized differently than females that result in sex differences in mathematical ability and course selection? However, through closer examination, it will become evident both that the gender gap for career opportunities and academic achievement is decreasing and that options for women are changing.

Sex Differences in Mathematics Achievement

Boys' and girls' mathematics performance in early school years (5.72 to 8.73 year olds) was examined to determine early manifestations of possible sex differences in mathematics achievement, mathematics ability, mathematics related skills, reading related skills, and visual spatial ability on commonly observed tasks (Lachance & Mazzocco, 2005). In their study, they found minimal or nonexistent sex differences in mathematics. One sex did not show an advantage over the other in overall mathematics performance during the longitudinal study or in any one area of the skills being assessed. They noted there were as many significant results in favour of boys outperforming girls as there were for girls outperforming boys. No significant correlations were observed that were unique to either sex.

A longitudinal study conducted by Kianian (1996) assessed the mathematics achievement of 479 (219 males and 260 females) students from 24 classrooms from two colleges in Denver. The study lasted over a 4-year period (1987 to 1990) assessing mathematics grades in algebra, statistics, and finite mathematics all taught by the author. Results showed no significant sex differences.

In addition, Tartre and Fennema (1995) tested students on cognitive factors related to performance in mathematics, such as mathematics achievement, spatial visualization, spatial orientation, and verbal skill. Affective factors were also tested, such as confidence in learning mathematics, perceived usefulness of mathematics, the perception of mathematics as a male domain, and the effect of the teacher on the learning of mathematics. Sixty students were randomly selected and their progress was monitored every two years beginning in grade 6 for four consecutive intervals afterwards. Researchers concluded no consistent significant sex differences for means in spatial skills, verbal skills, or mathematics achievement. Positive correlations were observed for mathematics achievement in relation to confidence, verbal skill, and spatial visualization for both sexes. Interestingly, spatial skills alone were found to be consistent significant predictors of mathematics achievement for females during each year of the study, while, verbal skills were found to be consistent significant predictors of mathematics achievement for males.

In a study conducted by Lloyd, Walsh, and Yailagh (2005), mathematics report card grades, self-efficacy and performance attribution scales, were used to examine sex differences in mathematics achievement, self-efficacy, and performance attributions (e.g. internal and external) using the 2001 Foundational Skills Assessment (FSA). Researchers reported girls had higher 2001 FSA numeracy subtest scores that were 14 points higher than boys. However, even though this difference was not found to be significant, girls' achievement, as indicated by report card grades, was significantly higher than that of boys.

In another study, Leahey and Guo (2001) tested the hypothesis that males would outperform females in mathematics. They analyzed large national data sets for sex differences. The sample was composed of students from elementary school through to high school. They examined achievement in several areas of mathematics in a sample of high achieving students. They found a small difference in mean mathematics scores for general mathematics skill, where girls had a higher average than boys until about age 11. The mean mathematics score for boys increased after the age of 11 very slightly but was found not to be significant. Specifically, for high scoring students, between the ages of 4 and 7, girls outperformed boys, but boys outperformed girls between the ages of 8 and 10. With respect to reasoning skills, (problems requiring more than one step to solve), researchers found few sex differences among younger children, but they found females to have scores slightly, yet significantly higher than males in the 11 to 13 age group. No clear sex differences in reasoning skills among eighth grade students were observed. There was, however, an increase in mean reasoning scores for males in high school, but this was not statistically significant at the 5% criterion level. Overall, among the general population, Leahey and Guo (2001) found males to have a slight emerging advantage in mathematics later in high school. These findings are inconsistent with Benbow (1988) who found strong evidence for sex differences at the age of 12; yet, consistent with Hyde, Fennema, and Lamon (1990) who report sex differences to emerge in adolescence. This demonstrates that results vary from study to study, and what may be viewed as statistically significant in one study may be found to be slight in another.

Sex Differences in Test Performance

Marsh and Yeung (1998) conducted a study to determine whether or not changes in academic self-concept led to changes in academic achievement in mathematics and English in relation to sex. They used data from a multi-wave questionnaire that was given to the same students in 1988 when they were in grade 8 and on two occasions afterwards. Consequently, their data consisted of English and mathematics grades, and English and mathematics self-concept scores from grades 8, 10, and 12. Their results showed that sex differences in areas traditionally favouring boys are diminishing or shifting to favour girls, and sex differences traditionally favouring girls are increasing. Sex differences in school grades favoured girls largely in both English and mathematics, but the test scores did not.

In another study, Goldstein, Haldane, and Mitchell (1990) found that males had an advantage on a mental rotation test. When they analyzed the number of attempted questions and correct answers they found that sex differences diminished. This is because even though females did not attempt to solve as many questions as males, they had the same proportion of attempted and correct answers. Halpern (2000) offers potential explanations as to why females may score significantly lower than males on tests and rationalizes that females may be more cautious when selecting answers on a test and may respond slower than males. In addition, Marsh and Yeung (1998) found that, although girls tended to outperform boys on school grades based on self-reports and official school transcripts, they achieved at a lower level on standardized test scores. Further examination revealed that females achieved consistently higher English grades than did boys, but they were only slightly better on English test scores. Male achievements do not

match the gradual educational gains experienced by females over the past couple of decades (Marsh & Yeung, 1998). Brophy (1985) hypothesized that sex differences in academic achievement would decline to eventually lead to these differences becoming non-existent. With respect to college competition, Buchmann and DiPrete (2006) found that the gender gap favoured females. They found that the effect of women's higher academic performance did not emerge to create as dramatic a gender gap until after the transition to college. This may be due either to growing incentives for women to attain a higher education (e.g. intellectual development, job opportunities) (Buchmann & DiPrete, 2006) or to the level of parental involvement with sons and daughters (Muller, 1998).

Catsambis (1994) examined the development of sex differences in learning opportunities, achievement, and choices, in mathematics among Caucasian, African American, and Latino students. The sample consisted of 8th grade students who were resurveyed two years later in grade 10. They found that females did not fall behind males in test scores and grades. In addition, Caucasian female students were exposed to more learning opportunities in mathematics than Caucasian males. Overall, female students tended to have less interest and confidence in their mathematical abilities. Latino students proved to have the largest sex differences, while African Americans had the smallest sex differences. One of the major barriers for minority students for mathematics achievement was the limited learning opportunities. Class ability levels, as reported by the teacher in 8th grade, and the types of mathematics curriculum the students were enrolled in, in the 10th grade measured the limited learning opportunities. More specifically, Kohr, Masters, Coldiron, Blust, and Skiffington (1989) found mathematics achievement increased as

students' socio-economic-status increased, and Caucasian students achieved at a higher level than did African American students.

The findings for sex differences are inconsistent among studies and some believe that sex differences in mathematics are declining and will continue to do so over the generations to come (Hyde, Fennema, & Lamon, 1990).

Where do Parents fit in?

Muller (1998) speculates that sex differences in achievement may be attributed to daughters experiencing more nurturing and more restrictions on activities than sons. As well, students reported that as females they form supportive verbal relationships with their parents. Males on the other hand, report that parents intervene in their lives, and males are more likely to engage in relationships outside the home. As a result, the difference observed in this study may partly be due to socialization differences of boys and girls. Furthermore, they found parental restrictions on activities to be the strongest positive predictor of grade 10 mathematics achievement, while parental intervention showed a moderate negative association to mathematics scores. Achievement scores in grade 8 were strongly related to how much students talked to their parents about school. The variance in predictors at each grade level may be accounted for by their developmental age, as older adolescents necessitate increased autonomy.

A study examining the influence of academic support from mothers, fathers, and teachers, on 14 to 17 year old Latino adolescents' academic motivation found academic support from mothers' and teachers' to be positively related to adolescent girls' academic motivation (Alfaro, Umana-Taylor, & Bamaca, 2006). They also found, that academic

support from fathers, and teachers, was positively influential to boys' academic motivation.

The Importance of a Caring Environment

Students need to feel that adults in school know and care about them (Klem & Connell, 2004). They also need to feel that they can make some important decisions for themselves and that their schoolwork has some relevance to their lives. Solomon, Battistich, Watson, Schaps, and Lewis, (2000) examined success in establishing a caring community in the school. Researchers looked at classroom observations, teacher questionnaires, student questionnaires, and student achievement measures after implementing the Child Development Project to assess the programs success. Students who reported caring and supportive interpersonal relationships in school had more positive academic attitudes and values and were more satisfied with school. McCroskey (1992), as cited in Teven and McCroskey (1996), suggested that it is important for a teacher to learn to communicate with students in a way which will allow them to perceive that the teacher "cares" about them. It is optimal to have the teacher sincerely care about his or her students. Caring may be difficult to convey in larger classrooms. As a result, in difficult situations, it is more beneficial to be perceived as caring despite whether or not the teacher actually cares. Similarly, some teachers may care deeply, yet they may not express this to the student, which can be as unpleasant as not caring at all.

Teacher Support

The importance of teacher support is signified by the idea that students at risk of dropping out of high school are more likely to persist through school until graduation, when adolescents are able to trust and receive guidance from their teachers (Croninger &

Lee, 2001). Students who are socially at risk, who enter high school with low educational expectations, and who have a history of school related problems benefit from support the most.

Connolly et al. (1998) studied the link between personal attitudes and parental and teacher support for school and student achievement in Canada. The sample consisted of 2377 young Canadian adolescents who were 10 and 11 years old. Students were asked to complete a questionnaire and a mathematics test. The questionnaire assessed attitudes toward school, self-esteem, perception of parental pressure, and perception of parental support. Part of the questionnaire asked parents to respond to two items dealing with the importance of school and hopes for their child's education. Teachers were asked to rate students on their mathematical ability, reading, written work, and overall skills. In addition, children evaluated the extent to which their teacher provided help when needed and treated them fairly – along with being asked to report the presence of physical changes associated with puberty.

The results showed that girls felt parents were supportive of their efforts in school, placed fewer academic pressures on them, and felt their teacher provided them with more school support. Overall, this suggests that, in the later years of elementary school, girls perceived to experience more support than boys. This may be because adolescent girls are more responsive to their teachers' interpersonal cues (Debold, Brown, Wessen, & Brookins, 1999). No differences in school achievement between boys and girls were observed; however, girls displayed a more positive attitude towards school and were rated higher by their teachers on their academic skill than were boys (Connolly et al., 1998). Parent and teacher supports, and positive attitudes all contributed to

academic success for girls, while only parental support was a predictor for boys' academic success.

In another study conducted by Midgley, et al. (1989) 1,301 students and their mathematics teachers were provided with questionnaires that pertained to students' perceptions of the value of mathematics, the quality of student-teacher relationships, and students mathematics achievement to determine any changes in these constructs before and after the transition to junior high school. Results showed there to be an interaction between students' perceptions of mathematics' usefulness and importance with achievement level. Students' intrinsic value of mathematics increased when they transitioned from having elementary school teachers whom they perceived to be low in teacher support to junior high school teachers they perceived to be high in teacher support. In contrast, those who went from having teachers they perceived to be high in teacher support to teachers perceived to be low in teacher support, reported a decline in intrinsic value and perceived usefulness and importance in mathematics. When comparing high and low achieving students, the latter resulted in having sharper declines in mathematics values when moving from supportive to less supportive teachers.

Similarly, Fry and Coe (1980) report that students who perceived the social climate of their classroom to be characterized by emphasis being placed on student-teacher rapport, support, and interaction had students reporting more enjoyment of learning and motivation for academic success. On the other hand, students who perceived the social climate of their classroom to be high on teacher control where emphasis was given to organization and order reported lower enjoyment of learning and a significant level of anti-school feeling. Other researchers also reported an increase in students' self-

esteem and intrinsic motivation in classrooms of autonomy supporting teachers (Deci, Nezlek, & Sheinman, 1981; Grolnick & Ryan, 1987). Results indicate that of the learning dimensions assessed, teacher's emotional support yielded the strongest association between on-task-orientation and students' perceptions of the meaningfulness of schoolwork. In other words, it was the teachers' approval and care (Fry & Coe, 1980).

In other research, Reddy, et al. (2003), conducted a longitudinal study examining changes in students' well-being and perceptions of teacher-support in addition to detecting any gender specific patterns among these variables. Over 2,500 students in grade 6 responded to questionnaires assessing the quality of their teacher-student relationships indexing perceived teacher-support, depression and self-esteem levels, and demographic characteristics. Students were asked to participate for a 3-year period. Results supported the finding that over time students report a decreased sense of support from their teachers. Those that reported an increased level of teacher support also had corresponding increased self-esteem and decreased depression.

Pianta, Stuhlman, and Hamre (2002) considered approaches to foster stronger connections between teachers and students. On the basis that relationships between children and parental and non-parental adults have an exceptional role in the development of abilities through to high school (Birch & Ladd, 1996), these relationships function as emotional and social supports, sources of information and role modeling, and problem solving resources and guides (Pianta et al., 2002). They exclaim that a cost effective option for support within the school setting is to facilitate adult-student relationships within the school since students already spend a considerable amount of time there.

Teachers and other adults in the school settings are underused and underdeveloped (Pianta, 1999).

Teacher Support and Student Engagement

Some researchers perceive student engagement as the link between teacher support and academic achievement (Klem & Connell, 2004). Chen (2005) hypothesized that students' self-perceived academic support from parents, peers, and teachers is related to their achievement directly and indirectly through students' own perceived academic engagement. Participants included 270 adolescents with a mean age of 15.41 from a secondary school in Hong Kong. Results illustrated perceived parental and teacher support, but not peer support, to be directly related to academic achievement for this sample. They found that, although perceived parental support and academic achievement had a significant relationship, the value was negative. A plausible reason offered by Chen (2005) suggests that high parental support may not be welcomed at a time where adolescents seek autonomy and detachment from their parents and as a result, adolescents may view higher levels of parental involvement as interfering with their needs to be independent.

In another study, Klem and Connell (2004) found teacher support to be important to student engagement in school as reported by both students and teachers. Students who perceived teachers as creating a caring, well-structured learning environment in which expectations were high, clear, and fair, were more likely to report engagement in school. Their model predicts experiences of support from teachers to lead to student engagement in the learning environment, which ultimately has outcomes of higher school performance and higher school commitment.

Thuen and Bru (2000), explored dimensions of the learning environment related to on-task-orientation associated to students' perceptions of the meaningfulness of schoolwork with 9th grade students in Norway. The researchers define on-task-orientation as "a student's concentration during the accomplishment of tasks at school, and their attention during teachers' instructions" (p. 394). Researchers chose teacher-support, teacher monitoring, student influence, competition for grades, and relations between classmates as the main learning environment dimensions. Thuen and Bru (2000) hypothesize that the formal leader role of the teacher in the classroom and the supportive and monitoring aspects of the teacher function are likely to influence on-task-behaviour directly and indirectly. The researchers further hypothesize there to be two important dimensions of teachers' support to students, academic and emotional.

Academic teacher-support is defined as teachers who provide thorough instruction and explanation and offer students relevant and needed help with their work resulting in students knowing what the task is and how to complete it. Emotional teacher-support in addition to academic approval includes social approval and expression of care and appreciation. In turn, this can be viewed as a method for developing positive relations between teachers and students (Thuen & Bru, 2000), which can lead to an increase in students' willingness to be committed to goals for schoolwork (e.g. Schmuck & Schmuck, 2000). Researchers found both dimensions to be important in influencing student school-related behaviours and highlighted that improvement is necessary in the area of teachers' emotional support in Norway.

Does the Sex of the Teacher Matter?

Warwick and Jatoui (1994) analyzed the relationship between teacher sex and mathematics achievement among elementary school students in Pakistan. Interviewers gave students in grade 4 and 5 curriculum based achievement tests in mathematics and science, along with a brief questionnaire. Two categories of schools were examined; those with the same sex of both teacher and students, (e.g., male teacher for male students), and coeducational schools with male and female teachers and students. In Pakistan, mathematics is considered a male domain, and as a result, females are less likely to enrol in mathematics programs at post-secondary levels. They found that male students scored significantly higher than female students on both tests of mathematics. In addition, mean mathematics scores for male schools were significantly higher than for female schools. They also found that in classrooms with male teachers, the mean mathematics score was higher than classrooms with female teachers. It is difficult, however, to distinguish whether it was the teachers' or students' sex that determined the difference in mathematics achievement.

Parents, Peers, and Teachers

Rosenfeld, et al. (2000) studied the extent to which students perceived their parents, friends, and teachers as important sources of social support. Over 2000 public school students in grades 6 to 12 in the United States were asked to respond to a national survey. Results showed that students who reported receiving low support from parents, friends, and teachers had the poorest school outcomes. Students who reported perceiving support from parents, friends, and teachers in comparison to those who perceived support from only one or two of the sources, indicated having better attendance, spending more

hours studying, avoiding problem behaviour, having higher school satisfaction, engagement, and self-efficacy, and obtaining better grades.

Domagala-Zysk (2006), also demonstrated the importance of social support from parents peers and teachers and compared two groups of adolescents in Poland. The sample consisted of 100 adolescents experiencing school failure and another 100 not experiencing any problems with learning as dictated by their grades. Each group had an even distribution of males and females, and the mean age was 14. Students were asked to fill out a questionnaire booklet that examined the strength and quality of their relationships with significant others. It was hypothesized that those failing in school and those who were not, as measured by the perceived amount of social support from mothers, fathers, peers, and teachers, would experience the quality of relationships, differently. The results showed that students, who were failing, perceived their parents to give them less emotional support where they wanted to be given more. For example, help in dealing with personal problems, praise, and encouragement to do better in school. They nominated fewer friends as significant others and they did not feel equal to their peers. With respect to teachers, failing students did not perceive their teacher to be helpful in managing everyday school problems, and they viewed the teacher as somebody who made it more difficult for them to learn.

Alternatively, Yeung and McInerney (1999) conducted a study evaluating American high school students in grades 7 and 8 on their self-esteem, interest in schoolwork, their personal expectancy of completing high school, and perceived support from their teachers, parents, and peers for this expectancy. Their findings showed that

support from all three groups had a positive impact on all four outcomes. In a school setting, however, the teacher had the most significant influence.

Japanese Schooling and Culture

Japan has both public and private schools and universities (Maciamo, 2004); both types of schools have fees, but public schools are not as expensive as private schools. Most elementary and junior high schools in Japan are public, while most kindergartens, colleges, and universities are private. Japanese children must be in school between the ages of 6 and 15 (White, 1987) and most enter formal schooling at the age of 3 or 4 (i.e. private nursery schooling). The school year consists of three terms (35 weeks) and half day classes on Saturday twice a month in addition to, daily schooling during the weekdays (Maciamo, 2004). On average, one teacher is assigned to approximately 42 students. Children are less often dealt with by the teacher on a one-to-one basis and more often as a group.

Students are required to take an entrance examination for junior high school, high school, and university, anytime they change institutions in public schools and universities (Maciamo, 2004). As a result, Japanese students have home-tutors (White, 1987). At some private schools, students are required to take one entrance examination or interview when they join the school, and are generally exempt afterwards (Maciamo, 2004).

In comparison to the United States, the responsibility of a student's development in Japan is shared by the family, school, and workplace (White, 1987). In addition, parents are expected to provide daily assistance with homework. For instance, mothers are assist their children more frequently than other adults on academic work and both parents are fully engaged in their children's social and moral conduct, and academic

progress. Students who regularly attend their classes are almost never held back a grade or skipped ahead during compulsory schooling in Japan (U.S. Study of Education in Japan, 1987 as cited in Lewis, 1995). Rarely are distinctions made between students on the basis of ability or achievement (Lewis, 1995).

More traditionally, Japanese cultural values and goals support the idea that a good person is one who studies, and that learning contributes to, as well as reflects, virtue (White, 1987). Hess and Azuma (1991) argue that two very different classroom climates in two countries can be created through the interaction of student characteristics and teacher strategies. The Japanese culture differs in that they tend to place emphasis on developing an overall adaptive nature different from Americans who try to make the learning context more attractive by modifying the classroom environment. The researchers argue that schools in general are not user-friendly and that some students are more ready than others from the attributes they bring to the classroom including the willingness to: master skills and engage in tasks, whether appealing or not; accept authority and rules of teachers; accept rules of social behaviour necessary for learning in groups.

In a study comparing the school climates of four Japanese high schools, it was revealed that school climate, as perceived by the students and teachers, was different across all four of the high schools (Hattler & Taylor, 1992). As well, students and teachers differed in their perceptions of the climate in the same school; teachers perceived the school climate more favourably than did students in the same school. Caring, as perceived by the students in all four schools, was also seen as one of the most

positive factors of climate; illustrating that students feel that they are a part of the school and feel cared for by other students and teachers.

Achievement Comparisons

Mayer, Tajika, and Stanley (1991) explored the discrepancy between Japanese and U.S. fifth grade student's mathematics test scores. One hundred and thirty two American and 110 Japanese students were given a mathematics achievement test and a mathematical problem solving test that evaluated computational skills, and problem representation and solution planning skills respectively. The first test had 15 items and the second test had 18 items and students were given 15 minutes to complete each test. Results showed that Japanese students answered more items correctly on both the mathematics achievement and problem solving tests. On a scale of relative comparisons, where a difference score was computed for each participant by subtracting their z-score on the mathematics achievement test from the z-score on the problem solving test, there was a surprising finding; U.S. children excelled at mathematical problem solving when compared to Japanese students who were equivalent in basic mathematics achievement. Some plausible explanations offered by the authors suggest that different levels of exposure to mathematics could explain this interesting finding.

In another study, conducted by Stevenson, et al. (1990) academic achievement in American, Chinese, and Japanese students was compared. This comparison was used to address some of the reasons that may lead Chinese and Japanese students to have higher academic achievement scores than their American counterparts. Their study included 240 first and fifth graders from each Minneapolis, Taipei (Taiwan), and Sendai (Japan). Students were given achievement tests in reading and mathematics, teachers filled out a

questionnaire, interviews were held with both the children and their mothers, and school principals were interviewed.

Further exploration by the researchers revealed that there was greater attention to academic activities among Chinese and Japanese students than among American students. Chinese and Japanese mothers viewed academic achievement as their child's most important pursuit, whereas this was not a central concern for American mothers. Stevenson et al. (1990) found all 3 of the cultures to vary significantly in terms of parents' interest in their child's academic achievement, involvement of the family in the child's education, standards and expectations of parents concerning their child's academic achievement, and parents' and childrens' beliefs about the relative influence of effort and ability on academic achievement. It was found that American mothers attempted to provide experiences that fostered cognitive growth than academic excellence and also overestimated their child's abilities and expressed greater satisfaction with their child's accomplishments than Chinese and Japanese mothers. In interviewing the children's mothers, it was possible to arrange interviews with 87% of the American, 96% of the Chinese, and 99% of Japanese parents.

Children in both China and Japan did significantly better on the mathematics test than the American sample. The mathematics test contained items that involved the application of mathematical principles to the solution of word problems and items requiring only calculation. They also found that the students in China and Japan were adept at using their knowledge about mathematics in solving problems. The researchers claim that these results are understandable considering the shorter hours in an American school day and shorter school year, and the relative emphasis given to reading and

language arts and relative neglect of mathematics. Lastly, they found that teachers from all three cities appeared to work hard, yet faced different obstacles whether it was the presence of a national curriculum, the hours they had to be responsible for their class or the possibility of assistance from specialists.

Chapter Three: Methodology

Participants

The Programme for International Student Assessment (PISA) is an internationally standardized assessment of student performance in the literacy of reading, mathematics, science, and problem solving, and was jointly developed by the Organization for Economic Co-operation and Development (OECD) countries (OECD, 2003). For PISA 2003, the assessments were administered to a target population of 15-year old students in educational programmes in all 30 OECD countries plus 11 other participating countries. The target population of 15-year olds was chosen because at this age, in most participating countries, students are approaching the end of their required schooling (OECD, 2005). As a result, PISA provides a comprehensive overview of the cumulative effect of the education the student receives over the years of schooling. The test is administered to between 5,000 and 10,000 students from at least 150 schools in each country (OECD, 2003). Some countries were over-sampled (such as Canada where over 27,000 students were tested) to allow for results to be produced at the provincial level.

Sampling occurs in two stages; PISA 2003 implemented a two-stage stratified sample design where the first stage sampling units consisted of individual schools having 15-year old students (OECD, 2005a). The second stage sampling units, in countries, were students within sampled schools. From a list, 35 students were randomly selected from the sampled schools. If there were more than 35 eligible students, then 35 were selected with equal probability. On the other hand, if there were less than 35 eligible students, then all the students on the list were selected. Students were excluded from participating

if they had an intellectual or functional disability, or had limited proficiency in the language of the PISA test.

The test covers four domains of reading, mathematical and scientific literacy, and problem solving (OECD, 2005). The tests' emphasis is on the understanding of concepts, the ability to function in various situations within each domain, and on the mastery of processes, important knowledge, and skills needed in adult life. This approach is in contrast to assessment programs focusing on the mastery of the school curriculum (e.g. TIMSS) (Holliday & Holliday, 2003).

Procedure

The assessment takes place every three years, and the first assessment was in the year 2000 (OECD, 2003). The data that will be used in this study is PISA 2003; the second of three assessment cycles to date. Each cycle provides an in-depth look at one of the four domains and provides a summary profile of skills for the other domains. The major domain of PISA 2003 was mathematical literacy, and two-thirds of the testing time was devoted to this domain.

The paper and pencil test lasts a total of two hours for each student, and consists of a combination of multiple choice and short answer questions (OECD, 2003). Different students are given different combinations of test items. This allows more questions to be covered in a shorter period of time. School principals were asked to answer a 20 minute questionnaire about their schools, and students were asked to answer an additional 30 minute background questionnaire. More specifically, students were asked about information on their habits, life inside their school, their family environment, their

economic, social, and cultural capital, and their learning style, among many other student and school characteristics.

Instrumentation

Translation of PISA Materials

PISA 2003 had 55 national versions of their materials for use in all the participating countries and was translated into 33 languages (e.g. Japanese version was translated from both English and French) (OECD, 2005a). Translation errors can be quite frequent and can result in items functioning poorly on international tests. In using tests to rank countries or students a few problematic items are unlikely to affect the overall estimate of a country's mean significantly. Since PISA aims to develop descriptive scales, PISA has implemented strict verification procedures for translation equivalence to avoid biases from one country to another by unstable item characteristics. These verification procedures include: providing two parallel source versions of the test, (in English and French), and recommending that each country develop two independent versions in their instruction language in order to later assemble them into one national version; including frequent translation notes to help with possible translation or adaptation problems; developing detailed translation and adaptation guidelines for the test material and for revisions; training key staff on each national team on translation procedures; appointing and training a group of professional translators proficient in English and French and with native command of each target language in order to verify the national versions against the source version.

At any point when serious flaws in specific items were detected, National Project Managers (NPM) were asked to review their translation of the item and provide possible

explanations (OECD, 2005a). In general, no obvious translation errors were found in the majority of cases; however, some residual errors were identified leading to the deletion of 21 items from the computation of national scores. Twelve items were deleted due to confusing translations, 3 items were deleted due to poor printing, 2 items were deleted because of failure to include them in all the booklets containing the same unit, 2 items were deleted because of typographical errors in key numerical data, and 2 items were deleted due to omission of a key word, and the failure to adapt some mathematical convention.

How is mathematics achievement measured?

PISA 2003 focused on the domain of mathematical literacy. This will be used as an indicator to assess mathematics achievement. Mathematical literacy is defined as:

Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen (OECD, 2003a, p. 24).

Mathematics achievement is related to the students' ability to analyze, reason, and communicate ideas effectively (OECD, 2003a). Mathematics achievement is assessed in relation primarily to content, and secondarily to numbers, algebra, and geometry. More specifically, there are four overall concepts for mathematical content and five situations that identify the framework of the questions.

Content

Four mathematical content areas were developed by the OECD based on mathematics research literature to create a foundation to compare mathematics

performance internationally (OECD, 2003a). The 4 mathematics content areas used in the PISA assessment are: space and shape, change and relationships, quantity, and uncertainty.

Space and shape requires a student to engage in their geometry and spatial skills in order to analyze similarities and differences between shapes and the components of shapes (Figure 2). The understanding of properties of objects and their relative positions is also necessary for this content area.

How many cubes have been used to make this object?

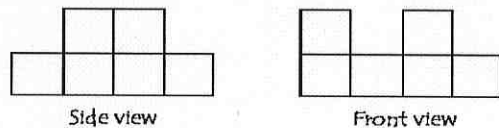


Figure 2: An Example of a Space and Shape Problem (OECD, 2003a)

Change and relationships requires a student to engage in their algebra skills and refers to the recognition and understanding of fundamental relationships and types of change (OECD, 2003a). Relationships in the questions may be represented symbolically, graphically, or even geometrically; however, students should recognize that difference representations may have different properties or may function with different purposes (Figure 3). As such, dealing with this type of question often involves translating between representations.

Cell growth

Doctors are monitoring the growth of cells. They are particularly interested in the day that the cell count will reach 60 000 because then they have to start an experiment. The table of results is:

Time (days)	4	6	8	10	12	14	16	18	20
Cells	597	893	1 339	1 995	2 976	2 976	14 719	21 956	32 763

When will the number of cells reach 60 000?

Figure 3: An Example of a Change and Relationships Problem (OECD, 2003a)

Quantity requires the student to engage in their arithmetic skills and relates to the recognition of numerical patterns, the understanding of relative size, and the use of numbers to represent quantities of real-world objects (Figure 4) (OECD, 2003a). Quantitative reasoning is one of the main aspects of this content area as it involves representing numbers, understanding the meaning of operations, estimating, and number sense.

Percents

Carl went to a store to buy a jacket with a normal price of 50 zed that was on sale for 20% off. In Zedland there is a 5% sales tax. The clerk first added the 5% tax to the price of the jacket and then took 20% off. Carl protested: he wanted the clerk to deduct the 20% discount first and then calculate the 5% tax.

Does it make any difference?

Figure 4: An Example of a Quantity problem (OECD, 2003a)

Lastly, uncertainty involves such problems as probabilities, statistics, and such relationships prevalent in the information society (Figure 5).

Average age

If 40% of the population of a country are at least 60 years old, is it then possible for the average age to be 30?

Figure 5: An Example of an Uncertainty Problem (OECD, 2003a)

Process

In order for a student to engage in “mathematisation” various competencies are required including reasoning, argumentation, modeling, problem solving, and representation (OECD, 2003a). Mathematisation is a multi-step process and in the case of a problem situated in reality a student must organize and identify the situation according to mathematical concepts to gradually transform the problem from reality into a direct

mathematical solution (Figure 6). More specifically, students must engage in specific processes including simplifying assumptions, and understanding the relationships between the language used in the problem and patterns and symbolic representations that would link the problem to mathematics in order to work towards a solution.

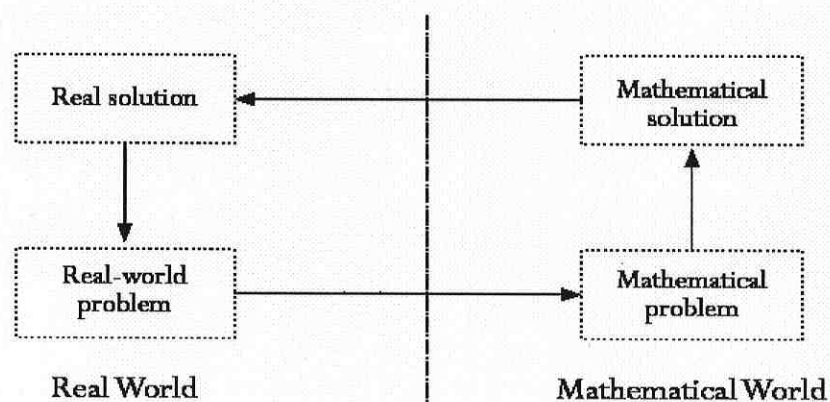


Figure 6: The Mathematisation Cycle (OECD, 2003a)

The problems in the PISA mathematics test were constructed to allow the student to engage in the use of at least one of these competencies. The competencies were organized into 3 clusters: reproduction, connections, and reflection (OECD, 2003a).

Reproduction cluster plays a role in questions that require the reproduction of practiced knowledge such as facts, recognition of equivalents, performance of routine procedures, and manipulation of expressions containing symbols and formulae in a familiar or standard form.

1 000 zed is put in a savings account at a bank, with an interest rate of 4%.
How many zed will there be in the account after one year?

Figure 7: Example of Reproduction Cluster Item (OECD, 2003a)

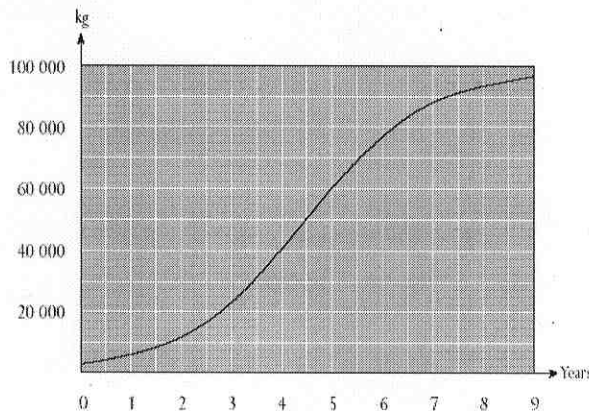
Connections cluster builds upon the reproduction cluster in order to tackle problems that are not routine, yet involve somewhat familiar settings. Problems from this cluster require the student to make links between different representations of the situation and different aspects of the problem.

*Mary lives two kilometres from school, Martin five.
How far do Mary and Martin live from each other?*

Figure 8: Example of Connections Cluster Item (OECD, 2003a)

Reflection cluster builds upon the connections cluster where these types of questions require some insight, reflection, creativity in identifying mathematical concepts, and relevant knowledge to create solutions. Additional demands in solving this type of problem usually arise for the student in attempting to justify their results.

Some fish were introduced to a waterway. The graph shows a model of the growth in the combined weight of fish in the waterway.



Suppose a fisherman plans to wait a number of years and then start catching fish from the waterway. How many years should the fisherman wait if he or she wishes to maximise the number of fish he or she can catch annually from that year on? Provide an argument to support your answer.

Figure 9: Example of Reflection Cluster Item (OECD, 2003a)

Context

The questions on the PISA 2003 student questionnaire were split into 4 contexts. They related to personal, educational or occupational, public and scientific situations (OECD, 2003a). Personal situations related directly to activities in the students' daily lives. These types of problems require interpretation to a higher degree as it is dependant upon how the individual perceives the context of the problem before it can be solved.

Educational or occupational situations require the student to confront a particular problem that requires mathematics to solve. These may be situations the student may face at school or in a work setting.

Public situations require the student to observe some aspect of the local or broader community to understand relationships among elements in their surroundings. This is intended to activate students' mathematical skills to evaluate aspects of an external situation that may have relevant consequences to public life.

Lastly, scientific situations involve understanding a technological process, theoretical situation, or an explicit mathematical problem where no attempt is made to place the problem in some broader context. These problems are more abstract and are sometimes referred to as "intra-mathematical" contexts.

Student Level Variables

Other variables that may influence the outcome of mathematics achievement, as reported by the literature, will also be examined. For instance, socio-economic-status plays an important role in educational success or failure of high school students (Will, 2001); similarly this relates to the economic, social, and cultural status variables, in the

PISA 2003 data set. Please see Appendix A for student and school level derived indices and reliabilities for both Canada and Japan.

Economic, Social, and Cultural Status (ESCS)

The economic, social, and cultural status index for PISA 2003 is comprised of 3 variables related to student responses to questionnaire items on family background: the highest level of parental education in number of years, the highest parental occupation status, and the number of home possessions (OECD, 2005). There was no direct measure of income on the questionnaire and as a result, the latter variable (home possessions) was used to measure approximate family wealth (OECD, 2005a). ESCS may be viewed as being synonymous to socioeconomic status (SES) as it is a derived index of parental education, occupational status, and income. The terms SES and ESCS will be used interchangeably throughout this paper.

Students' Perceptions of Teacher Support

Students were asked to respond to 5 items that were developed to measure the construct of teacher support. The responses to these statements, as provided by the students, were used to create an index for the classroom environment in relation to teacher support (Thompson et al., 2004). Students were asked to report the frequency with which the following teaching practices occurred in their mathematics lessons: The teacher shows an interest in every student's learning; The teacher gives extra help when students need it; The teacher helps students with their learning; The teacher continues teaching until the students understand; The teacher gives students an opportunity to express opinions. Items were inverted for item response theory (IRT) scaling and positive values on this index indicate students' perceptions of higher levels of teacher support

(OECD, 2005). Items were inverted for item response theory (IRT) scaling and positive values indicated that students have increased perceptions of teacher support.

School level variables

Students may perform better academically, in a good learning environment at school as dictated by students' morale and commitment, and the disciplinary climate at school (Gu, 2006). Thus, it may be important to examine the relationship of student mathematics performance and school level variables, such as principals' perceptions of student and teacher-related factors affecting school climate, and principals' views on teachers' and students' morale and commitment in school.

School Principals' Perceptions of Teacher Morale and Commitment

This variable measures the school principal's perceptions of teachers at their school. Responses were on a 4-point scale: "strongly agree", "agree", "disagree", and "strongly disagree". The latter 2 categories were collapsed into one category for IRT scaling as in PISA 2000 it was discovered that very few responses were in the "strongly disagree" category.

For this variable, principal's were asked to think about the teachers in their school and state how much they agree with the following statements: The morale of teachers in this school is high; Teachers work with enthusiasm; Teachers take pride in this school; Teachers value academic achievement. All items are inverted for IRT scaling and as a result positive values on this index indicate reports of higher levels of teacher morale and commitment from the perspective of the principal.

School Principals' Perceptions of Student Morale and Commitment

The items used in this variable are parallel to those used in the teacher morale and commitment factor as perceived by the principal. Recoding was similarly done in terms of IRT scaling and collapsing “disagree” and “strongly disagree” into one category. As such, positive values on this index indicate higher levels of student morale and commitment as reported by the principal. Principals were asked to think about students in their school and how much they agree with the following statements: Students enjoy being in school; Students work with enthusiasm; Students take pride in this school; Students value academic achievement; Students are cooperative and respectful; Students value the education they can receive in this school; Students do their best to learn as much as possible.

School Principals' Perceptions of Teacher-related Factors Affecting School Climate

PISA 2003 measured principals' perceptions of teacher-related factors affecting the school climate. Principals were asked to respond to 7 items related to the extent of which the learning of their students is hindered by the following: Teachers' low expectations of students; Poor student-teacher relations; Teachers not meeting individual students' needs; Teacher absenteeism; Staff resisting change; Teachers being too strict with students; Students not being encouraged to achieve their full potential. The responses are either “not at all”, “very little”, “to some extent”, or “a lot”. These items were inverted for IRT scaling and higher levels of school principals' perceptions of teacher-related factors hindering students' learning (i.e. teacher behaviours) are indicated by positive values on this index.

School Principals' Perceptions of Student-related Factors Affecting School Climate

PISA 2003 aimed to measure principal's perceptions of potential factors hindering the learning of students at their school using the following 6 items: Student absenteeism; Disruption of classes by students; Students skipping classes; Students lacking respect for teachers; Student use of alcohol or illegal drugs; Students intimidating or bullying other students; The 4 point responses of "not at all", "very little", "to some extent", and "a lot" were recoded on to a 4 point response scale of "strongly agree" to "strongly disagree". Higher levels of school principals' perceptions of student related factors hindering student's learning (i.e. student behaviours) were indicated by positive values on this index and items were inverted for IRT scaling.

Survey Design Weights

Large surveys usually collect data from a sample rather than surveying the whole population especially when dealing with national or international populations. For instance, in some countries it is not possible for researchers to identify all members of a target population due to the amount of time this would take. Dealing with the whole population requires a large budget, is time consuming, and does not necessarily help with obtaining additional or required information. In sampling such populations, biases may develop; schools may not want to participate as might some students within these schools, and students may be absent on the day of the assessment. International education surveys require a minimum participation rate as low achievers may be more likely to be absent on the assessment day than high achievers. The minimum participation rate for PISA is 80 %. As well, if sampling units did not have the same probability of being selected as other units or if the population parameters were estimated without taking

these varying probabilities into account then bias may result. In order to compensate for this, data may need to be weighted.

Weighting considers that some units in the sample take precedence over others in that they contribute more to any population estimates. In essence, weights are inversely proportional to the probability of selection. For instance, a sampling unit with a small probability of being selected would be weighted as more important than a sampling unit with a high probability of being selected (OECD, 2005). Design weights can also compensate for the potential bias of non-response to the survey; for instance, if girls are less likely than boys to refuse to do the survey (Willms & Smith, 2005).

Ideally, the role of the design weight is to reduce if not eliminate these biases by weighting students differentially (Willms & Smith, 2005). The weight for a student should reflect the probability of his or her school being selected, as well as the probability that he or she will be selected within that school. The sample is drawn in two stages. First schools are drawn from a population of schools with a probability proportional to their size. Second, a fixed number of students are sampled from within that school. The overall design weights used in this study (final student weights) were entered into the multilevel modeling program, HLM 6.03 (Raudenbush, Bryk, Cheong, & Congdon, 2004), to run a weighted multilevel regression analysis.

Plausible Values

Plausible values are a representation of the range of abilities that a student might reasonably display in order to calculate accurate estimates of country level standard error (OECD, 2005). PISA uses a rotated-booklet design to measure the outcome variables in order to give each student a score for the full test from having each student only complete

a small portion of a very long achievement test (Willms & Smith, 2005). In other words, instead of each student having only one score, there is a distribution of plausible scores that the student might have obtained had he or she completed the full test, while accounting for measurement error associated with the test. In other words, plausible values consist of “mathematically computing distributions (denoted as posterior distributions) around the reported values and the reported length in the example; and assigning to each observation a set of random values drawn from the posterior distributions” (OECD, 2005, p. 73). When using HLM version 6.03 (Raudenbush et al., 2004), an “estimation settings” option was chosen to specify the five plausible values that were used in the analysis (Willms & Smith, 2005).

Secondary Data Analysis

Secondary data analysis uses already existing sources of data and refers to the re-analysis of quantitative data. Data may be routinely collected by governments, businesses, schools, and other organizations and stored in electronic databases to later access and analyze (Trochim, 2006). Secondary analysis often involves combining information from multiple databases to examine research questions. For example, one might join crime data with census information to assess patterns in criminal behaviour by geographic location and group. In the present study, secondary data will be analyzed, more specifically, analyses will be run using the PISA 2003 dataset.

The advantages of secondary data analysis are that it is efficient, makes use of data that has previously been collected, often allows the scope of the study to be extended considerably, and saves on the costs of collecting international data (Trochim, 2006). As well, this type of data allows for comparisons within, and between groups, nations, and

societies. Methodologically, this type of data provides opportunity for replication (Trochim, 2006), and the availability of the data over a period of time enables the researcher to employ longitudinal designs (Lockwood, 2006). Secondary data analysis, however, is not without difficulties. Often researchers have to make assumptions about what data to combine and which variables are appropriately grouped together. In addition, one often does not know the problems that may have occurred in collecting the original data.

Hierarchical Linear Modeling

Arnold (1995) explains hierarchical linear modeling (HLM) to be a multilevel regression analysis that allows nested data to be examined, such as students within schools. Linear equations are estimated at the student level within schools and at the school level between schools simultaneously. HLM uses both student and school level variables to help explain variation in achievement scores while accounting for the variance at each level. It is assumed in this type of multilevel regression modeling that there is a hierarchical data set (Hox, 1994). There are explanatory variables that exist on all levels and a single dependent variable that is measured at the lowest level, which in this study refers to students. HLM recognizes that sampled units are nested within larger units, for example, students that are nested within schools, and computes a regression equation per larger unit, instead of computing one regression equation for the whole dataset (OECD, 2005). As a result, a regression equation per school is computed resulting in a more detailed analysis.

HLM Models

The software program HLM 6.03 (Raudenbush, et al., 2004) was chosen for this analysis because it is capable of producing multi-level models and is equipped to handle plausible values and sample weights. PISA 2003 also includes replicate weights in the dataset; however, they were not used in this study because they do not considerably influence the results (Willms & Smith, 2005).

In this study, the analyses began with a null model that was created for each of the two countries. The null model enables researchers to determine whether mean school mathematics achievement scores (β_{0j}) vary significantly across schools and how much of this variability can be accounted for at the school level; the intra-class correlation (ρ) is calculated as such:

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2)$$

where

τ_{00} is the school level variance

σ^2 is the student level variance (Bryk & Raudenbush, 1992).

For example, if each school has equal means then $\tau_{00} = 0.00$; likewise, if each student within each school j had identical scores then $\sigma^2 = 0.00$ (Schreiber & Griffin, 2004).

Rejecting the null hypotheses demonstrates that there is variability at the student and school levels, and therefore it is justified to further explore with a multilevel model.

The first level analysis, in the simplest of terms, involves no predictors and is analogous to a one-way analysis of variance with random effects (Raudenbush & Bryk, 2002). The null model differentiates the variance in the dependant variable (e.g.

mathematics achievement) into within and between school components (Willms & Smith, 2005):

$$Y_{ij} = \beta_{0j} + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

where

Y_{ij} , is the mathematics achievement scores for student i in school j ;

β_{0j} is the mathematics intercept;

r_{ij} is unique error associated with the student i in school j ;

γ_{00} is mean mathematics achievement for all the schools in the sample; and

u_{0j} is the unique error to the intercept associated with school j .

For the second portion of analyses, a two-level model was created using student and school level correlates for each of the two countries. The school-level variables were added to examine whether the between-school variability in the mathematics achievement scores could be explained by some or all of the variables used in the analysis. The models, used in this study, incorporate student level variables such as, sex, students' perceptions of teacher support, and SES, and school level variables relating to the learning environment, and school climate. The equations are:

Level 1:

$$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{Sex}) + \beta_{2j}(\text{Teacher Support}) + \beta_{3j}(\text{ESCS}) + r_{ij}$$

Level 2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Student morale and commitment}) + \gamma_{02}(\text{Teacher morale and commitment}) + \gamma_{03}(\text{Student behaviours}) + \gamma_{04}(\text{Teacher behaviours}) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{Students morale and commitment}) + \gamma_{12}(\text{Teachers' morale and$$

commitment) $+ \gamma_{13}$ (Student behaviours) $+ \gamma_{14}$ (Teacher behaviours) $+ u_{1j}$

$\beta_{2j} = \gamma_{20} + \gamma_{21}$ (Students morale and commitment) $+ \gamma_{22}$ (Teachers' morale and commitment) $+ \gamma_{23}$ (Student behaviours) $+ \gamma_{24}$ (Teacher behaviours) $+ u_{2j}$

$\beta_{3j} = \gamma_{30} + \gamma_{31}$ (Students morale and commitment) $+ \gamma_{32}$ (Teachers' morale and commitment) $+ \gamma_{33}$ (Student behaviours) $+ \gamma_{34}$ (Teacher behaviours) $+ u_{3j}$

After running the first series of models, non-significant variables were removed and then the models were run once again. The resulting final models for Canada and Japan are discussed in the Results section; they demonstrate the final estimation of fixed effects and variance components. It is important to note that significant school variations indicate that mathematics achievement is significantly different across schools even after controlling for principals' perceptions of student and teacher behaviour, and student and teacher morale and commitment. As well, the variance in mathematics scores that remains after student-level and school-level variables are accounted for, in the models, is signified by the student level error variance (σ^2).

Chapter Four: Results

The PISA 2003 dataset was used to analyze variables, at both the student and school levels, that influenced mathematics achievement in both Canada and Japan. Descriptive and correlational statistics were analyzed using SYSTAT 11.0 and two-level models were run using HLM 6.03 (Raudenbush et al., 2004). Student level variables were comprised of sex, student perceived teacher-support and ESCS (i.e. SES). School level variables were teacher and student morale and commitment as perceived by the school principal, and teacher and student related factors affecting the school climate as perceived by the principal. In this section, school and student level descriptive statistics, correlations, and HLM models for Canada and Japan are presented.

Student Level Variables

Descriptive Statistics for Student Level Variables

The descriptive statistics for student level variables for Canada and Japan are presented in Table 1. The Canada dataset has a total sample size of 27,953 15-year students from 1,075 schools, comprised of 13,469 males and 13,748 females with 736 missing cases in sex. The Japan dataset has a total sample size of 4,707 15-year old students from 144 schools; including 2,304 males and 2,402 females (all but one case failed to report sex). The mean mathematics achievement scores are higher in Japan than in Canada; the standard deviation indicates a larger spread of scores around the mean in Japan, and consequently a larger range of scores (140.40 to 865.12). Values for mean teacher support and ESCS are negative for Japan meaning they are below the OECD average. In other words, on average in Japan, students report to have lower teacher support and have lower SES than in Canada.

Table 1: Descriptive Statistics of Student Level Variables in Canada and Japan

Variable	Country	Mean	Standard Deviation	Minimum	Maximum
Mathematics Achievement	Canada	521.63	87.95	160.34	859.28
	Japan	533.00	99.83	140.40	865.12
Sex	Canada	1.49	0.50	1.00	2.00
	Japan	1.49	0.50	1.00	2.00
Teacher Support	Canada	0.24	1.00	-2.92	2.10
	Japan	-0.33	0.85	-2.92	2.10
ESCS	Canada	0.35	0.84	-3.59	2.42
	Japan	-0.08	0.73	-3.17	2.11

Note. Plausible value 1 for mathematics achievement is used to report descriptives and correlation statistics. All plausible values are highly correlated in both Canada ($r = 0.90$) and Japan ($r = 0.91$). For the variable of Sex, 1 = Female, 2 = Male (Appendix A).

Correlation Matrices for Student Level Data

A correlation matrix was created for student level variables for both Canada and Japan (Tables 2 and 3 respectively). Most correlations were near zero except for ESCS which was moderately correlated to mathematics achievement. In other words, those students having a high SES background tend to have higher mathematics achievement scores.

Table 2: Correlation Matrix for Student Level Variables in Canada

Variable	1	2	3	4
Mathematics Achievement	1.00			
Sex	0.04*	1.00		
Teacher Support	0.10*	-0.03*	1.00	
ESCS	0.33*	-0.01	0.05*	1.00

* Correlation is significant at the 0.05 alpha level (2-tailed)

Similarly for Japan most correlations are near zero and teacher support and student sex illustrate no relationship ($r = 0$). As well, ESCS is correlated to mathematics achievement indicating a student's level positively relates to mathematics scores.

Table 3: Correlation Matrix for Student Level Variables in Japan

Variable	1	2	3	4
Mathematics Achievement	1.00			
Sex	0.03	1.00		
Teacher Support	0.12*	0	1.00	
ESCS	0.34*	-0.04*	0.08*	1.00

* Correlation is significant at the 0.05 alpha level (2-tailed)

*School Level Variables**Descriptive Statistics for School Level Variables*

Descriptive statistics were calculated for all school level variables for Canada and Japan (Table 4). All distributions, in the Canada dataset, have positive means except for student behaviour. In the Japan dataset, both teacher morale and teacher behaviour had negative means, accounting for 50% of the school-level variables used in the analysis. This suggests that on average principals in Canada perceived student behaviours to be lower than in Japan, and principals in Japan perceived teacher morale and commitment to be lower on average than in Canada. Principals' perceptions of student behaviour in Japan had the highest mean (0.43), and principals' perceptions of student morale and commitment had the highest standard deviation (1.40) indicating a larger spread of perceptions between schools. Please see Appendix B for histograms of distributions.

Table 4: Descriptive Statistics for School Level Variables in Canada and Japan

Variable	Country	Mean	Standard Deviation	Minimum	Maximum
Student Morale	Canada	0.34	0.95	-2.77	2.59
	Japan	0.23	1.40	-2.77	2.59
Teacher Morale	Canada	0.20	1.00	-2.81	1.65
	Japan	-0.43	1.14	-2.81	1.65
Student Behaviour	Canada	-0.23	0.92	-2.87	2.61
	Japan	0.43	1.00	-1.50	2.61
Teacher Behaviour	Canada	0.16	0.89	-2.44	2.49
	Japan	-0.23	0.90	-1.76	2.49

Correlation Matrices for School Level Data

Correlation matrices, for Canada and Japan, were created to assess the relationships between all school level variables in tables 5 and 6 respectively. Overall, Japan has higher correlational values demonstrating there are stronger relationships between the school level variables. In both datasets, teacher behaviour is positively related to student behaviour and has the highest correlations ($r = 0.61$ for Canada and $r = 0.73$ for Japan). Table 5: Correlation Matrix for School Level variables in Canada

Variable	1	2	3	4
Student Morale	1.00			
Teacher Morale	0.46*	1.00		
Student Behaviour	0.43*	0.32*	1.00	
Teacher Behaviour	0.30*	0.44*	0.61*	1.00

* Correlation is significant at the 0.05 alpha level (2-tailed)

Table 6: Correlation Matrix for School Level Variables in Japan

Variable	1	2	3	4
Student Morale	1.00			
Teacher Morale	0.71*	1.00		
Student Behaviour	0.67*	0.60*	1.00	
Teacher Behaviour	0.66*	0.66*	0.73*	1.00

* Correlation is significant at the 0.05 alpha level (2-tailed)

Hierarchical Linear Modeling

Two-level models were generated using HLM 6.03 (Raudenbush et al., 2004) to analyze both student and school level variables. In this analysis, 5 plausible values for the PISA 2003 mathematics assessment were used as the outcome variable, and student level

data were weighted using a student level weight. In order to incorporate all plausible values and design weights in the analysis, estimation settings in HLM were first modified. The analysis was then processed five times, one for each plausible value, and the correct standard errors for the regression coefficients were calculated (e.g. Willms & Smith, 2005).

School records were deleted from the analysis, in HLM, if any missing data were detected for any of the variables being used at the school-level. In this study, 9 schools in Canada were omitted from the analysis and no schools were omitted from the Japan data.

Null Models

The null models were estimated for both Canada and Japan:

$$Y_{ij} = \beta_{0j} + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

Results from the analysis are presented in Table 7.

The mathematics intercept for students in Canada is 531.14 (SE = 2.10) and for Japan is 531.12 (SE = 6.41). These results demonstrate that students have mathematics scores that vary significantly around their school means ($p < .001$). As well, in both countries there is significant variation in school means ($\tau_{00} = 1446.34$, $p < .001$ for Canada and $\tau_{00} = 5516.72$, $p < .001$ for Japan).

More specifically, for Canada, the school level variability in mathematics achievement scores is estimated at 1446.34, while the student level variability is estimated at 5723.10. The proportion of between school variance derived from the student and school variance estimates is 0.20 ($\rho = 1446.34 / (1446.34 + 5723.10)$). In other

words, 20% the variability in mathematics achievement scores in Canada can be attributed to schools.

In Japan, 54% of the variation ($\rho = 5516.72 / (5516.72 + 4733.76)$) in mathematics achievement scores can be attributed to between school variance; this intra-class correlation is much higher than the variance estimate for Canada. In other words, the effects of school characteristics on students' mathematics achievement in Canada are more consistent across schools than in Japan.

Table 7: Null Models for Canada and Japan: Mathematics Intercept and Student and School Variance Components

Fixed Effects	Canada	Japan
	Coefficients	
Mathematics Intercept	531.14	531.12
Random Effects	Variance Components	
School-Level Effect	1446.34	5516.72
Student-Level Effect	5723.10	4733.76

Reliability coefficients are 0.84 for Canada and 0.97 for Japan. Intra-class correlation is 0.20 for Canada and 0.54 for Japan.

Final Models

After running the models, non-significant variables were removed resulting in the final models for both Canada and Japan. The final models include all significant student and school level variables. The models differ mainly in the level of student perceived teacher support; mathematics achievement scores are significantly related to teacher support in Canada but not in Japan. The findings for Canada and Japan are discussed.

The final model for Canada is:

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Sex}) + \beta_{2j} (\text{Teacher Support}) + \beta_{3j} (\text{ESCS}) + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Student Morale}) + \gamma_{02} (\text{Student Behaviour}) + u_{0j}$$

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

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

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

The final model for Japan is:

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Sex}) + \beta_{2j} (\text{Teacher Support}) + \beta_{3j} (\text{ESCS}) + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Student Morale}) + \gamma_{02} (\text{Student Behaviour}) + u_{0j}$$

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

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

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

Table 8 displays the outputs of the final models for both Canada and Japan. To interpret the results in Table 8, all coefficients are identified in terms of being conditioned on all other significant variables. The average school mathematics achievement intercept in Japan is estimated at 490.03 ($p < 0.001$), slightly lower than the intercept for Canada (499.16, $p < 0.001$).

In Canada, males outperform females in mathematics achievement scoring, on average, 14 points higher when conditioned by ESCS and teacher support. As students' perceptions of teacher support, in their mathematics classroom, increase by 1 unit, so do their mathematics scores by approximately 5 units. Student's economic, social, and cultural status (i.e. SES) is a significant predictor of average mathematics achievement; as this value increases by 1 unit, mathematics achievement increases by approximately 27

points. In other words, students who report having a higher SES, on average, do better on the mathematics assessment than those who report having a lower SES.

Table 8: Final HLM Models for Canada and Japan: Slopes and Intercepts

Fixed Effects	Canada	Japan
	Coefficients	
Intercept	499.16	490.03
Student Morale and Commitment	8.78	16.99
Student Behaviour	4.96	30.94
Sex slope	14.22	16.85
Teacher slope	5.20	NS
ESCS slope	26.78	5.14
Random Effects	Variance Components	
School-Level Effect	783.34	2596.24
Sex slope	228.53	NS
Teacher support slope	100.38	140.13
ESCS slope	120.12	NS
Student-Level Effect	4872.85	4525.35

Note. NS indicates non-significance ($p > 0.05$).

In Japan, males outperform females on mathematics achievement by approximately 17 points when conditioned on ESCS, and students with a high economic, social, and cultural status achieve approximately 5 points higher on the mathematics assessment compared to students with a lower ESCS. The influence of ESCS on mathematics achievement in Canada is almost 5 times larger than the coefficient for Japan. There may be more homogeneity across school in Japan in terms of SES and

students being assigned to schools, than in Canada. Unlike Canada, Japan did not show any significant relations between the level of student perceived teacher support and mathematics achievement ($p = 0.52$). Interestingly, however, the relationship between mathematics achievement and students' perceptions of teacher support in Japan is shown to significantly vary from school to school ($p < 0.001$).

There were no significant school-level correlates that influenced the slopes of the student-level variables; however, in both Canada and Japan, there are positive associations between mathematics achievement (school mean) and principals' perceptions of both student morale and commitment and student-related factors affecting school climate. The intercept (β_{0j}) pertains to average school scores; in Canada, as principals' perceptions of students' morale and commitment increase by 1 unit, average school mathematics scores increase by almost 9 points. Similarly, as principals' perceptions of student behaviour increase by 1 unit, average school mathematics achievement increases by nearly 5 points.

In Japan, average school mathematics scores increase by approximately 17 points as principals' perceptions of student morale and commitment increase by 1 unit (which is 1 standard deviation). Correspondingly, mean school mathematics scores increase by an estimate of 31 points as principals' perceptions of student behaviour in their school increase by 1 unit. These level-two correlates have larger coefficients in Japan than in Canada.

In Canada, results indicate significant school level variance; meaning that average mathematics scores vary from school to school after accounting for principals' perceptions of both student morale and commitment and student-related factors affecting

school climate. Student sex, perceived teacher support, and ESCS slopes vary significantly between schools although there are no significant school correlates. Similarly in Japan, there is significant variance between schools in average mathematics scores; however, unlike Canada, the slopes for sex ($p > 0.05$) and ESCS ($p = 0.21$) do not vary significantly across schools. As a result, the variance components were removed from the final model for Japan. Interestingly, the teacher support slope in the final model for Japan varies across schools but is not a significant level-one predictor. In both final models, significant school variation exists after controlling for student level variables, and there is still much variance that is unaccounted for in mathematics scores.

In Canada, the variance in mathematics scores, at the student level, drops approximately 15% from the null model ($\sigma^2 = 5723.10$) to the final model ($\sigma^2 = 4872.85$). In Japan, the variance in mathematics scores, at the student level, drops approximately 4% from the null model ($\sigma^2 = 4733.76$) to the final model ($\sigma^2 = 4525.35$). At the school level, there is a 46% and 53% decrease in variance scores in Canada and Japan respectively. In other words, there are other student and school-level variables that may help account for the remaining variation (Bryk & Raudenbush, 1992).

Chapter 5: Discussion

Discussion

In 2003, PISA of the OECD focused mainly on measuring mathematics achievement. HLM was used to measure mathematics achievement within and between schools in both Canada and Japan. Three student level variables were analyzed against the outcome variable of mathematics achievement, and four school level variables relating to the school climate. In this section, research questions are addressed to provide more insight on topics such as, achievement differences due to sex differences, the level of student perceived teacher support, SES, and school climate related factors. In addition, the marked implications relating to variations in mathematics achievement will be compared between Canada and Japan.

Do Sex Differences Exist in Mathematics Achievement?

The literature on sex differences in mathematics achievement has demonstrated a trend that shows mixed findings. In this study, males were shown to outperform females in mathematics achievement in both Canada and Japan. This finding is contradictory to more recent research that indicates that trends are changing to favour females in mathematics achievement (Buchmann & DiPrete, 2006; Llyod et al., 2005). Marsh and Yeung (1998) claim that these inconsistent trends in sex differences may be the case when examining grades, but not test scores; they suggest males outperform females in testing situations, which may help to clarify why scores are higher for males in both Canada and Japan in this study. Goldstein et al. (1990) further clarify the testing phenomenon by asserting that males and females may answer the same proportion of items correctly, yet females may spend a longer amount of time answering each question

overall. Sex differences favouring males in mathematics achievement are apparent in almost all participating countries (OECD, 2004). Such a trend may not solely be explained by socialization differences as the influence of ones' culture on an individual varies. Alternately, these disparities may be a combination of the differences in the socialization process (Muller, 1998), and evolutionary outcomes (Halpern, 2000).

Is there a Relationship between Student Perceived Teacher Support and Mathematics Achievement?

The classroom teacher can be an influential person in a students' life (Yeung & McNerny, 1999). Students spend many hours at school. In most countries, as students enter middle school and high school, the number of teachers they have increases. This can be a source of concern for some students as all teachers do not express the same level of support with their students (Teven & McCroskey, 1996).

From the results, of the present study, the level of student perceived teacher support is shown to have a significant positive relationship with mathematics achievement in Canada, but not in Japan. Positive values of teacher support denote that as students perceive their teacher showing an interest in every student's learning, providing extra help with learning, persisting to teach until the student understands, and providing opportunities for students to express their opinions, mathematics scores increase. Teacher-support is viewed to be one of four (e.g. academic and school attachment, teacher-support, peer values, and mental health) critical social-emotional components of learning opportunities for academic success that has an effect on achievement (Becker & Luthar, 2002). Teacher support may have an indirect influence on academic achievement through engagement (Chen, 2005) or influence students in other ways such as increasing

student self-esteem and decreasing depression (Reddy et al., 2003). As well, this index of teacher support may not be as strongly related to mathematics achievement as other indices of teacher support. For instance, Thuen and Bru (2000) found that emotional teacher support and academic teacher support could be distinguished as two separate dimensions. Emotional teacher support should also be examined in terms of the relationship to mathematics achievement as there may be explicit or even implicit influences on student achievement. Subsequently, teacher support may simply have a greater impact on encouraging those students who are at risk of failing to persist through school (Will, 2000; Battstich et al., 1997; Croninger & Lee, 2001). In other words, teacher support may help to decrease a student's level of distress who may then become motivated to do well in school (Wentzel, 1997; Solomon et al., 2000; Fry & Coe, 1980). More specifically, social approval and expression of care and appreciation, as demonstrated by the teacher, may be important in developing positive relations between students and teachers at school, and as a result increase students' perceptions of the meaningfulness of schoolwork (Thuen & Bru, 2000). This in turn may translate into improved academic performance. Other researchers (Bru, Boyesen, Munthe, & Roland, 1998), have further broken down overall teacher support into academic, emotional, and managerial support. After examining the items, academic teacher support (i.e. ensuring task is explained and understood) and portions of managerial teacher support (i.e. interest in helping students learn) were more similar to the type of items in the teacher support index in PISA 2003 (see Bru et al., 1998 for items).

One reason why teacher support may not significantly be related to mathematics achievement in Japan is due to differences in the school culture. In Japan, the largest

amount of student support is mainly seen to come from parents as they are expected to provide daily assistance with homework and are fully engaged in their child's academic endeavours (Stevenson et al., 1990; White, 1987). As well, children have home-tutors who help prepare for future school entrance examinations (White, 1987). As a result, even though teacher support in Japan is not significant, support may come from other sources (e.g. parents) (Stevenson et al., 1990).

Variance proportions of teacher support, for both countries, indicate that even after accounting for the differences in the level of student perceived teacher support, there are still significant school to school differences in mathematics achievement. Alternately, other variables, such as parent or peer support should be examined to help explicate the 20% and 54% of between school variance in Canada and Japan respectively. Although the teacher support slope was not significant in the model for Japan, there were significant between school differences. Similarly, Hattler and Taylor (1992) found that the school climates (i.e. cared for by teachers) in all 4 schools in Japan included in their study differed.

Are there Significant Relationships between Other Variables?

As seen from the results, economic, social, and cultural status, an indicator of student socioeconomic status, is the most influential student level variable of mathematics achievement in Canada. The ESCS coefficient is over 5 times larger in Canada than in Japan. Otherwise stated, on average in Japan, the school environment is more equitable in terms of SES influencing mathematics achievement as there were no between school differences. Similar to Kohr et al. (1989) as students' socio-economic status increased, so did mathematics achievement.

Principals' perceptions of student-related factors affecting school climate and perceptions of student morale and commitment were two influential level-2 variables. These variables predicted higher average school mathematics scores in Japan, than in Canada. This may be because autonomy and initiative are respected more in western cultures (Hess & Azuma, 1991) while a sense of community may be valued more in Japan (Hattler & Taylor, 1992). Theoretically, as principals perceive students in their school to have consistent attendance, respect for their teachers, and responsible conduct, an increase in average school mathematics scores results. In the same way, as students display behaviours that suggest to principals that they are valuing, enjoying, and respecting the importance of academic achievement and school, mathematics scores increase.

Interestingly, in Canada, student morale and commitment as perceived by the principal ($\gamma = 8.78$) relates to an increase in average school mathematics achievement that is approximately two times larger than the influence of student-related factors affecting school climate ($\gamma = 4.96$), as perceived by the principal in Canada. On the contrary, in Japan, student morale and commitment ($\gamma = 16.99$) has an impact on mean school mathematics scores that is two times smaller than student-related factors affecting school climate ($\gamma = 30.94$) in Japan. This discrepancy may be due to differences between what each culture values more. It may be that students attending schools, who value their education and appreciate a positive school climate, put their best effort forward in their achievements and ultimately increase their levels of performance. In Canada, however, due to the emphasis on individual achievements these same variables may not hinder a student's performance to as great a degree.

Limitations

It is important to interpret the results while keeping in mind that there are several limitations. Firstly, limitations associated with secondary data analysis may lead the researcher to make assumptions on how the data were originally collected and which variables are appropriately grouped together, and leaves the researcher restricted to the indices they can analyze (Trochim, 2006).

Secondly, causation cannot be implied from this study as the HLM analysis is correlational and non-experimental. Thirdly, the questionnaire items may be too general and more appropriate for wide-ranging analyses, but not for examining any one variable in depth. As well, translating items creates potential to lose some integrity in the equivalency of what is being asked from one country to the next. What one culture may value in measuring another culture may not. Holliday and Holliday (2003) express that language and what is of high regard in specific cultures, even differences between the United States and Canada, should be taken seriously. An equivalent word in one country may be interpreted differently by students in another; for instance, even if adults from the target country are translating items, students may interpret the message in different ways.

The school level variables used in this study assessing principals' perceptions of student and teacher-related factors affecting school climate, and student and teacher morale and commitment may not necessarily be good indicators of the information pertaining to students and teachers. Also, obtaining this information from a single source's perspective may not necessarily be generalizable. As well, most principals may have other administrative duties and as a result are unable to assess the reality of the climate created by teachers and students. Teachers and students perceptions of similar

indices may provide a more accurate overall picture of the learning process and the school environment.

In order to better measure some of these variables relating to school effectiveness it may be important to obtain information through interviews and observations by meeting with the participants. The learning process encompasses many domains and therefore other variables such as the environment and how the students behave in the context cannot necessarily be seen or interpreted from questionnaire responses. Parent's and teacher's perceptions may explain more of the between school variance than the variables in this analysis.

Hierarchical linear modelling enables data analysis on both within and between school differences. Unfortunately, there was no access to classroom data nested within schools; HLM cannot be used to investigate individual classrooms (Arnold, 1992). Conceptually, HLM is an overall estimate of theoretical relationships as it evaluates information from all the schools for each school equation. As well, in this study, statistical significance, between differences of statistically significant coefficients for Japan and Canada, were not tested. For instance, is the approximate 16.85 point increase in mathematics scores in Japan associated with student sex, significantly different from the 14.22 point increase in mathematics scores related to the same variable in Canada? Lastly, in HLM, school files are omitted from the analysis as a result of any missing data in the variables being used. This can significantly reduce sample sizes and consequently alter results. Fortunately, the samples used in this study are large and therefore have sufficient power to detect any associations that may exist in the population. Also, the

sampling nature of the survey means that the results may be generalized to a national student population

Suggestions for Future Research

Suggestions for future research would be to include more parent, teacher, and student information. For example, conducting observations and interviews would allow one to gain in depth knowledge of the school climate versus solely using a questionnaire. As a result, it would be possible to evaluate differences between classrooms and even instructors. Such as, what are some of the behaviours displayed by teachers that are perceived by students as being supportive behaviours in the school setting? Therefore, gaining more insight on other effective classroom practices may further explain the variability in mathematics literacy. In addition, other types of teacher support as perceived by the students may be valuable to assess in future research; for instance, comparing support from classroom teachers to support from parents and peers between countries. More research should examine the implications of positive teacher support to health concerns or psychological issues, like depression and self-esteem levels. Even though the influence of teacher support in our study did not increase mathematics achievement as much as ESCS, this type of support may have other positive effects on the student that were not measured here such as overall well-being.

Future research should include variables to help account for more of the between school variance and more studies on sex differences. For instance, examining sex differences in the level of perceived teacher support and how this influences mathematics achievement differently in males than in females. As well, there was no information on teacher sex and in the future it would be interesting to examine whether or not the sex of

the teacher has an influence on academic achievement and if the findings vary from culture to culture. Also, sex differences in achievement may shift from middle school to high school, for that reason, longitudinal or cross-sectional research, testing students at several different stages of their academic career would help to track trends related to sex differences for many subjects, not only for mathematics achievement, and across cultures.

Implications

A reoccurring implication in this study pertains to the importance of teachers and the school environment in student's learning. As students perceive their teacher's to be supportive, and as principals perceive their students as having positive attitudes about school, and a healthy school climate, student mathematics achievement increase. Teachers can reduce academic failure through support (Will, 2001). Consequently, teachers are encouraged to support their students psychologically in addition to academically. A sense of belonging, acceptance, and encouragement from teachers contribute to creating a positive school climate and increase student's interest in school (Deci, 1992; Goodenow, 1993). The implications of a supportive environment may not only increase academic achievement, but can also enhance students' self-concept and self-image in a positive way (Cooper & Simonds, 2003). Teachers have the ability to create an environment, especially within their classroom, that can foster students to create a sense of community and a network of support where students feel safe and less distressed. In turn, this can enhance a students' social skills and offer a foundation for students to build other supportive networks; whether at home or in other classes. In doing so, students can feel an increased sense of personal autonomy. As well, teacher support is linked to an increase in self-esteem and a decrease in depression (Reddy et al., 2003),

which provides a basis for creating this type of positive classroom and school environment. Ultimately, teachers have the ability to model specific behaviours including expressing warmth and open communication (e.g. Pianta 1999), which can set the tone of the environment where students have the opportunity to achieve positive social and academic outcomes (Wentzel, 2002).

Increased communication and collaboration between researchers and other groups such as policymakers and those in professional development would ensure that issues relevant to education are addressed in meaningful ways and that we are effectively able to contribute to the fundamental goal of enhancing student's learning (Rogers, Anderson, Klinger, & Dawber, 2006). In addition, the relationship between these agencies seen in Figure 10 are more importantly bidirectional in that research influences policymakers and those in professional development directly and classroom practices and student learning indirectly; but also, these agencies may inform researchers for instance, on which variables to effectively group together to ensure that pertinent and applicable issues to education are addressed.

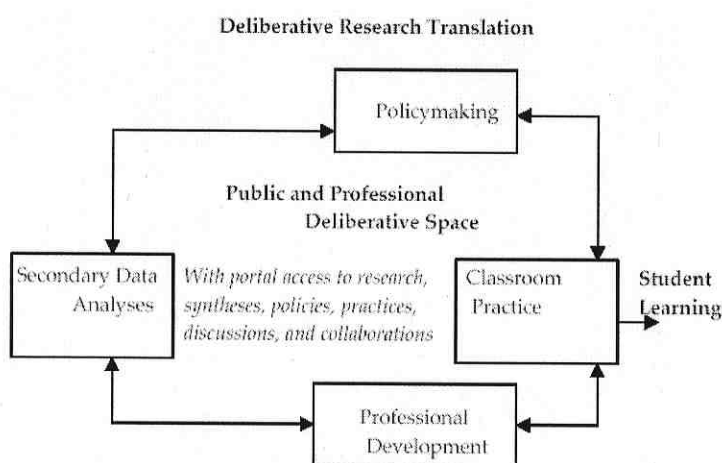


Figure 10: Deliberative Research Translation (Rogers et al., 2006)

Conclusion

“Although learning is a natural process, schools are not naturally conducive to learning” (Hess & Azuma, 1991, p. 2). Most students feel as though they are obligated to attend school and have little choice in the content of the curriculum. They also may have to share the teacher’s time and other resources with peers, and work at a pace that may not necessarily be suited to their interests; classmates will differ from one another in their abilities and experiences. Relationships with adults that are burdened by conflict or are unhealthy are a source of risk in levels of various forms of failure in school (e.g. social, behavioural, or achievement) (Pianta, 1999). Relationships with teachers are an essential part of the classroom experience and a potential resource for improving developmental outcomes.

Students are more likely to have positive goals and interests (Wentzel, 2002) and perform better in schools (Edmonds, 1979; Stedman, 1987) where teachers have high academic expectations. On the other hand, negative feedback for students may be related to poor academic performance and social behaviour (Wentzel, 2002). In order to bring about changes in the learning environment, providing school personnel with information on how to create a supportive learning environment with teacher-support and positive school climate could be one important way of approaching this subject (Thuen & Bru, 2000). More research needs to be conducted to further contribute to the differences in cultural findings and inform educators.

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Appendix A

*Student-Level Variables**Sex*

Sex was coded with 1 being female and 2 being male (OECD, 2005).

Teacher Support

Teacher support pertains to the learning climate at school and is an important factor in explaining school performance (OECD, 2005a). PISA 2003 included such items because literature involving classroom observations has shown that overall performance of schools is influenced by general school environment factors (e.g. teacher behaviour). The reliability of the teacher support index is 0.85 in Canada and 0.78 in Japan. Table A1 shows the items that were posed to the students in order to evaluate the level of student perceived teacher support.

Table A1: Teacher Support Items

Q38 How often do these things happen in your mathematics lesson?	
ST38Q01	(a) The teacher shows an interest in every student's learning.
ST38Q03	(c) The teacher gives extra help when students need it.
ST38Q05	(e) The teacher helps students with their learning.
ST38Q07	(g) The teacher continues teaching until the students understand.
ST38Q10	(j) The teacher gives students an opportunity to express opinions.

Economic, Social and Cultural Status (ESCS)

The ESCS index was created to assess wider aspects of a student's family and home background (OECD, 2005a). It was derived from the following variables: highest level of parental education (in number of years of education); highest international socioeconomic index of parental occupation; and number of home possessions. Home possessions was related to asking students whether or not they had at their home: a desk for studying, their own room, computer for school work, educational software, a quiet place to study, access to internet, dictionary, books to help with their school work, classic literature, poetry, artwork, and their own calculator. This index is used as an indicator of students' SES. Principal component analysis revealed all three components contributed to the index in similar ways across countries. The index has a reliability of .62 for Canada and 0.56 for Japan.

School Level Variables

Principals were asked to answer questions regarding their perceptions of both teachers (Table A2) and students in their school (Table A3). The reliability index for teacher morale is 0.85 in Canada and 0.81 in Japan. Similarly, the reliability for the student morale index in Canada is 0.86 and 0.93 in Japan.

Table A2: Items for Teacher Morale and Commitment Index

Think about the teachers in your school. How much do you agree with the following statements?

SC24Q01 The morale of teachers in this school is high.

SC24Q02 Teachers work with enthusiasm.

SC24Q03 Teachers take pride in this school.

SC24Q04 Teachers value academic achievement.

Table A3: Items for Student Morale and Commitment Index

Think about the students in your school. How much do you agree with the following statements?

SC11Q01 a) Students enjoy being in school.

SC11Q02 b) Students work with enthusiasm.

SC11Q03 c) Students take pride in this school.

SC11Q04 d) Students value academic achievement.

SC11Q05 e) Students are co-operative and respectful.

SC11Q06 f) Students value the education they can receive in this school.

SC11Q07 g) Students do their best to learn as much as possible.

Factors Affecting School Climate

Principals were asked to evaluate the extent to which teacher-related (Table A4) and student-related (Table A5) factors hindered the learning of students at school. The reliability for the teacher-related factors is 0.83 for Canada and 0.80 for Japan. The reliability index for student-related factors is 0.85 for Canada and 0.83 for Japan.

Table A4: Items for Teacher-Related Factors Affecting School Climate

In your school, to what extent is the learning of students hindered by:

- SC25Q01 Teachers' low expectations of students?
- SC25Q03 Poor student-teacher relations?
- SC25Q05 Teachers not meeting individual students' needs?
- SC25Q06 Teacher absenteeism?
- SC25Q09 Staff resisting change?
- SC25Q11 Teachers being too strict with students?
- SC25Q13 Students not being encouraged to achieve their full potential?
-

Table A5: Items for Student-Related Factors Affecting School Climate

In your school, to what extent is the learning of students hindered by:

- SC25Q02 b) Students absenteeism.
- SC25Q04 d) Disruption of classes by students.
- SC25Q07 g) Students skipping classes.
- SC25Q08 h) Students lacking respect for teachers.
- SC25Q10 j) Student use of alcohol or illegal drugs.
- SC25Q12 l) Students intimidating or bullying other students.
-

Appendix B

Student Level Distributions for Canada

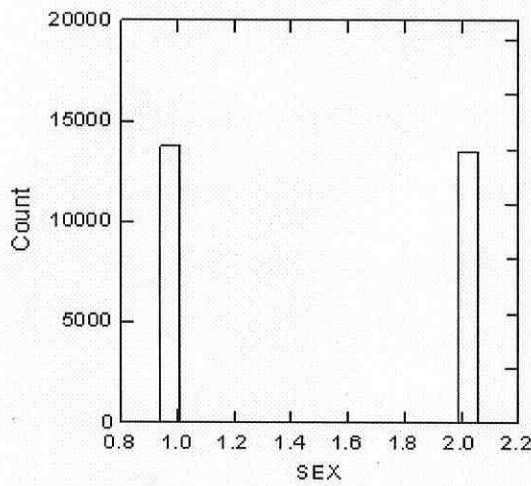


Figure B1: Histogram of sex distribution in Canada

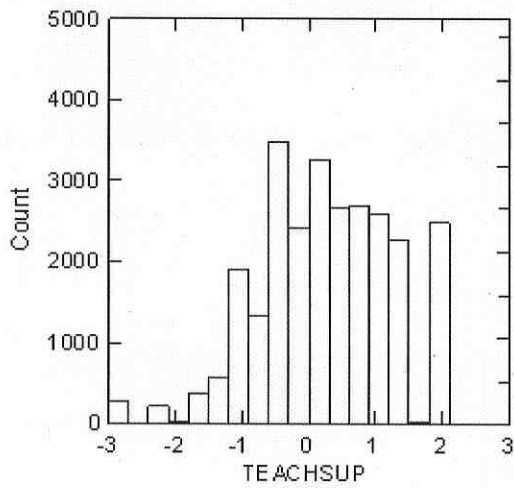


Figure B2: Histogram of teacher support in mathematics index in Canada

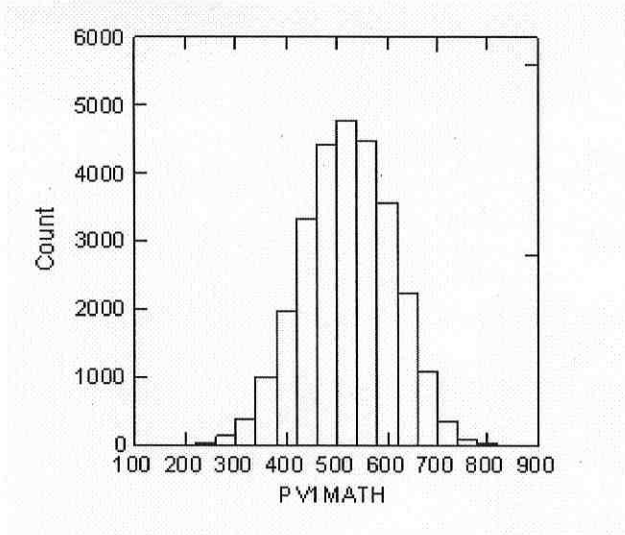


Figure B3: Histogram of plausible value 1 in mathematics in Canada

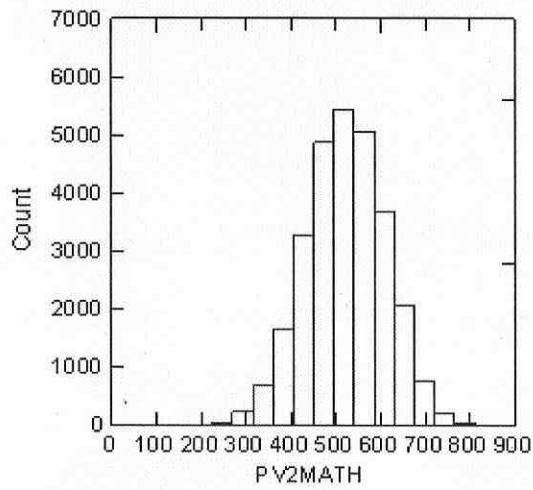


Figure B4: Histogram of plausible value 2 in mathematics in Canada

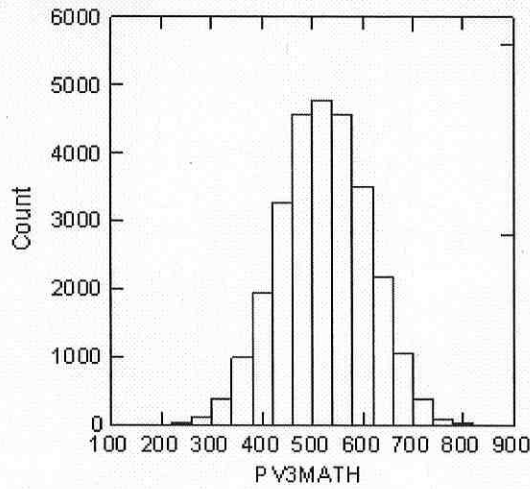


Figure B5: Histogram of plausible value 3 in mathematics in Canada

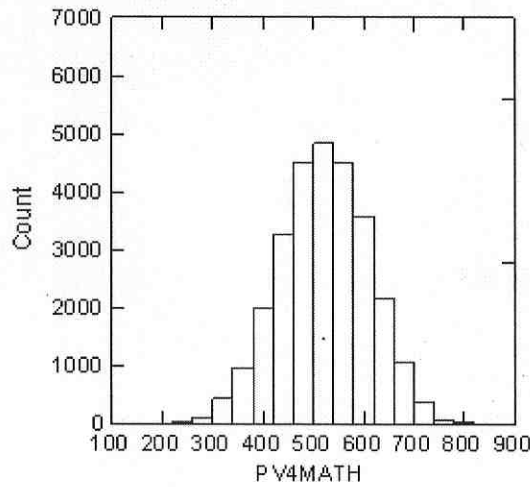


Figure B6: Histogram of plausible value 4 in mathematics in Canada

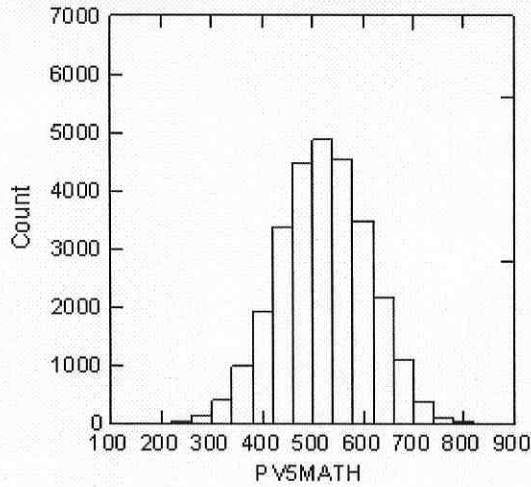


Figure B7: Histogram of plausible value 5 in mathematics in Canada

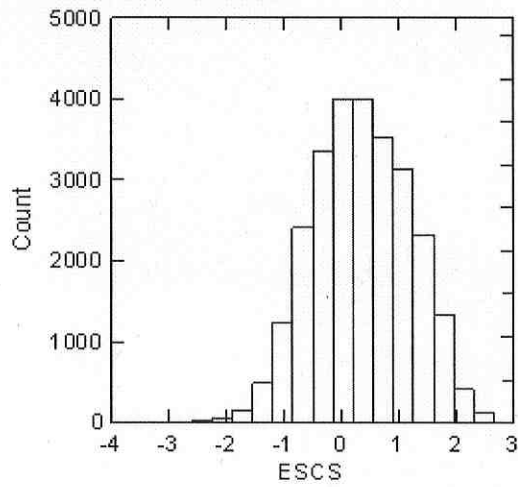


Figure B8: Histogram of the index for economic, social and cultural status in Canada

Student Level Distributions for Japan

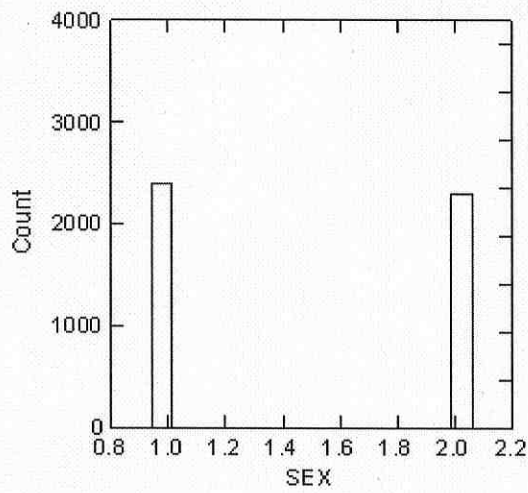


Figure B9: Histogram of sex distribution in Japan

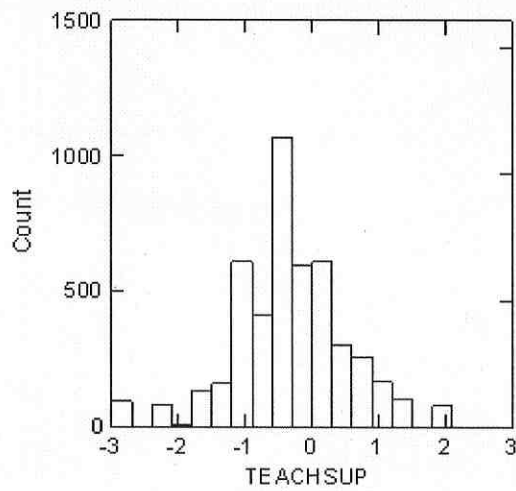


Figure B10: Histogram of teacher support in mathematics index in Japan

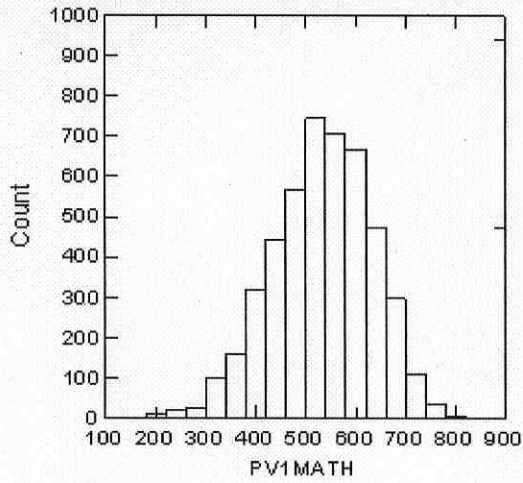


Figure B11: Histogram of plausible value 1 in mathematics in Japan

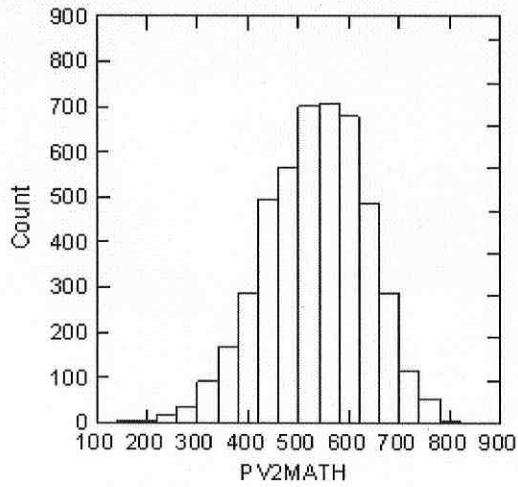


Figure B12: Histogram of plausible value 2 in mathematics for Japan

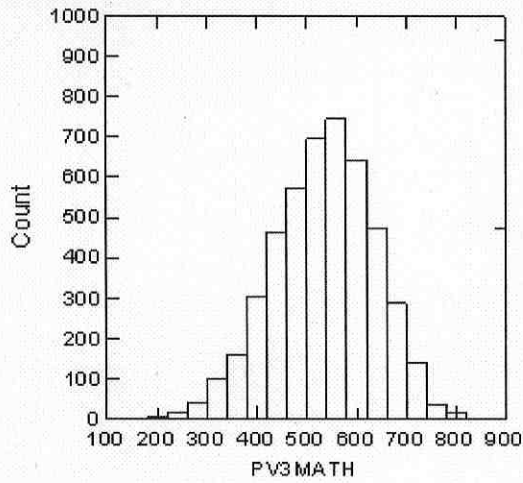


Figure B13: Histogram of plausible value 3 in mathematics in Japan

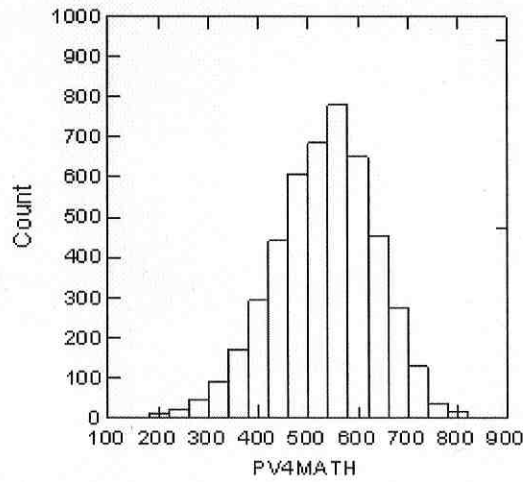


Figure B14: Histogram of plausible value 4 in mathematics in Japan

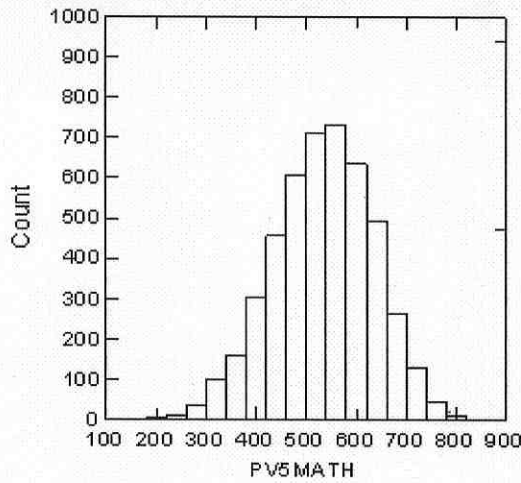


Figure B15: Histogram of plausible value 5 in mathematics in Japan

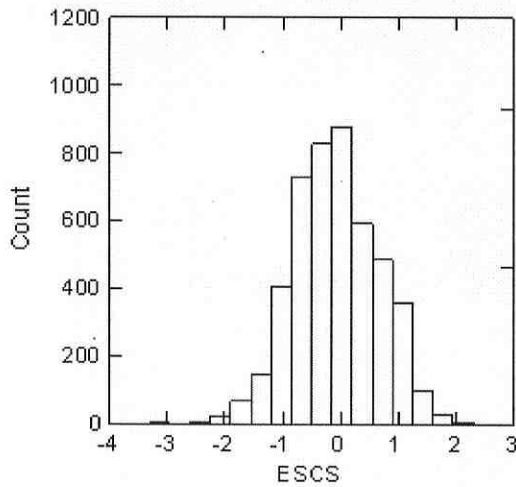


Figure B16: Histogram of the index for economic, social and cultural status in Japan

School Level Distributions for Canada

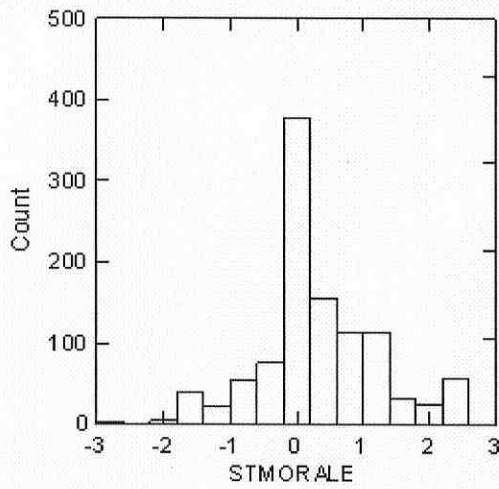


Figure B17: Histogram of principals' perceptions of student morale and commitment in Canada

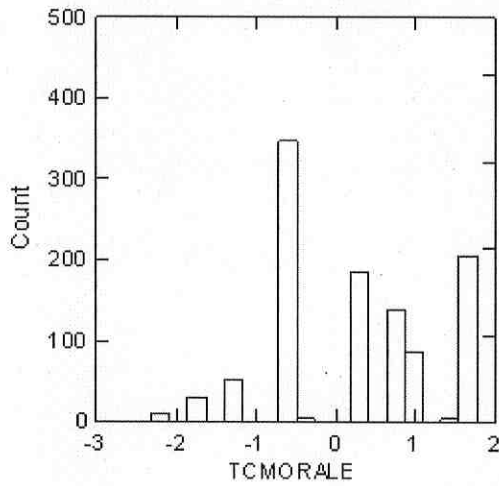


Figure B18: Histogram of principals' perceptions of teacher morale and commitment in Canada

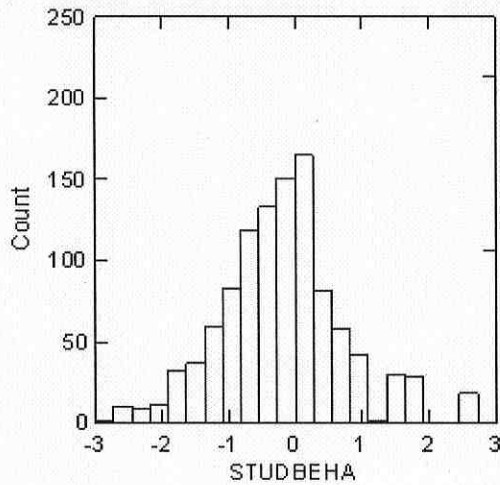


Figure B19: Histogram of principals' perceptions of student-related factors affecting school climate in Canada

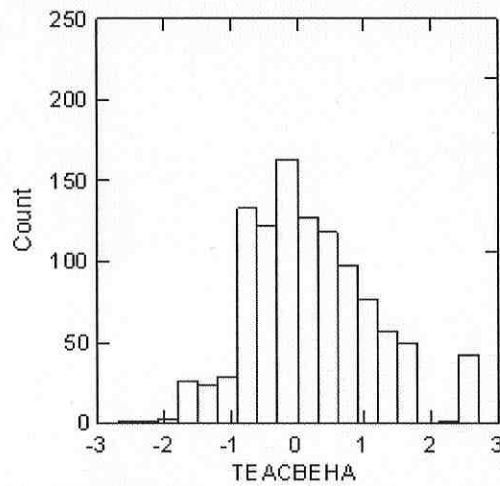


Figure B20: Histogram of principals' perceptions of teacher-related factors affecting school climate in Canada

School Level Distributions for Japan

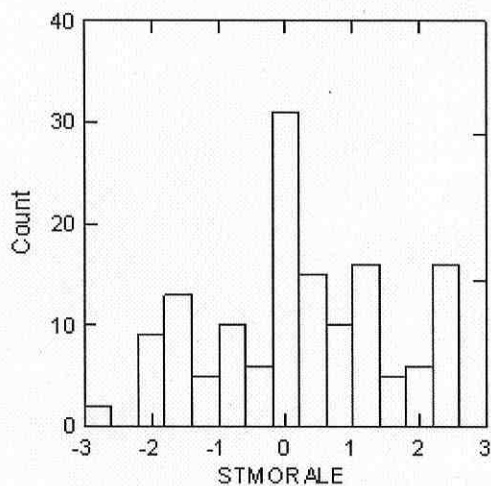


Figure B21: Histogram of principals' perceptions of student morale and commitment in Japan

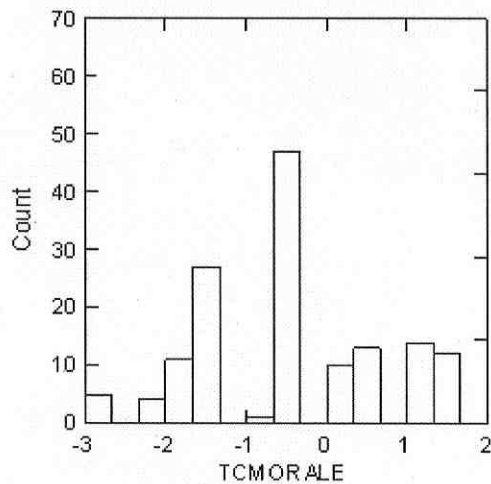


Figure B22: Histogram of principals' perceptions of teacher morale and commitment in Japan

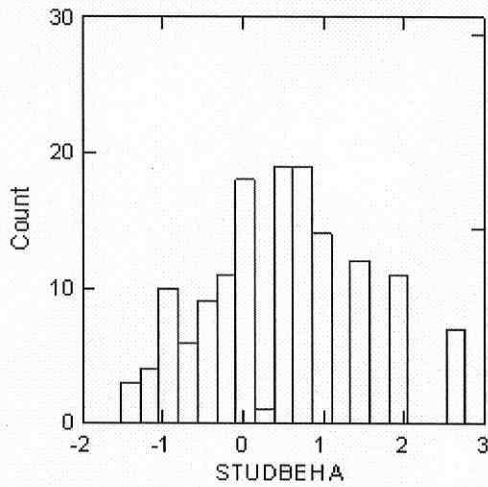


Figure B23: Histogram of principals' perceptions of student-related factors affecting school climate in Japan

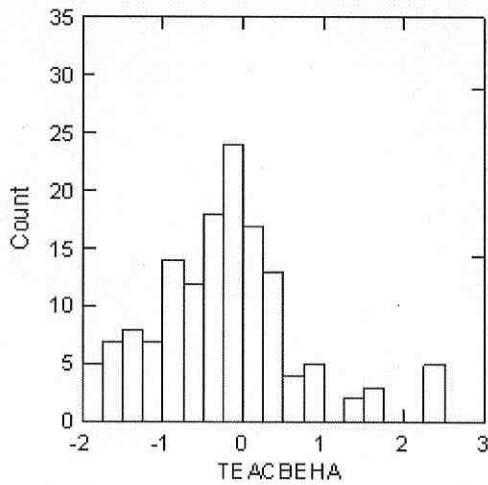


Figure B24: Histogram of principals' perceptions of teacher-related factors affecting school climate in Japan