A Multilevel Analysis of Mathematics Literacy:  
The Effects of Intrinsic Motivation, Teacher Support, and Student-Teacher Relations  

by  

Ming-Sze Goh  
B.Bus., Nanyang Technological University, 1998  

A Thesis Submitted in Partial Fulfillment of the  
Requirements for the Degree of  

MASTERS OF ARTS  

in the Department of Educational Psychology and Leadership Studies  

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University of Victoria  

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ABSTRACT

This research investigated the importance of students' intrinsic motivation, perceptions of teacher support in mathematics classrooms, and perceptions of student-teacher relations in the school on 15-year-old mathematics literacy in Canada in separate models while controlling for students' gender and socioeconomic status. In order to provide a clear national picture of the effects of these variables, a large-scale dataset was used in the analysis. With the use of hierarchical linear modeling, school-level variables were used to explain between-school variability in mathematics literacy, and variability in school slopes of each contextual student-level variable in separate models. Consistent with prior research, all three contextual student-level variables were significant positive predictors of mathematics literacy. 20% of the variability in mathematics literacy was attributed to schools. Principals' perceptions of teacher behaviors affecting students' learning was a significant school correlate in all three between-school variability models, suggesting the important role teachers play in students' educational outcomes.
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ACKNOWLEDGEMENTS

The completion of my thesis could not have been possible without the help and support of several people. First, I would like to acknowledge the positive advice and improvements made by my committee members: Dr. B. Harvey, Dr J. Walsh, and Dr L. Yore. Their invaluable insights and expertise contribute greatly to my thesis and my understanding of the process of educational research.

I would especially like to acknowledge the immeasurable contributions and improvements made to my thesis and to my personal development in the field of educational research and measurement by my supervisor, Dr John O. Anderson. He has given me insurmountable support, guidance, and opportunities to develop in the field. I could not thank him enough for the wisdom and professional integrity he has demonstrated in the last two years.

To my family and friends, I would like to thank them for their encouragement and support. I would especially like to thank Shelley Ross for providing me with helpful advice and direction in the initial stage of my thesis writing.
Chapter One: Introduction

Overview

“Curiosity is a basic propensity in human functioning” (Deci & Ryan, 1985, p. 245). Psychologists and educators have often observed that young children are intrinsically motivated to learn (Deci & Ryan, 1985; Newman, 2002). They have inexhaustible energy to explore and acquire new knowledge that interests them (Deci, 1992). As students progress through school, however, their curiosity, interests and attitudes toward learning deteriorate (Harter, 1981; Hidi & Harackiewicz, 2000; Makri-Botsari, 1999). Specifically, their motivation, interests, and attitudes toward school in general and toward academic subjects such as mathematics, science, and reading, tend to decline (Eccles & Midgley, 1989; Wigfield & Eccles, 1992). In a comprehensive review of the literature on children’s and adolescents’ motivation, Anderman and Maehr (1994) concluded that there is an overall decline in motivation toward academic activities and an increase in motivation toward non-academic activities during the middle school years. In a longitudinal study, Gottfried and colleagues (Gottfried, Fleming, & Gottfried, 2001) found that average academic intrinsic motivation declines over the ages for mathematics, science, and reading.

What are schools doing to reverse this trend? How can schools nurture and strengthen students’ motivation, and ensure that our young adults leave the school system with the motivation and necessary skills to continue a life-long learning journey? In their developmental first two decades, students spend about 15,000 hours in schools (Deci, Vallerand, Pelletier, & Ryan, 1991). Schools, therefore, have significant impact on the course of students’ lives. Students’ experiences in schools influence not only the
development of their cognitive abilities but also their affective and psychological well
being (Deci & Ryan, 1985). Only with the development of the right attitudes, motivation,
and skills can an individual be competent to acquire the knowledge and skills necessary
to be successful in adapting to changing real-life situations (Organization for Economic
Co-operation and Development [OECD], 2001, 2004). Ideally, schools should nurture
students’ interests and enthusiasm for learning, and impart in them a sense of voluntary
involvement in the academic realm (Deci et al., 1991).

The simplest definition of motivation is that it manifests an enduring personal
interest in a particular task or subject. Students who are motivated, therefore, learn and
achieve because of this enduring interest (Linnenbrink & Pintrich, 2002). When faced
with the question of how much motivation is needed, most practitioners advocate
nurturing more rather than less motivation. People have different levels of and
orientations to motivation (Ryan & Deci, 2000a). Orientation of motivation is concerned
with the motive behind the actions. For example, a student can be highly motivated to
finish the mathematics homework out of interest, or because he or she wants to please a
teacher or a parent. A student could be motivated to learn a new skill because he or she
knows the utility or value of learning the new skills. The nature and emphasis of students’
motivation, therefore, varies. Deci and Ryan (1985) distinguish between intrinsic
motivation and extrinsic motivation. An intrinsically motivated person engages in the
task for no apparent reason except the task itself. In contrast, an extrinsically motivated
individual only performs a task for external reasons such as for a reward.

Research has shown that intrinsic motivation is important to learning and
achievement, and that it can be systematically enhanced or undermined by parents and
teachers (Deci & Ryan, 1985; Ryan & Deci, 2000a, 2000b). Academic intrinsic motivation has significant positive association with academic achievement (Gottfried, 1985, 1990). It is, therefore, important to evaluate the factors and forces that promote versus undermine intrinsic motivation at the student-level and at the school-level.

Students’ experiences of interpersonal relations in the school environment can significantly influence their school-related functioning (Ryan, Stiller, & Lynch, 1991). As students transit to middle school, however, they experience a drop in their perceptions of teacher support (Eccles & Midgley, 1989). As a result, young adolescents have to try harder to negotiate and establish positive student-teacher relations under less than ideal conditions (Wentzel, 1998). The main worry is that students who do not enjoy strong teacher support and positive student-teacher relations may be at higher risk for academic problems such as task persistency and poor grades (Goodenow, 1993; Midgley, Feldlaufer, & Eccles, 1989). In the present study, the predictive value of students’ intrinsic motivation, perceptions of teacher support in the mathematics classroom, and perceptions of student-teacher relations in the school on mathematics literacy score is examined. In addition, the effects of school-level variables descriptive of school effectiveness on schools’ mathematics literacy gap, students’ intrinsic motivation, perceptions of teacher support and perceptions of student-teacher relations are examined.

Purpose

The purpose of this study was to examine the student- and school-level correlates of mathematics literacy for young adults, at age 15, with a particular focus on students’ intrinsic motivation, perceptions of teacher support in the mathematics classrooms, and perceptions of student-teacher relations in the school using data from the Programme for
International Student Assessment (PISA). Analysis of large-scale national data can enrich the national picture by showing the areas of strength and weaknesses, and helping educators to better understand and monitor students’ learning progress. These analyses can also provide directions for public education policy, for school reform and for student learning. With the right strategies, students can be motivated to learn better and achieve more, educators to teach better, and schools to be more effective (OECD, 2001, 2004). To accomplish the goal of examining both student- and school-level factors, hierarchical linear modeling (HLM) was employed.

**Research Questions**

This study is guided by the following research questions:

1. How much variability in 15-year-old mathematics literacy scores in Canada is explained by student- versus school-level factors, with a particular focus on intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations while controlling for gender and socioeconomic status (SES)?

2. With gender and SES controlled, are students’ intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations significant predictors of students’ mathematics literacy scores in Canada?

3. What are the school-level variables descriptive of school effectiveness accounting for between schools variability in 15-year-old students’ mathematics literacy scores in Canada while controlling for student-level variables?
4. What are the school-level variables descriptive of school effectiveness accounting for variability in school slopes of students' intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations in Canada while controlling for gender and SES?

**Summary of Chapter One**

This chapter introduced the notion that young children are intrinsically motivated to learn. The problem of declining academic motivation in schoolchildren warrants the investigation of school variables. In the next chapter, existing literature on the role of intrinsic motivation and the role of teachers on different educational outcomes is presented. In order to facilitate the discussion on intrinsic motivation, the self-determination theory is discussed. A discussion of school-level variables descriptive of school effectiveness used in the present study follows. In chapter three, the research design, PISA dataset, sampling, instrumentation, procedure, and analytic models are discussed in detail. The fourth chapter presents the results of the multilevel models. The final chapter includes the discussion, limitation, implications, and conclusion of the present research.
Chapter Two: Literature Review

Overview

Research on motivation in education has shown the importance of intrinsic motivation in the enhancement of students' learning (Deci & Ryan, 1985). Growing evidence has pointed to the significant association between students' perceptions of teacher support and positive aspects of motivation (Wentzel, 1998). Classrooms and school environments have significant impact not only on learning and motivation, but also other personal adjustment attributes (Ryan, Connell, & Deci, 1985). As such understanding of the influence of students' intrinsic motivation, perceptions of teacher support and perceptions of student-teacher relations on academic achievement is of utmost importance. In addition, identifying school-level factors that account for school differences can provide useful information on how to make schools more effective. This chapter reviews previous research on intrinsic motivation and educational outcomes. The self-determination theory is reviewed so as to provide the operational definition of intrinsic motivation that is used in the present study. The association between students' perceptions of teacher-support and perceptions of student-teacher relations with positive outcomes of education will also be reviewed. Finally, the literature on school-level variables descriptive of school effectiveness is reviewed to provide a theoretical basis for the model in the present study.

The Role of Intrinsic Motivation

Self-determination Theory

In most studies of intrinsic motivation, it was assumed that humans are constantly working hard to comprehend their external and internal surroundings. (Deci & Ryan,
1985). Deci and Ryan proposed the self-determination theory (SDT) where self-determination is an essential ingredient of intrinsic motivation and that other extrinsic factors undermine intrinsic motivation. SDT integrates the perspective that humans are driven to maintain an optimal level of arousal (Hebb, 1955), and the perspective that humans have basic need for effectance (White, 1959) and personal causation (deCharms, 1968, as cited in Deci & Ryan, 1985). The SDT of motivation begins with the assumption that “humans are active, growth-oriented organisms who are naturally inclined toward integration of their psychic elements into a unified sense of self and integration of themselves into larger social structures” (Deci & Ryan, 2000, p. 229). SDT focuses on three innate psychological needs for competence, relatedness and autonomy (Deci & Ryan, 1985, 1991). Competence means being able to accomplish different external and internal results, and being proficient in the imperative actions. The need for competence leads people to seek out optimal challenges and to overcome them (Deci & Ryan, 1985; White, 1959). Humans seek relatedness with others in their social groups. Relatedness involves seeking secure and satisfying relationships with significant others in one’s social environment (Ryan, 1995). Lastly, humans want autonomy, to be able to self-initiate and self-regulate their own behaviors (Deci et al., 1991). The results of these psychological needs are that humans have innate curiosity to engage in interesting tasks, to show competence, and to pursue relatedness with others in their social groups.

Humans function within a larger social context, and we are always conscious of what is going on around us; therefore the quality of our relationships with other people in our social circle can have significant influence on our sentimentality of ourselves and our overall development (Deci & Ryan, 1991). SDT recognizes the power of one’s social
environment to enhance or weaken the three innate needs (Deci & Ryan, 1985, 1991; Ryan, 1995; Ryan & Deci, 2000a). The basis of SDT is built on "a dialectic view which concerns the interaction between an active, integrating human nature and social contexts that either nurture or impede the organism’s active nature" (Ryan & Deci, 2002, p. 6). It focuses on the dimension of autonomy, structure and involvement to evaluate the social context.

First, autonomy refers to the organism’s drive to self-systematize experience and behavior, and participates in activities that are in harmony with one’s integrated perception of self (Deci & Ryan, 2000). Children, especially older children, detest coercion and control, often resulting in rebellion (Edwards, 1994). Optimal learning is often self-regulated and based on personal interest. Autonomy support, therefore, refers to an environment that promotes choice, non-conformity, and initiative (Deci & Ryan, 1991). Second, structure refers to the degree to which expectations are clearly mapped out and the number of feedback given. The degree of structure provided by a social context has a direct impact on one’s self-efficacy and perceptions of control over one’s accomplishments (Skinner, Wellborn, & Connell, 1990). Third, involvement refers to the psychological resources provided by others who are close to the target person. These resources can be used by the person as a basis of support to achieve competency (Deci & Ryan, 1991).

According to SDT, an environment that is autonomous, moderately structured, and that involved significant others is best for a student because it communicates greater competence and self-determination. On the other hand, an environment that is controlling, that is unstructured or overstructured, and that does not provide
psychological support by significant others impedes self-determination and undermine development (Deci & Ryan, 1991).

**Definition of Intrinsic Motivation**

In a classic paper, White (1959) argued for a different concept of motivation. He defined competence as one's ability to interact efficaciously with his surroundings and that motivation to achieve competence is derived outside the primary drives and instinct. White posited an effectance motivation that is either inborn or learned. A person who possesses effectance motivation is curious to find out how the surrounding can be changed and what repercussions result from the change. Effectance motivation might lead a person to perform the task even if it does not increase his ability or chances of survival. By performing the task, he or she will gain satisfaction that exceeds what is necessary to get the work done. Intrinsic motivation is defined as the performance of a task for its basic contentedness rather than some external cause. An intrinsically motivated person engages in a task because he or she is interested in and enjoys it rather than because of external rewards and pressure. Intrinsically motivated tasks are the ones in which the reward is in the task itself.

In humans, there are different kinds of motivation. Intrinsic motivation, however, is the most omnipresent and important one (Ryan & Deci, 2000b). Intrinsically motivated behaviors are driven by inner needs for competence and self-determination according to SDT (Deci & Ryan, 1985). These inner needs drive a person to seek out opportunities and to overcome optimal challenges to enhance his competence and self-determination.
Operational Definitions of Intrinsic Motivation

Intrinsic motivation has been operationally defined in many ways. The first approach builds on the definition that intrinsically motivated behaviors can occur without the presence of any external reward. This free choice measure has been used in many experimental studies. In Deci’s (1971) first experiment, experimental participants were paid $1 for each puzzle solved within thirteen minutes. In the third session, the reward was removed. To measure intrinsic motivation, the experimenter left the room for eight minutes under a credible context and the participants were told that they could do whatever they like. The amount of time participants spent engaging in the experimental task during this free-choice period was used as a measure for intrinsic motivation. This operational definition assumes that if there is no external reason to engage in the activity, then the more time participants spend on the activity, the more intrinsically motivated they are for the activity (Ryan & Deci, 2000a). This definition is important because it challenges the operant psychology’s proposition that behaviors are externally motivated, and because it has been used in experimental research for almost three decades. It does not, however, provide any information on the psychological processes involved in intrinsic motivation (Deci & Ryan, 1985, 1991).

A second operational definition proposes that intrinsically motivated behaviors are those that a person commits out of interest and enjoyment. Intrinsic motivation is the essence of free will and is associated with feelings of interest, enjoyment, and autonomy (Deci & Ryan, 2002). A common approach to the measurement of this operational definition is the use of self-reports of interest and enjoyment. Lepper (1985) identified three conceptualization of intrinsic motivation that have the same attributes as interest:
(a) humans as problem solvers (e.g. in research on challenge, effectance, competence, and mastery motivation); (b) humans as information processors (e.g. in research on curiosity and complexity); and (c) humans’ need to control their environment and feel self-determined (e.g. in research on autonomy, choice, and self-determination). In SDT, interest is an important aspect of intrinsic motivation because intrinsically motivated behaviors are the model of self-determined activity which are of interest to one’s intrinsic self, and therefore, perform without any separable reason (Deci, 1992; Deci & Ryan, 1991). Deci (1998) argued cogently that “intrinsically motivated behavior is done because it is interesting” (p. 149, as cited in Hidi, 2000). A person who reads a book because of personal interest is intrinsically motivated whereas a person who reads the book because of an exam or an assignment is extrinsically motivated. In the present study, intrinsic motivation for mathematics is operationally defined as students’ self reported interest and enjoyment in mathematics.

*Intrinsic Motivation and Educational Outcomes*

Lepper (1988) provided two reasons for focusing on intrinsic motivation in education. First, helping students to enjoy the learning process is itself an important educational outcome. Second, intrinsic motivation may be a way of increasing students’ learning in educational tasks. In many studies, intrinsic motivation has been associated with various educational outcomes across the age span, ranging from early elementary students to college students (Deci et al., 1991). Research on SDT has focused on different educational outcomes such as quality of experience, intensity of learning, creativity and general well being of students (Deci & Ryan, 2002). Examples of cognitive outcomes that have been studied in the intrinsic motivation and extrinsic motivation research are
recall and conceptual learning (Benware & Deci, 1984; Grolnick & Ryan, 1987; Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004). Affective outcomes include positive emotion (Ryan & Connell, 1989), satisfaction (Vallerand, Pelletier, Blais, Briere, Senecal, & Vallieres, 1993), and lower anxiety (Gottfried, 1985, 1990; Ryan & Connell, 1989). Finally, behavioral outcomes include persistency (Vallerand & Bissonnette, 1992) and task involvement (Cordova & Lepper, 1996). In the following section, research that relates intrinsic motivation to different educational outcomes is reviewed. Some of the studies have associated intrinsic motivation with the educational outcomes directly, whereas others have examined the effects on the relevant factors that have influenced intrinsic motivation; therefore, inferring that intrinsic motivation is a mediating variable in the observed relationship. The latter is only appropriate if the relationship is theoretically supported within the research findings regarding intrinsic motivation and self-determination (Deci & Ryan, 1992).

*Cognitive outcomes.* Benware and Deci (1984) examined the hypothesis that students who learn in order to teach the material would be more intrinsically motivated to learn and would learn more than students who learn in order to be tested. They gave 40 college students a moderately difficult article on brain functioning to read and learn at home. The participants were assigned randomly to the experimental group and the control group. The experimental participants were told that they would have to teach the material to other students when they returned. This learning context would enhance intrinsic motivation because the reasons for learning were more meaningful and useful. The control participants were told that they would be tested on the material when they returned. This learning context was similar to the regular controlling and extrinsic
oriented environment in many classrooms. All participants were told to record how long they spent studying the material. Two weeks later, all participants were given a 24-item examination, which consisted of items that assessed recall of facts and conceptual understanding of the material. In addition, they were required to complete a questionnaire to assess their interest and enjoyment of the material.

The results indicated that participants who learned in order to teach showed significantly higher conceptual understanding and intrinsic motivation than participants who learned in order to be tested. Both groups did not differ significantly in recall of facts and the amount of time spent learning the material. This study showed that environment where the reasons for learning are meaningful and where students are not pressured enhances intrinsic motivation that lead to higher conceptual learning. In contrast, an environment that is pressured and controlled impedes intrinsic motivation that impairs the quality of learning.

In another experiment, Grolnick and Ryan (1987) assigned randomly 91 fifth-grade students to three conditions: (a) noncontrolling-directed; (b) controlling-directed; and (c) nondirected. The three groups of students were brought individually to a learning lab and given a text material to read. After reading, they were given a questionnaire that focused on their interest/enjoyment and feelings of pressure. Students in the noncontrolling-directed group were then told to learn the material because they would be tested on it but not given a grade. Students in the controlling-directed group were told to learn the material because they would be tested on it and given a grade. Students in the nondirected group were told merely to read the passage so that they could report how interesting they found it. After each student had read the material, he or she was tested on
recall of facts and conceptual understanding. Each student was also given a questionnaire to measure his or her interest/enjoyment. About one week later, a different experimenter entered the students’ classrooms unexpectedly to administer a second examination and interest questionnaire.

Results showed that students in the noncontrolling-directed and nondirected groups reported significantly higher interest and displayed greater conceptual understanding than students in the controlling-directed group. Students in the noncontrolling-directed and controlling-directed groups showed more recall of facts than students in the nondirected group. Students in the controlling-directed group, however, reported more pressure and tension than the other two groups. In addition, students in the controlling-directed group exhibited significantly higher memory deterioration one week after the learning than the other two groups. Orienting students to the task of learning can increase rote memorization, however, in order to increase the quality of learning and retention rate requires more internal locus of causality of learning. That is higher intrinsic motivation improves the quality of learning.

Cordova and Lepper (1996) investigated the effects on the learning process of contextual strategies to improve intrinsic motivation. 72 fourth and fifth graders were assigned randomly to five conditions with different learning contexts where students worked on a computer game to learn arithmetic computations and problem solving. The results showed that providing students with choice and an interest context for learning increased intrinsic motivation and usage of complex operations. Parker and Lepper (1992) evaluated the effectiveness of presenting instructional materials in fantasy contexts on students’ learning and motivation. The results revealed that when
instructional materials were presented in fantasy contexts, students exhibited more intrinsic motivation to learn and higher retention of the learning material. People are most creative when they are intrinsically motivated rather than by external pressures (Amabile & Hennessey, 1992). Amabile (1985) asked 72 young adults to write two short poems in order to test the hypothesis that intrinsic motivation enhances creativity whereas extrinsic motivation is detrimental to creativity. Participants were assigned randomly to the three conditions: (a) control group; (b) intrinsic orientation group; and (c) extrinsic orientation group. Before writing the second poem, participants in the intrinsic orientation group were asked to complete a questionnaire that emphasized intrinsic reasons for involvement. Participants in the extrinsic orientation group completed a questionnaire that emphasized extrinsic reasons for involvement. Those in the control group were not given any questionnaire. The poems were rated by 12 poets on a 40-point scale of creativity. The results indicated that there was no significant difference on the creativity of the first poem between all the groups. For the second poem, the creativity of the control group and the intrinsic orientation group were high and comparable to the score for the first poem. For the extrinsic orientation group, the creativity of the second poem was significantly lower. Amabile, Hennessey, and Grossman (1986) found complementary results in their study.

Gottfried (1985) investigated the importance of academic intrinsic motivation for students' education in three different studies. Altogether, 567 middle-class students attending fourth through eighth grades participated in the survey. Students' intrinsic motivation was measured using a 122-item self-reported Children's Academic Intrinsic Motivation Inventory (CAIMI). Students' achievement was measured by standardized
achievement tests and teachers’ ratings of achievement. Results from the correlational analyses indicated that there was a significant positive relationship between academic intrinsic motivation and achievement. Academic intrinsic motivation accounted for approximately 20% of the variability in school achievement. Further analysis indicated that the mathematics CAIMI subscale was explicitly and uniquely associated with mathematics achievement when other subscales were held constant. Gottfried explained that it could be because mathematics is perceived as a more difficult and demanding subject area than others. Students with higher intrinsic motivation, therefore, are more able to tackle the difficult and demanding mathematics problems, and show higher academic achievement in this subject. Gottfried (1990) examined the relationship between academic intrinsic motivation and academic achievement in two studies, one longitudinal and one cross-sectional. Both studies showed that students with higher intrinsic motivation have significantly higher academic achievement and more intellectual accomplishments, and were rated more favorably by their teachers in terms of motivation.

Wigfield and Guthrie (1997) investigated how different aspects of children’s motivation for reading relate to the amount and breadth of their reading. 105 fourth- and fifth-grade students completed a revised reading motivation questionnaire twice during a school year. Data of students’ reading was collected from questionnaires and personal diaries. The result indicated that the amount and breadth for reading were significantly higher for students with higher intrinsic motivation than students with higher extrinsic motivation. In other non-experimental research, higher intrinsic motivation has been significantly associated with higher academic performance (Fortier, Vallerand, & Guay,
1995; Grolnick, Ryan, & Deci, 1991; Lepper, Corpus, & Iyengar, 2005; Lloyd & Barenblatt, 1984; Mevarech, 1988; Pintrich & De Groot, 1990; Vallerand et al., 1993; Weymer, 2002). Black and Deci (2000) found that students who became more intrinsically motivated during the semester obtained better grades.

Grolnick et al. (1991) found that intrinsic motivation accounted for 13% of the variance for grades, 17% of the variance for achievement and 16% of the variance for teacher-rated competence. Based on SDT, Fortier et al. (1995) constructed a motivational model of scholastic achievement that accounted for 28% of the variance in achievement. In a survey research of 391 students from ninth through twelfth grade, Nolen and Haladyna (1990) reported that intrinsic motivational orientation accounted for a significant variance in students' utility of sophisticated processing strategies across age and/or ability groups. Results highlighted the importance of intrinsic motivation in the prediction of scholastic achievement. In another correlational study, Lepper et al. (2005) found that intrinsic motivation was positively related to overall grade point average from third through eighth grade.

Some studies have tried to identify differential motivational orientations between high- and low-performing students. Soto (1988) found that Puerto Rican students who were classified as higher achievers using a standardized test score tended to be more intrinsically oriented than students who were classified as low achievers. Hagborg (1992) divided students into three groups based on their self-reported grade point average: (a) high (90% or above); (b) medium (80% to 89%); and (c) low (below 80%). Students in the high group were significantly more intrinsically motivated than students in the medium and low group.
In a recent three-year longitudinal study of 115 first graders, Bouffard and colleagues (Bouffard, Marcoux, Vezean, & Bordeleau, 2003) found no significant relationship between intrinsic motivation and academic achievement in reading and mathematics after controlling for self-perceptions of competence. The authors, however, cautioned that “even though intrinsic motivation is not directly related to academic achievement among young elementary schoolchildren, its importance may increase with school level” (Bouffard, et al., p. 181).

**Affective outcomes.** Studies have found that academic intrinsic motivation is positively associated with self-perception of academic competence and achievement (Cordova & Lepper, 1996; Fortier et al., 1995; Harter, 1981; Makri-Botsari, 1999). Ryan and Connell (1989) found significant positive correlation between intrinsic regulatory styles and coping strategies, whereas more extrinsic and controlling regulatory styles were associated with higher anxiety, less enjoyment and negative failure coping strategies. Students with higher intrinsic motivation exhibit significantly lower academic anxiety (Gottfried, 1982, 1985, 1990), more positive emotions in the classroom and greater academic satisfaction (Vallerand et al., 1993), more positive attitudes toward the subject matter (Lepper & Cordova, 1992; Parker & Lepper, 1992), and enhanced confidence (Lepper & Cordova) than students with lower intrinsic motivation. In a study based on SDT perspective, Black and Deci (2000) found that students with higher initial intrinsic motivation in an undergraduate introductory organic chemistry course had more positive experiences and lower anxiety at the end of the course.

**Behavioral outcomes.** Vallerand and Bissonnette (1992) investigated the influence of intrinsic, extrinsic, and amotivational styles as predictors of behavioral
persistence in a classroom setting. During the beginning of the academic year, 1042 first-
year college students who were enrolled in a compulsory French course completed a
questionnaire to evaluate their academic motivational orientations. Four months later,
students who persisted reported higher intrinsic motivation at the beginning of the
semester than students who dropped out of the course. Students with higher intrinsic
motivation have greater intentions to continue schooling and exhibit higher level of task
involvement (Cordova & Lepper, 1996; Vallerand et al., 1993). High achievers who also
have higher intrinsic motivation are more willing to seek out academic challenges and are
more persistence on academic work than low achievers (Hagborg, 1992). Black and Deci
(2000) found that student with higher intrinsic motivation are not only less likely to drop
out of a course but also more able to adjust to it. In another study, Hudley and colleagues
(Hudley, Daoud, Hershberg, Wright-Castro, & Polanco, 2002) found that intrinsic
motivation was negatively related to detention frequency and absenteeism among middle
school Anglo students.

In summary, the studies reviewed in this section indicate that students who are
intrinsically motivated for doing academic work are more likely to achieve, to show
conceptual understanding, to stay in school, and to show more positive affective attitudes
than students who are less intrinsically motivated. Intrinsic motivation is, therefore, an
important source of learning. As many of the studies reviewed in this section are more
than ten years old, the present study aims to supplement the existing literature by
investigating the predictive value of intrinsic motivation on mathematics achievement
while taking into account students’ gender and SES.
The Role of Teachers

Environments that are conducive to competence, autonomy and relatedness will likely induce students to learn, to do and to develop (Deci & Ryan, 1985, 1991; Ryan & Deci, 2000a; Ryan & Powelson, 1992). Ryan and Powelson went further to argue that students’ needs are mainly interpersonal in nature. That is, students who experience support for their autonomy feel affiliated to and supported by significant others, are more likely to be motivated to learn. In the educational context, teachers are the principal adult models and play influential roles in students’ socialization. The association between teacher support and educational outcomes is, therefore, likely to be strong (Ryan et al., 1994).

Teachers’ Role in Students’ Engagement

Marks (2000) conducted a multilevel analysis of students’ engagement across grade levels and subject areas. The sample consisted of 3,669 students from 24 elementary, middle, and high schools. The results showed that students who experienced supportive teachers had higher level of engagement across all grade levels regardless of students’ characteristics. Voelkl (1995) examined the relationship between perceived school support, students’ engagement in class activities, and scholastic achievement. The results indicated that students who reported their learning environment as more supportive were more engaged in class. This increased in scholastic engagement was accompanied by higher achievement. Skinner et al. (1990) tested a model where teacher support was hypothesized to have an impact on students’ perceptions of control, which in turn influence students’ scholastic achievement through its effects on their engagement in
school. The results of data analysis from 200 students in third through sixth grade provided support for their model.

Klem and Connell (2004) examined the threshold level of teacher support and engagement that are important to later scholastic success, and how much difference these threshold levels influence school success or difficulty. Longitudinal data from six elementary and three middle schools was collected. The results revealed that teacher support was critical to student engagement in school as reported by students and teachers. Students with more positive perceptions of teacher support had higher school engagement, which in turn was associated with higher level of attendance and scholastic achievement. Further, elementary students who reported low teacher support were twice as likely as the average student to be disengaged whereas middle school students were 68% more likely to be disengaged when they reported low teacher support. Middle school students were almost three times more likely to be engaged if they perceived strong teacher support while elementary students were 89% more likely to be engaged than those with average levels of support. Middle school students reported higher percentage increase in levels of scholastic performance if they had higher engagement than elementary students. The results suggested that students who experience supportive teachers are more likely to be engaged academically, which in turn lead to higher scholastic achievement. This effect, however, differs for students of different age groups.

Skinner and Belmont (1993) examined the effects of teachers’ involvement, structure, and autonomy support on the behavioral and emotional engagement of 144 students from third through fifth grade. Correlational and path analyses showed that supportive teachers affected students’ experiences in the classroom. Teachers’ liking for
students was conveyed to them and had significant influence on the way in which students perceived their teachers as supportive. Students of more supportive teachers felt that their needs for relatedness, competence, and self-determination were met. The results also showed that students who reported their teachers as providing clear standards, immediate feedback and strategic help were more likely to be behaviorally engaged. When students experienced their teachers as more caring and warm, they were more likely to be emotionally engaged in class. In addition, the results also indicated that students who showed higher initial behavioral engagement received more teacher support. This suggested that there is a reciprocal effect and students who are behaviorally disengaged might not receive teacher support that will enhance their motivation.

_Teachers' Role in Students' Motivation_

Research has shown that securing a strong and satisfying affiliation with significant others in one’s social milieu is one of the core foundations of motivation (Connell & Wellborn, 1990; Deci et al., 1991; Ryan & Powelson, 1992). Students who are less motivated but who have a strong relationship with their teacher may experience less discourse than students with similar low motivation and a poor relationship with their teacher. It seems that for the first group of students, relatedness may buffer the negative effects of low motivation and allow students to continue to learn. This could eventually translate into more motivation to strive hard in school (Connell & Wellborn).

Ryan and Grolnick (1986) argued that when significant others support and respect the child’s autonomous functioning, children are better able to value themselves, which lead to enhancement of self-worth. They found that elementary students who perceived their teachers to be more autonomy-oriented and warm were significantly more
intrinsically motivated, had higher perception of competence and had higher self-esteem. They also found that there were significant differences within the classroom in terms of how the students perceived their teachers, suggesting that students’ experience of the environment is unique and individualized. Similarly, Deci, Schwartz, Sheinman, and Ryan (1981) found that students of autonomous-oriented teachers were more intrinsically motivated and had higher self-esteem than students of control-oriented teachers. In addition, this relationship was formed within the first two months of the school year and remained stable over the rest of the school year.

In a longitudinal study of 1301 students and their mathematics teachers, Midgley et al. (1989) examined whether changes across the transition to junior high school in students’ perceptions of teacher support were related to changes in their valuing of mathematics. They found that students who transited from classrooms where they experienced low teacher support to classrooms where the perceptions of teacher support were higher exhibited higher intrinsic interest and more positive attitudes. On the other hand, students who moved from teachers they perceived as supportive to teachers they perceived as less supportive showed a significant decrease in both their intrinsic interest, and the perceived utility and importance of mathematics. In addition, there was an interaction between achievement level and students’ perceptions of the utility and importance of mathematics. Perceptions of utility and importance of mathematics declined more significantly during the first year of junior high for low-achieving students who moved from supportive to less supportive teachers than high-achieving students who experienced similar transition. Low-achievers who experienced a sharp decline in the value of mathematics may be more likely to give up trying to be competent in
mathematics and to drop it. Eccles and Midgley (1989) found that the majority of students experienced higher teachers' control and a decline in their affective relationships with the teachers as they transited into traditional junior high schools, which resulted in a decrease in students' interest and motivation.

In a longitudinal study, Wentzel (1997) examined the association between perceptions of teachers' pedagogical support and motivation to achieve positive social and scholastic achievement in middle school students. The results indicated a significant positive association between perceptions of teachers' pedagogical support to students' motivational outcomes and scholastic achievements even when all the other variables were controlled. In addition, perceptions of teachers' pedagogical support were negatively associated with students' distress.

Wentzel (1998) examined adolescents' perceptions of supportive relationships with parents, teachers, and friends in relation to motivation. Motivation was measured in terms of school- and class-related interest, academic goal orientations, and social goal seeking. 167 sixth-grade students completed the questionnaires during regular class session in late spring. The results indicated that perceptions of teacher support had the most direct influence on students' interest in school. Perceptions of teacher support were positively associated with all motivational measures except performance goal orientations. In addition, perceptions of teacher support were positively associated with higher grades and lower distress. Goodenow (1993) investigated young adolescents' perceptions of support by their peers and teachers among 353 middle school students. The results showed that teacher support explained over a third of students' evaluation of interest and importance of learning. Students who perceived their teachers to be more
supportive reported higher academic motivation. This implies that young adolescents may derive a significant proportion of their academic motivation from their perceptions of teacher support.

Ryan et al. (1994) examined how young adolescents’ representations of relationships to teachers, parents and friends are related to each other and to different measures of school adjustment, motivation and self-esteem. 606 students from a public middle school completed a survey that included measures for representations of relationships, school-related functioning, motivation, and self-esteem. The results highlighted the importance of a strong and cordial teacher-student relationship within the educational domain. Students who reported higher quality of teacher relationship also reported more positive attitudes and higher motivation in school. In addition, young adolescents with higher perceptions of teacher support and willingness to rely on teachers for emotional and school support also have higher perceptions of control, autonomy, and engagement in school.

*Teachers' Role in Students' Help Seeking*

Students with low self-efficacy and low self-esteem are unlikely to seek help in class (Newman, 1990; Ryan, Gheen, & Midgley, 1998). Ryan et al., however, found that unwillingness to seek help was associated less strongly to students’ academic self-efficacy in classrooms in which teachers believe their role is to attend to students’ social and emotional as well as academic well-being. Further evidence of the importance of teachers’ role in students’ help seeking was provided by Newman and Schager (1993). In their study, 177 students in second, fifth and seventh grade were interviewed individually to investigate students’ perceptions of their teachers and peers in relation to academic
help seeking. At all grade levels, a strong perception of affiliation with the teacher was predictive of help seeking. In addition, teachers’ direct encouragement of questioning also predicted help seeking at fifth and seventh grade. It seems, therefore, that students at all grade levels appreciate the affective value of teacher support. Ryan et al. (1994) found that students who experienced higher quality of student-teacher relations felt more secure and were more willing to seek help when they have a problem.

Karabenick and Sharma (1994) examined college students’ perceptions of their teachers’ support to student questioning and its influence on students’ motivation orientations and learning strategies. In the first study, they tested the hypothesis that students who were more motivated and self-regulated have more positive perceptions of teacher support than do less motivated and self-regulated students. The second study investigated the hypothesis that students with positive perceptions of teacher support were more likely to ask questions in the classroom. The results from both studies supported the hypotheses. Students who perceived their teachers as more supportive were significantly more intrinsically motivated and self-regulated than students who perceived their teachers as less supportive. These students also asked more questions in the classroom.

Taken together, the studies reviewed in this section show the importance of interpersonal experience between students and teachers in the facilitation of positive outcomes within the educational domain. Strong teacher support and positive perceptions of teacher-student relations are associated with greater academic engagement, interest and motivation, which in turn lead to higher academic achievement. In addition, caring
and supportive teachers may provide students with a more secure environment for help seeking.

_The Role of School Effectiveness_

Edmonds (1979) and Stedman (1987) identified six school characteristics that facilitate student achievement. They are strong principal leadership, high teacher expectations on students' scholastic achievement, emphasis on basic performance objectives, orderly school climate, frequent evaluation of students, and time-on-tasks. The present study investigates the significance of school-level variables descriptive of school practices and school climate on school mean academic achievement.

_School Practices_

_School autonomy._ An environment that supports autonomy is conducive to intrinsic motivation (Deci & Ryan, 1985). Increasing school autonomy will result in more superior and effective school processes (Nir, 2002). In his research on the characteristics of efficacious schools, Little (1982) contended that efficacious schools are those which allow staff more authority in school decisions, and which facilitate communications between teachers, students and parents. Teachers are the ones with the most experience and knowledge about students' instructional, psychological and classroom needs, and problems (Conley, 1991). It is, therefore, prudent to utilize teachers' expertise to improve school effectiveness. Research done to study the affective outcomes of school-based management have found that increasing teachers' participation in decision making increases teachers' sense of efficacy and sense of community (Gaziel, 1998; Newmann, Rutter, & Smith, 1989), teachers' sense of commitment (Gaziel; Nir), teachers' satisfaction (Conley; Pearson & Moomaw, 2005), and teachers' morale (Jones, 1997;
Newmann et al., 1989). Further, greater teacher autonomy in the curriculum design has been found to decrease on-the-job stress (Pearson & Moomaw, 2005).

In a longitudinal study of the instructional outcomes of school-based decision making, Smylie, Lazarus, and Brownlee-Conyers (1996) found that teachers’ participation in decision making is positively correlated with instructional improvement and students’ academic achievement. In other studies, however, no association was found between greater teachers’ participation and students’ academic achievement (Jenkins, Ronk, Schrag, Rude, & Stowitschek, 1994; Jones, 1997). In a three-year longitudinal study, Jenkins et al. studied the effects of a program using school-based decision making to improve the education of at risk students or students with learning disabilities. Principals of selected schools were first trained on the strategies for organizing interventions for remedial and special needs students. When the principals returned to school, they worked with the staff to implement a consensual reform. The results indicated that teachers in the school-based approach were more positive about the program and students exhibited less behavioral problems. Students in the experimental schools, however, did not evidence significantly higher achievement than students in the control schools.

Use of Assessments. Stedman (1985) noted that many of the effective schools divided their curriculum into teachable sections of skills and students will frequently assess on the specific performance objectives. Classroom formative assessment that is designed to provide students with frequent and useful feedback can increase learning substantially (Black & William, 1998). Formative assessment can help to improve learning by enhancing students’ motivation to learn, helping students to identify what to
learn, teaching students how to learn and helping students to evaluate the effectiveness of their learning (James & Gipps, 1998). In a review of the literature, Dempster (1991) found that frequent testing enhances learning; especially if the material is tested soon after it is taught. Iverson and Iverson (1994) conducted a quasi-experiment to test the effectiveness of frequent ungraded testing. The control group did not get any formative assessment while the experimental group was tested in class at the end of formal instruction after each chapter. The results indicated that there was no difference in summative test scores between the two groups. More students from the experimental group, however, were able to attain mastery when mastery was defined as passing of 70% on the summative scores. Although the result was statistically nonsignificant, it has some practical significant. Kika, McLaughlin, and Dixon (1992) evaluated the effect of frequent testing on the performance of high school algebra students. The study employed a counterbalanced ABAB research design where students were given tests on a weekly or biweekly basis. The results showed that weekly testing improved students’ performance significantly and that students preferred the weekly testing condition.

In a meta-analysis, Bangert-Drowns and colleagues (Bangert-Drowns, Kulik, & Kulik, 1991) found that students who have taken at least one assessment in a 15-week term scored half a standard deviation higher on achievement tests than those who did not. The average effect of frequent assessment increased achievement test scores by .23 standard deviation. This improvement, however, decreased as the number of assessment increased.

Deci and Ryan (1985) argued that intrinsic motivation is undermined in an environment where the emphasis is on grades because grades are deemed as controlling.
When students learn in order to be tested, their intrinsic motivation is undermined (Benware & Deci, 1984). Grover, Becker, and Davis (1989) did not find any significant difference in students' test scores for those who were tested chapter by chapter versus those who were given a summative test. However, they allowed their subjects to choose and participate in their preferred test options. It is, therefore, unclear whether the results would be different if the subjects were not given any choice.

School Climate

Different researchers use different definitions for the term “school climate”, including school disciplinary problems, psychological factors within the school or school management issues (Esposito, 1999). A school climate can be defined as the general trait of the school environment that affects students' and teachers' behaviors (Hoy & Sabo, 1998, as cited in Roach & Kratochwill, 2004). In a comprehensive review of the literature, Anderson (1982) found that results of school climate research are often anomalous due to deficient causal models.

Although researchers are unable to arrive at a clear definition of school climate, it has profound influence on students' cognitive and affective behavior, values, personal growth, and satisfaction (Anderson, 1982). From the motivational theorists’ perspective, school climate influences students' attitudes and perceptions of themselves, which in turn influences their accomplishments (Loukas & Robinson, 2004). A positive school climate is distinguished by high morale, caring and warm environment, and strong togetherness (Miller, 1981). A school climate that emphasizes interpersonal relations and opportunities for all to succeed can lead to higher students’ academic achievement and motivation (McEvoy & Welker, 2000). Some of the factors that influence a supportive school
climate are emphasis on academic motivation, consensual decision-making among staff, quality of interactions and relations within the school community, and student-teacher relations (Haynes, Emmons, & Ben-Avie, 1997).

Research has shown that the morale of the staff can have positive impact on students’ learning and attitudes (Miller, 1981). When teachers’ morale decreases, students’ achievement decline and other problems emerge. Low teachers’ morale is more likely to lead to callousness toward other staff, scornful attitudes toward students, less enthusiasm in lesson preparation, enthrallment in leaving the teaching profession, frequent use of medical leave, and spell of depression (Black, 2001). Zigarelli (1996) examined the independent effects of six constructs of school effectiveness on students’ academic achievement. The findings indicated that high teacher morale was an important predictor of students’ academic achievement. Stevens and White (1987) examined the direct relationship between teachers’ morale and students’ academic achievement. The results indicated a nonsignificant relationship between the two variables. The authors, however, cautioned that academic achievement is a multi-dimensional variable and no single study has shown a direct relationship between teachers’ morale and students’ academic achievement.

In a survey of 80 middle schools, Hoy and Hannum (1997) found that teachers’ commitment to students and colleagues, and teachers’ enthusiasm was positively correlated with mathematics and reading achievement. Kushman (1992) surveyed 750 teachers to investigate the effects of teachers’ organization commitment and commitment to students’ learning on achievement. The results showed that organizational commitment has a significant positive association with student achievement. There was no significant
statistical association between commitment to student learning and achievement, although there was a positive relationship. In addition, there was an interaction between teacher commitment and students' achievement. This implies that teacher commitment can be both a cause and an effect of student achievement.

In summary, school climate refers to the quality and homogeneity of interpersonal relations with the school environment that influence students' cognitive, social and psychological well-being (Haynes et al., 1997). A positive school climate can enhance students' learning and achievement.

Student Demographic Variables

Gender Differences

Research has found minute or no gender differences in mathematics in general (Friedman, 1989; 1995; Hall, Davis, Bolen, & Chia, 1999; Hyde, Fennema, & Lamon, 1990). Friedman's (1989) meta-analysis examining studies between 1974 and mid 1987 on gender differences in mathematics led to the conclusion that the gender differences in mathematics performances have been decreasing over the years. Further analysis of the data, however, revealed that a general statement about gender differences in mathematics performance is beguiling. Hyde et al. found females performed better in computation, no gender gap in understanding of mathematical concepts, and males performed better in problem solving in high school. They also found that there was no significant gender difference in mathematics performance between elementary and middle school; they did, however, find significant male advantage from high school through adulthood. Friedman (1995) conducted a meta-analysis of correlation of spatial and mathematical skills. She
found that the association was stronger in males than females, implying certain gender-specific association patterns that favored males.

*SES Differences*

In a recent meta-analysis, Sirin (2005) found that family SES at the student-level is one of the most significant predictors of academic performance. The correlation between general academic outcomes and SES was .22; however, the correlation between mathematics achievement and SES was .35. He also found that parents' position in the socioeconomic structure has a significant influence on students' academic achievement. Rech and Stevens (1996) found that among fourth-grade Black students, those with lower SES are at higher risk of lower levels of mathematics achievement. In a study that sampled 398 students from seventh to ninth grade, Felner and colleagues (Felner, Brand, DuBois, Adan, Mulhall, & Evans, 1995) found that students whose parents have lower occupational status evidence lower grade point average, self-esteem, and perceived competence than students whose parents have higher occupational status. The former group of students also exhibited more classroom behavioral problems. McCoy (2005) examined the influence of demographic variables and attitudes on achievement of eighth grade algebra students. Parents' educational level was used to determine students' SES. The results indicated that SES significantly affects mathematics achievement.
Summary of Chapter Two

This chapter began with an introduction of SDT, which emphasizes the role of social context to facilitate intrinsic motivation. An environment that promotes autonomy, competence, and relatedness is conducive to intrinsic motivation. The studies reviewed in this chapter indicate that higher intrinsic motivation, supportive teachers, and positive student-teacher relations result in positive educational outcomes. A positive school environment can improve students’ learning and attitudes. Gender and SES differences in academic achievement were also reviewed. In the preceding chapter, the methodology used in the present study is discussed.
Chapter Three: Methodology

Overview

This chapter describes the research design used in the present study. The study involved secondary data analysis (SDA); therefore, the pros and cons of secondary analysis are reviewed. An overview of PISA 2003, sampling procedures and instrumentation are discussed in detail. The variables used in the study are discussed in Appendix A and Appendix B. Finally, this chapter concludes with an in depth review of research procedures implemented in PISA 2003, and the analytic models used in the present study.

Research Design

Secondary Data Analysis

SDA involves using statistical techniques to analyze existing datasets whereas primary data analysis involves both data collection and analysis (Kiecolt & Nathan, 1985). SDA has the benefits of saving time, money and resources. It helps researchers to overcome the problems of data collection because existing datasets provide the advantages of large national samples, standard items and standard indices. It gives researchers access to huge amount of data that would be otherwise difficult for them to collect individually (Hyman, 1972; Kiecolt & Nathan). These datasets can provide more information on social conditions, measurement domains, and variables than primary data analysis. SDA, therefore, can produce more detailed and complete empirical study of the problems the researchers has formulated (Hyman). SDA can help researchers to discover areas of a research problem that require more comprehensive analysis, subgroups that need to be oversampled, and the need to improve on existing dimensions (Hyman;
Kiecolt & Nathan). SDA is suitable for different types of research techniques such as trend, cohort, time-series and comparative designs. Finally, existing materials can be combined with other measures to examine a problem more comprehensively (Kiecolt & Nathan, 1985).

Despite its increasing popularity and many benefits, SDA also has some limitations that were highlighted by Kiecolt and Nathan (1985). First, finding the specific variables that the researcher requires may be difficult in a large dataset because data may only be available in aggregate, index or scaled form. Second, there may be incomplete or inadequate documentation of the data, which limits interpretation for the researcher and may even make it difficult or impossible to find required information. Third, errors made in the original data collection may be difficult to detect because it is impossible to differentiate interviewing, coding and data entry errors. Further, the data collection procedures might not be sufficiently documented to enable secondary analysts to assess errors in the data. Minor errors in the original data may be magnified if the data is used for purposes other than its original intent. Fourth, it is difficult for a researcher to focus on a specific subpopulation in a wide-based, national sample because there may be too few cases to conduct the desirable statistical analysis. Fifth, the quality of the dataset may be influenced by measurement problems because the original items may not be an accurate measurement of the constructs the researcher has in mind or it may be poorly operationalized.

SDA can be used as an auxiliary to new research, either in the beginning stages of research development, or as a complement to new research (Hakim, 1982). Some of the
limitations discussed above, such as poor documentation, can be alleviated by using datasets that are collected mainly for secondary analysis (Kiecolt & Nathan, 1985).

Hierarchical Linear Modeling

In the present study, HLM was used to model student- and school-level variables affecting 15-year-old mathematics literacy scores in Canada. Most educational research involves multilevel data structure where individuals may be nested within organizational settings (Raudenbush & Bryk, 2002). HLM is a useful statistical technique to analyze multilevel data where two (or more) sources of data, obtained from two (or more) levels of structure, are combined (Kreft, 1995). For example, a multilevel structure can be found in schools where the student is the first level and the school is the second level. Even though any number of levels can be represented, most of the useful statistical information is found in the basic two-level model (Raudenbush & Bryk, 2002). HLM allows the simultaneous modeling of student- and school-level factors while avoiding the problems of aggregation bias, misestimated standard errors, and heterogeneity of regression (Lee, 2000).

HLM generates linear equations that explain results for members of groups as a function of the features of the groups in addition to the features of the members (Arnold, 1992). A two-level HLM model, with students’ mathematics literacy scores modeled at the student-level, nested under schools at the second level, was run using HLM version 6.02 program (Raudenbush, Bryk, Cheong, & Congdon, 2004).

An Overview of PISA

The purpose of PISA is to measure how well young adults, at age 15, are prepared for the challenges ahead as they approach the end of compulsory education in the
member countries of OECD (OECD, 2001). In order to achieve its goal, PISA is forward-looking, emphasizing how young adults apply their knowledge and skills to solve problems in authentic context, rather than the degree to which they have mastered a particular curriculum.

PISA 2003 assessed reading, mathematics and scientific literacy, and problem solving with the main emphasis on mathematical literacy (OECD, 2004, 2005a). Students also completed a questionnaire while the school principals completed the school questionnaire. An international consortium of experts and consultants were responsible for designing and implementing the PISA surveys. During the development of the instruments, the different cultural and educational contexts of OECD member countries were taken into account in order to ensure that the instruments were internationally valid and sound (OECD, 2001, 2004, 2005a). The results of PISA can significantly improve our understanding of the outcomes of education and the factors influencing these outcomes. By focusing on students’ ability to solve problems relating to real-life situations, PISA can enrich our knowledge of what countries are doing to prepare our young adults to meet the challenges of today knowledge society (OECD, 2001, 2004).

Sampling

The target population of PISA assessment in each country is 15-year-old students attending educational institutions within the country. This includes 15-year-olds who are enrolled in full-time and part-time educational institutions, 15-year-olds who are enrolled in vocational training or any other related types of educational programs, and students who are enrolled in foreign institutions within the country as well as foreign students who are enrolled in programs in the first three categories. As such, students who are schooled
at home, workplace or out of the country are not included in the target population (OECD, 2004, 2005a).

PISA used a two-level stratified sampling method within countries where the first-level sampling units were the individual institutions with 15-year-old students and the second-level sampling units were the students in the sampled institutions. The institutions were sampled from a national list of institutions with probabilities that were proportional to institutional size that was measured by the number of eligible 15-year-old students enrolled. Once the school was selected, a list of 15-year-old students in the school was compiled. For schools with more than 35 students, 35 students were randomly selected. If there were fewer than 35 students, all students on the list were included in the assessment. In order to collect a good representation of the population, exclusion rate within each country was kept below 5 percent. To increase accuracy and precision, a minimum of 150 schools were selected in each country (or all schools if fewer than 150). Within each sampled school, students have equal probability of being selected. If the initial school response rate fell below 85%, replacement schools were used. For every one sampled school that did not participate, two replacement schools were identified where possible. The response rate for students in sampled schools was set at 80% (OECD, 2005a).

Instrumentation

Mathematics Literacy in PISA

The PISA mathematical literacy assessment focuses on students' abilities to analyze, argue, and convey ideas competently as they develop, pose, solve, and interpret
Mathematical problems in different real-life situations. Mathematical literacy for OECD/PISA 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 judgements 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, 2003, p. 24).

In PISA 2003, students' mathematics literacy was evaluated in relation to three elements of the mathematical content to which different problems and questions apply; the process is used to relate the authentic problem to mathematics and to solve it; and the contexts that are used as catalyst and in which problems are posed (OECD, 2003, 2004).

Content. Following extensive literature review and comprehensive consensus building among OECD countries on what would be a suitable basis to compare mathematics internationally, the following four content areas were chosen: space and shape, change and relationship, quantity, and uncertainty (OECD, 2003, 2004).

Space and shape emphasizes the concepts of spatial and geometry. It involves looking for similarities and differences when studying the parts of a whole and recognizing shapes in different forms and different dimensions. In order to achieve this, the student must understand the properties of objects and their relative positions (OECD, 2003). Change and relationships relates to the mathematical construct of change, in addition to logical relationships and interconnection among variables. In mathematics, relationships are often expressed as equalities and inequalities. In reality, however, relationships have different representations and manifestations. Hence, it is critical to be able to translate between representations in different contexts (OECD, 2003).
Quantity focuses on the comprehension of proportionate size, the understanding of numerical patterns, and the use of numbers to represent quantities and quantifiable characteristics of authentic objects. In addition, quantity involves the knowledge that numbers are presented in different ways. An important attribute of quantity is to be able to reason quantitatively. Therefore, students must have a strong understanding of number patterns, number sense, magnitude of numbers, the meaning of operations and arithmetic computations (OECD, 2003). Uncertainty covers the mathematical subject areas of statistics and probability. This area is very important in this informational age as we are constantly confronted with a lot of uncertainties and data that require our own interpretation (OECD, 2003).

Process. The PISA mathematics assessment requires students to use mathematical concepts to solve problems that are presented in real-world situations. In order to do so, students have to go through a “multi-step process of “mathematisation”” (OECD, 2004, p. 40). First, the students must identify the relevant mathematical concepts presented in the real-world problems. Next, they have to transform the real-world problem into a mathematical problem by making assumptions and generalizations. Once the problem has been transformed into a mathematical problem, students have to solve it by using the mathematical concepts that they have learnt. The final step involves translating the mathematical result into a solution that works in authentic context.

In order to engage in successful mathematisation, a student must possess the following competencies: (a) thinking and disputation; (b) argumentation; (c) communication; (d) modeling; (e) problem posing and solving; (f) representation; (g) use of symbols, formal and technical language and operations; and (h) use of aids and tools
(OECD, 2003, 2004). PISA 2003 classifies the competencies into three clusters. The reproduction cluster involves the recall of knowledge of facts and common mathematical computations. The connections cluster builds on the reproduction cluster to solve problems that are not common. It requires more interpretation and integration of different representations and aspects of the problem to solve it. The reflection cluster builds further on the connections cluster. It requires more application of knowledge of facts as well as getting students to reflect on and justify their solutions (OECD, 2003, 2004).

**Contexts.** An essential aspect of mathematical literacy is to be able to engage mathematics in different circumstances (OECD, 2003). PISA emphasizes tasks that are related to different real-world contexts, and the use of mathematical concepts to solve authentic problems. The items in PISA 2003 mathematics assessment are classified into four different contexts. First, personal contexts draw parallels to students’ daily activities, and it requires extensive evaluation before the problem can be solved. Second, the educational or occupational contexts relate to students’ life in school or in the workplace. Third, the public contexts require students to make observations of their local and broader community. Finally, scientific contexts are more complex and involve specific mathematical concepts. The four contexts differ in terms of their degree of closeness to the students. The personal contexts are the closest to the students and have the most explicit impact on them, whereas scientific contexts have the largest gap between students and the problems (OECD, 2003).

**Construction of PISA Assessment Items**

Once the PISA assessment framework has been established, items were constructed to cover the different aspects of the framework. After the items were
developed, experts from participating countries conducted a qualitative analysis on each item. This involves identifying the areas of cognitive demands of the items and their relevancy to the PISA mathematics assessment framework. The items were reviewed at the national and international level. Every item was field tested with a sizable number of students at the same age range. Usually, many versions of the items were field tested so that the best version could be chosen. The data from the field tests were analyzed using general item response techniques. The items were revised after the field test, in some cases; the revised items were field tested again (OECD, 2005a).

Altogether, 85 mathematics items were used in PISA 2003. The items were arranged in seven clusters, with each cluster representing 30 minutes of testing time. The testing time was divided equally across the four contents and four contexts of the PISA mathematics assessment framework. The ratio of items reflecting the competency clusters of reproduction, connections, and reflections is about 1:2:1. One third of the items were multiple-choice questions, one third was closed constructed-response questions, and the remaining one third was open constructed-response questions (OECD, 2005a).

*Development of PISA Context Questionnaire*

In order to examine the social, economic, cultural, and educational factors that are associated with student achievement, data on the characteristics of students and their schools were also collected. The student and school questionnaires were completed by the students and their principals in the sampled schools respectively. The questionnaire items collected data about the whole scholastic system, the schools, the instructional and learning environment within the schools, and the students in learning activities (OECD, 2005a).
The development of the new questionnaire items was a collaborative effort by a group of international experts, the OECD and national centers. The first version of the questionnaire items were field tested in a few participating countries, in order to examine the quantitative and qualitative aspects of the item responses. After an extensive review, two different versions of student questionnaire and a school questionnaire were administered in a field test in all participating countries. The final student questionnaire took students about 35 minutes to complete. The questionnaire surveyed variables such as student characteristics, family background, perceptions of school climate, self-related cognitions in mathematics, learning strategies and preference in mathematics, and classroom climate. The school questionnaire took the school principals about 20 minutes to complete. It covered variables such as school characteristics, admittance policies, pedagogical practices, school resources, administrative structure, and school climate (OECD, 2005a).

Procedure

PISA was executed in each country by a National Project Manager (NPM). The NPMs were assisted by school coordinators and test administrators. The main task of the NPM was to execute the procedures prepared by PISA (see OECD, 2005a for detailed responsibilities and duties of NPM). The role of the school coordinators was to coordinate school-related activities together with the NPM and the test administrators. The main role of the test administrators was to administer the PISA fairly and impartially. In order to maintain validity and reliability, the assessments must be administered in a uniform way that was congruent with international standards and PISA procedures. Prior to the assessment, test administrators were given a comprehensive review of the test
administrator manual, and the script to follow during the administration of the test and questionnaire.

The NPMs followed the meticulous details in the school sampling preparation manual to map out the school sampling strategy. First, the national target population was identified, followed by school and student level exclusion. In addition, the extent of small schools and the congruity of students within schools were taken into account in the school sampling strategy. After the school sampling strategy was planned at the national level, they were submitted to the PISA consortium that selected the school sample. This helps to minimize sampling errors and ensure that the process was uniform for all participating countries. Throughout this process, the NPMs worked closely with the consortium to ensure that national specific issues were addressed. After the schools have been selected by the consortium, the list of sampled schools was given to the NPMs who then contacted the schools and requested for a list of all PISA eligible students. The list was used by the NPMs to select the within-school sample. The students were selected using sampling and data entry software developed by the consortium. In some rare cases, the NPMs selected the students without using the software.

Several months before the assessment dates, the test units and questionnaire items were sent to the NPMs to allow translation to begin. There were 13 different test booklets altogether and elaborative instructions were given to NPMs on how to put together their items into booklets. To ensure uniformity, NPMs had to follow the template in the English master copies. After the booklets have been put together by the NPMs, they were submitted to the consortium for checking. After the NPMs had assimilated feedback from the initial verification, the booklets were resubmitted to the consortium for a final visual
check. The NPMs sent the materials for printing after the feedback from the final visual check were included. The construction of the questionnaires went through the same process as the test booklets. NPMs were allowed to add questions of national interest at the end of the international version.

The rating process was an intricate operation because for the large number of responses that had to be evaluated. Multiple rating was needed in some cases to ensure inter-rater reliability. Altogether, 42% of the items for mathematics required manual rating by trained raters. To maintain uniformity, a comprehensive rating guideline was prepared by the consortium and given to the NPMs. The NPMs were responsible for hiring qualified raters to rate the test booklets. The raters were required to have a good comprehension of secondary level mathematics and to be familiar with ways in which secondary students verbalize themselves. Potential raters have to be committed to the project, which could take up to two months. NPMs were provided with a rater recruitment kit to assist them in evaluating applicants. An average of sixteen raters was required for mathematics with another two as backup raters. PISA provided a rating questioning service for all participating countries through a secure website where any ratings questions that could not be solved at a national level were addressed. All selected raters had to undergo a comprehensive training program where they were given sampled items to rate. The booklets were randomly assigned to the raters. The booklets were rated cluster-by-cluster, and item-by-item. About 900 booklets were selected for multiple rating, which was done at or towards the end of the rating period by three raters so that raters had familiarized themselves with the rating guides (OECD, 2005a).
Purposes of Survey Design Weights and Plausible Values

Survey Design Weights

Most surveys collect data from subjects who have been randomly selected from a target population. In the simplest case, each member of the population has an equal opportunity of being selected. This is, however, rarely the case in large-scale national and international surveys. This is because researchers occasionally want to study a particular subgroup in the population that leads to over sampling from small subgroups and under sampling from large subgroups (Willms & Smith, 2005). In PISA 2003 survey for Canada, small provinces such as Prince Edward Island and New Brunswick were oversampled while large provinces such as Ontario and Quebec were under-sampled. This enables researchers to collect approximately equal samples from each province. Any statistics that are calculated for the national sample without taking into account this sampling design would be biased (Willms & Smith). In Canada, not using weights could underestimate the average math performance by nearly 11 score units (OECD, 2005b). Other factors contributing to biases include refusal by students and schools to participate, outdated list of potential participants, and student absenteeism on test dates.

To eliminate or reduce the effects of biases, survey design weights are used to weigh students differentially. Using weights take into account the fact that some units in the sample are proportionately larger than others, and they contribute more to the population estimates (OECD, 2005b). For example, a subject with a low probability of selection will be regarded as more important than a subject with a high probability of selection. The weights can also make adjustment to non-response in the survey (OECD, 2005a; Willms & Smith, 2005).
As mentioned earlier, PISA 2003 used a two-level stratified sampling procedure where schools are the first level and students are the second level. The weight for a student must, therefore, take into account the probability of his or her schools being selected, and the probability of he or she being selected within those schools (Willms & Smith, 2005). PISA 2003 provides an overall sample design weight that is used for data analysis, to calculate accurate statistical estimates and to make valid inferences (OECD, 2005a). In the present study, this overall design weight was input into the multilevel regression package, HLM 6.02 (Raudenbush et al., 2004), to run a weighted multilevel regression analysis.

Plausible Values

PISA 2003 used a rotated-booklet design for testing students’ mathematics literacy (Willms & Smith, 2005). This means that each student completes only a small fraction of the whole set of test items. Researchers, however, are interested in assigning a full score to each student. The plausible values are a representation of the possible range of scores that the student might have achieved had he completed the whole test, and taking into account the measurement error in the test (Willms & Smith). The logic behind the plausible values consists 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, 2005b, p. 73).

With HLM version 6.02 program (Raudenbush et al., 2004), there is an option to specify that there are plausible values to be taken into account. When this option is
chosen, the analysis is processed five times, one for each plausible value, and the correct standard errors for the regression coefficients are calculated (Willms & Smith, 2005).

Analytic Models

The research protocol using HLM is described in this section. Previous research has demonstrated support for controlling for individual students’ demographic variables such as SES and gender when investigating the relation of achievement to school-level correlates (Battistich, Solomon, Kim, Watson, & Schaps, 1995; Gregoire & Algina, 2000; Lee & Smith, 1993). In the present study, two student-level demographic variables; gender and the index of economic, social, and cultural status (ESCS) were used as within-school controls in all multilevel models. The variability of these parameters as a function of school-level variables was not modeled. That is, their between-school variance was fixed at 0 in the multilevel models. The ESCS was used as an indicator of students’ SES by PISA. The results of the multilevel models should be interpreted with all other variables in the model held constant.

Null Model

The simplest analysis involves the use of a one-way ANOVA with random effects (Raudenbush & Bryk, 2002). The null model separates the variability of the outcome into within- and between-school component:

\[ Y_{ij} = \beta_{0j} + r_{ij} \]

\[ \beta_{0j} = \gamma_{00} + u_{0j} \]

where

\[ Y_{ij} \] is the mathematics literacy scores for student \( i \) in school \( j \);

\[ \beta_{0j} \] is the mathematics intercept;
\( r_{ij} \) is unique error associated with the student \( i \) in school \( j \);
\( \gamma_{00} \) is mean mathematics literacy for all the schools in the sample; and
\( u_{0j} \) is the unique error to the intercept associated with school \( j \).

The null model was used to answer the following questions: (a) how much do individual students differ around their school means? (b) how much of total variance in mathematics literacy is attributable to schools? (c) how accurate an estimate of the population mean is the school mean \( \beta_{0j} \)? and (d) do school means vary significantly? The questions were answered by examining the variance estimates for within schools and between schools. The intraclass correlation, which represents the proportion of variance in mathematics literacy between schools, was examined.

*Random Coefficient Models with Student-Level Predictors*

In the next series of HLMs, contextual student-level variables and demographic controls were added into the equations to answer the following questions: (a) given the estimated within-school variance, what proportion of that variance in mathematics literacy scores can be accounted for by a student’s intrinsic motivation while controlling for gender and ESCS? and (b) controlling for student’s gender and ESCS, what is the mathematics literacy gap between students with different intrinsic motivation? The same questions were answered using perceptions of teacher support, and perceptions of student-teacher relations as contextual variables in separate models. All student-level variables were entered into the equations uncentered, and the estimated coefficients showed the within-school mathematics literacy differential, controlling for other student-level variables. The models were evaluated against the null model by examining the
proportion of unexplained within-school variance that was accounted for after all the
student-level predictors were included in the model.

The level-one model included one contextual variable (intrinsic motivation,
perceptions of teacher support, and perceptions of student teacher relations were analyzed
separately) and two student demographic variables. In order to control the effects of these
variables, the between-school variability of individual student-level characteristics was
fixed at 0 (i.e. $u_{ij}$ through $u_{3j}$ equal to 0).

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Intrinsic Motivation}) + \beta_{2j} (\text{Gender}) + \beta_{3j} (\text{ESCS}) + r_{ij}$$

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

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

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

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

where

$\beta_{1j}$ to $\beta_{3j}$ are the parameters of student-level variables; and

$\gamma_{10}$ to $\gamma_{30}$ are the average regression slopes across schools.

*Random Intercept Models with Student- and School-Level Predictors*

In the third series of HLMs, school-level variables were added to explain
between-school variability in mathematics literacy controlling for student-level variables.
The following questions were answered using these models: (a) which school-level
variables significantly predict the school mean mathematics literacy? and (b) how much
variation in the school mean mathematics literacy is explained by school-level variables?
Students’ perceptions of teacher support and perceptions of student-teacher relations were
used as level-1 contextual variables in separate models. The reduction in the variance
estimate, $u_{0j}$, allowed a calculation of the proportion of the original estimated between-school variance (from the null model) that could be accounted for by the school-level variables chosen, and an evaluation of the usefulness of the models. Slope parameters for student-level variables were again fixed; that is, the effect of individual student-level variables was not set to vary by schools.

$$Y_{ij} = \beta_0 + \beta_{1j} \text{(Intrinsic Motivation)} + \beta_{2j} \text{(Gender)} + \beta_{3j} \text{(ESCS)} + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} \text{(Mean Intrinsic Motivation)} + \gamma_{02} \text{(Mean Perception of Teacher Support)} + \gamma_{03} \text{(Mean Student-teacher Relations)} + \gamma_{04} \text{(School Autonomy)} + \gamma_{05} \text{(Teacher Participation)} + \gamma_{06} \text{(Use of Assessment)} + \gamma_{07} \text{(Teacher Morale and Commitment)} + \gamma_{08} \text{(Teacher-related Factors Affecting School Climate)} + u_{0j}$$

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

$$\beta_{2j} = \gamma_{20},$$

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

Random Intercepts and Slopes Models

The final series of HLMs examined whether mathematics literacy varied due to a student’s intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations modeled in the student-level equation and schools in which they belonged modeled at the second-level. The slopes for these contextual variables were allowed to vary in the models. Student demographic variables were added in level-1 as controls. When statistically significant slope variance was found, the slope parameter was modeled with school-level correlates to investigate significant explanatory variables. For example, with the intrinsic motivation variable, the questions were: (a) does mathematics
literacy vary significantly in high versus low intrinsically motivated students who belong in different schools? and if so (b) what school-level correlates significantly explain the mathematics literacy variance in the slopes. The equations were:

\[ Y_{ij} = \beta_{0i} + \beta_{1i} (\text{Intrinsic Motivation}) + \beta_{2i} (\text{Gender}) + \beta_{3i} (\text{ESCS}) + r_{ij} \]

\[ \beta_{0i} = \gamma_{00} + u_{0i} \]

\[ \beta_{1i} = \gamma_{10} + u_{1i} \]

\[ \beta_{2i} = \gamma_{20} \]

\[ \beta_{3i} = \gamma_{30} \]

to examine if the intrinsic motivation slope, \( \beta_{1ij} \), had significant variance when modeled as a random variable. To identify explanatory school-level correlates, the subsequent equation was modeled as follows:

\[ \beta_{1ij} = \gamma_{10} + \gamma_{11} (\text{Mean Intrinsic Motivation}) + \gamma_{12} (\text{Mean Perception of Teacher Support}) + \gamma_{13} (\text{Mean Student-teacher Relations}) + \gamma_{14} (\text{School Autonomy}) + \gamma_{15} (\text{Teacher Participation}) + \gamma_{16} (\text{Use of Assessment}) + \gamma_{17} (\text{Teacher Morale and Commitment}) + \gamma_{18} (\text{Teacher-related Factors Affecting School Climate}) + u_{1ij} \]

**Summary of Chapter Three**

The beginning of this chapter introduced the concept of secondary data analysis, and its pros and cons. Some of the cons can be avoided by using datasets that are meant for secondary analysis. PISA is an international effort to evaluate students' literacy and to collect data on student, home, and institutional factors. HLM allows the simultaneous analysis of student- and school-level factors. The analytic models used in the present study were also discussed.
Chapter Four: Results

Preliminary Data Analyses

The Canadian data was collected from 27953 15-year-old students in 1087 schools. There were 13748 female and 13469 male with 736 missing cases in gender. Table 1 presents the descriptive statistics for the plausible values of mathematics and the student-level variables used in level-1 HLM models (see Appendix A and B for description of all variables).

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plausible Values 1</td>
<td>160.34</td>
<td>859.28</td>
<td>521.63</td>
<td>87.95</td>
</tr>
<tr>
<td>Plausible Values 2</td>
<td>83.14</td>
<td>866.83</td>
<td>521.14</td>
<td>87.39</td>
</tr>
<tr>
<td>Plausible Values 3</td>
<td>123.96</td>
<td>856.47</td>
<td>521.55</td>
<td>87.48</td>
</tr>
<tr>
<td>Plausible Values 4</td>
<td>119.75</td>
<td>853.28</td>
<td>521.25</td>
<td>87.86</td>
</tr>
<tr>
<td>Plausible Values 5</td>
<td>191.03</td>
<td>844.48</td>
<td>521.42</td>
<td>87.87</td>
</tr>
<tr>
<td>Intrinsic Motivation</td>
<td>-1.78</td>
<td>2.37</td>
<td>-.01</td>
<td>1.02</td>
</tr>
<tr>
<td>Student-teacher Relations</td>
<td>-3.09</td>
<td>2.85</td>
<td>.22</td>
<td>.99</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>-2.92</td>
<td>2.10</td>
<td>.24</td>
<td>1.00</td>
</tr>
<tr>
<td>ESCS</td>
<td>-3.59</td>
<td>2.42</td>
<td>.35</td>
<td>.84</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>2</td>
<td>1.49</td>
<td>.50</td>
</tr>
</tbody>
</table>

The questionnaires items in PISA 2003 were scaled using item response theory modeling (OECD, 2005a). The scores were then standardized with an OECD average of
zero and a standard deviation of one. For example the mean intrinsic motivation score of 
-.01 (as shown in Table 1) indicates that the intrinsic motivation index for Canada is .01
standard deviation below the OECD average.

Table 2 presents the descriptive statistics for school-level variables used in the
level-2 equations. The descriptive statistics and graphic representations (*see Appendix C*)
show that the distributions are approximately normal. There are no univariate or
multivariate within-cell outliers at $p < .05$ level. The intercorrelation matrices for student-
and school-level variables (as shown in Table 3 and Table 4 respectively) do not indicate
any multicollinearity between the variables. The results of evaluation of assumptions of
normality, homogeneity of variance-covariance matrices, linearity, and multicollinearity
are met.

Table 2

*Descriptive Statistics for School Variables Used in Level-2 HLM*

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Morale</td>
<td>-2.81</td>
<td>1.65</td>
<td>.20</td>
<td>1.00</td>
</tr>
<tr>
<td>Teacher Behaviors</td>
<td>-2.44</td>
<td>2.49</td>
<td>.16</td>
<td>.89</td>
</tr>
<tr>
<td>School Autonomy</td>
<td>-2.13</td>
<td>1.69</td>
<td>.00</td>
<td>.90</td>
</tr>
<tr>
<td>Teacher Participation</td>
<td>-1.61</td>
<td>2.79</td>
<td>-.04</td>
<td>.99</td>
</tr>
<tr>
<td>Assessment</td>
<td>1</td>
<td>3</td>
<td>2.11</td>
<td>.46</td>
</tr>
<tr>
<td>Mean Intrinsic Motivation</td>
<td>-1.21</td>
<td>1.30</td>
<td>.01</td>
<td>.33</td>
</tr>
<tr>
<td>Mean Student-teacher Relations</td>
<td>-1.40</td>
<td>2.13</td>
<td>.26</td>
<td>.40</td>
</tr>
<tr>
<td>Mean Teacher Support</td>
<td>-1.36</td>
<td>1.73</td>
<td>.27</td>
<td>.39</td>
</tr>
</tbody>
</table>
Table 3

*Intercorrelations Between Student Variables Used in Level-1 HLM*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plausible Values 1</td>
<td>—</td>
<td>.90*</td>
<td>.90*</td>
<td>.90*</td>
<td>.25*</td>
<td>.14*</td>
<td>.10*</td>
<td>.04*</td>
<td>.33*</td>
<td></td>
</tr>
<tr>
<td>2. Plausible Values 2</td>
<td>—</td>
<td>.90*</td>
<td>.90*</td>
<td>.90*</td>
<td>.25*</td>
<td>.14*</td>
<td>.10*</td>
<td>.04*</td>
<td>.33*</td>
<td></td>
</tr>
<tr>
<td>3. Plausible Values 3</td>
<td>—</td>
<td>.90*</td>
<td>.90*</td>
<td>.25*</td>
<td>.14*</td>
<td>.10*</td>
<td>.04*</td>
<td>.33*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Plausible Values 4</td>
<td>—</td>
<td>.90*</td>
<td>.25*</td>
<td>.14*</td>
<td>.10*</td>
<td>.04*</td>
<td>.33*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Plausible Values 5</td>
<td>—</td>
<td>.25*</td>
<td>.14*</td>
<td>.10*</td>
<td>.04*</td>
<td>.33*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Intrinsic Motivation</td>
<td>—</td>
<td></td>
<td>.31*</td>
<td>.31*</td>
<td>.07*</td>
<td>.08*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Student-teacher Relations</td>
<td>—</td>
<td></td>
<td>.43*</td>
<td>.06*</td>
<td>.10*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Teacher Support</td>
<td>—</td>
<td></td>
<td></td>
<td>-.03*</td>
<td>.05*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Gender</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. ESCS</td>
<td>—</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
Table 4.

*Intercorrelations Between School Variables Used in Level-2 HLM*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
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<tr>
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<td>.44*</td>
<td>.07*</td>
<td>.08*</td>
<td>.07*</td>
<td>.06*</td>
<td>.21*</td>
<td>.07*</td>
</tr>
<tr>
<td>2. Teacher Behaviors</td>
<td>—</td>
<td>.08*</td>
<td>.03</td>
<td>.08*</td>
<td>.09*</td>
<td>.25*</td>
<td>.13*</td>
<td></td>
</tr>
<tr>
<td>3. School Autonomy</td>
<td>—</td>
<td>.20*</td>
<td>.04</td>
<td>-.01</td>
<td>.03</td>
<td>.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Teacher Participation</td>
<td>—</td>
<td>-.01</td>
<td>-.04</td>
<td>-.01</td>
<td>.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Assessment</td>
<td>—</td>
<td>.03</td>
<td>.09*</td>
<td>.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mean Intrinsic Motivation</td>
<td>—</td>
<td>.37*</td>
<td>.40*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Mean Student-teacher Relations</td>
<td>—</td>
<td></td>
<td></td>
<td>.49*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Mean Teacher Support</td>
<td>—</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
Results from HLM Models

The results of the final models are presented in Tables 5-14. Variables that were statistically nonsignificant were dropped from the model. The results presented in this section are discussed with gender and SES controlled at the student level. That is, the between-school variability of these two student demographic variables is fixed at 0 in all the models. The results of each variable should be interpreted by taking into account other variables included in the model as well as their statistical properties.

Null Model

The results from the null model are presented in Table 5.

Table 5

Mathematics Literacy Scores Variance Partitioned to Student versus Schools: Results from the Null Model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>Estimate</th>
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<th>p</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Coefficient</td>
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<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Intercept</td>
<td>531.15</td>
<td>2.11</td>
<td>252.28</td>
<td>1054</td>
</tr>
<tr>
<td>Random Effects</td>
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<td></td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>1457.42</td>
<td>38.18</td>
<td>8072.46</td>
<td>1054</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>5723.79</td>
<td>75.66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .84
Variance attributable to schools = \frac{1457.42}{1457.42 + 5723.79} = .20

Students are found to vary significantly around their school means \(t(1054) = 252.28, p < .001\). The student-level variability in mathematics literacy is estimated at 5723.79 while the school-level variability is estimated at 1456.52. This yielded an
intraclass coefficient of .20, showing that about 20% of the total variability in
mathematics literacy could be attributed to schools (i.e. between-school variance). The
mathematics intercept is 531.15 (SE = 2.11). There is significant variation in school
means (τ₀₀ = 1457.42, p < .001) The reliability of this estimate is .84.

Random Coefficient Models

Table 6 shows the results of the random coefficient model with students' intrinsic
motivation, gender, and ESCS in the level-1 model.

Table 6

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>SE</td>
<td>t</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Intercept</td>
<td>508.16</td>
<td>3.02</td>
<td>168.13</td>
</tr>
<tr>
<td>Within-School Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsic Motivation</td>
<td>18.66</td>
<td>.84</td>
<td>22.34</td>
</tr>
<tr>
<td>Gender</td>
<td>10.23</td>
<td>1.77</td>
<td>5.80</td>
</tr>
<tr>
<td>ESCS</td>
<td>25.67</td>
<td>1.22</td>
<td>21.08</td>
</tr>
<tr>
<td>Random Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>1066.34</td>
<td>32.65</td>
<td>6770.64</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>4756.74</td>
<td>68.97</td>
<td></td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .80
Within-school variance accounted for by Level 1 predictors = \( \frac{5723.79 - 4756.74}{5723.79} = .17 \)
The mathematics intercept is estimated at 508.16 ($t(284) = 168.13$, $p < .001$). A one unit increase in intrinsic motivation increases mathematics literacy by 18.66 units ($p < .001$), controlling for other variables. A male student is predicted to score 10.23 units ($p < .001$) higher than a female student; a one unit increase in ESCS is estimated to increase mathematics literacy by 25.67 units ($p < .001$). About 17% of the variability in students’ mathematics literacy is explained by the variables modeled.

Table 7

<table>
<thead>
<tr>
<th>Results from Random Coefficient Model with Level 1 Student Demographic Controls and Students’ Perceptions of Teacher Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Fixed Effects</td>
</tr>
<tr>
<td>Mathematics Intercept</td>
</tr>
<tr>
<td>Within-School Effects</td>
</tr>
<tr>
<td>Teacher Support</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>ESCS</td>
</tr>
<tr>
<td>Random Effects</td>
</tr>
<tr>
<td>School-Level Effect</td>
</tr>
<tr>
<td>Student-Level Effect</td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .78

Within-school variance accounted for by Level 1 predictors = $\frac{5723.79 - 5047.36}{5723.79} = .12$

Table 7 coefficients show that male students score significantly higher in mathematics literacy than female students ($b = 14.12$, $p < .001$). High ESCS students
scored 27.49 units higher than low ESCS students \( (p < .001) \). Students who experience higher teacher support are predicted to have significantly higher mathematics literacy \( (b = 5.41, p < .001) \) than students who experience lower teacher support, controlling for gender and ESCS. About 12% of the variance in students' mathematics literacy is explained by the variables in the model, a lower proportion than that in Table 6.

Table 8

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>SE</td>
<td>t</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Intercept</td>
<td>499.52</td>
<td>3.02</td>
<td>165.37</td>
</tr>
<tr>
<td>Within-School Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student-teacher relations</td>
<td>7.82</td>
<td>1.01</td>
<td>7.73</td>
</tr>
<tr>
<td>Gender</td>
<td>14.29</td>
<td>1.80</td>
<td>7.95</td>
</tr>
<tr>
<td>ESCS</td>
<td>27.17</td>
<td>1.25</td>
<td>21.65</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Variance Component</td>
<td>SD</td>
<td>( \chi^2 )</td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>1012.34</td>
<td>31.81</td>
<td>6277.32</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>5036.83</td>
<td>70.97</td>
<td></td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .78
Within-school variance accounted for by Level 1 predictors = \( \frac{5723.79 - 5036.83}{5723.79} = .12 \)

Table 8 shows the model with students' perceptions of student-teacher relations, gender, and ESCS as level-1 predictors. With students' perceptions of student-teacher relations in the school as a level-1 predictor, there is significant gender gap \( (b = 14.29, p \)
favoring male students and significant ESCS gap \( (b = 27.17, p < .001) \) favoring high ESCS students. As students’ perceptions of student-teacher relations increase by one unit, students’ mathematics literacy increases by 7.82 units \( (p < .001) \). 12% of the variability in students’ mathematics literacy is explained by this model, the same proportion when students’ perceptions of teacher support was the level-1 predictor. Significant school variation exists after controlling for the level-1 variables.

**School-level Correlates of Mathematics Intercept**

The results presented in Tables 9-11 are for models that use contextual student-level variables and school-level correlates to account for between-school variability in mathematics literacy while controlling for gender and ESCS.

In Table 9, school-level correlates are used to explain between-school variability in mathematics literacy controlling for students’ intrinsic motivation, gender, and ESCS. Teacher behaviors have a significant effect \( (b = 4.64, p < .05) \), showing that as principals’ perceptions of teacher-related factors affecting students’ learning become more positive, mathematics intercept increases by 4.64 units. A one-unit increase in school mean students’ perceptions of student-teacher relations increases the mathematics intercept by 15.19 units \( (p > .05) \). As school mean students’ intrinsic motivation increases by one unit, mathematics intercept decreases by 12.56 units \( (b = -12.56, p > .05) \). Altogether 30% of the estimated between-school variance reported in Table 5 \( (\tau_{00} = 1457.42) \) is explained by the modeled school-level correlates.

In Table 10, school-level correlates are used to explain between-school variability in mathematics literacy while controlling for students’ perceptions of teacher support, gender, and ESCS. Consistent with the model shown in Table 9, as principals’
perceptions of teacher-related factors affecting students’ learning increases by one unit, mathematics intercept increases by 4.64 units ($p < .05$). As the school mean students’ perceptions of student-teacher relations increases by one unit, mathematics intercept increases by 14.99 units ($p < .05$). 34% of the estimated between-school variability is explained by the modeled school-level correlates.

Table 9

*Effects of School Variables in Level 2: Results of HLM with Level-1 Student Demographic Controls and Students’ Intrinsic Motivation*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>$df$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>$SE$</td>
<td>$t$</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Intercept</td>
<td>504.31</td>
<td>3.71</td>
<td>135.81</td>
</tr>
<tr>
<td>Teacher Behaviors</td>
<td>4.64</td>
<td>1.96</td>
<td>2.37</td>
</tr>
<tr>
<td>Mean Intrinsic motivation</td>
<td>-12.56</td>
<td>6.82</td>
<td>-1.84</td>
</tr>
<tr>
<td>Mean Student-teacher Relations</td>
<td>15.19</td>
<td>8.65</td>
<td>1.76</td>
</tr>
<tr>
<td>Control Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsic Motivation</td>
<td>18.80</td>
<td>.84</td>
<td>22.43</td>
</tr>
<tr>
<td>Gender</td>
<td>10.28</td>
<td>1.76</td>
<td>5.83</td>
</tr>
<tr>
<td>ESCS</td>
<td>25.58</td>
<td>1.23</td>
<td>20.88</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Variance Component</td>
<td>$SD$</td>
<td>$\chi^2$</td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>1022.72</td>
<td>31.98</td>
<td>6591.65</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>4757.24</td>
<td>68.97</td>
<td></td>
</tr>
</tbody>
</table>

Reliability of school mean mathematics literacy score = .79

Between-school variance in mathematics literacy accounted for by school correlates = \[
\frac{1457.42 - 1022.72}{1457.42} = .30
\]
Table 10

**Effects of School Variables in Level 2: Results of HLM with Level-1 Student Demographic Controls and Students’ Perceptions of Teacher Support**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>SE</td>
<td>t</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Intercept</td>
<td>496.66</td>
<td>3.49</td>
<td>142.22</td>
</tr>
<tr>
<td>Teacher Behaviors</td>
<td>4.64</td>
<td>1.94</td>
<td>2.39</td>
</tr>
<tr>
<td>Mean Student-teacher Relations</td>
<td>14.99</td>
<td>7.13</td>
<td>2.10</td>
</tr>
<tr>
<td>Control Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Support</td>
<td>5.23</td>
<td>1.10</td>
<td>4.74</td>
</tr>
<tr>
<td>Gender</td>
<td>14.12</td>
<td>1.79</td>
<td>7.87</td>
</tr>
<tr>
<td>ESCS</td>
<td>27.41</td>
<td>1.25</td>
<td>21.87</td>
</tr>
<tr>
<td>Random Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Component</td>
<td>956.29</td>
<td>30.92</td>
<td>6096.23</td>
</tr>
</tbody>
</table>

Reliability of school mean mathematics literacy score = .77

Between-school variance in mathematics literacy accounted for by school correlates = \[
\frac{1457.42 - 956.29}{1457.42} = .34
\]

Table 11 shows the results of the model that uses school-level correlates to explain between-school variability in mathematics literacy controlling for students’ perceptions of student-teacher relations in the school. Similar to the previous two models, teacher behaviors are significant predictors, indicating that as principals’ perceptions of teacher-related factors affecting students’ learning increases by one unit, mathematics intercept increases by 5.16 units (p < .05). 32% of the estimated between-school
variability in mathematics literacy is explained by the modeled school-level correlates.

Table 11

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>$df$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>$SE$</td>
<td>$t$</td>
</tr>
<tr>
<td><strong>Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Intercept</td>
<td>499.41</td>
<td>3.03</td>
<td>165.09</td>
</tr>
<tr>
<td>Teacher Behaviors</td>
<td>5.16</td>
<td>1.91</td>
<td>2.70</td>
</tr>
<tr>
<td><strong>Control Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student-teacher Relations</td>
<td>7.79</td>
<td>1.01</td>
<td>7.70</td>
</tr>
<tr>
<td>Gender</td>
<td>14.30</td>
<td>1.80</td>
<td>7.96</td>
</tr>
<tr>
<td>ESCS</td>
<td>27.12</td>
<td>1.26</td>
<td>21.57</td>
</tr>
<tr>
<td><strong>Random Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>989.28</td>
<td>31.45</td>
<td>6232.68</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>5037.65</td>
<td>70.98</td>
<td></td>
</tr>
</tbody>
</table>

Reliability of school mean mathematics literacy score = .78

Between-school variance in mathematics literacy accounted for by school correlates = $\frac{1457.42 - 989.28}{1457.42} = .32$

*Random Intercept and School Slope Models*

*Intrinsic motivation slope.* Because the schools were found to have statistically significant intrinsic motivation slopes, further analyses were conducted to examine if the school-level correlates could explain the variability in the school slopes when gender and ESCS were controlled. Table 12 shows that there is no statistically significant school-level correlate that could explain the variance in the intrinsic motivation slopes.
Table 12

*Effects of School Variables in Level 2 Intrinsic Motivation Slopes: Results of HLM with Level-1 Student Demographic Controls*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>SE</td>
<td>t</td>
</tr>
<tr>
<td><strong>Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept for Intrinsic Motivation Slope Teacher Morale</td>
<td>19.55</td>
<td>1.02</td>
<td>19.11</td>
</tr>
<tr>
<td>Mean Student-teacher relations</td>
<td>-5.41</td>
<td>2.79</td>
<td>-1.94</td>
</tr>
<tr>
<td><strong>Random Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>1050.90</td>
<td>32.42</td>
<td>6278.64</td>
</tr>
<tr>
<td>Intrinsic Motivation Slopes</td>
<td>39.92</td>
<td>6.32</td>
<td>1355.48</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>4723.69</td>
<td>68.73</td>
<td></td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .78  
Reliability estimate of intrinsic motivation slope = .15  
Variance accounted for in intrinsic motivation slopes = \( \frac{40.64 - 39.92}{40.64} = .02 \)

The result, however, shows that as school mean students’ perceptions of student-teacher relations increase, the effect of individual intrinsic motivation become less (\( \gamma_{12} = -5.41, p > .05 \)). The result also shows that individual intrinsic motivation has a greater effect on mathematics literacy for schools with higher teacher morale (\( \gamma_{11} = 1.54, p > .05 \)). The initial variance estimates for school intrinsic motivation slope without any school-level variable is 40.64 (p < .001). The intercept for the intrinsic motivation slope is 19.55 (p < .001). There is still significant school variance in the intrinsic motivation slopes after conditioning for school-level correlates because only there is a 2% reduction
in unaccounted variability.

_Teacher support slope._ Table 13 shows the results of the model that uses school-level correlates to explain school variability in the teacher support slope controlling for student demographic variables. The intercept for teacher support is 6.02 (\(p < .05\)), a higher value than the initial gap estimate of 5.15 in Table 7.

Table 13

<table>
<thead>
<tr>
<th>Effects of School Variables in Level 2 Teacher Support Slopes: Results of HLM with Level-1 Student Demographic Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Fixed Effects</td>
</tr>
<tr>
<td>Intercept for Teacher Support Slope</td>
</tr>
<tr>
<td>School Autonomy</td>
</tr>
<tr>
<td>Mean Student-teacher Relations</td>
</tr>
<tr>
<td>Random Effects</td>
</tr>
<tr>
<td>School-Level Effect</td>
</tr>
<tr>
<td>Teacher Support Slopes</td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .75
Reliability estimate of teacher support slope = .24
Variance accounted for in teacher support slopes = \(\frac{100.79 - 92.60}{100.79} = .08\)

The result shows that individual perceptions of teacher support have larger effect on mathematics literacy in more autonomy schools. With increase school autonomy, students with one unit higher in perceptions of teacher support score significantly higher...
by 2.33 units ($p < .05$), over and above the initial gap estimate of 6.02 units. Individual perceptions of teacher support have a smaller effect on mathematics literacy in schools with higher mean student-teacher relations ($\gamma_{12} = -5.80$, $p < .05$). The modeled variables dropped the initial variance estimate of 100.79 to 92.60, reducing 8% of the variability evidenced in teacher support slope.

Table 14

*Effects of School Variables in Level 2 Student-teacher Relations Slopes: Results of HLM with Level-1 Student Demographic Controls*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters Estimate</th>
<th>$df$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>$SE$</td>
<td>$t$</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept for Student-teacher Relations</td>
<td>7.72</td>
<td>1.03</td>
<td>7.49</td>
</tr>
<tr>
<td>Relations Slope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Intrinsic Motivation</td>
<td>-7.75</td>
<td>3.45</td>
<td>-2.25</td>
</tr>
<tr>
<td>Random Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School-Level Effect</td>
<td>1022.30</td>
<td>31.97</td>
<td>5567.19</td>
</tr>
<tr>
<td>Student-teacher Relations Slopess</td>
<td>84.71</td>
<td>9.20</td>
<td>1392.89</td>
</tr>
<tr>
<td>Student-Level Effect</td>
<td>4973.49</td>
<td>70.52</td>
<td></td>
</tr>
</tbody>
</table>

Reliability estimate of school mean mathematics literacy score = .75
Reliability estimate of teacher support slope = .21
Variance accounted for in student-teacher relations slopes = $\frac{90.01 - 84.71}{90.01} = .06$

*Student-teacher relations slope.* Table 14 shows the results of the model that includes school-level correlates to explain school variability in student-teacher relations slope. The intercept for student-teacher relations is 7.72 units ($p < .001$). Individual perceptions of student-teacher relations have a lower effect on mathematics literacy in
schools with higher mean intrinsic motivation ($\gamma_{11} = -7.75, p < .001$). The initial school variance for the student-teacher relations slope is 90.01 ($p < .001$). The variance estimate in the model with school correlates drops to 84.71, reducing only 6% of the variability evidenced in school student-teacher relations slopes.

**Summary of Chapter Four**

The results of the HLM models were discussed in this chapter. Students’ intrinsic motivation, perceptions of teacher support in the mathematics classrooms, and perceptions of student-teacher relations in the school are significant positive predictors of mathematic literacy among 15-year-olds. Principals’ perceptions of teacher-related factors affecting students’ learning are statistically significant in all three models used to explain variability in mathematics literacy between-schools. Models used to explain variability in school slopes of intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations were also discussed.
Chapter Five: Discussion

Before any discussion on the results begins, it is emphasized again that the results discussed in this section have taken students’ gender and SES into consideration. That is, both student demographic variables were controlled in the HLM models. As the focus of this study is on students’ intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations, results associated with gender and SES will not be discussed in this chapter.

To answer the first research question, the total variance in mathematics literacy was partitioned into within- and between-school component. 20% of the total variance in students’ mathematics literacy is attributed to schools and there is significant variation in school means. Students’ intrinsic motivation, perceptions of teacher support in the mathematics classroom, and perceptions of student-teacher relations in the school are significant positive predictors of 15-year-old mathematics literacy. At the student-level, a one-unit increase in students’ intrinsic motivation increases mathematics literacy by 18.66 units, which is almost .21 standard deviation. This finding is consistent with prior non-experimental research that shows intrinsic motivation has a positive association with academic achievement (e.g. Fortier et al., 1995; Gottfried, 1985; Lepper, et al., 2005; Vallerand et al., 1993). As students’ perceptions of teacher support in the mathematics classrooms and students’ perceptions of student-teacher relations in the school increase by one unit, mathematics literacy increases by 5.41 and 7.82 units respectively. This result echoes the findings of previous research reviewed in the present study. Intrinsic motivation, teacher support and student-teacher relations explain between 12% to 17% of
the student-level variance in mathematics literacy, with intrinsic motivation accounting for the most variance.

School-level variables were entered into the level-2 equations to account for between-school variability in mathematics literacy while controlling for contextual student-level and demographic variables. The models explain between 30% to 34% of the estimated between-school variance. School variables such as teacher morale and commitment, school autonomy, teachers' participation, and frequency of assessment are statistically nonsignificant in all three models, and significant school variation persists after the variables have been added. This is inconsistent with previous research that shows these school variables facilitate students' academic achievement (e.g. Kika et al., 1992; Miller, 1981; Smylie et al., 1996; Stedman, 1985). Researchers, however, have not been successful in providing a clear definition of variables contributing to a positive school environment (Anderson, 1982). Further, critics of the school effectiveness research have suggested that the influence of effective schools on academic achievement is minimal (Stedman). Stevens and White (1987) did not find any significant association between teachers' morale and students' academic achievement. Kushman (1992) did not find any statistically significant association between staff commitment and students' achievement. In a series of studies, Beaulieu and colleagues (Beaulieu & Frost, 1989; Beaulieu & Utech, 1987; Beaulieu & Zar, 1986) did not find any significant utility of examination frequency on students' achievement.

Principals' perceptions of teacher-related behaviors that affect students' learning are statistically significant in all three models to estimate between-school variability in mathematics literacy. As principals' evaluation of teacher behaviors affecting students'
learning become more positive, the mathematics intercept increases. Mean perceptions of the student-teacher relations in the school also have a significant statistical positive effect on mathematics intercept with teacher support as the contextual student-level variable. As student-teacher relations increases by one unit, mathematics intercept increases by 14.99 units. In the model with intrinsic motivation as contextual student-level variable, as mean perceptions of student-teacher relations increases by one unit, mathematics intercept increases by 15.19 units. This result, however, is statistically nonsignificant. All in all, these results accentuate the important role that teachers play in students' academic achievement. Although statistically nonsignificant, the main effects model with intrinsic motivation and student demographic variables at level 1 (as shown in Table 9) shows that when school mean intrinsic motivation increases, mathematics intercept decreases. This result is unexpected and inconsistent with previous research and more research is needed before any conclusion can be made.

In order to identify school-level variables that could account for the variability in school slopes of students' intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations, the slope parameters were allowed to vary while controlling for gender and SES. No statistically significant school-level variable is found for the intrinsic motivation slope. The results, however, show that higher mean student-teacher relations is associated with smaller differences in mathematics literacy between students with differential intrinsic motivation whereas higher teacher morale and commitment is associated with larger differences. Although both variables are statistically nonsignificant, there may be considerable practical significance in these results. The results imply that there is less inequality among students with different
intrinsic motivation in schools where students feel more positive about their relationship with schoolteachers on average. Students with lower intrinsic motivation is likely to do better in schools with more positive student-teacher relations. As students have different levels of intrinsic motivation, teachers should try to build good relations with their students so that students with low intrinsic motivation can perform better academically.

For the teacher support slope, two school-level variables are statistically significant. More school autonomy is associated with bigger mathematics literacy differences between students with different perceptions of teacher support while higher mean student-teacher relations narrow the differences. This is means that there is more equity in mathematics literacy among students with different levels of perceptions of teacher support in schools with more positive mean student-teacher relations. School average intrinsic motivation reduces the individual effect of student-teacher relations. This implies that there is more equity among students in schools with higher mean intrinsic motivation. That is, students with less positive perceptions of student-teacher relations perform better in schools with higher average students’ intrinsic motivation than schools with lower average intrinsic motivation.

In summary, the results of the present study indicate the significant positive impact of intrinsic motivation, teacher support in the mathematics classrooms, and student-teacher relations in the school on students’ mathematics literacy. Teacher behaviors that affect students’ learning also significantly influence school average mathematics literacy. Further, schools with higher mean student-teacher relations and higher mean intrinsic motivation are more equitable for students.
Limitations

The results of the present study must be interpreted with caution for several reasons. First, using a large international database such as PISA 2003 for research has its advantages and disadvantages. The sample size is large; therefore, there is sufficient power to detect any associations that may exist in the population. Further, the sampling nature of the survey means that the results can be generalized to a diverse national student population. On the other hand, as the purpose of the survey is to allow a wide variety of researchers to make use of the data to answer different research questions, the questionnaire items may be too general. Second, the inability of the present study to find any significant school effectiveness variables may be more of a problem with the methodology. In a review of the school effectiveness research, Vincenzi and Ayrer (1985) noted that most variables that described school effectiveness are variables that are arduous to quantify. These variables are better measured by school visitations, and interviews with teachers, students, and principals. Although most of the school effectiveness variables are statistically nonsignificant in the present study, the role schools play in students' learning cannot be underestimated. Perhaps, some other school effectiveness variables that are not measured in this study such as principal leadership and parental involvement have greater influence on the between-school variability in mathematics literacy.

Third, secondary data analysis of large national dataset does not allow causal interpretation of the school effects. That is, the HLM analyses on these students are correlational and nonexperimental. Although results in the present study have sometimes been described as effects, it could not provide empirical evidence of causal direction.
Finally, the school-level variables were derived from the questionnaires completed by school principals, and there are several limitations that should be taken into account in the interpretation of the data. First, it is difficult to generalize from a single source of information for each school because students’ academic achievement is a multi-dimensional construct and is dependable on many factors. Second, principals may not be the best source of information for information related to teachers such as teachers’ morale and commitment. Principals may potentially overestimate their staff morale so that their schools ‘look good’ in the survey. Third, PISA is measuring the cumulative effect of about ten years of school and the school variables examined in this study may not be predictive of the school environment that shaped the experiences of the 15-year-olds earlier in their schooling years (OECD, 2004). It is impossible to model the convolution of an educational system with just a few school variables. If the current school environment of the students differ from that in their early school career, the school data collected by PISA become an inaccurate estimate for the cumulative school environment of students and their effects on mathematics literacy is likely to be attenuated.

*Suggestions for Future Research*

In this study, only two student demographics variables were controlled. Future researchers may want to examine if they get different results when other student demographics variables such as ethnicity and home language are controlled at the student-level analysis. Next, teachers’ and students’ perceptions of the staff morale, teachers’ commitment, teacher behaviors, and school variables contributing to students’ learning may demonstrate better reliability and validity than principals’ perceptions of school environment. Future research should, therefore, consider analyzing data collected
from teachers and students. In addition, data collected from school observations and
terviews may potentially capture more attributes of effective schools than large-scale
survey.

Direct and moderating effects of other school variables, such as methods of
classroom instructions and student autonomy in the classrooms should be investigated in
future research to better inform school policies and practices. Future research could also
collect data on classroom variables to investigate between-classroom variability. Three-
level HLM models can be used to examine student-level, classroom-level, and school-
level effects of 15-year-old mathematics literacy. This would provide teachers with more
information on effective classroom practices, and help to explain more variability in
mathematics literacy.

The results of this study show that principals’ perceptions of teacher behaviors
affecting students’ learning are positively associated with higher school mean
mathematics literacy. Further research could examine the specific teacher behaviors that
influence students’ learning outcomes, perceptions of teacher support and student-teacher
relations, and how these perceptions are formed. An unexpected finding in this study is
that as school mean intrinsic motivation increases, school mean mathematics literacy
decrease, controlling for student’s gender, SES and intrinsic motivation. This finding is
inconsistent with most prior research. Although the correlation between students’
intrinsic motivation and plausible values of mathematics is moderate at .25 in this study,
more research is warranted.

Future research could also examine the effects of school climate on students’
intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher
relations by using these variables as outcome variables and school variables in level-2
equations, while controlling for student demographic variables. This could better inform
educators on the school practices and policies that influence such important variables in
students' academic achievement. Future research could also build HLM models using
data from Asian countries such as Hong Kong and Korea to make cross-national
comparisons. This would enable Canadian schools to learn from other countries some of
the effective strategies for improving mathematics literacy.

Implications for Educators

The major implication of this study for educators is that teachers play an
important role in students' learning outcome in addition to students' intrinsic motivation.
Students who think positively about their teachers in the schools in general are more
likely to do well in academic achievement. According to self-determination theory,
securing a strong relationships with significant others in one's social circle will likely
motivate students to learn (Deci & Ryan, 1985). In schools, teachers play an influential
role in students' learning outcomes (Ryan et al., 1994). Students who feel more related to
their teachers, therefore, will be more motivated to learn which in turn improves their
academic achievement. A supportive and caring school environment where teachers and
school leaders demonstrate the belief that all students can learn is conducive to students'
academic achievement (Johnson, Schwartz, Livingston, & Slate, 2000).

Teachers should show that they are interested in students' well being, not just
academically but also psychologically. In addition, they should give a listening ear to
what students have to say, and provide extra help and advice when necessary. Students
are more likely to perform better in schools where teachers have high academic
expectations (Edmonds, 1979; Stedman, 1987). Teacher should encourage students to
achieve their full potential, and try to meet students’ individual needs. In addition to the
general school climate, teachers should provide a favorable environment for learning in
the mathematics classroom by giving students all the support they need. Students should
be allowed opportunities to express opinions in the classrooms. Students in classrooms
where teachers are enthusiastic about their learning and continue teaching until they
understand are more likely to feel supported. Teachers should also be available to provide
extra help when students need it.

Given the apparent value of intrinsic motivation in education, educators should try
different ways to enhance students’ intrinsic motivation. Research has shown that
providing students’ with meaningful and practical reasons for learning can increase
students’ intrinsic motivation (Benware & Deci, 1984). Students’ intrinsic motivation
increase when they have more perceived autonomy over a task (Eisenberger, Rhoades, &
Cameron, 1999). Choices of learning contexts (Cordova & Lepper, 1996) and interesting
instructional materials (Parker & Lepper, 1992) also significantly increase students’
intrinsic motivation for learning. “Learning would be exceedingly laborious, not to
mention hazardous, if people had to rely solely on the effects of their own actions to
inform them what to do” (Bandura, 1977, p. 22). Most behaviors, therefore, are learned
by watching other people. Students are more intrinsically motivated to change their
behaviors when they see good adult role models (Swanson, 1995). In school, teachers can
model good behaviors and learning habits, while at the same time get students to take
over the learning themselves. Contextualization and personalization of the content can
increase students’ intrinsic motivation to learn (Cordova & Lepper; Covington, 1999).
Teachers should try to link the curriculum to real world applications and bring in students' personal experiences in classroom discussion. Students in classrooms where learning goals are emphasized are more likely to engage in challenging learning opportunities and respond positively to failure (Elliot & Dweck, 1988). Teachers can acquaint students with goal setting strategies and provide some guidance initially. Ultimately, students should be able to set their own goals based on their ability.

Conclusion

The results of the present study show the importance of teacher behaviors on school mean mathematics literacy. In addition, students' intrinsic motivation, perceptions of teacher support in the mathematics classrooms, and perceptions of student-teacher relations in the schools are significant positive predictors of 15-year-old mathematics literacy. Schools with more positive students' perceptions of student-teacher relations in general are more equitable for students with different intrinsic motivation and different perceptions of teacher support in the mathematics classrooms. Schools with higher average students' intrinsic motivation are more equitable for students with different perceptions of student-teacher relations. Teachers should try to build positive relationships with students and try to meet students' needs so as to increase students' academic achievement. Facilitating students' intrinsic motivation can also improve their performance. Researchers should continue to monitor academic achievement gaps, and identify other school correlates of achievement from the PISA survey to better inform policy makers.
References


*Psychological Review, 66*, 297-333.


APPENDIX A

Items Descriptors and Reliabilities
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>$\alpha$ if Item Deleted</th>
</tr>
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</table>
| **Intrinsic Motivation in Mathematics**  
$\alpha = .91$ |                                                            |                          |
| ST30Q01    | I enjoy reading about Maths.                                | .90                      |
| ST30Q03    | I look forward to my Mathematics lessons.                  | .88                      |
| ST30Q04    | I do Mathematics because I enjoy it.                        | .86                      |
| ST30Q06    | I am interested in the things I learn in Maths              | .88                      |
| **Teacher Support**  
$\alpha = .86$ |                                                            |                          |
| ST38Q01    | The teacher shows an interest in every student’s learning.  | .83                      |
| ST38Q03    | The teacher gives extra help when students need it.         | .83                      |
| ST38Q05    | The teacher helps students with their learning.             | .82                      |
| ST38Q07    | The teacher continues teaching until the students understands.| .82                      |
| ST38Q10    | The teacher gives students an opportunity to express opinions.| .85                      |
| **Student-teacher Relations**  
$\alpha = .82$ |                                                            |                          |
| ST26Q01    | Students get along well with most teachers.                 | .81                      |
| ST26Q02    | Most teachers are interested in students’ well-being.       | .77                      |
| ST26Q03    | Most of my teachers really listen to what I have to say.    | .77                      |
| ST26Q04    | If I need extra help, I will receive it from my teachers.   | .80                      |
| ST26Q05    | Most of my teachers treat me fairly.                        | .78                      |
| **School Principals Perceptions of Teacher Morale and Commitment**  
$\alpha = .83$ |                                                            |                          |
<p>| SC24Q01    | The morale of teachers in this school is high.              | .79                      |
| SC24Q02    | Teachers work with enthusiasm.                              | .75                      |
| SC24Q03    | Teachers take pride in this school.                         | .76                      |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC24Q04</td>
<td>Teachers value academic achievement.</td>
<td>.85</td>
</tr>
<tr>
<td>SC25Q01</td>
<td>Teachers’ low expectations of students?</td>
<td>.80</td>
</tr>
<tr>
<td>SC25Q03</td>
<td>Poor student-teacher relations?</td>
<td>.78</td>
</tr>
<tr>
<td>SC25Q05</td>
<td>Teachers not meeting individual students’ needs?</td>
<td>.78</td>
</tr>
<tr>
<td>SC25Q06</td>
<td>Teacher absenteeism?</td>
<td>.80</td>
</tr>
<tr>
<td>SC25Q09</td>
<td>Staff resisting change?</td>
<td>.79</td>
</tr>
<tr>
<td>SC25Q11</td>
<td>Teachers being too strict with students?</td>
<td>.79</td>
</tr>
<tr>
<td>SC25Q13</td>
<td>Students not being encouraged to achieve their full potential?</td>
<td>.79</td>
</tr>
</tbody>
</table>

*School Principals’ Perceptions of Teacher-related Factors affecting School Climate

$\alpha = .82$

A four-point scale with the response “strongly agree”, “agree”, “disagree”, and “strongly disagree” was used. All items were inverted for IRT scaling and positive weighted likelihood estimate scores indicate higher level of the index.

* Categories for IRT scaling were 0 = “Disagree/Strongly disagree”, 1 = “Agree”, 2 = “Strongly agree”.
APPENDIX B

Description of Student-Level and School-Level Variables
Outcome Variable

Plausible Values in Mathematics

There are five plausible values of the mathematics literacy scores in PISA 2003 dataset. These five plausible values are used as the outcome variable. The overall sample design weights provided by PISA are also used in the HLM analysis.

Student-Level Variables

Intrinsic Motivation in Mathematics

According to SDT, intrinsic motivated behaviors are prototypes of autonomy (Deci & Ryan, 1985). They are performed out of personal interest and enjoyment. Because intrinsic motivation involves interest and enjoyment, students’ intrinsic motivation can be inferred from their interest and enjoyment of the subject. The PISA 2003 index of intrinsic motivation in mathematics was determined from students’ self-reported enjoyment and interests in mathematics (see Appendix A). Positive values indicate higher level of intrinsic motivation in mathematics.

Teacher Support

The PISA index of teacher support was determined from students’ reports on the support they received from their mathematics teachers (see Appendix A). Positive values represent perceptions of higher teacher support.

Student-teacher Relations

The PISA 2003 index of student-teacher relations was determined from students’ report of their relationships with teachers at their schools (see Appendix A). Positive values represent perception of better student-teacher relations at school.
Student Demographics Control Variables

Gender

Gender was coded with 1 being female and 2 being male.

Economic, Social and Cultural Status (ESCS)

The ESCS index was computed from highest level of parental education (in number of years of education), parental occupation, and number of home possessions. This index is used as an indicator of students’ SES. The index has a reliability of .62 for Canada. Positive values indicate higher level of SES.

School-level Variables

School Autonomy and Teacher Participation

School principals reported whether teachers, heads of departments, the school principal, an appointed or elected committee or education authorities at a higher level had the main responsibility for: (1) selecting teachers for hire; (2) firing teachers; (3) establishing teachers’ starting salaries; (4) determining teachers’ salary increases; (5) formulating school budgets; (6) deciding on budget allocations within the school; (7) establishing student disciplinary policies; (8) establishing student assessment policies; (9) approving students for admittance to school; (10) choosing which textbooks to use; (11) determining course content; and (12) deciding which courses are offered. Responses that indicate the decision-making are not a school responsibility was coded 0 and the rest was coded 1.

The 12 items were IRT scaled to construct the indicator of school autonomy ($\alpha = .76$), and positive scores indicate higher school autonomy in decision-making. Responses indicating that teachers have a responsibility were recoded 1 and other responses were
re-coded 0. The 12 items were IRT scaled to construct the indicator of teacher participation ($\alpha = .59$), and positive scores indicate higher teacher participation in decision-making. OECD (2004).

*Use of Assessments*

According to OECD (2004), the PISA 2003 indicator for use of assessment was derived by asking school principals to rate the frequency of which these assessment modes were used to evaluate the 15-year-old students at school: (1) standardized tests; (2) teacher-developed tests; (3) teachers’ judgmental ratings; (4) student portfolios; and (5) student assignments/projects/homework. All five items were recoded to represent the regularity of evaluation per year (“never” = 0, “1-2 times a year” = 1.5, “3-5 times a year” = 4, “monthly” = 8, “more than once a month” = 12). The sum of all these recoded items was divided into three categories to determine the indicator (less than 20 times a year, 20-39 times a year, more than 40 times a year).

*Teacher Morale and Commitment*

The PISA 2003 index of teacher morale and commitment was determined from principals’ perceptions of the teacher morale and commitment at their schools (see Appendix A). Positive values present principals’ perceptions of higher teacher morale and commitment.

*Teacher-related Factors Affecting School Climate*

The indicator of teacher-related factors affecting school climate was determined from school principals’ reports of potential teachers’ behaviors undermining students’ learning at school (see Appendix A). Positive values represent positive assessment of this domain.
Mean Intrinsic Motivation, Mean Teacher Support and Mean Student-teacher Relations

Data for students’ intrinsic motivation, perceptions of teacher support, and perceptions of student-teacher relations at the student-level was aggregated to provide measurement of school means for these variables. Positive values represent higher evaluation of these domains.
APPENDIX C

Histograms of All Student-level and School-level Variables
Figure C1. Histogram of plausible value in mathematics 1 with normal curve.

Figure C2. Histogram of plausible value in mathematics 2 with normal curve.
Figure C3. Histogram of plausible value in math 3 with normal curve.

Figure C4. Histogram of plausible value in math 4 with normal curve.
Figure C5. Histogram of plausible value in math 5 with normal curve.

Figure C6. Histogram of intrinsic motivation in mathematics index with normal curve.
Figure C7. Histogram of teacher support in mathematics index with normal curve.

Figure C8. Histogram of student teacher relations index with normal curve.
**Histogram C9.** Histogram of gender with normal curve.

**Histogram C10.** Histogram of the index for economic, social and cultural status with normal curve.
Histogram C11. Histogram of school mean intrinsic motivation for mathematics with normal curve.

Histogram C12. Histogram of school mean teacher support with normal curve.
Histogram C13. Histogram of school mean student-teacher relations with normal curve.

Histogram C14. Histogram of school autonomy with normal curve.
Histogram C15. Histogram of teacher participation with normal curve.

Histogram C16. Histogram of estimated use of assessment per year with normal curve.
Histogram C17. Histogram of principals’ perceptions of teacher morale and commitment with normal curve.