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Believe and Achieve: An Examination of Predictors of Mathematical Achievement in Secondary Mathematics Students

Malia L. Hite

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BELIEVE AND ACHIEVE: AN EXAMINATION OF PREDICTORS OF MATHEMATICAL
ACHIEVEMENT IN SECONDARY MATHEMATICS STUDENTS

by

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Presented to Educational Foundations and Leadership Department

and the School of Education, George Fox University

In partial fulfillment of the requirements for the degree of

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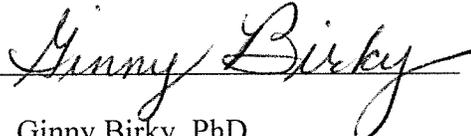
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“BELIEVE AND ACHIEVE: AN EXAMINATION OF PREDICTORS OF MATHEMATICAL ACHIEVEMENT IN SECONDARY MATHEMATICS STUDENTS,” a Doctoral research project prepared by MALIA HITE in partial fulfillment of the requirements for the Doctor of Education degree in the Educational Foundations and Leadership Department.

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ABSTRACT

This research addressed the following research question: which specific variable has the greatest predictive power of mathematical literacy and problem solving competency while controlling for socioeconomic status (SES)? The variables that were studied were categorized as follows: demographic and personal history variables, attitudinal variables, behavioral variables, and school organization and structure variables. Much of the existing literature cites SES as the most powerful predictor of math achievement. Using multiple linear regression modeling, this study found that many variables studied were determined to be significant predictors of mathematical literacy and/or problem solving competency while controlling for SES. Every category of variables had at least one statistically significant predictor: demographic and personal history variables, attitudinal variables, behavioral variables, and school organization and structure variables. The attitudinal variables had the most significant predictors of math literacy and problem solving competency and categorically proved to be the most powerful.

The statistically significant predictors were categorized as major predictors and minor predictors of mathematical achievement. The variables with a significant but less powerful effect on math achievement are designated as minor predictors; these minor predictors include: gender, immigration status, student attribution to failure, perceived math support, number of minutes in math class, math education of teachers, and class size. The variables with the greatest significant and powerful effect on math achievement are designated as major predictors; these major predictors include: socioeconomic status, math self-efficacy, math anxiety, and math teacher certification. The associated predictive powers of the major predictors were greater than the predictive power of SES, the control variable. Even when not controlling for SES, the

attitudes of students' self-efficacy was the most powerful predictor of math literacy and problem solving competency. These results hold substantial implications in the areas of math literacy and problem solving competency for practitioners of math education and academic researchers. This study may be used to inform pedagogical practices, districts, policy makers, and future areas of research.

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There are simply no adequate words to express my gratitude to all those who helped on this fantastic and amazing journey. But since I rarely am at a complete loss of words, I will endeavor to author appropriately.

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He knew there'd be moments when no earthly words could take away your sorrow

And no human eyes could see what you're going through

When you've taken your last step and done all that you can do

He will lift your heavy load and carry you

- Hilary Weeks

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CHAPTER 1

INTRODUCTION

Since the 1966 Coleman Report on education in the United States there has been an overwhelming focus on the effectiveness and perceptions of the US public educational system (Coleman, 1966; Marzano, 2003). The public perception was that the educational system was severely lacking and not globally competitive (Gardner, Larsen, & Baker, 1983; Lunenburg & Irby, 1999; Marzano, 2003). The 1987 report by the US Department of Education, *A Nation at Risk: The Imperative for Educational Reform* has only fueled the scrutiny and is considered by some as proof that the irreversible erosion of the educational system and culture of mediocrity was producing lasting negative effects on the nation (Gardner et al., 1983; Marzano, 2003). More recently with the *No Child Left Behind Act*, the state of public education was deemed a national crisis (Behind, 2002; Bush, 2001).

There has been much discussion, exhortation, and legislation in the field of education reform with the singular goal to improve education for all students. Many studies of student achievement and its determinants have cited socioeconomic status, student background, school effectiveness, and teacher preparations as key factors (Aaronson, Barrow, & Sander, 2007; Astone & McLanahan, 1991; Battle, 2002; Bembenuddy, 2005; Black & Wiliam, 2010; Campbell & Mandel, 1990; Christenson, Rounds, & Gorney, 1992; Datnow, 2006; Epstein, 1984; Flanders, 1960; Gardner et al., 1983; Greenwald, Hedges, & Laine, 1996; Halle, Kurtz-Costes, & Mahoney, 1997; Ham, 2004; Hammond, 1979; Hoffer, 1995; Hrabowski III, 2003; Lee & Ready, 2007; Marzano, 2003; National Council of Teachers of Mathematics, 1989). In an effort to mitigate the negative effects of these factors, the National Council of Teachers of Mathematics

(1989) developed five goals for students, 40 new curriculum standards, and a concrete philosophy of mathematics education in order to improve mathematical literacy and problem solving skills. Many changes in curriculum, instruction, and assessment have been implemented since the 1989 National Council of Teachers of Mathematics (NCTM) report.

One such change that has radically affected the educational arena in the United States is the Common Core State Standards (National Governors Association, 2010). Citing more than a decade of research, the Common Core State Standards (CCSS) attempt to address the inferior academic performance of students in the United States as compared to those in other countries by articulating a more focused and coherent math curriculum. Most states, including the District of Columbia, have individually adopted the CCSS as a springboard to more carefully defined curriculum and greater student achievement (Porter, McMaken, Hwang, & Yang, 2011; Wu, 2014). The CCSS for mathematical practice indicate processes and proficiencies that are essential to increase mathematical understanding. The proficiencies are the specific math content that are to be addressed in associated math strands of curriculum. The processes refer to the NCTM standards of problem solving, reasoning and proof, communication, representation, and connections; these are the facets of mathematical literacy (National Governors Association, 2010).

With a national focus on educational reform, specifically the focus on mathematical literacy, current research regarding the determinants of mathematical literacy and problem solving competency is necessary. The continually changing cultures and experiences of students in the United States contribute to the need for further investigation. The purpose of this study is to investigate the predictors, including demographic, personal history, attitudinal, and behavioral factors, of mathematical literacy and problem solving competency.

Statement of the Problem

The researcher is a secondary mathematics teacher that has spent considerable time working with students who struggle in the area of math achievement. For each of the past 14 years, the researcher has taught at least one course designed to provide additional math instruction outside the regular math course sequence. Examples of these courses include a math support class taught in Spanish, basic math skills course, a math lab class taught concurrently with Algebra 1, and a course designed to assist seniors to meet the Oregon essential skills in mathematics, a graduation requirement. In addition to student difficulties found in regular math courses, the researcher has seen significant problems of English Language Learners, special education students, immigrant students, and other student subgroups in critical thinking and problem solving skills. In spite of sheltered teaching practices and pedagogy, additional support is needed to help all students find academic success in the area of mathematics; this research can inform pedagogical practice in a way that will maximize the efforts of educators.

The purpose of this study is to explore factors associated with mathematical literacy and problem solving in secondary education using existing data derived from the 2012 Program for International Student Assessment (PISA), an international survey of 15 year old students and their achievement, administered and published by the Organisation for Economic Co-operation and Development (OECD). PISA focuses on the process of solving mathematics rather than the content knowledge; the data are more indicative of mathematical literacy and problem solving because of this emphasis. Specifically, this research will examine the predictive power of a number of demographic, personal history, attitudinal, and behavioral variables on mathematics literacy and problem solving competency as measured by the PISA, while controlling for socioeconomic status (SES). The findings of this study will give insight to the impact of

demographic, personal history, attitudinal, and behavioral factors on literacy and problem solving in mathematics.

Research Questions

This investigation will explore two primary research questions and nine secondary questions.

Primary Research Questions

1. Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of mathematics literacy while controlling for SES?
2. Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of problem solving competency while controlling for SES?

Secondary Research Questions

3. Which specific demographic and personal history variable has the greatest predictive power of mathematics literacy while controlling for SES?
4. Which specific attitudinal variable has the greatest predictive power of mathematics literacy while controlling for SES?
5. Which specific behavioral variable has the greatest predictive power of mathematics literacy while controlling for SES?
6. Which specific school organization and structure variable has the greatest predictive power of mathematics literacy while controlling for SES?
7. Which specific demographic and personal history variable has the greatest predictive power of problem solving competency while controlling for SES?

8. Which specific attitudinal variable has the greatest predictive power of problem solving competency while controlling for SES?
9. Which specific behavioral variable has the greatest predictive power of problem solving competency while controlling for SES?
10. Which specific school organization and structure variable has the greatest predictive power of problem solving competency while controlling for SES?
11. What is the nature of relationship between the demographic, personal history, attitudinal, behavioral, and school organization and structure variables?

Definition of Terms

Mathematical literacy:

An individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens (OECD, 2013).

Mathematical processes:

These are defined in terms of three categories (*formulating situations mathematically; employing mathematical concepts, facts, procedures and reasoning; and interpreting, applying and evaluating mathematical outcomes* – referred to in abbreviated form as *formulate, employ and interpret*) and describe what individuals do to connect the context of a problem with the mathematics, thus solving the problem. These three processes each draw on the seven fundamental mathematical capabilities (*communication;*

mathematizing; representation; reasoning and argument; devising strategies for solving problems; using symbolic, formal and technical language and operations; using mathematical tools) which in turn draw on the problem solver's detailed mathematical knowledge about individual topics (OECD, 2013).

Parental structure/family structure:

The parental structure of a student refers to the parent(s) that usually live at home with the student: single mother, single father, or intact nuclear family. Family structure, inclusive of all who live in the home with the student, may include extended family members such as grandparents, aunts, uncles or none of the aforementioned.

Problem solving:

Mayer (1990) defines problem solving as cognitive processing directed at transforming a given situation into a goal situation when no obvious method of solution is available. This definition is widely accepted in the problem-solving community (Klieme, 2004; Mayer & Wittrock, 2006; OECD, 2013; Reeffer, Sabal, & Blech, 2006).

Problem-solving competency:

An individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen (OECD, 2013).

Socioeconomic status (SES):

Socioeconomic status (SES) includes both economic and sociological factors. Typically, SES measures take into account a person's work experience, economic and social

position relative to the entire population. Household income, education level, race, and occupation contribute to a family's SES.

Limitations and Delimitations

When using existing data sets, there are many inherent limitations; such is the case in this study. The 2012 PISA data, while extensive, are not entirely inclusive of all demographic, attitudinal, or behavioral factors. For the purposes of this study, the limitations include the ability to analyze only the data that were collected. Additionally, the data were analyzed with respect to the way they were coded. Simply, the researcher had no control of what data were collected. The 2012 PISA is an international assessment and item choices were coded in such a way to be consistent and valid in all participating countries. Specifically, the socioeconomic status of participants was reported using categorical coding. Additionally, it was necessary that the researcher use the definitions of mathematical literacy and problem solving competency as defined by PISA.

The quantity of data available in the 2012 PISA is immense; around 510,000 students participated in 65 countries. In this study, the researcher investigated only the data that represents students from the United States; this is the most restrictive delimitation in the study. In the United States, slightly more than 6,000 students from 161 schools participated in the assessment. In addition to analyzing only United States data, the researcher chose to focus on a limited number of variables and data that address the research questions; this delimitation makes the study feasible and more meaningful. Specifically, the researcher chose to study variables that, in addition to basic demographic variables, can be impacted and mitigated by educational practices and pedagogy. The former variables included personal history, attitudinal, and behavioral factors on mathematical literacy and problem solving competency.

Summary

Given the climate, attitudes, and perceptions regarding public education in the United States, information regarding the determinants of mathematical achievement is desirable. The purpose of this study was to explore some factors associated with mathematical literacy and problem solving in order to establish which determinants had the greatest predictive power. Specifically, using existing data derived from the 2012 Program for International Student Assessment (PISA), this research examined the predictive power of a number of demographic, personal history, attitudinal, and behavioral variables on mathematics literacy and problem solving competency as measured by the PISA while controlling for socioeconomic status (SES). The findings of this study will provide detailed statistical analyses of demographic, personal history, attitudinal, and behavioral effects on literacy and problem solving in mathematics.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

More than three decades ago the United States was slipping in academic achievement in the international arena (Hanushek, Peterson, & Woessmann, 2011). In the landmark report, “A Nation at Risk,” many factors were attributed to the weakness of primary and secondary education in the United States (Gardner, Larsen, & Baker, 1983). In particular, researchers found there was a decrease of rigorous academic expectations for students, a shortage of qualified teachers, an unfocused curriculum, and a serious lack of international clout (Schoenfeld, 2004). The result of this national study and other similar studies was a call for educational reform, an ideal that is still at the forefront of educational research (Berliner & Biddle, 1995; Darling-Hammond, 1997, 2010; Powell, Farrar, & Cohen, 1985; Ravitch, 2010; Schoenfeld, 1985, 2002; Sizer, McDonald, & Rogers, 1992; Wu, 2014). The recent adoption of the national Common Core Standards, the movement toward standards driving the curriculum rather than the economy of textbook publication, is the most heavily discussed aspect of educational reform (Porter, McMaken, Hwang, & Yang, 2011; Wu, 2014). Additionally, within the area of secondary mathematics, there is a greater focus on mathematical literacy (ML) and problem solving competency (PSC) for all students (Schoenfeld, 1985, 2002, 2004; Wu, 2014).

With all of the educational reform one may assume that academic achievement, specifically in the area of mathematics, has increased for secondary students. However, the National Assessment of Educational Progress (NAEP) and other researchers cite that 17 year-old students have shown consistent levels of achievement for the last 40 years, and that graduation

rate has declined (Hanushek et al., 2011; Lee, 2010). Since the implementation of national content standards has not increased student achievement in the area of mathematics, the study of other factors that affect student achievement is critical in understanding how to improve student achievement (Battle, 2002; Hanushek et al., 2011; Schoenfeld, 2004).

Predicting student achievement in any area, including mathematics, is difficult to delineate. Some of the most prevalent and documented factors that affect student achievement are general cognitive ability, socioeconomic status (SES), student motivation, and characteristics of family and school (Karchach, Gottschling, Spengler, Hegewald, & Spinath, 2013; Palardy & Rumberger, 2008). Determining which of these factors is most impactful is challenging and is, therefore, greatly debated amongst researchers. Some state that the most powerful predictor is general cognitive ability while others identify SES as making up as much as 50% of the factors that explain low academic achievement (Astone & McLanahan, 1994; Brooks-Gunn, Duncan, & Aber, 1997; Di Giunta, Alessandri, Gerbino, Luengo Kanacri, Zuffiano, & Caprara, 2013; Karchach et al., 2013). Some argue that educators have limited affect on students with low general cognitive ability; it is generally agreed that the most important and impactful predictor is SES (Astone & McLanahan, 1994; Lee, 2002; Tate, 1997).

Home and family factors, such as family constellation, heritage language, and parental encouragement, have a significant effect on academic achievement in students (Amato, 2000; Coleman, 1988; Garasky, 1995; Ham, 2004; Rosenbaum, Reynolds, & DeLuca, 2002; Sun & Li, 2001; Tate, 1997). Beyond the effects of home and family, the school and community can also affect student achievement. The size of the school, classes, and community can create different environments where student academic achievement is affected (Allen, Gregory, Mikami, Lun, Hamre, & Pianta, 2013; Lee & Smith, 1995; Tate, 1997). The influence that the teacher can have

on academic achievement is of great consequence; the training, content knowledge, qualifications, and attitudes of the teacher (Chingos, Whitehurst, & Gallaher, 2013; Darling-Hammond, 1996; Schoenfeld, 2002; Wayne & Youngs, 2003). The attitudes and behaviors of students, including their self-efficacy, are also significant factors in the investigation of academic achievement (Cooper, 1989; Gottfried, Marcoulides, Gottfried, & Oliver, 2009, 2013; Hofer, Farran, & Cummings, 2013; Paschal, Weinstein, & Walberg, 1984; Rivera, 2012). Because these factors are not independent of each other in that some influence the status of others, it is difficult to clearly specify which factor is at the root of the effect on student achievement, but the relationships between the differing predictors and the associated effects will be discussed in depth. This review of the literature will focus on the following: socioeconomic status, parental involvement, family structure, heritage language, immigration, community, school and class size, teacher attributes, student attitudes, and student behaviors. The literature findings are directly related to general student achievement unless specified as associated with mathematical achievement.

Socioeconomic Status Factors

As discussed in chapter 1, socioeconomic status (SES) includes both economic and sociological factors. Typically, SES measures take into account a person's work experience, economic and social position relative to the entire population. Household income, education level, race, and occupation contribute to a family's SES.

SES and academic achievement

There is a strong positive correlation between SES and academic achievement. Namely, higher SES is associated with higher achievement and education attainment rates (Astane & McLanahan, 1991; Battle, 2002; J. Lee, 2002; Reyes & Stanic, 1988). As much as 50% of all

factors that explain low academic achievement can be attributed to low SES (Astone & McLanahan, 1994; Brooks-Gunn et al., 1997). There are a wide variety of proposed explanations for this relationship. Typical explanations of lower academic achievement include a lower level of parental support because they spend more time working (Clark-Lempers, Lempers, & Netusil, 1990), a familial culture and history of lower education attainment (Astone & McLanahan, 1994), less academic confidence (Brody & Flor, 1997) and self-efficacy (Di Giunta et al., 2013; Özgen & Bindak, 2011), lower normative expectations for minority students (J. Lee, 2002), and lower academic access and enrollment (Catsambis, 1994).

SES and mathematical achievement

The effects of SES on mathematical achievement are similar to the general effects of SES on all academic achievement (Lee, 2002). Students who have a low SES do not routinely enroll in higher level math courses such as advanced math and calculus (Catsambis, 1994). Even when there are a greater number of low SES students in higher level math classes, the achievement gap remains the same (Riegle-Crumb & Grodsky, 2010). Students from a family with low SES will typically have low self-esteem and confidence in their mathematical skills contributing to poorer performance on math assessments (Di Giunta et al., 2013, Özgen & Bindak, 2011).

Home and Family Factors

There are many aspects of a student's home life that contribute to academic success. The involvement of parents, family structure, heritage language, and immigration history are some of these home and family factors.

Parental involvement

It is well established that parental involvement has a positive impact on student success. There is consistent evidence, both cross-sectional and longitudinal, that demonstrates an

association between higher parental school involvement and higher academic achievement (Gottfried et al., 2009; Hill & Taylor, 2004). Some researchers argue that family support is more impactful on student achievement than SES due to the impact of family attitudes, guidance, interaction, culture, tradition, environment, and overall stability (Christenson, Rounds, & Gorney, 1992).

There are many ways that parental or guardian involvement in a student's life can affect scholastic success; the impact can be measured by student school behavior, grade advancement, standardized test scores, grade point average, school attitudes, literacy, and many other measures (Sun & Li, 2001). Although some of these measures lack academic standardization, they may still be important measures of academic achievement (Rogers, Theule, Ryan, Adams, & Keating, 2009).

There are some studies which indicate that much of the parental impact on academic success can be attributed to parental attitudes and expectations (Jacobs & Harvey, 2005). These effects can often mitigate other negative effects of familial structure, parental education level, or socioeconomic status. Higher parental education levels are generally associated with greater parental involvement (Bogenschneider, 1997). The more involved that parents are in the schooling of their children, regardless of parental gender, education level, ethnicity, family structure, or child's gender, the greater the academic achievement (Bakker, Denessen, & Brus-Laeven, 2007, Bogenschneider, 1997). Some studies suggest that the effect of parental involvement on students with parents who have lower levels of education is greater and more positive than parents who have higher educational attainment (Bogenschneider, 1997; Hill Castellino, Lansford, Nowlin, Dodge, Bates, & Pettit, 2004).

Traditional family structure

For the purposes of this review, nuclear or “traditional” families are made up of a mother and father who are married or cohabitating and are parents to their biological children. There are many positive impacts on a child’s educational success if the child lives in a two-parent nuclear family (Ferrel, 2009; Milne, Myers, Rosenthal, & Ginsburg, 1986). Children living with both biological parents remain in school longer (Manski, Sandefur, McLanahan, & Powers, 1992), have greater academic success, including higher GPAs (Hines & Holcomb-McCoy, 2013), positive academic behavior (Baker & Iruka, 2013), and greater psychosocial well being (Potter, 2010) than children who live in alternate family structures. A longitudinal study and empirical analysis found that high school students who live in a nuclear family have a greater likelihood of completing a secondary education (Astone & McLanahan, 1991). Additionally, students who lived in a nuclear family completed one more year of college and earn \$10,000 more annually than students who grew up in alternate families (Lang & Zagorsky, 2001).

There is substantial research that indicates that two-parent or nuclear families have a higher socioeconomic status (Ferrel, 2009). Students who come from a higher socioeconomic status achieve significantly higher academically (Popham, 1999). While there is evidence to support students from “traditional” families having higher academic achievement (Astone & McLanahan, 1991; Hatos & Bălțătescu, 2013), it is unclear if the relationship is causal because of the other uncontrolled variables such as socioeconomic status and parental education level (Painter & Levine, 2000).

Non-traditional family structure

In recent decades many children in the United States spend a significant part of their childhood in non-traditional families (Blau & van der Klaauw, 2008). Non-traditional families

come in varied situations: single-parent, multi-generational, step-families, same-sex partnerships, foster families and many more. Most non-traditional families are caused by divorce at a rate more than four times greater than any other circumstance (Lang & Zagorsky, 2001). There is much accumulated research that indicates the turmoil caused divorce in a family (Amato, 2000). Part of the adverse effects of divorce is lower academic achievement for the children, indicated by higher drop-out rates (Martin, 2012), lower test scores (Pong, Dronkers, & Hampden-Thompson, 2003), poorer grades (Hines & Holcomb-McCoy, 2013), and less academic confidence (Brody & Flor, 1997; Garasky, 1995).

Some theorists purport that children from remarried or step-families find greater academic success than those from single parent families (Amato, 2000; Hampden-Thompson, 2013). However, other research indicates that students from remarried or step-families do as well or poorer than students from single parent families (Jeynes, 1999). Still others state that there are strengths associated with single parent families (Amato, 1987; Richards & Schmiede, 1993), but the academic effects are all negative (Dumont, 2013; Hampden-Thompson, 2013; Hatos & Bălățescu, 2013).

The rate of cohabitating couples and parents is soaring (DiFonzo, 2011); most adults have cohabitated (Brown & Manning, 2009). The definition of cohabitating families, however, is quite ambiguous as children indicate a cohabiting household half as often as do the adults in the same household (Blau & van der Klaauw, 2008; Brown & Manning, 2009). This ambiguity is creating a culture of indefinable family structures, which makes the study of student success in these households difficult (Brown & Manning, 2009).

Same-sex unions have recently come under the scrutiny of the nation. One aspect of the debate is the effect of non-traditional family structure on children (Rosenfeld, 2010). The

evidence indicates a greater level of academic success and achievement on standardized tests; at the same time, there is a significantly higher rate of grade retention amongst students from non-traditional families resulting from same-sex unions (Perrin, Siegel, Pawelski, Dobbins, Lavin, Mattson, Yogman, 2013; Rosenfeld, 2010; Telingator & Patterson, 2008). These conflicting results continue to be researched (Perrin et al., 2013). However, there are also conflicting conjectures and explanations for these relationships; some indicate that a generally higher SES of gay and lesbian couples is associated with a greater academic achievement while others contend the need for adoption and lower school readiness cause poorer performance (Rosenfeld, 2010; Telingator & Patterson, 2008).

Heritage language and immigration

Students who do not speak English as their native language have significantly lower academic achievement in all areas, but as English language proficiency (ELP) increases so does math achievement (Tate, 1997). Students who are first generation immigrants to the United States also demonstrate lower academic achievement, although the association is very limited (Geay, McNally, & Telhaj, 2013) and the causal relationship unclear (Pong et al., 2003). Second generation immigrant students generally perform better on standardized assessments due to increased ELP (Kao & Tienda, 1995). Immigrant families are frequently educationally disadvantaged, having low SES, low ELP, and cultural differences that impact educational experiences due to discrepancies in home and family values compared to systemic educational values (Westphal & Kämpfe, 2013). Because of the closely related and overlapping attributes of these students it is challenging to determine which factor is most impactful on academic achievement (Geay et al., 2013; Kao, Tienda, & Schneider, 1996).

School and Community

The size of a community, school, and class can affect academic achievement. Additionally, teacher training, education, and attitudes can also directly impact a student's educational success.

Community, school, and class size

Research indicates that the size of community, school, and class affects student achievement. The size of a school's community is not a significant predictor of academic achievement unless there is a strong association to SES (Tate, 1997) which can explain the negative effect that smaller, rural communities have on student achievement (Clark-Lempers et al., 1990). However, the larger size of the school does have an inversely associated effect on academic achievement where smaller schools foster higher achievement as long as the skill of the teachers can be mitigated (Lee & Ready, 2007; Lee & Smith, 1995). It is important to note that very small schools tend to have cross-curricular teachers that are teaching outside of their area of expertise, which directly affects the quality of instruction and, consequently, academic achievement (Lee & Smith, 1995).

With the recent decrease of educational funding in the U.S., class sizes have increased by as many as 10 students per class (Datnow, 2006; Gardner et al., 1983, Sparks, 2010). Smaller classes are associated with greater academic achievement (Allen et al., 2013). There are several positive attributes of smaller class sizes that foster greater achievement in mathematics and all academic areas. Smaller classes allow for a more supportive environment by increasing the quality of student-teacher interactions (Allen et al., 2013). This provides greater emotional and instructive support to students which increases focus on math analysis and problem solving

(Allen et al., 2013; Greene, Miller, Crowson, Duke, & Akey, 2004). Smaller classes provide more opportunities for support and higher academic achievement.

Teacher attributes

Many claim that the single most impactful factor of academic achievement is the teacher (Aaronson, Barrow, & Sander, 2007; Chingos et al., 2013; Coleman, 1966; Darling-Hammond, 1996, 1997). The attitude and competence of the teacher can have a direct effect on student achievement, especially in the area of mathematics (Chingos et al., 2013; Schoenfeld, 2002; Wayne & Youngs, 2003). With respect to the attitude and characteristics of the teacher, academic achievement increases in classes with teachers who are perceived to be more helpful and effective in the classroom (Etuk, Afangideh, & Uya, 2013; Jacob & Gupta, 2013; Lazarides & Ittel, 2012; Palardy & Rumberger, 2008). This increase of achievement may be attributed to a positive learning environment (Allen et al., 2013), increased cognitive student engagement (Greene et al., 2004), and greater student self-efficacy (Etuk et al., 2013).

Teacher knowledge, education, and certification all have significant positive effects on academic achievement, especially in the area of mathematics. The *No Child Left Behind Act* (2001) attempted to address these factors by requiring US teachers to be highly qualified to teach their subject area; teachers' qualifications are dependent upon coursework, content knowledge, and certification. Teacher content knowledge has a positive effect on learning gains in mathematics (Hill, Rowan, & Ball, 2005; Monk, 1994; Sanders & Rivers, 1996); the power of that effect is greater than the educational background of the teacher which also shows a significant positive relationship on math achievement (Aaronson et al., 2007; Fetler, 1999; Hill et al., 2005). While certification to teach mathematics is based upon education and content knowledge, a license to teach math is not a significant predictor of student achievement (Hill et

al., 2005; Palardy & Rumberger, 2008). Teacher attitudes and morale affect student self-efficacy and academic achievement (Etuk et al., 2013).

Student Attitudes and Behaviors

The attitudes of students toward the subject area (Gottfried et al., 2009, 2013), their teacher (Lazarides & Ittel, 2012), and their self-efficacy (Chen & Stevenson, 1995; Komarraju & Nadler, 2013) have a significant positive correlation to academic achievement even when controlling for SES and other family factors (Di Giunta et al., 2013). The self-concept of mathematics students is a significant predictor of academic achievement for some student groups, but not others (Halle, Kurtz-Costes, & Mahoney, 1997; Rivera, 2012). However, a student's confidence and self-efficacy have a strong impact on self-regulatory behaviors and perseverance in the learning process (Komarraju & Nadler, 2013). Conversely, math anxiety, which is associated with poor math knowledge and low grades (Ashcraft & Krause, 2007; Ramirez, Gunderson, Levine, & Beilock, 2013), causes poor mathematical achievement and low problem solving competency (Ashcraft, 2002; Wigfield & Meece, 1988). Students with high levels of academic confidence, regardless of subject matter, and self-efficacy have lower incidence of math anxiety (Ashcraft & Krause, 2007; Komarraju & Nadler, 2013; Ramirez, Gunderson, Levine, & Beilock, 2013).

Study habits and academic efforts have a significant effect on student achievement, especially in mathematics (Chen & Stevenson, 1995; Komarraju & Nadler, 2013; Özgen & Bindak, 2011). The amount of time spent on homework is positively correlated to mathematical achievement at the high school level (Bush, 2001; Cooper, 1989). This relationship does not exist in junior high students because the students who spend more time on homework also tend to have greater cognitive ability (De Jong, Westerhof, & Creemers, 2000). The amount of time

that a student spends talking about mathematics significantly increases academic achievement (Hofer et al., 2013).

Conclusion

There is a complex web of predictors of student achievement. Not only are there a plethora of factors, they do not exhibit static effects on academic achievement, including in the area of mathematics. The effects of SES on academic achievement are well documented and are most reliable as a predictor; any study should indicate that SES is the most powerful predictor of academic achievement. However, there are many family factors, which are part of SES, that affect student attitudes, parental involvement, ELP, and even school and community factors. A teacher can mitigate some of the negative effects of SES, student attitudes and behaviors, ELP, class size, and family factors. There are gaps in the literature regarding which of all of these are most impactful on academic achievement and what educators can do to best mitigate the negative effects. These gaps relate to pedagogy and policy, including certification requirements and teacher training.

CHAPTER 3

METHODS

The following study explored factors associated with mathematical literacy and problem solving in an effort to establish which influences have the greatest predictive power.

Specifically, using existing data derived from the 2012 Program for International Student Assessment (PISA), this research examined the predictive power of a number of demographic, personal history, attitudinal, and behavioral variables on mathematics literacy and problem solving competency as measured by the PISA while controlling for socioeconomic status (SES). The findings of this study should provide insight on the impact of demographic, personal history, attitudinal, and behavioral factors on literacy and problem solving in mathematics. Specifically, the research sought to identify which variable had the greatest predictive power of mathematics literacy while controlling for and which variable has the greatest predictive power of problem solving competency while controlling for SES. As such, the researcher attempted to answer two primary research questions:

1. Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of mathematics literacy while controlling for SES?
2. Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of problem solving competency while controlling for SES?

Research Design, Nature of the Data Set, and Analytical Procedures

In 2012, the Organisation for Economic Co-operation and Development (OECD) coordinated an international student assessment. The Program for International Student Assessment (PISA) has been administered every three years since 2000. Sixty-five countries, including the United States and other education systems, participated in the assessment. The PISA assesses content knowledge and skills, not specifically limited to school-based curricula, of 15 year-old students in the subject areas of math, reading, and science literacy. It is guided by the following question, “how well can students nearing the end of compulsory schooling apply their knowledge to real-life situations?” The data from the United States PISA were used for this study.

The 2012 PISA data were released on December 7, 2013. The researcher manipulated and formatted the data using Microsoft Excel, employing sound statistical practices. Using the SPSS file provided by OECD, the data were analyzed using appropriate statistical procedures most notable being multiple regression, the most powerful predictive statistical model. PISA produces high quality instruments and outcomes using strong quality assurance mechanisms for sampling, item production, and test administration, and advanced technology and methodology for data handling. They have achieved superior levels of validity and reliability.

Included in the 2012 PISA are data from the principal, parent, and student questionnaires. Testing occurred in the students’ school settings. Mathematical literacy and problem solving competency were measured using the mathematical and problem solving frameworks included in the 2012 PISA (OECD, 2013). These measures were reported with a composite score with a mean of 500 and standard deviation of 100. All data collected and reported from US participants were used in the research.

The participants for this study were chosen by the OECD for the 2012 PISA. The student participants are 15-year-olds enrolled in formal schooling and work-based programs. Just over 6,000 students were randomly selected in the United States representing 161 randomly selected schools. Students completed the standardized assessment; paper-and-pencil exams lasted a total of two hours with an additional computer-based assessment for 40 minutes. For each participating school, the principals completed a questionnaire about their schools and communities. Students also completed a background questionnaire. Additionally, parents completed a questionnaire to provide information about the family and household. The data are reported, associated by individual student.

Research Ethics

George Fox University Institutional Review Board (IRB) approval is not required for this study. The ethics of measurement, data collection, and reporting of this study are covered in the original research approval of the 2012 PISA. Furthermore, because all data are provided in complete anonymity; all participants' confidentiality and anonymity are maintained. All PISA data are available publically to any interested party on the OECD website.

Conceptualization and Operationalization of Variables

All variables were measured using data and survey items from the 2012 PISA. Independent and dependent variables were conceptualized and operationalized as follows:

Dependent Variables –

- Math Literacy – conceptualized as Process; operationalized as one of the five reported PISA math literacy scores with a mean of 500 and a standard deviation of 100. The five scores had a high level of consistency, as determined by Cronbach's alpha of 0.985. The math literacy score that

showed the least difference from the mean (PV3MATH) was chosen by the researcher as the math literacy dependent variable.

- Problem Solving – conceptualized as Problem Solving Competency; operationalized as one of the five reported PISA problem solving competency scores with a mean of 500 and a standard deviation of 100. The five scores had a high level of consistency, as determined by Cronbach’s alpha of 0.976. The problem solving competency score that showed the least difference from the mean (PV4CPRO) was chosen by the researcher as the problem solving competency dependent variable.

Control Variable –

- SES – conceptualized as economic, social, and cultural status; operationalized as a component score (ESCS) from five indices: highest occupational status of parents (PA03 and PA05), highest education level of parents (ST14 and ST19), family wealth (PA07, ST13, ST14, and ST15), cultural possessions, and home educational resources (ST25 and ST27). The data were obtained from responses to the Parent Questionnaire (see Appendix C) and the Student Questionnaire (see Appendix B). The component score is a probabilistic comparative value to the mean where the mean is zero and standard deviation of one. The data were reported on a scale.

Independent Variables –

Most variables were reported using IRT scaling methodology (one-parameter Rasch model). Similar to the reporting of SES, the data are reported on a scale comparative to

the average of zero and standard deviation of one. All variables were reported with this scale unless otherwise indicated.

- Demographic and Personal History Variables:
 - Family structure – conceptualized as the cohesion of students’ parents; operationalized by the categorical response to the question, “who usually lives at your home with you?” Student questionnaire item Q11 (ST11). Categorical data (FAMSTRUC) are reported as single-parent family (1), two-parent family (2), or other family structure (3). (see Appendix B)
 - Gender – conceptualized as the gender of students; operationalized by the categorical response to the question, “are you female or male?” Student questionnaire item Q4 (ST04). Data are reported as female (1) or male (2).
 - Immigration status – conceptualized as the number of generations that students’ families were born in the United States; operationalized as the categorical aggregation of responses to Student Questionnaire item Q22 (ST22, see Appendix B). Data are reported in the following categories: (1) native students (students born in the US with at least one parent born in the US), (2) first-generation students (students born outside the US and whose parents were also born outside the US), and (3) second generation students (students born in the US but whose parents were born in another country).

- Attitudinal Variables:
 - Attribution to failure – conceptualized as perceived self-responsibility for failing in mathematics; operationalized as a scale (FAILMAT) of student responses student questionnaire item Q30 (ST44, see Appendix B).
 - Math anxiety - conceptualized as the perceived anxiety of students regarding the completing of math tasks; operationalized as a scale (ANXMAT) of student responses to select items (ST42Q01, ST42Q03, ST42Q05, ST42Q08, and ST42Q10) student questionnaire item Q29 (ST42, see Appendix B).
 - Math self-concept – conceptualized as the perceived math ability of students; operationalized as a scale (SCMAT) of student responses to select items (ST42Q02, ST42Q04, ST42Q06, ST42Q07, and ST42Q09) student questionnaire item Q29 (ST42, see Appendix B).
 - Math self-efficacy – conceptualized as confidence in performing mathematics tasks; operationalized as a scale (MATHEFF) of student responses to student questionnaire item Q28 (ST37, see Appendix B).
 - Perceived math support – conceptualized as the perceived helpfulness of math teachers by students; operationalized as a scale (MTSUP) of student responses to student questionnaire Q48 (ST77, see Appendix B).
 - Teacher-student relations – conceptualized as the perceived strength of relationships between teachers and students; operationalized as a scale (STUDREL) of student responses to student questionnaire Q56 (ST86, see Appendix B).

- Behavioral Variables:
 - Math minutes - conceptualized as the total number of minutes spent studying mathematics in school during a typical week; operationalized as the product (MMINS) of numerical responses to the questions, “how many minutes, on average, is in a class period in mathematics?” and “how many class periods per week do you typically have in mathematics?” Student questionnaire Q46 and Q47 (ST69 and ST70, see Appendix B).
 - Math work ethic – conceptualized as degree of effort put into homework completion, test preparation and class engagement of high school math students; operationalized as scaled scores (MATWKETH) from responses to student questionnaire Q32 (ST46, see Appendix B).
 - Study hours – conceptualized as the number of hours spent studying all subjects outside of school hours; operationalized as the sum of numerical responses (OUTHOURS) to the question, “how many hours do you spend each week on the following?” Student questionnaire Q43 (ST57)
 - Homework or other study set by your teachers
 - Work with a personal tutor (whether paid or not)
 - Attend out of school classes organized by a commercial company, and paid for by your parents
 - Study with a parent or other family member
 - Repeat and train content from school lessons by working on a computer

- School Organization and Structure Variables
 - Average class size – conceptualized as the number of students in a typical high school class; operationalized as the nominal responses to the question, “on average, about how many students attend your English class?” Student questionnaire Q43 (ST72, see Appendix B).
 - Math teacher certifications – conceptualized as certification of high school math teachers; operationalized as the proportion of math teachers with certifications to the total number of math teachers (PROMATQUAL). Data are reported as a scaled value from zero to one. School questionnaire item Q8 (SC10, see Appendix A).
 - Math teacher education – conceptualized as the undergraduate degree in mathematics of high school math teachers; operationalized as the proportion of math teachers with math degrees to the total number of math teachers (PROMATMAJ). Data are reported as a scaled value from zero to one. School questionnaire item Q8 (SC10, see Appendix A).

Role of the Researcher

The researcher is a graduate student completing a doctoral degree through conducting this research. Additionally, the field of study is associated with the profession of the researcher, namely education. Therefore, the researcher has a professional responsibility to provide honest, authentic, and genuine research as an appropriate representation of the educational community. The researcher has 15 years of experience in public education as a mathematics and music teacher. As a teacher in public education and member of a district-level articulation committee, the researcher has a responsibility to seek sound research that can positively affect academic

achievement for students. Additionally, the researcher has a vested interest in the potential contributions to math pedagogy and policy. As a mathematician, there is an expectation to provide mathematically sound quantitative analysis of the data. This study will be the first of such a magnitude for the researcher.

Potential Contributions of the Research

This research identifies factors that currently affect student math achievement. While there is extensive research investigating the effect of SES, family structure, and other student factors on academic achievement, much of the research does not include such recent data as provided by the 2012 PISA. Additionally, the research will also investigate the hierarchal effect of each predictor. This aspect of the investigation is greatly needed in the scholarship on math achievement.

There are many factors that educators cannot control or affect. For example, educators do not have the ability to mitigate the effects of family structure or size of community. However, there are ways that educators can positively influence the learning and achievement of students. Teachers can directly increase student self-efficacy and confidence as well as instructing appropriate study strategies. Using sheltered pedagogy, teachers can make content more accessible for students with limited English proficiency. This research will help educators identify the most impactful practices with respect to student achievement, thus maximizing efforts for an already busy professional.

Districts have the ability to directly control certain aspects of the educational process. Within budgetary and resource constraints, districts control class sizes and teacher qualifications. Districts and schools can control the teachers they hire and can define standards for employment that will directly affect student achievement; they can demand that teachers have certain

educational experiences and certifications. Furthermore, schools and districts can monitor and, if necessary, make changes to foster an increase in teacher morale. With the trend of decreased funding for education, districts need to maximize the power of each dollar. This research may indicate ways in which schools and districts can increase student achievement and which arrangements would be most cost effective. Additionally, governmental agencies may identify the most beneficial modifications to standards and practices of teachers, schools, and districts in order to increase student achievement.

CHAPTER 4

RESULTS

The purpose of this study was to explore factors associated with mathematical literacy and problem solving in secondary education using existing data derived from the 2012 Program for International Student Assessment (PISA), an international survey of 15 year old students and their achievement. Specifically, this research examined the predictive power of a number of demographic, personal history, attitudinal, behavioral and school organization variables on mathematics literacy and problem solving competency as measured by the PISA while controlling for socioeconomic status (SES).

This chapter will give the results of the multiple regression analyses performed to answer the two primary research questions and the secondary supporting questions. Due to the large number of variables investigated, the variables were analyzed by strand: demographic and personal history, attitudinal, behavioral, and school organization and structure variables. Moreover, each of the following analyses addresses one of the supporting research questions.

Primary Research Question #1: Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of mathematics literacy while controlling for SES?

Demographic and Personal History Variables

A multiple regression analysis was performed to examine if any of the demographic and personal history variables could significantly predict math literacy for 15 year old US math students while controlling for SES (see Table 1). The demographic and personal history variables account for 15.7% of the variance in the math literacy scores and was significant, $F(4, 4369) = 204.311, p < .0005$.

Table 1

Summary of Multiple Regression Analyses of Demographic and Personal History Variables on Math Literacy while controlling for SES (N=4374)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	35.929	1.326	0.401	27.104	0.000
Family structure (FS)	0.987	2.874	0.005	0.343	0.731
Gender (G)	9.993	2.426	0.057	4.118	0.000
Immigration status (IS)	5.701	2.229	0.037	2.557	0.011

Note: $F(4, 4369) = 204.311, p < .0005, R^2 = .157$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of math literacy. Both gender ($p < .0005$) and immigration status ($p = .011$) were significant predictors of math literacy. Family structure ($p = .731$) was not a significant predictor of math literacy in this model. Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$35.929*SES + 0.987*FS + 9.993*G + 5.701*IS + 456.466 = \text{Math Literacy Score}$$

Of the significant predictors, gender and immigration status, gender had a greater effect on the dependent variable with a standardized beta 0.02 greater than immigration status.

Attitudinal Variables

A multiple regression analysis was performed to determine if any of the attitudinal variables could significantly predict math literacy for 15 year old US math students while controlling for SES (see Table 2). The attitudinal variables account for 40.3% of the variance in the math literacy scores and was significant, $F(7, 1581) = 153.829, p < .0005$.

Table 2

Summary of Multiple Regression Analyses of Attitudinal Variables on Math Literacy while controlling for SES (N=1589)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	21.942	1.847	0.242	11.883	0.000
Attribution to failure (ATF)	5.416	1.601	0.075	3.383	0.001
Math anxiety (MA)	-21.625	2.626	-0.250	-8.235	0.000
Math self-concept (MSC)	4.272	2.793	0.047	1.529	0.126
Math self-efficacy (MSE)	32.278	2.121	0.365	15.221	0.000
Perceived math support (PMS)	-5.167	1.925	-0.060	-2.685	0.007
Teacher-student relations (TSR)	-0.438	2.107	-0.005	-0.208	0.835

Note: $F(7, 1581) = 153.829, p < .0005, R^2 = .403$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of math literacy. Teacher-student relations ($p = .835$) and math self-concept ($p = .126$) were not significant predictors of mathematical literacy. All other variables significantly predicted math literacy: attribution to failure ($p = .001$), math anxiety ($p < .0005$), math self-efficacy ($p < .0005$), and perceived math support ($p = .007$). Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$21.942*SES + 5.416*ATF - 21.625*MA + 4.272*MSC + 32.278*MSE - 5.176*PMS \\ - 0.438*TSR + 478.760 = \text{Math Literacy Score}$$

Of the significant predictors math self-efficacy ($\beta = 0.365$) and math anxiety ($\beta = -0.250$) had the greatest effect on math literacy. Of the two, math self-efficacy was the most powerful predictor.

Behavioral Variables

A multiple regression analysis was performed to explore if any of the behavioral variables could significantly predict math literacy for 15 year old US math students while

controlling for SES (see Table 3). The behavioral variables account for 17.3% of the variance in the math literacy scores and was significant, $F(4, 1490) = 78.652, p < .0005$.

Table 3

Summary of Multiple Regression Analyses of Behavioral Variables on Math Literacy while controlling for SES (N=1495)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	33.413	2.202	0.368	15.172	0.000
Math minutes (MM)	0.083	0.015	0.131	5.526	0.000
Math work ethic (MWE)	4.081	2.200	0.045	1.855	0.064
Study hours (SH)	0.243	0.223	0.027	1.094	0.274

Note: $F(4, 1490) = 78.652, p < .0005, R^2 = .172$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of math literacy. Only the number of math minutes ($p < .0005$) was a significant predictor. However, math work ethic ($p = .064$) was not a statistically significant predictor of math literacy. The number of study hours ($p = .274$) was not a significant predictor. Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$33.413*SES + 0.083*MM + 4.081*MWE + 0.243*SH + 452.676 = \text{Math Literacy Score}$$

There was only one statistically significant predictor, math minutes ($\beta = 5.526$). The standardized beta was almost three times greater than the math work ethic ($\beta = .045$) variable, which was nearly a significant predictor of math literacy.

School Organization and Structure Variables

A multiple regression analysis was performed to ascertain if any of the school organization and structure variables could significantly predict math literacy for 15 year old US math students while controlling for SES (see Table 4). These variables account for 16.3% of the variance in the math literacy scores and was significant, $F(4, 2995) = 146.906, p < .0005$.

Table 4

Summary of Multiple Regression Analyses of School Organization and Structure Variables on Math Literacy while controlling for SES (N=4373)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	35.998	1.533	0.393	23.486	0.000
Average class size (ACS)	0.592	0.179	0.056	3.314	0.001
Math teacher certifications (MTC)	30.969	8.704	0.063	3.558	0.000
Math teacher education (MTE)	5.148	3.859	0.023	1.334	0.182

Note: $F(4, 2995) = 146.906, p < .0005, R^2 = .163$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of math literacy. Math teacher education ($p = .182$) was not a significant predictor. However, average class size ($p = .001$) and math teacher certifications ($p < .0005$) were statistically significant predictors of math literacy. Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$35.998*SES + 0.592*ACS + 30.969*MTC + 5.148*MTE + 429.340 = \text{Math Literacy Score}$$

Of the significant predictors math teacher certifications ($\beta = 0.063$) and average class size ($\beta = 0.056$) had very close standardized betas, but the unstandardized beta for math teacher certification is more than fifty times that of the average class size. Therefore, the math teacher certifications variable makes a greater effect on the math literacy score.

Primary Research Question #2: Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of problem solving competency while controlling for SES?

Demographic and Personal History Variables

A multiple regression analysis was performed to determine if any of the demographic and personal history variables could significantly predict problem solving competency (PSC) for 15 year old US math students while controlling for SES (see Table 5). The demographic and personal history variables account for only 10.4% of the variance in the PSC scores and was significant, $F(4, 4369) = 127.644, p < .0005$.

Table 5

Summary of Multiple Regression Analyses of Demographic and Personal History Variables on Problem Solving Competency while controlling for SES (N=4373)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	29.842	1.398	0.326	21.349	0.000
Family structure (FS)	-0.807	3.031	-0.004	-0.266	0.790
Gender (G)	6.455	2.559	0.036	2.523	0.012
Immigration status (IS)	2.236	2.351	0.014	0.951	0.342

Note: $F(4, 4369) = 127.644, p < .0005, R^2 = .104$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of PSC. Only gender ($p = .012$) was a statistically significant predictor of PSC scores. Both family structure ($p = .790$) and immigration status ($p = .342$) were not significant predictors in this model. Based on the unstandardized coefficients returned by the model, the predictor equation for PSC scores is:

$$29.842*SES - 0.807*FS + 6.455*G + 2.236*IS + 497.701 = \text{PSC Score}$$

Attitudinal Variables

A multiple regression analysis was performed to examine if any of the attitudinal variables could significantly predict math literacy for 15 year old US math students while

controlling for SES (see Table 6). The attitudinal variables account for 29.5% of the variance in the PSC scores and was significant, $F(7, 1581) = 95.890, p < .0005$.

Table 6

Summary of Multiple Regression Analyses of Attitudinal Variables on Problem Solving Competency while controlling for SES (N=1589)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	19.740	2.106	0.207	9.375	0.000
Attribution to failure (ATF)	5.228	1.826	0.069	2.863	0.004
Math anxiety (MA)	-26.892	2.994	-0.297	-8.981	0.000
Math self-concept (MSC)	-1.029	3.185	-0.011	-0.323	0.747
Math self-efficacy (MSE)	25.852	2.418	0.279	10.690	0.000
Perceived math support (PMS)	-4.164	2.195	-0.046	-1.897	0.058
Teacher-student relations (TSR)	0.883	2.403	0.009	0.367	0.713

Note: $F(7, 1581) = 95.890, p < .0005, R^2 = .295$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of PSC. Teacher-student relations ($p = .713$) and math self-concept ($p = .1747$) were not significant predictors of PSC. Perceived math support ($p = .058$) was close to being a statistically significant predictor. All other variables significantly predicted PSC: attribution to failure ($p = .004$), math anxiety ($p < .0005$), and math self-efficacy ($p < .0005$). Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$19.740*SES + 5.228*ATF - 26.892*MA - 1.029*MSC + 25.852*MSE - 4.164*PMS + 0.883*TSR + 511.632 = \text{PSC Score}$$

Of the significant predictors math self-efficacy ($\beta = 0.279$) and math anxiety ($\beta = -0.297$) had the greatest effect on PSC and were even more powerful than the control variable, SES ($\beta = 0.207$).

Of the two significant predictors, math anxiety was slightly more powerful.

Behavioral Variables

A multiple regression analysis was performed to determine if any of the behavioral variables could significantly predict PSC for 15 year old US math students while controlling for SES (see Table 7). The behavioral variables account for 10.3% of the variance in the PSC scores and was significant, $F(4, 1490) = 43.732, p < .0005$.

Table 7

Summary of Multiple Regression Analyses of Behavioral Variables on Problem Solving Competency while controlling for SES (N=1495)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	25.234	2.271	0.280	11.111	0.000
Math minutes (MM)	0.072	0.016	0.114	4.631	0.000
Math work ethic (MWE)	-0.113	2.269	-0.001	-0.050	0.960
Study hours (SH)	0.405	0.230	0.045	1.765	0.078

Note: $F(4, 1490) = 43.732, p < .0005, R^2 = .103$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of PSC. Only the number of math minutes ($p < .0005$) was a significant predictor. Math work ethic ($p = .960$) and number of study hours ($p = .078$) were not statistically significant predictors of PSC, but the number of study hours was close to being a significant predictor. Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$25.234*SES + 0.072*MM - 0.113*MWE + 0.405*SH + 484.568 = \text{PSC Score}$$

There was only one statistically significant predictor, math minutes ($\beta = .114$). The standardized beta was almost three times greater than the study hours ($\beta = .045$) variable, which was nearly a significant predictor of PSC.

School Organization and Structure Variables

A multiple regression analysis was performed to explore if any of the school organization and structure variables could significantly predict PSC for 15 year old US math students while controlling for SES (see Table 8). These variables account for 10.7% of the variance in the math literacy scores and was significant, $F(4, 2995) = 91.084, p < .0005$.

Table 8

Summary of Multiple Regression Analyses of School Organization and Structure Variables on Problem Solving Competency while controlling for SES (N=4373)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	28.801	1.613	0.308	17.858	0.000
Average class size (ACS)	0.396	0.188	0.036	2.105	0.035
Math teacher certifications (MTC)	43.649	9.158	0.087	4.766	0.000
Math teacher education (MTE)	8.268	4.060	0.037	2.036	0.042

Note: $F(4, 2995) = 91.084, p < .0005, R^2 = .107$

Socioeconomic status, the control variable, was a significant predictor ($p < .0005$) of PSC. All variables in this model were statistically significant: average class size ($p = .035$), math teacher certifications ($p < .0005$), and math teacher education ($p = .042$). Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$28.801*SES + 0.396*ACS + 43.649*MTC + 8.268*MTE + 447.130 = \text{PSC Score}$$

Of the significant predictors, math teacher education ($\beta = 0.037$) and average class size ($\beta = 0.036$) had very close standardized betas, but math teacher certification ($\beta = 0.087$) indicates that it is the most powerful predictor of PSC. In fact, it has a much greater effect on the PSC score than the control variable.

Secondary Research Questions

Major Predictors of Math Literacy

A linear regression analysis was performed to determine if any of the variables that could significantly predict math literacy for 15 year old US math students without controlling for SES (see Table 9). The variables included in the analysis were those previously identified as the most powerful predictors, major predictors, of math literacy: SES, math anxiety, math self-efficacy, and math teacher certifications. The included variables account for 40.2% of the variance in the math literacy scores and was significant, $F(4, 1558) = 262.991, p < .0005$.

Table 9

Summary of Linear Regression Analysis of Math Literacy and Most Powerful Predictors WITHOUT controlling for SES (N=1563)

Variable	B	SE B	β	t	p
SES	22.193	1.891	0.239	11.735	0.000
Math anxiety (MA)	-20.337	1.916	-0.234	-10.615	0.000
Math self-efficacy (MSE)	32.160	1.998	0.365	16.098	0.000
Math teacher certifications (MTC)	44.333	9.959	0.087	4.452	0.000

Note: $F(4, 1558) = 262.991, p < .0005, R^2 = .402$

All variables were significant predictors ($p < .0005$) of math literacy. Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$22.193*SES - 20.337*MA + 32.160*MSE + 44.333*MTC + 433.577 = \text{ML Score}$$

Comparisons of the standardized beta values indicate that math self-efficacy ($\beta = .365$) is the strongest predictor of math literacy, even greater than SES ($\beta = .239$). Math anxiety ($\beta = -.234$) was nearly as powerful as SES as a predictor of math literacy. Math teacher certifications ($\beta = .087$), though a statistically significant predictor, was much less powerful than the other variables.

Major Predictors of Problem Solving Competency

A linear regression analysis was performed to ascertain if any of the variables that could significantly predict PSC for 15 year old US math students without controlling for SES (see Table 10). The variables included in the analysis were those previously identified as the most powerful predictors, major predictors, of PSC: SES, math anxiety, math self-efficacy, and math teacher certifications. The included variables account for 30.3% of the variance in the PSC scores and was significant, $F(4, 1558) = 170.740, p < .0005$.

Table 10

Summary of Linear Regression Analysis of Problem Solving Competency and Most Powerful Predictors WITHOUT controlling for SES (N=1563)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
SES	20.126	2.130	0.208	9.448	0.000
Math anxiety (MA)	-22.635	2.158	-0.250	-10.489	0.000
Math self-efficacy (MSE)	24.750	2.250	0.269	10.999	0.000
Math teacher certifications (MTC)	58.136	11.217	0.110	5.183	0.000

Note: $F(4, 1558) = 170.740, p < .0005, R^2 = .305$

All variables were significant predictors ($p < .0005$) of PSC. Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$20.126*SES - 22.635*MA + 24.750*MSE + 58.136*MTC + 452.722 = \text{PSC Score}$$

Comparisons of the standardized beta values indicate that math self-efficacy ($\beta = .269$) is the strongest predictor of PSC. Math anxiety ($\beta = -.250$) was also a more powerful predictor of PSC than SES ($\beta = .208$). Math teacher certifications ($\beta = .110$), though a statistically significant predictor, was about half as powerful as the other predictors.

Most Powerful Predictors of Math Self-Efficacy

Since math self-efficacy was the strongest predictor of both math literacy and problem solving competency regardless of controlling for SES, the researcher was interested in predictors

of math self-efficacy. The predictors that were analyzed using linear regression analysis were those that could be directly impacted by the educator using pedagogical and instructional practices, specifically math work ethic, perceived math support, and teacher-student relations were investigated (see Table 11). The included variables account for 13.7% of the variance in math self-efficacy and was significant, $F(3, 1579) = 84.502, p < .0005$.

Table 11

Summary of Linear Regression Analysis of Math Self-Efficacy (N=1583)

Variable	B	SE B	β	<i>t</i>	<i>p</i>
Math work ethic (MWE)	0.238	0.025	0.242	9.522	0.000
Perceived math support (PMS)	0.078	0.026	0.080	2.974	0.003
Teacher-student relations (TSR)	0.159	0.029	0.151	5.515	0.000

Note: $F(3, 1579) = 84.502, p < .0005, R^2 = .137$

All variables were significant predictors of math self-efficacy: MWE ($p < .0005$) and TSR ($p < .0005$), and PMS ($p = .003$). Based on the unstandardized coefficients returned by the model, the predictor equation is:

$$0.238 * \text{MWE} + 0.078 * \text{PMS} + 0.159 * \text{TSR} + 0.047 = \text{Math Self-Efficacy}$$

Comparisons of the standardized beta values indicate that MWE ($\beta = .242$) is the strongest predictor of math self-efficacy and is more than three times as powerful as PMS ($\beta = .080$).

CHAPTER 5

DISCUSSION AND CONCLUSIONS

Introduction

This final chapter discusses the findings outlined in chapter 4. The results are summarized as they relate to the primary research questions: Which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of mathematical literacy and problem solving competency while controlling for SES? The implications of the research are identified as they relate to the researcher, educators, and scholars. The limitations of the research are reviewed; suggestions for future study, including ways to improve this study were it to be completed again, are brought forward. The findings are then compared to existing research and current phenomena in education in order to inform educators and scholars on the predictors of math achievement.

Summary of the Findings

Demographic and Personal History Variables

The demographic and personal history variables with the greatest predictive power did not vary significantly between mathematical literacy (ML) and problem solving competency (PSC). The variables that were statistically significant predictors of ML while controlling for SES were gender and immigration status; only gender was a significant predictor of PSC. However, both variables had a limited effect on the math achievement scores as their standardized betas effectively caused a 1% increase in scores for males than females and an even smaller effective increase for a change in immigration status.

Family structure was not a significant predictor of ML or PSC. While the prior research indicates that the family constellation of students makes an impact on student achievement, this research did not indicate such an association. There is a possibility that the reporting, more specifically the scaling, of this variable caused for results that were not in agreement with the existing findings. It is not surprising that SES was the most powerful predictor for both ML and PSC, even while doing a multiple regression, when compared to the other demographic and personal history variables.

Attitudinal Variables

The attitudinal variables offered the most interesting and significant predictors of ML and PSC. Both models, ML and PSC, had the greatest values of Pearson's r that indicates that the attitudinal variables had the greatest effect on math scores than all the other classes of variables. Of the six variables investigated, four were significant predictors of ML: math self-efficacy, math anxiety, attribution of failure, and perceived math support. These four variables were also the strongest predictors of PSC; it is important to note that perceived math support was not a statistically significant predictor of PSC ($p = 0.058$), but was very close to being significant.

The confidence that a student has in their mathematical abilities, reported as math self-efficacy and math anxiety, is the most powerful predictor of both ML and PSC. In the model that controlled for the effects of SES, these attitudinal variables had a greater impact on the math scores than SES. This result was so important and in sharp contrast with the established literature on SES and math achievement that the researcher investigated these relationships closer. The resulting correlations, some of which were quite surprising, will be discussed later in this chapter.

There were two attitudinal variables that were not significant predictors of either ML or PSC: math self-concept and teacher-student relations. Of the two, the ML model math self-concept was much closer to a significant predictor ($p = 0.126$) than the teacher-student relations ($p = 0.835$). In both the ML and PSC models, the type of relationships that a teacher has with students, specifically if the students believe that teachers have positive relationships with students, does not predict math achievement.

Math self-concept was not a significant predictor of ML or PSC, but math self-efficacy was a statistically significant predictor of both ML and PSC. The conceptual similarities between math self-efficacy and math self-concept makes the difference in predictability with these variables and interesting one. When looking at the specific items on the student questionnaire (see Appendix B) that were used to quantify math self-concept and math self-efficacy, the subtle differences between the two give light to the relationship between these variables and math achievement. Math self-concept is a measure of the student's perception as a mathematician, including historical relationships with marks and comparisons to other subjects. Math self-efficacy is a measure of the student's belief that they can be successful in specific mathematical tasks independent of external influences such as teachers or test scores. The subtle difference indicates that the past experiences of a math student do not necessarily indicate future achievement, however the student's confidence and belief in their abilities to be successful can improve future math achievement.

Behavioral Variables

The behavioral variables investigated did not offer a good predictable model for ML or PSC. Only the number of minutes in math class was a significant predictor of ML and PSC. The greater the number of minutes spent on mathematics during the school day, the greater the

achievement in ML and PSC. It is not surprising that the more time spent learning mathematics increases ML.

The number of hours spent studying outside of school was not a significant predictor of ML ($p = 0.274$), but was close to a statistically significant predictor of PSC ($p = 0.078$). This indicates that a student who works longer on school work outside of class, regardless of subject area, has better problem solving skills than students who do not spend the extra time studying outside of school. Since problem solving is typically an area of mathematics that requires a greater level of perseverance and time in order to be successful, it is not a surprise that students who are familiar with spending extended time on schoolwork would be more successful in PSC.

The other behavioral variable, math work ethic, was not a significant predictor of PSC ($p = 0.960$), but was nearly a significant predictor of ML ($p = 0.064$). Math work ethic is a measure of behaviors such as completing homework, studying for exams, and being on task in class. It is interesting that these behaviors will increase ML but do not increase PSC. This shows that problem solving competency requires more than the rote practice of static math skills; as indicated earlier, the ability to spend appropriate time on a task even when it is difficult can increase PSC.

School Organization and Structure Variables

The most powerful predictor of ML and PSC with respect to school organization and structure is the certification of math teachers. This indicates that students with math teachers that have completed a teacher preparation program outside of a bachelor's degree will have greater ML and PSC. Contrary to the existing literature, this research states that teachers with math degrees do not yield higher ML in their students. However, students whose teachers have math degrees did perform better in problem solving. The greater mathematical background knowledge

of teachers, as indicated by a completed math degree, perhaps allows teachers to teach the integrated parts of math so that students can use the complex relationships between multiple math topics in their problem solving. Because ML is measured by static and independent math tasks there is no need to access and utilize multiple strands of mathematics within one problem; this could be one possible explanation of the lack of predictability of ML by the math education of teachers.

Class size is a significant predictor of ML and PSC. However, contrary to current literature, larger classes are associated with higher ML and PSC scores. The increase is very small with unstandardized betas less than one and a constant around 450. One possible explanation for this discrepancy is in the large data set and lack of variability in class size and potential skewed nature of the data set; there was a mean of 24 students per class and a standard deviation of eight students. Only 3.5% of the class sizes reported were larger than one standard deviation above the mean of the data but 11.1% of the class sizes were smaller than one standard deviation below the mean. Therefore, there is a skew in the data toward smaller class sizes. Regardless of the potential difference between this research and established literature, the very small unstandardized beta indicates that this variable not very powerful or impactful.

Most Powerful Predictors of Dependent Variables

Although the supporting literature indicates that SES is a powerful predictor of student achievement, the models performed in this research showed some indication that it was not the most powerful predictor of ML or PSC. Looking at the most powerful predictors of ML and PSC regardless of their categorization of variable, a linear regression analysis was performed to determine if any could significantly predict math achievement for 15 year old US math students without controlling for SES. The variables included in the analysis were those previously

identified as the most powerful predictors of math literacy: SES, math anxiety, math self-efficacy, and math teacher certifications. All four variables were significant predictors ($p < .0005$) of both ML and PSC. A comparison of the standardized betas reveal that math self-efficacy is much more powerful than SES. It also indicates that math anxiety is as powerful as SES with a difference of 0.005 in the absolute value of the standardized beta. However, socioeconomic status is almost three times as powerful as math teacher certifications, which supports the existing literature.

For both ML and PSC, what a student believes about their math ability was as powerful or more powerful of a predictor than SES. The math self-efficacy of students is more impactful on ML and PSC than any other variable investigated in this study including SES. Since math self-efficacy was the strongest predictor, the researcher was interested in predictors of math self-efficacy. The predictors that were analyzed using linear regression analysis were those that could be directly impacted by the educator using pedagogical and instructional practices, specifically math work ethic, perceived math support, and teacher-student relations were investigated.

All variables were significant predictors of math self-efficacy. If students want to increase their self-efficacy then an increase in math work ethic, or positive student behaviors, offers the greatest possibility. The actions of the students will make a greater impact on their own self-efficacy, but teachers can make an impact too. The other two predictors of math self-efficacy, perceived math support and teacher-student relations, are ones that can be affected by the teacher and are almost one-third as powerful as math work ethic. If teachers want to improve the self-efficacy of their math students, they can foster better relationships with students and provide more helpful support.

Implications

This research addressed the following research question: which specific variable among the demographic and personal history, attitudinal, behavioral, and school organization and structure variables has the greatest predictive power of mathematical literacy and problem solving competency while controlling for SES? Many of the variables studied were determined to be significant predictors of ML and/or PSC. Every category of variables had at least one statistically significant predictor: demographic and personal history variables, attitudinal variables, behavioral variables, and school organization and structure variables. The attitudinal variables had the most significant predictors of ML and PSC and categorically proved to be the most powerful. These results hold substantial implications in the areas of math literacy and problem solving competency for math education practitioners and academic researchers.

Implications for practitioners

One of the major facets of the NCLB Act (2001) is that teachers must be considered highly qualified to teach in their subject area. In the US this means that they have completed a teacher preparation program. This research supports that having a teacher who is qualified to teach mathematics will improve math achievement (Hill, Rowan, & Ball, 2005). Administrators should seek out and hire teachers who have completed such a qualification. Additionally, when considering teachers for a mathematics appointment administrators and school districts should look for candidates who have a degree in the area of mathematics since problem solving competency will improve if teachers have this education (Hill, Rowan, & Ball, 2005; Monk, 1994; Sanders & Rivers, 1996).

The number of minutes spent on mathematics during the school day impacts math achievement. This supports the claim that double dosing struggling math students has a positive

effect on math achievement (Franco, 2013). Thus, educators should look for ways to increase the number of minutes spent doing mathematics. When structuring schedules for secondary schools, administrators and school district officials should be mindful not to cut class time in the area of mathematics. As seat time is another requirement for NCLB (2001), this research supports another facet of this US educational act.

Since the greatest impact on math literacy and problem solving came from the attitudinal variables, most of the implications for practitioners are related to student attitudes. Unlike the circumstances surrounding SES, educators have the ability to directly impact student attitudes. There are several ways that math teachers, specifically, can improve student achievement in the area of mathematics. Students who feel that they have a teacher who is helpful have greater ML and PSC (Etuk et al., 2013; Lazarides & Ittel, 2012). In this study students who observed the following attributes of math teachers felt that they had sufficient math support: the teacher shows an interest in every student's learning, the teacher gives extra help when students need it, the teacher helps students with their learning, the teacher continues teaching until the students understand, and the teacher gives students an opportunity to express opinions (Etuk, Afangideh, & Uya, 2013; Jacob & Gupta, 2013; Lazarides & Ittel, 2012; Palardy & Rumberger, 2008). Teachers should strive for equitable teaching practices that will help all students to feel supported and valued in the learning of mathematics.

Greater math support for all students can increase math self-efficacy, which can directly impact ML and PSC. In addition to equitable math pedagogy, teachers can improve students' math self-efficacy by fostering positive relationships with students. More specifically, they should strive to get along with students, show an interest in students' well-being, really listen to students, help all students, and treat all students fairly. By creating a safe environment where all

students equitably feel that the teachers have a unique interest in their lives as students and also as people, educators can increase math self-efficacy, decrease math anxiety, and foster an improvement in math achievement (Ashcraft & Krause, 2007; Komarraju & Nadler, 2013; Ramirez, Gunderson, Levine, & Beilock, 2013).

Study habits and academic efforts have a significant effect on student achievement, especially in mathematics (Chen & Stevenson, 1995; Komarraju & Nadler, 2013; Özgen & Bindak, 2011). The amount of time spent on homework is positively associated with mathematical achievement (Bush, 2001; Cooper, 1989). While teachers do not have a direct effect on the number of minutes that students work on math homework, they can implement pedagogical practices that will encourage students to foster positive study habits (Hofer et al., 2013).

Implications for researchers

Many studies have established that the socioeconomic status of students have the greatest impact on math achievement (Astone & McLanahan, 1991; Battle, 2002; J. Lee, 2002; Reyes & Stanic, 1988). As much as 50% of all factors that explain low academic achievement can be attributed to low SES (Astone & McLanahan, 1994; Brooks-Gunn et al., 1997). While there are many explanations for why this phenomenon exists, this research found that the attitudes of students were more powerful predictors of ML and PSC than SES. The findings that are contrary to much of the existing literature indicate that future research should focus on the relationship between self-efficacy and student achievement. In addition to this shift in research focus, educational researchers should also investigate curricula and pedagogical practices that will foster positive teacher-student relationships and greater self-efficacy.

Limitations of the Research

The purpose of this study was to investigate the predictive power of a variety of predictive variables on math achievement while controlling for SES. The study included a vast amount of data. Though statistically sound, the grandeur of the data limits the investigation to exclude specific subtle nuances that might have been more easily available if the data set was smaller. Additionally, due to the scaling of most variables, one might argue that the integrity of the responses was compromised; this is a limitation to the study.

Another limitation that results from the nature of the data is the inability to disaggregate the data into student subgroups. The NCLB Act emphasizes the importance of achievement for all student subgroups including special education students, English language learners, and students of underrepresented ethnic groups. This research only looks at students as a large homogenous group. Additionally, this group is made up of only 15 year old students in the US. Though we may extrapolate these results to all secondary students and potentially all school aged children, the data limits the participants to only 15 year old students.

Perhaps the greatest limitation of this research is the use of existing data from an established instrument. The researcher had no control of what information was gathered nor of how the data were reported. As such, some of the variables that should have, based on the literature review, yielded significant findings did not show a causal relationship. For example, there was much established research to support the impact of family structure on academic achievement (Ferrel, 2009; Milne, Myers, Rosenthal, & Ginsburg, 1986), but the results of this study indicated no such statistically significant relationship. It is likely that the reporting of this data yielded the inconsistent results.

Suggestions for Future Study

This research identified factors that currently affect student achievement in the area of mathematics. While there is extensive research investigating the effect of SES, family structure, and other student factors on academic achievement, much of the research does not focus on the importance of math self-efficacy. Future study should look at the relationship between self-efficacy and student achievement including a disaggregated study of student subgroups as reported by NCLB. Additionally, finding the predictors of self-efficacy will allow educators to identify potential ways to improve student attitudes towards mathematics.

Since math self-efficacy was identified as the greatest predictor of math achievement, future research should investigate how students can increase their self-efficacy and decrease math anxiety. Specific strategies should be developed so educators can positively affect the achievement of secondary math students and positively influence the learning and achievement of students. Future research should help educators identify the most impactful practices with respect to student attitudes and achievement, thus maximizing efforts for an already busy professional.

Districts have the ability to directly control certain aspects of the educational process. Within budgetary and resource constraints, districts control class sizes and teacher qualifications. Districts and schools can control the teachers they hire and can define standards for employment that will directly affect student achievement; they can demand that teachers have certain educational experiences and certifications. Future study should identify which of these factors will have the greatest impact on student achievement and investigate the relationship between these factors and student attitudes. This future research may indicate ways in which schools and districts can increase student achievement and which arrangements would be most cost effective.

Conclusions

Given the climate, attitudes, and perceptions regarding public education in the United States, information regarding the determinants of mathematical literacy and problem solving competency is desirable. This study discovered some factors associated with mathematical literacy and problem solving. The statistically significant predictors could be categorized as major predictors and minor predictors. The minor predictors with a much less predictive power include: gender, immigration status, student attribution to failure, perceived math support, number of minutes in math class, math education of teachers, and class size. The major predictors with the greatest predictive power included: socioeconomic status, math self-efficacy, math anxiety, and math teacher certification.

Teachers who have certifications to teach will have the greatest impact on math achievement. The teacher can improve math self-efficacy by fostering positive relationships with students and provide support for all students. There is much that classroom teachers can do in order to improve student achievement in the area of mathematics; the use of equitable pedagogical practices that increase student confidence may even mitigate the negative effects of socioeconomic status.

Perhaps most interestingly, the predictive power of the major predictors was greater than the predictive power of SES, the control variable. Even when not controlling for SES, the attitudes of students' self-efficacy was the most powerful predictor of math literacy and problem solving competency. This finding is in stark contrast to existing literature and research. The effect of a student's belief in their math ability is greater than the effect of their SES. Perhaps the activation of one's faith in their own ability accesses Godly power, which is far grander than any other power available, that magnifies their cognitive aptitude and academic ability. Greater

self-efficacy acknowledges the relationship between God and man, specifically that God is the Father and that all of His children are heirs of his eternal glory (Romans 8: 16-17). Students who believe in their own intellectual abilities are drawing on this inherited glorified power and the endless knowledge of the Omniscient One.

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APPENDICES

APPENDIX A

SCHOOL QUESTIONNAIRE

The school questionnaire is administered to the school principal and takes about 30 minutes to complete. It covers a variety of school-related aspects:

- Structure and organisation of the school
- Student and teacher body
- School's resources
- School's instruction, curriculum and assessment
- School climate
- School's policies and practices
- Financial education at school
- Additional question for ONLINE school questionnaire

Technical terms are given in <brackets> and are adapted to the national context by the national data collection centre of the participating country or economy. In this annex, an explanation of the technical terms is given below the questionnaire item.

The structure and organisation of the school

Q1 Is your school a public or a private school?

(Please tick only one box.)

A public school

(This is a school managed directly or indirectly by a public education authority, government agency, or governing board appointed by government or elected by public franchise.)

A private school

(This is a school managed directly or indirectly by a non-government organisation; e.g. a church, trade union, business, or other private institution.)

Q2 About what percentage of your total funding for a typical school year comes from the following sources?

(Please write a number in each row. Write 0 (zero) if no funding comes from that source.)

- a) Government (includes departments, local, regional, state and national)
- b) Student fees or school charges paid by parents
- c) Benefactors, donations, bequests, sponsorships, parent fundraising
- d) Other

Total 100 %

Q3 Which of the following definitions best describes the community in which your school is located?

(Please tick only one box.)

A village, hamlet or rural area (fewer than 3 000 people) 1

A small town (3 000 to about 15 000 people) 2

A town (15 000 to about 100 000 people) 3

A city (100 000 to about 1 000 000 people) 4

A large city (with over 1 000 000 people) 5

We are interested in the options parents have when choosing a school for their children.

Q4 Which of the following statements best describes the schooling available to students in your location?

(Please tick only one box.)

There are two or more other schools in this area that compete for our students 1

There is one other school in this area that competes for our students 2

There are no other schools in this area that compete for our students 3

Q5 What is the average size of <test language> classes in <national modal grade for 15-year-olds> in your school?

(Please tick only one box.)

15 students or fewer 1

16-20 students 2

21-25 students 3

26-30 students 4

31-35 students 5

36-40 students 6

41-45 students 7

46-50 students 8

More than 50 students 9

Notes: <national modal grade for 15-year-olds> is the name of the grade attended by most 15-year-olds in the participating country or economy.

<test language> is replaced with the name of the language used in the PISA mathematics literacy test.

The student and teacher body

Q6 As at <month day, 2012>, what was the total school enrolment (number of students)?

(Please write a number on each line. Write 0 (zero) if there are none.)

a) Number of boys

b) Number of girls

Note: <month day, 2012> should be a date about one month before the data collection.

Q7 How many of the following teachers are on the staff of your school?

Include both full-time and part-time teachers. A full-time teacher is employed at least 90% of the time as a teacher for the full school year. All other teachers should be considered part-time.

(Please write a number in each space provided. Write 0 (zero) if there are none.)

Full-time Part-time

a) Teachers in TOTAL

b) Teachers fully certified by <the appropriate authority>

c) Teachers with an <ISCED 5A> qualification

Notes: <the appropriate authority> refers to the government agency which is empowered to certify that a person is permitted to work as a school teacher.

<ISCED 5A> refers to qualification obtained from a tertiary study programme with a strong theoretical foundation typically with a minimum duration

of three years' full time equivalent, providing entry into a profession with high skills requirements or an advanced research programme.

Q8 How many of the following are on the <mathematics staff> of your school?

Include both full-time and part-time teachers. A full-time teacher is employed at least 90% of the time as a teacher for the full school year. All other teachers should be considered part-time.

Please count only those teachers who have taught or will teach mathematics during the current school year.

(Please write a number in each space provided. Write 0 (zero) if there are none.)

Full-time Part-time

- a) Teachers of mathematics in TOTAL
- b) Teachers of mathematics with an <ISCED 5A> qualification
- c) Teachers of mathematics with an <ISCED 5A> qualification <with a major> in mathematics
- d) Teachers of mathematics with an <ISCED 5A> qualification in <pedagogy>
- e) Teachers of mathematics with an <ISCED 5B> but not an <ISCED 5A> qualification

Notes: For a definition of <ISCED 5A> see Q7.

<ISCED 5B> refers to qualification obtained in tertiary programmes that are generally more practical/technical/occupationally specific and typically shorter than ISCED 5A programmes. Typically, these programmes have a minimum of two years' full-time equivalent duration and prepare students to enter a particular occupation.

<with a major> refers to the focus of study in an undergraduate university degree. A major in mathematics is a complete sequence of mathematics in an ISCED 5A qualification.

The school's resources

The goal of the following set of three questions is to gather information about the student-computer ratio for students in the <national modal grade for 15-year-olds> at your school.

Q9a At your school, what is the total number of students in the <national modal grade for 15-year-olds>?

Q9b Approximately, how many computers are available for these students for educational purposes?

Q9c Approximately, how many of these computers are connected to the Internet/ World Wide Web?

Note: For a definition of <national modal grade for 15-year-olds> see Q5.

Q10 In all subjects taken together, for how much of the work does the school expect <national modal grade for 15-year-olds> students to access the Internet/ World Wide Web?

(Please tick only one box in each row.)

<10% 10-25% 26-50% 51-75% >75%

- a) Work during lessons 1 2 3 4 5
- b) Homework 1 2 3 4 5
- c) Assignments or projects 1 2 3 4 5

Note: For a definition of <national modal grade for 15-year-olds> see Q5.

Q11 Is your school's capacity to provide instruction hindered by any of the following issues?

(Please tick one box in each row.)

1-Not at all 2-Very little 3-To some extent 4-A lot

- a) A lack of qualified science teachers 1 2 3 4
- b) A lack of qualified mathematics teachers 1 2 3 4
- c) A lack of qualified <test language> teachers 1 2 3 4
- d) A lack of qualified teachers of other subjects 1 2 3 4
- e) Shortage or inadequacy of science laboratory equipment 1 2 3 4
- f) Shortage or inadequacy of instructional materials (e.g. textbooks) 1 2 3 4
- g) Shortage or inadequacy of computers for instruction 1 2 3 4

- h) Lack or inadequacy of Internet connectivity 1 2 3 4
 - i) Shortage or inadequacy of computer software for instruction 1 2 3 4
 - j) Shortage or inadequacy of library materials 1 2 3 4
 - k) Shortage or inadequacy of school buildings and grounds 1 2 3 4
 - l) Shortage or inadequacy of heating/cooling and lighting systems 1 2 3 4
 - m) Shortage or inadequacy of instructional space (e.g. classrooms) 1 2 3 4
- Note: For a definition of <test language> see Q5.

School instruction curriculum and assessment

Schools sometimes organise instruction differently for students with different abilities and interests in mathematics.

Q12 Which of the following options describe what your school does for <national modal grade for 15-year-olds> students in mathematics classes?

(Please tick one box in each row.)

1-For all classes 2-For some classes 3-Not for any classes

- a) Mathematics classes study similar content, but at different levels of difficulty 1 2 3
- b) Different classes study different content or sets of mathematics topics that have different levels of difficulty 1 2 3
- c) Students are grouped by ability within their mathematics classes 1 2 3
- d) In mathematics classes, teachers use pedagogy suitable for students with heterogeneous abilities (i.e. students are not grouped by ability) 1 2 3

Note: For a definition of <national modal grade for 15-year-olds> see Q5.

Q13 <This academic year>, which of the following activities does your school offer to students in the <national modal grade for 15-years-olds>?

(Please tick one box in each row.)

1-Yes 2-No

- a) Band, orchestra or choir 1 2
- b) School play or school musical 1 2
- c) School yearbook, newspaper or magazine 1 2
- d) Volunteering or service activities, e.g. <national examples> 1 2
- e) Mathematics club 1 2
- f) Mathematics competitions, e.g. <national examples> 1 2
- g) Chess club 1 2
- h) Club with a focus on computers/ Information and Communication Technology 1 2
- i) Art club or art activities 1 2
- j) Sporting team or sporting activities 1 2
- k) <country specific item> 1 2

Notes: <This academic year> refers to the year of schooling which is not necessarily the calendar year. For a definition of <national modal grade for 15-year-olds> see Q5.

Q14 In your school, are assessments of students in <national modal grade for 15-year-olds> used for any of the following purposes?

(Please tick one box in each row.)

1-Yes 2-No

- a) To inform parents about their child's progress 1 2
- b) To make decisions about students' retention or promotion 1 2

- c) To group students for instructional purposes 1 2
- d) To compare the school to <district or national> performance 1 2
- e) To monitor the school's progress from year to year 1 2
- f) To make judgements about teachers' effectiveness 1 2
- g) To identify aspects of instruction or the curriculum that could be improved 1 2
- h) To compare the school with other schools 1 2

Notes: For a definition of <**national modal grade for 15-year-olds**> see Q5.

<**district or national**> performance refers to comparison with a larger administrative region which could be the district, region, province and/or the country as a whole.

Q15 In your school, are achievement data used in any of the following <accountability procedures>?

*Achievement data include **aggregated** school or grade-level test scores or grades, or graduation rates. (Please tick one box in each row.)*

1-Yes 2-No

- a) Achievement data are posted publicly (e.g. in the media) 1 2
- b) Achievement data are tracked over time by an administrative authority 1 2

Note: <**accountability procedures**> means the regular use of school-level statistics on student achievement to report on the quality of the school functioning to parents or external authorities.

Q16 Does your school offer mathematics lessons in addition to the mathematics lessons offered during the usual school hours?

(Please tick only one box.)

Yes 1 *go to the next question*

No 2 *go to Q18*

Q17 What is the purpose of these additional mathematics lessons?

(Please tick only one box.)

<Enrichment mathematics> only 1

<Remedial mathematics> only 2

Both <enrichment mathematics> and <remedial mathematics> 3

Without differentiation depending on the prior achievement level of the students 4

Notes: <**Enrichment mathematics**> is mathematics offered outside of normal class time to extend/stimulate/challenge students who are of higher ability.

<**Remedial mathematics**> is mathematics offered outside of normal class time to help students who have fallen behind the performance level of their peers to catch up.

School climate

Q18 In your school, to what extent is the learning of students hindered by the following phenomena?

(Please tick one box in each row.)

1-Not at all 2-Very little 3-To some extent 4-A lot

- a) Student truancy 1 2 3 4
- b) Students skipping classes 1 2 3 4
- c) Students arriving late for school 1 2 3 4
- d) Students not attending compulsory school events (e.g. sports day) or excursions 1 2 3 4

- e) Students lacking respect for teachers 1 2 3 4
- f) Disruption of classes by students 1 2 3 4
- g) Student use of alcohol or illegal drugs 1 2 3 4
- h) Students intimidating or bullying other students 1 2 3 4
- i) Students not being encouraged to achieve their full potential 1 2 3 4
- j) Poor student-teacher relations 1 2 3 4
- k) Teachers having to teach students of heterogeneous ability levels within the same class 1 2 3 4
- l) Teachers having to teach students of diverse ethnic backgrounds (i.e. language, culture) within the same class 1 2 3 4
- m) Teachers' low expectations of students 1 2 3 4
- n) Teachers not meeting individual students' needs 1 2 3 4
- o) Teacher absenteeism 1 2 3 4
- p) Staff resisting change 1 2 3 4
- q) Teachers being too strict with students 1 2 3 4
- r) Teachers being late for classes 1 2 3 4
- s) Teachers not being well prepared for classes 1 2 3 4

Note: '**Student truancy**' is used differently in PISA 2012 and refers ONLY TO THE UNAUTHORISED failure to attend classes, whereas in previous cycles 'student absenteeism' included the unauthorised AND authorised (e.g. illness) absence of students from school.

Q19 During <the last academic year>, what proportion of students left your school without a <certificate or qualification that allows students to enter post-school destinations such as university, technical, further or vocational education, apprenticeships or employment>? %

Note: <the last academic year> refers to the previous year of schooling, not necessarily the previous calendar year.

Q20 Which statement below best characterises parental expectations towards your school?

(Please tick only one box.)

There is *constant pressure* from many parents, who expect our school to set very high academic standards and to have our students achieve them 1

Pressure on the school to achieve higher academic standards among students comes from a *minority of parents* 2

Pressure from parents on the school to achieve higher academic standards among students is *largely absent* 3

Q21 During <the last academic year>, what proportion of students' parents participated in the following school-related activities?

(Please write a number in each row. Write 0 (zero) if no parents participated in the activity. Write 100 (one hundred) if all parents participated in the activity.) %

- a) Discussed their child's behaviour with a teacher on their own initiative
- b) Discussed their child's behaviour on the initiative of one of their child's teachers
- c) Discussed their child's progress with a teacher on their own initiative
- d) Discussed their child's progress on the initiative of one of their child's teachers
- e) Volunteered in physical activities, e.g. building maintenance, carpentry, gardening or yard work
- f) Volunteered in extra-curricular activities, e.g. book club, school play, sports, field trip
- g) Volunteered in the school library or media centre
- h) Assisted a teacher in the school
- i) Appeared as a guest speaker
- j) Participated in local school <government>, e.g. parent council or school management committee
- k) Assisted in fundraising for the school
- l) Volunteered in the school <canteen>

Note: For a definition of <the last academic year> see Q19.

Q22 Think about the teachers in your school. How much do you agree with the following statements?

(Please tick one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) The morale of teachers in this school is high 1 2 3 4
- b) Teachers work with enthusiasm 1 2 3 4
- c) Teachers take pride in this school 1 2 3 4
- d) Teachers value academic achievement 1 2 3 4

Q23 How much do you agree with these statements about teachers in your school?

(Please tick one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) Mathematics teachers are interested in trying new methods and teaching practices 1 2 3 4
- b) There is a preference among mathematics teachers to stay with wellknown methods and practices 1 2 3 4

Q24 How much do you agree with these statements about teachers in your school?

(Please tick one box in each row.)

- c) There is consensus among mathematics teachers that academic achievement must be kept as high as possible 1 2 3 4
- d) There is consensus among mathematics teachers that it is best to adapt academic standards to the students' levels and needs 1 2 3 4

Q25 How much do you agree with these statements about teachers in your school?

(Please tick one box in each row.)

- e) There is consensus among mathematics teachers that the social and emotional development of the students is as important as their acquisition of mathematical skills and knowledge in mathematics classes 1 2 3 4
- f) There is consensus among mathematics teachers that the development of mathematical skills and knowledge in students is the most important objective in mathematics classes 1 2 3 4

Q26 During the last year, have any of the following methods been used to monitor the practice of mathematics teachers at your school?

(Please tick one box in each row.)

1-Yes 2-No

- a) Tests or assessments of student achievement 1 2
- b) Teacher peer review (of lesson plans, assessment instruments, lessons) 1 2
- c) Principal or senior staff observations of lessons 1 2
- d) Observation of classes by inspectors or other persons external to the school 1 2

Q27 To what extent have appraisals of and/or feedback to teachers directly led to the following?

(Please tick one box in each row.)

1-No change 2-A small change 3-A moderate change 4-A large change

- a) A change in salary 1 2 3 4
- b) A financial bonus or another kind of monetary reward 1 2 3 4
- c) Opportunities for professional development activities 1 2 3 4
- d) A change in the likelihood of career advancement 1 2 3 4
- e) Public recognition from you 1 2 3 4
- f) Changes in work responsibilities that make the job more attractive 1 2 3 4

g) A role in school development initiatives (e.g. curriculum development group, development of school objectives) 1 2 3 4

Q28 How often are the following factors considered when students are admitted to your school?

(Please tick one box in each row.)

1-Never 2-Sometimes 3-Always

- a) Student's record of academic performance (including placement tests) 1 2 3
- b) Recommendation of feeder schools 1 2 3
- c) Parents' endorsement of the instructional or religious philosophy of the school 1 2 3
- d) Whether the student requires or is interested in a special programme 1 2 3
- e) Preference given to family members of current or former students 1 2 3
- f) Residence in a particular area 1 2 3
- g) Other 1 2 3

Q29 Regarding your school, who has a considerable responsibility for the following tasks?

(Please tick as many boxes as appropriate in each row.)

Principal Teachers

1-<School governing board> 2-<Regional or local education authority> 3-National education authority

- a) Selecting teachers for hire 1 2 3 4 5
- b) Firing teachers 1 2 3 4 5
- c) Establishing teachers' starting salaries 1 2 3 4 5
- d) Determining teachers' salary increases 1 2 3 4 5
- e) Formulating the school budget 1 2 3 4 5
- f) Deciding on budget allocations within the school 1 2 3 4 5
- g) Establishing student disciplinary policies 1 2 3 4 5
- h) Establishing student assessment policies 1 2 3 4 5
- i) Approving students for admission to the school 1 2 3 4 5
- j) Choosing which textbooks are used 1 2 3 4 5
- k) Determining course content 1 2 3 4 5
- l) Deciding which courses are offered 1 2 3 4 5

Notes: <**school governing board**> is a board directly responsible for the governance of the school. This board may be totally external to the school or may have staff and student representation.

<**Regional or local education authority**> is an authority that is not a national authority and does not directly govern the school.

Q30 Below are statements about your management of this school. Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>.

(Please tick only one box in each row.)

1-Did not occur 2-1-2 times during the year 3-3-4 times during the year
4-Once a month 5-Once a week 6-More than once a week

- a) I work to enhance the school's reputation in the community 1 2 3 4 5 6
- b) I use student performance results to develop the school's educational goals 1 2 3 4 5 6
- c) I make sure that the professional development activities of teachers are in accordance with the teaching goals of the school 1 2 3 4 5 6
- d) I ensure that teachers work according to the school's educational goals 1 2 3 4 5 6
- e) I promote teaching practices based on recent educational research 1 2 3 4 5 6
- f) I praise teachers whose students are actively participating in learning 1 2 3 4 5 6
- g) When a teacher has problems in his/her classroom, I take the initiative to discuss matters 1 2 3 4 5 6
- h) I draw teachers' attention to the importance of pupils' development of critical and social capacities 1 2 3 4 5 6

- i) I pay attention to disruptive behaviour in classrooms 1 2 3 4 5 6
 - j) I provide staff with opportunities to participate in school decision-making 1 2 3 4 5 6
 - k) I engage teachers to help build a school culture of continuous improvement 1 2 3 4 5 6
 - l) I ask teachers to participate in reviewing management practices 1 2 3 4 5 6
 - m) When a teacher brings up a classroom problem, we solve the problem together 1 2 3 4 5 6
 - n) I discuss the school's academic goals with teachers at faculty meetings 1 2 3 4 5 6
 - o) I refer to the school's academic goals when making curricular decisions with teachers 1 2 3 4 5 6
 - p) I discuss academic performance results with the faculty to identify curricular strengths and weaknesses 1 2 3 4 5 6
 - q) I lead or attend in-service activities concerned with instruction 1 2 3 4 5 6
 - r) I set aside time at faculty meetings for teachers to share ideas or information from in-service activities 1 2 3 4 5 6
 - s) I conduct informal observations in classrooms on a regular basis (informal observations are unscheduled, last at least 5 minutes, and may or may not involve written feedback or a formal conference) 1 2 3 4 5 6
 - t) I review work produced by students when evaluating classroom instruction 1 2 3 4 5 6
 - u) I evaluate the performance of staff 1 2 3 4 5 6
- Note: For a definition of <the last academic year> see Q19.

Q31 During the last three months, what percentage of teaching staff in your school has attended a programme of professional development with a focus on mathematics?

A programme of professional development here is a formal programme designed to enhance teaching skills or pedagogical practices. It may or may not lead to a recognised qualification. The programme must last for at least one day in total and have a focus on mathematics teaching and education. %

- a) All staff at your school
- b) Staff who teach mathematics at your school

Q32 Which of the following measures aimed at quality assurance and improvement do you have in your school?

(Please tick one box in each row.)

1-Yes 2-No

- a) Written specification of the school's curricular profile and educational goals 1 2
- b) Written specification of student performance standards 1 2
- c) Systematic recording of data including teacher and student attendance and graduation rates, test results and professional development of teachers 1 2
- d) Internal evaluation/self-evaluation 1 2
- e) External evaluation 1 2
- f) Seeking written feed-back from students (e.g. regarding lessons, teachers or resources) 1 2
- g) Teacher mentoring 1 2
- h) Regular consultation aimed at school improvement with one or more experts over a period of at least six months 1 2
- i) Implementation of a standardised policy for mathematics (i.e. school curriculum with shared instructional materials accompanied by staff development and training) 1 2

Q33 Which of the following statements apply in your school?

A policy refers to written rules known to those concerned with the policy.

(Please tick one box in each row.)

1-Yes 2-No

- a) The school has a policy on how to use computers in mathematics instruction (e.g. amount of computer use in mathematics lessons, use of specific mathematics computer programs) 1 2
- b) All <national modal grade for 15-year-olds> mathematics classes in the school use the same

textbook 1 2

c) Mathematics teachers in the school follow a standardised curriculum that specifies content at least on a monthly basis 1 2

Note: For a definition of <national modal grade for 15-year-olds> see Q5.

Q34 In your school, how likely is it that a student in <national modal grade for 15-year-olds> would be transferred to another school for the following reasons?

(Please tick one box in each row.)

1-Not likely 2-Likely 3-Very likely

a) Low academic achievement 1 2 3

b) High academic achievement 1 2 3

c) Behavioural problems 1 2 3

d) Special learning needs 1 2 3

e) Parents' or guardians' request 1 2 3

f) Other 1 2 3

Note: For a definition of <national modal grade for 15-year-olds> see Q5.

APPENDIX B

STUDENT QUESTIONNAIRE

The student questionnaire is administered after the literacy assessment and takes students about 30 minutes to complete. The core questions on home background are similar to those used in the previous PISA assessments. The questionnaire covers the following aspects:

- Student characteristics and educational career
- Family context and home resources
- Learning mathematics
- Experience with different kinds of mathematics problems at school
- Mathematics experiences
- Classroom and school climate
- Problem solving experiences

Technical terms are given in <brackets> and are adapted to the national context by the national data collection centre of the participating country or economy. In this annex, an explanation of the technical terms is given below the questionnaire item.

Student characteristics and educational career

Q1 What <grade> are you in?

Grade

Note: <Grade> refers to the administrative level of the student in the school. In many countries the number of years in schooling is the usual measure of grade.

Q2 Which one of the following <programmes> are you in?

(Please tick only one box.)

- <Programme 1> 1
- <Programme 2> 2
- <Programme 3> 3
- <Programme 4> 4
- <Programme 5> 5
- <Programme 6> 6

Q3 On what date were you born?

(Please write the day, month and year you were born.)

19

Day Month Year

Q4 Are you female or male?

Female 1

Male 2

Q5 Did you attend <ISCED 0>?

No 1

Yes, for one year or less 2

Yes, for more than one year 3

Note: <ISCED 0> refers to pre-primary education defined as the initial stage of organised instruction designed primarily to introduce very young children to a school-type environment. Instruction is school-based or centre-based, typically for children between 3 and 6 years.

Q6 How old were you when you started <ISCED 1>?

Years

Note: <ISCED 1> refers to primary education which begins between age 5 and 7 and generally lasts 4 years (e.g. Germany) to 6 years (mode of OECD countries). Primary education is designed to provide a sound basic education in reading, writing and mathematics along with an elementary understanding of other subjects.

Q7 Have you ever repeated a <grade>?

(Please tick only one box in each row.)

1-No, never 2-Yes, once 3-Yes, twice or more

a) At <ISCED 1> 1 2 3

b) At <ISCED 2> 1 2 3

c) At <ISCED 3> 1 2 3

Notes: For a definition of <Grade> see Q1.

For a definition of <ISCED 1> level, see Q6.

<ISCED 2> refers to lower secondary level of education. Programmes at the start of level 2 should correspond to the point where programmes are beginning to be organised in a more subject-oriented pattern, using more specialised teachers conducting classes in their field of specialisation.

<ISCED 3> refers to upper secondary level of education. The final stage of secondary education in most OECD countries. Instruction is often more organised along subject-matter lines than at ISCED 2 and teachers typically need to have a higher level, or more subject-specific, qualification than at ISCED 2.

<ISCED 3A> is designed to provide direct access to ISCED 5A. <ISCED 3B> is designed to provide direct access to ISCED 5B. <ISCED 3C> is not designed to lead directly to ISCED 5A or 5B. These programmes lead directly to labour market, ISCED 4 programmes or other ISCED 3 programmes.

Q8 In the last two full weeks of school, how many times did you arrive late for school?

(Please tick only one box.)

None 1

One or two times 2

Three or four times 3

Five or more times 4

Q9 In the last two full weeks of school, how many times did you <skip> a whole school day?

(Please tick only one box.)

None 1

One or two times 2

Three or four times 3

Five or more times 4

Note: <Skip> refers to unauthorised failure to attend classes.

Q10 In the last two full weeks of school, how many times did you <skip> some classes?*(Please tick only one box.)*

None 1

One or two times 2

Three or four times 3

Five or more times 4

Note: For a definition of <Skip> see Q9.

Family context and home resources**Q11 Who usually lives at <home> with you?***(Please tick one box in each row.)***1-Yes 2-No**

a) Mother (including stepmother or foster mother) 1 2

b) Father (including stepfather or foster father) 1 2

c) Brother(s) (including stepbrothers) 1 2

d) Sister(s) (including stepsisters) 1 2

e) Grandparent(s) 1 2

f) Others (e.g. cousin) 1 2

Q12a What is your mother's main job?*(e.g. school teacher, kitchen-hand, sales manager)**(If she is not working now, please tell us her last main job.)**Please write in the job title:***Q12b What does your mother do in her main job?***(e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team)**Please use a sentence to describe the kind of work she does or did in that job:***Q13 What is the <highest level of schooling> completed by your mother?***If you are not sure which box to choose, please ask the <test administrator> for help.**(Please tick only one box.)*

<ISCED 3A> 1

<ISCED 3B, 3C> 2

<ISCED 2> 3

<ISCED 1> 4

She did not complete <ISCED 1> 5

Notes: For a definition of <ISCED 1> see Q6.

For a definition of <ISCED 2> and <ISCED 3> see Q7.

<Highest level of schooling> - should be adapted to refer to the sections of schooling that correspond to <ISCED 1> to <ISCED 3> levels.

Q14 Does your mother have any of the following qualifications?*If you are not sure how to answer this question, please ask the <test administrator> for help.**(Please tick one box in each row.)***1-Yes 2-No**

a) <ISCED 6> 1 2

b) <ISCED 5A> 1 2

c) <ISCED 5B> 1 2

d) <ISCED 4> 1 2

Notes: <ISCED 6> refers to advanced research qualification, devoted to advanced study and original research, requiring submission of a thesis or dissertation of publishable quality.

<ISCED 5A> refers to qualification obtained from a tertiary study programme with a strong theoretical foundation *typically* with a minimum duration of three years' full time equivalent, providing entry into a profession with high skills requirements or an advanced research programme.

<ISCED 5B> refers to qualification obtained in tertiary programmes that are generally more practical/technical/occupationally specific and typically shorter than ISCED 5A programmes. Typically, these programmes have a minimum of two years' full-time equivalent duration and prepare students to enter a particular occupation.

<ISCED 4> refers to qualification obtained in programmes that overlap the boundary between upper-secondary and post-secondary education. They are typically not significantly more advanced than programmes at ISCED 3 (see Q7) and have a full-time equivalent duration of between 6 months and 2 years.

Q15 What is your mother currently doing?

(Please tick only one box.)

Working full-time <for pay> 1

Working part-time <for pay> 2

Not working, but looking for a job 3

Other (e.g. home duties, retired) 4

Q16a What is your father's main job?

(e.g. school teacher, kitchen-hand, sales manager)

(If she is not working now, please tell us her last main job.)

Please write in the job title:

Q16b What does your father do in his main job?

(e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team)

Please use a sentence to describe the kind of work he does or did in that job:

Q17 What is the <highest level of schooling> completed by your father?

If you are not sure how to answer this question, please ask the <test administrator> for help.

(Please tick only one box.)

<ISCED 3A> 1

<ISCED 3B, 3C> 2

<ISCED 2> 3

<ISCED 1> 4

He did not complete <ISCED 1> 5

Notes: For a definition of <ISCED 1> see Q6.

For a definition of <ISCED 2> and <ISCED 3> see Q7.

For a definition of <Highest level of schooling> see Q13.

Q18 Does your father have any of the following qualifications?

If you are not sure which box to choose, please ask the <test administrator> for help.

(Please tick one box in each row.)

1-Yes 2-No

a) <ISCED 6> 1 2

b) <ISCED 5A> 1 2

c) <ISCED 5B> 1 2

d) <ISCED 4> 1 2

Note: For a definition of <ISCED 4> to <ISCED 6> levels see Q14.

Q19 What is your father currently doing?

(Please tick only one box.)

- Working full-time <for pay> 1
- Working part-time <for pay> 2
- Not working, but looking for a job 3
- Other (e.g. home duties, retired) 4

Q20 In what country were you and your parents born?

(Please tick one box in each column.)

You Mother Father

<Country A> 1 1 1

<Country B> 2 2 2

<Country C> 3 3 3

<Country D> 4 4 4

<...etc.> 5 5 5

Other country 6 6 6

Note: Usually <Country A> is the country of the test. The final variable is usually ‘Other country’. Between these two variables, each country or economy may choose certain countries of origin for this question.

Q21 If you were NOT born in <country of test>, how old were you when you arrived in <country of test>?

If you were less than 12 months old, please write zero (0).

If you were born in <country of test> please skip this question and go to Q22.

Q22 What language do you speak at home most of the time?

(Please tick only one box.)

<Language 1> 1

<Language 2> 2

<Language 3> 3

<...etc.> 4

Other language 5

Q23 Which of the following are in your home?

(Please tick one box in each row.)

1-Yes 2-No

- a) A desk to study at 1 2
- b) A room of your own 1 2
- c) A quiet place to study 1 2
- d) A computer you can use for school work 1 2
- e) Educational software 1 2
- f) A link to the Internet 1 2
- g) Classic literature (e.g. <Shakespeare>) 1 2
- h) Books of poetry 1 2
- i) Works of art (e.g. paintings) 1 2
- j) Books to help with your school work 1 2
- k) <Technical reference books> 1 2
- l) A dictionary 1 2
- m) A dishwasher 1 2

- n) A <DVD> player 1 2
 o) <Country-specific wealth item 1> 1 2
 p) <Country-specific wealth item 2> 1 2
 q) <Country-specific wealth item 3> 1 2

Q24 How many of these are there at your home?

(Please tick only one box in each row.)

1-None 2-One 3-Two 4-Three or more

- a) Cellular phones 1 2 3 4
 b) Televisions 1 2 3 4
 c) Computers 1 2 3 4
 d) Cars 1 2 3 4
 e) Rooms with a bath or shower 1 2 3 4

Q25 How many books are there in your home?

There are usually about 40 books per metre of shelving. Do not include magazines, newspapers, or your schoolbooks.

(Please tick only one box.)

- 0-10 books 1
 11-25 books 2
 26-100 books 3
 101-200 books 4
 201-500 books 5
 More than 500 books 6

Learning mathematics

Q26 Thinking about your views on mathematics: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) I enjoy reading about mathematics 1 2 3 4
 b) Making an effort in mathematics is worth it because it will help me in the work that I want to do later on 1 2 3 4
 c) I look forward to my mathematics lessons 1 2 3 4
 d) I do mathematics because I enjoy it 1 2 3 4
 e) Learning mathematics is worthwhile for me because it will improve my career <prospects, chances> 1 2 3 4
 f) I am interested in the things I learn in mathematics 1 2 3 4
 g) Mathematics is an important subject for me because I need it for what I want to study later on 1 2 3 4
 h) I will learn many things in mathematics that will help me get a job 1 2 3 4

Q27 Thinking about how people important to you view mathematics: how strongly do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) Most of my friends do well in mathematics 1 2 3 4
 b) Most of my friends work hard at mathematics 1 2 3 4
 c) My friends enjoy taking mathematics tests 1 2 3 4
 d) My parents believe it's important for me to study mathematics 1 2 3 4

- e) My parents believe that mathematics is important for my career 1 2 3 4
 f) My parents like mathematics 1 2 3 4

Q28 How confident do you feel about having to do the following mathematics tasks?

(Please tick only one box in each row.)

1-Very confident 2-Confident 3-Not very confident 4-Not at all confident

- a) Using a <train timetable> to work out how long it would take to get from one place to another 1 2 3 4
 b) Calculating how much cheaper a TV would be after a 30% discount 1 2 3 4
 c) Calculating how many square metres of tiles you need to cover a floor 1 2 3 4
 d) Understanding graphs presented in newspapers 1 2 3 4
 e) Solving an equation like $3x+5=17$ 1 2 3 4
 f) Finding the actual distance between two places on a map with a 1:10,000 scale 1 2 3 4
 g) Solving an equation like $2(x+3) = (x+3)(x-3)$ 1 2 3 4
 h) Calculating the petrol consumption rate of a car 1 2 3 4

Q29 Thinking about studying mathematics: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) I often worry that it will be difficult for me in mathematics classes 1 2 3 4
 b) I am just not good at mathematics 1 2 3 4
 c) I get very tense when I have to do mathematics homework 1 2 3 4
 d) I get good <grades> in mathematics 1 2 3 4
 e) I get very nervous doing mathematics problems 1 2 3 4
 f) I learn mathematics quickly 1 2 3 4
 g) I have always believed that mathematics is one of my best subjects 1 2 3 4
 h) I feel helpless when doing a mathematics problem 1 2 3 4
 i) In my mathematics class, I understand even the most difficult work 1 2 3 4
 j) I worry that I will get poor <grades> in mathematics 1 2 3 4

Note: <Grades> refers to the teacher's standardised evaluation of student performance in a course or subject and should be adapted to the national context.

Q30 Thinking about your mathematics lessons: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) If I put in enough effort I can succeed in mathematics 1 2 3 4
 b) Whether or not I do well in mathematics is completely up to me 1 2 3 4
 c) Family demands or other problems prevent me from putting a lot of time into my mathematics work 1 2 3 4
 d) If I had different teachers, I would try harder in mathematics 1 2 3 4
 e) If I wanted to, I could do well in mathematics 1 2 3 4
 f) I do badly in mathematics whether or not I study for my exams 1 2 3 4

Suppose that you are a student in the following situation:

Each week, your mathematics teacher gives a short quiz. Recently you have done badly on these quizzes.

Today you are

trying to figure out why.

Q31 How likely are you to have these thoughts or feelings in this situation?

(Please tick only one box in each row.)

1-Very likely 2-Likely 3-Slightly likely 4-Not at all likely

- a) I'm not very good at solving mathematics problems 1 2 3 4
- b) My teacher did not explain the concepts well this week 1 2 3 4
- c) This week I made bad guesses on the quiz 1 2 3 4
- d) Sometimes the course material is too hard 1 2 3 4
- e) The teacher did not get students interested in the material 1 2 3 4
- f) Sometimes I am just unlucky 1 2 3 4

Q32 Thinking about the mathematics you do for school: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) I finish my homework in time for mathematics class 1 2 3 4
- b) I work hard on my mathematics homework 1 2 3 4
- c) I am prepared for my mathematics exams 1 2 3 4
- d) I study hard for mathematics quizzes 1 2 3 4
- e) I keep studying until I understand mathematics material 1 2 3 4
- f) I pay attention in mathematics class 1 2 3 4
- g) I listen in mathematics class 1 2 3 4
- h) I avoid distractions when I am studying mathematics 1 2 3 4
- i) I keep my mathematics work well organised 1 2 3 4

Q33 For each pair of statements, please choose the item that best describes you.

(Please tick only one of the following two boxes.)

- a)
 - I intend to take additional mathematics courses after school finishes 1
 - I intend to take additional <test language> courses after school finishes 2
- b)
 - I plan on majoring in a subject in <college> that requires mathematics skills 1
 - I plan on majoring in a subject in <college> that requires <science> skills 2
- c)
 - I am willing to study harder in my mathematics classes than is required 1
 - I am willing to study harder in my <test language> classes than is required 2
- d)
 - I plan on <taking> as many mathematics classes as I can during my education 1
 - I plan on <taking> as many <science> classes as I can during my education 2
- e)
 - I am planning on pursuing a career that involves a lot of mathematics 1
 - I am planning on pursuing a career that involves a lot of <science> 2

Notes: <Test language> refers to the language of instruction in which the PISA reading assessment is administered. In some countries <test language> may be taught in different school subjects, e.g. English language and English literature. If this is the case, <test language> must be adapted accordingly.

<Science> refers only to the core science subjects of physics, chemistry, Earth science and biology either taught in the country's curriculum as separate science subjects, or taught within a single 'integrated-science' subject. The term does not include related subjects such as engineering, technology, mathematics, psychology, economics, nor possible Earth science topics included in geography courses. In many countries this term has been adapted to the national context.

<College> refers to university level or tertiary education and should be adapted to the national context.

<Take> refers to students who have the option of selecting additional elective courses in school. For countries with a mandatory curriculum that does not allow any choices or options, this item should be adapted to the national context.

Q34 How often do you do the following things at school and outside of school?*(Please tick only one box in each row.)***1-Always or almost always 2-Often 3-Sometimes 4-Never or rarely**

- a) I talk about mathematics problems with my friends 1 2 3 4
- b) I help my friends with mathematics 1 2 3 4
- c) I do mathematics as an <extracurricular> activity 1 2 3 4
- d) I take part in mathematics competitions 1 2 3 4
- e) I do mathematics more than 2 hours a day outside of school 1 2 3 4
- f) I play chess 1 2 3 4
- g) I program computers 1 2 3 4
- h) I participate in a mathematics club 1 2 3 4

Note: <Extracurricular> refers to activities performed by students that fall outside the realm of the normal curriculum of school education.

Q35 For each group of three items, please choose the item that best describes your approach to mathematics*(Please tick only one of the following three boxes.)*

- a)
 - When I study for a mathematics test, I try to work out what the most important parts to learn are 1
 - When I study for a mathematics test, I try to understand new concepts by relating them to things I already know 2
 - When I study for a mathematics test, I learn as much as I can off by heart 3
- b)
 - When I study mathematics, I try to figure out which concepts I still have not understood properly 1
 - When I study mathematics, I think of new ways to get the answer 2
 - When I study mathematics, I make myself check to see if I remember the work I have already done 3
- c)
 - When I study mathematics, I try to relate the work to things I have learnt in other subjects 1
 - When I study mathematics, I start by working out exactly what I need to learn 2
 - When I study mathematics, I go over some problems so often that I feel as if I could solve them in my sleep 3
- d)
 - In order to remember the method for solving a mathematics problem, I go through examples again and again 1
 - I think about how the mathematics I have learnt can be used in everyday life 2
 - When I cannot understand something in mathematics, I always search for more information to clarify the problem 3

Q36 How many hours do you typically spend per week attending <out-of-school-time lessons> in the following subjects?

These are only lessons in subjects that you are also learning at school, which you spend learning extra time on outside of normal school hours. The lessons may be given at your school, at your home or somewhere else.

*(Please tick only one box in each row.)***1-I do not attend <out-of-school-time lessons> in this subject****2-Less than 2 hours a week****3-2 or more but less than 4 hours a week****4-4 or more but less than 6 hours a week****5-6 or more hours a week**

- a) <Test language> 1 2 3 4 5
- b) Mathematics 1 2 3 4 5

- c) <Science> 1 2 3 4 5
 d) Other Subjects 1 2 3 4 5

Notes: <Out-of-school-time lessons> refers to any lessons in the student's school subjects that he or she spends extra time learning outside of normal school hours. The lessons might be held at school, at home, or elsewhere.
 For a definition of <test language> and <science> see Q33.

Q37 Thinking about all school subjects: on average, how many hours do you spend each week on the following?

When answering, include time spent on the weekend too.

Hours per week

- a) Homework or other study set by your teachers
 b) Out of the time spent in (a), how many hours do you work on your homework with somebody overlooking and providing help if necessary ("guided homework"), either at school or elsewhere?
 c) Work with a personal <tutor> (whether paid or not)
 d) Attend <out of school> classes organised by a commercial company, and paid for by your parents
 e) Study with a parent or other family member
 f) Repeat and train content from school lessons by working on a computer (e.g. learn vocabulary with training software)

Note: <Out of school> refers to any classes in the student's school subjects that he or she spends extra time learning outside of normal school hours.
 The lessons might be held at school, at home, or elsewhere.

Q38 How often have you encountered the following types of mathematics tasks during your time at school?

(Please tick only one box on each row.)

1-Frequently 2-Sometimes 3-Rarely 4-Never

- a) Working out from a <train timetable> how long it would take to get from one place to another 1 2 3 4
 b) Calculating how much more expensive a computer would be after adding tax 1 2 3 4
 c) Calculating how many square metres of tiles you need to cover a floor 1 2 3 4
 d) Understanding scientific tables presented in an article 1 2 3 4
 e) Solving an equation like $6x^2 + 5 = 29$ 1 2 3 4
 f) Finding the actual distance between two places on a map with a 1:10,000 scale 1 2 3 4
 g) Solving an equation like $2(x+3) = (x+3)(x-3)$ 1 2 3 4
 h) Calculating the power consumption of an electronic appliance per week 1 2 3 4
 i) Solving an equation like $3x+5=17$ 1 2 3 4

Q39 Thinking about mathematical concepts: how familiar are you with the following terms?

(Please tick only one box in each row.)

**1-Never heard of it 2-Heard of it once or twice 3-Heard of it a few times
 4-Heard of it often 5-Know it well, understand the concept**

- a) Exponential Function 1 2 3 4 5
 b) Divisor 1 2 3 4 5
 c) Quadratic Function 1 2 3 4 5
 d) <Proper Number> 1 2 3 4 5
 e) Linear Equation 1 2 3 4 5

- f) Vectors 1 2 3 4 5
- g) Complex Number 1 2 3 4 5
- h) Rational Number 1 2 3 4 5
- i) Radicals 1 2 3 4 5
- j) <Subjunctive Scaling> 1 2 3 4 5
- k) Polygon 1 2 3 4 5
- l) <Declarative Fraction> 1 2 3 4 5
- m) Congruent Figure 1 2 3 4 5
- n) Cosine 1 2 3 4 5
- o) Arithmetic Mean 1 2 3 4 5
- p) Probability 1 2 3 4 5

Q40 How many minutes, on average, are there in a <class period> for the following subjects?

Minutes

- a) Minutes in a <class period> in <test language>
- b) Minutes in a <class period> in mathematics
- c) Minutes in a <class period> in <science>

Notes: <Class period> refers to the length of time each lesson runs for in a normal school week.
For a definition of <test language> and <science> see Q33.

Q41 How many <class periods> per week do you typically have for the following subjects?

<class periods>

- a) Number of <class periods> per week in <test language>
- b) Number of <class periods> per week in mathematics
- c) Number of <class periods> per week in <science>

Notes: For a definition of <class period> see Q40.
For a definition of <test language> and <science> see Q33.

Q42 In a normal, full week at school, how many <class periods> do you have <in total>?

<class periods>

Number of ALL <class periods>

Note: For a definition of <class period> see Q40.

Q43 On average, about how many students attend your <test language> class?

Students

Note: For a definition of <test language> see Q33.

Experience with different kinds of mathematics problems at school

In the box is a series of problems. Each requires you to understand a problem written in text and perform the appropriate calculations. Usually the problem talks about practical situations, but the numbers and people and places mentioned are made up. All the information you need is given. Here are two examples:

1) <Ann> is two years older than <Betty> and <Betty> is four times as old as <Sam>. When <Betty> is 30, how old is <Sam>?

2) Mr <Smith> bought a television and a bed. The television cost <\$625> but he got a 10% discount. The bed cost <\$200>.

He paid <\$20> for delivery. How much money did Mr <Smith> spend?

Q44 We want to know about your experience with these types of word problems at school.

Do not solve them!

(Please tick only one box in each row.)

1-Frequently 2-Sometimes 3-Rarely 4-Never

- a) How often have you encountered these types of problems in your **mathematics lessons**? 1 2 3 4
 b) How often have you encountered these types of problems in the **tests you have taken at school**? 1 2 3 4

Below are examples of another set of mathematical skills.

- 1) Solve $2x + 3 = 7$.
 2) Find the volume of a box with sides $3m$, $4m$ and $5m$.

Q45 We want to know about your experience with these types of word problems at school. Do not solve them!

(Please tick only one box in each row.)

1-Frequently 2-Sometimes 3-Rarely 4-Never

- a) How often have you encountered these types of problems in your **mathematics lessons**? 1 2 3 4
 b) How often have you encountered these types of problems in the **tests you have taken at school**? 1 2 3 4

In the next type of problem, you have to use mathematical knowledge and draw conclusions. There is no practical application provided. Here are two examples.

1) Here you need to use geometrical theorems:

2 cm

12 cm

Determine the height of the pyramid

2 cm

A

D

B

S

C

2) Here you have to know what a prime number is:

If n is any number: can $(n+1)^2$ be a prime number?

Q46 We want to know about your experience with these types of problems at school. Do not solve them!

Do not solve them!

(Please tick only one box in each row.)

1-Frequently 2-Sometimes 3-Rarely 4-Never

- a) How often have you encountered these types of problems in your **mathematics lessons**? 1 2 3 4
 b) How often have you encountered these types of problems in the **tests you have taken at school**? 1 2 3 4

In this type of problem, you have to apply suitable mathematical knowledge to find a useful answer to a problem that arises in everyday life or work. The data and information are about real situations. Here are two examples.

Example 1:

A TV reporter says "This graph shows that there is a huge increase in the number of robberies from 1998 to 1999."

Do you consider the reporter's statement to be a reasonable interpretation of the graph?

Give an explanation to support your answer.

Number of robberies per year

Year 1998

Year 1999

505

510

515

520

Example 2:

For years the relationship between a person's recommended maximum heart rate and the person's age was described by the following formula:

Recommended maximum heart rate = 220 - age

Recent research showed that this formula should be modified slightly. The new formula is as follows:

Recommended maximum heart rate = 208 - (0.7 × age)

From which age onwards does the recommended maximum heart rate increase as a result of the introduction of the new formula? Show your work.

Q47 We want to know about your experience with these types of problems at school.

Do not solve them!

(Please tick only one box in each row.)

1-Frequently 2-Sometimes 3-Rarely 4-Never

a) How often have you encountered these types of problems in your **mathematics lessons**? 1 2 3 4

b) How often have you encountered these types of problems in the **tests you have taken at school**? 1 2 3 4

Mathematics experiences

Q48 How often do these things happen in your mathematics lessons?

(Please tick only one box in each row.)

1-Every lesson 2-Most lessons 3-Some lessons 4-Never or hardly ever

a) The teacher shows an interest in every student's learning 1 2 3 4

b) The teacher gives extra help when students need it 1 2 3 4

c) The teacher helps students with their learning 1 2 3 4

d) The teacher continues teaching until the students understand 1 2 3 4

e) The teacher gives students an opportunity to express opinions 1 2 3 4

Q49 How often do these things happen in your mathematics lessons?

(Please tick only one box in each row.)

1-Every lesson 2-Most lessons 3-Some lessons 4-Never or hardly ever

a) The teacher sets clear goals for our learning 1 2 3 4

b) The teacher asks me or my classmates to present our thinking or reasoning at some length 1 2 3 4

c) The teacher gives different work to classmates who have difficulties learning and/or to those who can advance faster 1 2 3 4

d) The teacher assigns projects that require at least one week to complete 1 2 3 4

e) The teacher tells me about how well I am doing in my mathematics class 1 2 3 4

f) The teacher asks questions to check whether we have understood what was taught 1 2 3 4

g) The teacher has us work in small groups to come up with joint solutions to a problem or task 1 2 3 4

h) At the beginning of a lesson, the teacher presents a short summary of the previous lesson 1 2 3 4

i) The teacher asks us to help plan classroom activities or topics 1 2 3 4

j) The teacher gives me feedback on my strengths and weaknesses in mathematics 1 2 3 4

k) The teacher tells us what is expected of us when we get a test, quiz or assignment 1 2 3 4

l) The teacher tells us what we have to learn 1 2 3 4

m) The teacher tells me what I need to do to become better in mathematics 1 2 3 4

Q50 Thinking about the mathematics teacher that taught your last mathematics class:

How often does each of the following happen?

(Please tick only one box in each row.)

1-Always or almost always 2-Often 3-Sometimes 4-Never or rarely

a) The teacher asks questions that make us reflect on the problem 1 2 3 4

b) The teacher gives problems that require us to think for an extended time 1 2 3 4

- c) The teacher asks us to decide on our own procedures for solving complex problems 1 2 3 4
- d) The teacher presents problems for which there is no immediately obvious method of solution 1 2 3 4
- e) The teacher presents problems in different contexts so that students know whether they have understood the concepts 1 2 3 4
- f) The teacher helps us to learn from mistakes we have made 1 2 3 4
- g) The teacher asks us to explain how we have solved a problem 1 2 3 4
- h) The teacher presents problems that require students to apply what they have learnt to new contexts 1 2 3 4
- i) The teacher gives problems that can be solved in several different ways 1 2 3 4

Q51 How often do these things happen in your mathematics lessons?

(Please tick only one box in each row.)

1-Every lesson 2-Most lessons 3-Some lessons 4-Never or hardly ever

- a) Students don't listen to what the teacher says 1 2 3 4
- b) There is noise and disorder 1 2 3 4
- c) The teacher has to wait a long time for students to <quiet down> 1 2 3 4
- d) Students cannot work well 1 2 3 4
- e) Students don't start working for a long time after the lesson begins 1 2 3 4

Q52 Below you will find descriptions of three mathematics teachers. Read each of the descriptions of these teachers, then let us know to what extent you agree with the final statement.

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) Ms. <name> sets mathematics homework every other day. She always gets the answers back to students before examinations

Ms. <name> is concerned about her students' learning 1 2 3 4

- b) Mr. <name> sets mathematics homework once a week. He always gets the answers back to students before examinations

Mr. <name> is concerned about his students' learning 1 2 3 4

- c) Ms. <name> sets mathematics homework once a week. She never gets the answers back to students before examinations

Ms. <name> is concerned about her students' learning 1 2 3 4

Q53 Thinking about the mathematics teacher who taught your last mathematics class: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) My teacher lets us know we need to work hard 1 2 3 4
- b) My teacher provides extra help when needed 1 2 3 4
- c) My teacher helps students with their learning 1 2 3 4
- d) My teacher gives students the opportunity to express opinions 1 2 3 4

Q54 Below you will find descriptions of three mathematics teachers. Read each of the descriptions of these teachers, then let us know to what extent you agree with the final statement.

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) The students' in Ms. <name's> class frequently interrupt her lessons. She always arrives five minutes early to class

Ms. <name> is in control of her classroom 1 2 3 4

- b) The students' in Ms. <name's> class are calm and orderly She always arrives on time to class

Ms. <name> is in control of her classroom 1 2 3 4

c) The students' in Mr. <name's> class frequently interrupt his lessons. As a result, he often arrives five minutes late to class

Mr. <name> is in control of his classroom 1 2 3 4

Q55 Thinking about the mathematics teacher who taught your last mathematics class: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) My teacher gets students to listen to him or her 1 2 3 4
- b) My teacher keeps the class orderly 1 2 3 4
- c) My teacher starts lessons on time 1 2 3 4
- d) The teacher has to wait a long time for students to <quiet down> 1 2 3 4

Classroom and school climate

Q56 Thinking about the teachers at your school: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) Students get along well with most teachers 1 2 3 4
- b) Most teachers are interested in students' well-being 1 2 3 4
- c) Most of my teachers really listen to what I have to say 1 2 3 4
- d) If I need extra help, I will receive it from my teachers 1 2 3 4
- e) Most of my teachers treat me fairly 1 2 3 4

Q57 Thinking about your school: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) I feel like an outsider (or left out of things) at school 1 2 3 4
- b) I make friends easily at school 1 2 3 4
- c) I feel like I belong at school 1 2 3 4
- d) I feel awkward and out of place in my school 1 2 3 4
- e) Other students seem to like me 1 2 3 4
- f) I feel lonely at school 1 2 3 4
- g) I feel happy at school 1 2 3 4
- h) Things are ideal in my school 1 2 3 4
- i) I am satisfied with my school 1 2 3 4

Q58 Thinking about what you have learnt at school: to what extent do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) School has done little to prepare me for adult life when I leave school 1 2 3 4
- b) School has been a waste of time 1 2 3 4
- c) School has helped give me confidence to make decisions 1 2 3 4
- d) School has taught me things which could be useful in a job 1 2 3 4

Q59 Thinking about your school: to what extent do you agree with the following statements?*(Please tick only one box in each row.)***1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree**

- a) Trying hard at school will help me get a good job 1 2 3 4
 b) Trying hard at school will help me get into a good <college> 1 2 3 4
 c) I enjoy receiving good <grades> 1 2 3 4
 d) Trying hard at school is important 1 2 3 4

Notes: For a definition of <college> see Q33.

For a definition of <grades> see Q29.

Q60 Thinking about your school: to what extent do you agree with the following statements?*(Please tick only one box in each row.)***1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree**

- a) If I put in enough effort, I can succeed in school 1 2 3 4
 b) It is completely my choice whether or not I do well at school 1 2 3 4
 c) Family demands or other problems prevent me from putting a lot of time into my school work 1 2 3 4
 d) If I had different teachers, I would try harder at school 1 2 3 4
 e) If I wanted to, I could perform well at school 1 2 3 4
 f) I perform poorly at school whether or not I study for my exams 1 2 3 4

Problem solving experiences**Q61 How well does each of the following statements below describe you?***(Please tick only one box in each row.)***1-Very much like me 2-Mostly like me 3-Somewhat like me 4-Not much like me 5-Not at all like me**

- a) When confronted with a problem, I give up easily 1 2 3 4 5
 b) I put off difficult problems 1 2 3 4 5
 c) I remain interested in the tasks that I start 1 2 3 4 5
 d) I continue working on tasks until everything is perfect 1 2 3 4 5
 e) When confronted with a problem, I do more than what is expected of me 1 2 3 4 5

Q62 How well does each of the following statements below describe you?*(Please tick only one box in each row.)***1-Very much like me 2-Mostly like me 3-Somewhat like me 4-Not much like me 5-Not at all like me**

- a) I can handle a lot of information 1 2 3 4 5
 b) I am quick to understand things 1 2 3 4 5
 c) I seek explanations for things 1 2 3 4 5
 d) I can easily link facts together 1 2 3 4 5
 e) I like to solve complex problems 1 2 3 4 5

*Suppose that you have been sending text messages from your mobile phone for several weeks. Today, however, you can't send text messages. You want to try to solve the problem.***Q63 What would you do? For each suggestion, tick the option that best applies to you.***(Please tick only one box in each row.)***1-I would definitely do this 2-I would probably do this
3-I would probably not do this 4-I would definitely not do this**

- a) I press every button possible to find out what is wrong 1 2 3 4
 b) I think about what might have caused the problem and what I can do to solve it 1 2 3 4

- c) I read the manual 1 2 3 4
- d) I ask a friend for help 1 2 3 4

Suppose that you are planning a trip to the zoo with your brother. You don't know which route to take to get there.

Q64 What would you do? For each suggestion, tick the option that best applies to you.

(Please tick only one box in each row.)

1-I would definitely do this **2-I would probably do this**
3-I would probably not do this **4-I would definitely not do this**

- a) I read the zoo brochure to see if it says how to get there 1 2 3 4
- b) I study a map and work out the best route 1 2 3 4
- c) I leave it to my brother to worry about how to get there 1 2 3 4
- d) I know roughly where it is, so I suggest we just start driving 1 2 3 4

Suppose that you arrive at the train station. There is a ticket machine that you have never used before. You want to buy a ticket.

Q65 What would you do? For each suggestion, tick the option that best applies to you.

(Please tick only one box in each row.)

1-I would definitely do this **2-I would probably do this**
3-I would probably not do this **4-I would definitely not do this**

- a) I check how similar it is to other ticket machines I have used 1 2 3 4
- b) I try out all the buttons to see what happens 1 2 3 4
- c) I ask someone for help 1 2 3 4
- d) I try to find a ticket office at the station to buy a ticket 1 2 3 4

APPENDIX C

PARENT QUESTIONNAIRE

One questionnaire is administered per student. The parent questionnaire takes about 20 minutes to complete. The parent questionnaire covers parental reports related to several aspects:

- Parental background
- Cost of educational service
- Attitudes to child's school
- Parents' involvement with school
- School choice
- Parental support for learning in the home
- Mathematics in child's career and job market
- Academic and professional expectations in mathematics
- Child's past academic performance
- Child's career interests
- Parents' migration background

Parental background

Q1 Who will complete this questionnaire?

(Please tick all that apply.)

- a) Mother or other female guardian 1
- b) Father or other male guardian 2
- c) Other 3

(If other, please specify):

Q2 How old are the child's parents?

(Please tick one box in each row.)

1-Younger than 36 years 2-36 – 40 years 3-41 – 45 years 4-46 – 50 years 5-51 years or older

- a) Father 1 2 3 4 5
- b) Mother 1 2 3 4 5

Q3 Does the child's father have any of the following qualifications?

(Please tick one box in each row.)

1-Yes 2-No

- a) <ISCED 5A, 6> 1 2
- b) <ISCED 5B> 1 2
- c) <ISCED 4> 1 2
- d) <ISCED 3A> 1 2

Notes: For a definition of <ISCED 3A> see the note in Q7 of the student questionnaire.

For a definition of <ISCED 4> to <ISCED 6> levels see the note in Q14 of the student questionnaire.

Q4 What is the main job of the child's father? (e.g. school teacher, kitchen-hand, sales manager.)

(If he is not working now, please tell us his last main job.)

Please write in the job title:

Q5 What does the child's father do in his main job? (e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team.)

Please use a sentence to describe the kind of work he does or did in that job:

Q6 Does the child's mother have any of the following qualifications?

(Please tick one box in each row.)

1-Yes 2-No

a) <ISCED 5A, 6> 1 2

b) <ISCED 5B> 1 2

c) <ISCED 4> 1 2

d) <ISCED 3A> 1 2

Notes: For a definition of <ISCED 3A> see the note in Q7 of the student questionnaire.

For a definition of <ISCED 4> to <ISCED 6> see the note in Q14 of the student questionnaire.

Q7 What is the main job of the child's mother? (e.g. school teacher, kitchen-hand, sales manager.)

(If she is not working now, please tell us her last main job.)

Please write in the job title:

Q8 What does the child's mother do in her main job? (e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team.)

Please use a sentence to describe the kind of work she does or did in that job:

Q9 What is your annual household income?

Please add together the total income, before tax, from all members of your household.

Please remember we ask you to answer questions only if you feel comfortable doing so, and that all responses are kept *strictly confidential*.

(Please tick only one box.)

Less than <\$A> 1

<\$A> or more but less than <\$B> 2

<\$B> or more but less than <\$C> 3

<\$C> or more but less than <\$D> 4

<\$D> or more but less than <\$E> 5

<\$E> or more 6

Notes: <\$> - This symbol denotes the national currency of the participating country or economy.

<\$C> is a suitably rounded value for the national **median household income**. For all households in the country, the median income is the amount for which half of the households have an income above this amount, and half, below.

<\$A> is a suitably rounded value equal to about half of the median household income. <\$B> is a value at about three quarters of the median household income, <\$D> is a value at about five quarters of the median household income, and <\$E> is a value at about one-and-a-half times the median household income.

Please answer the following question thinking just of expenses related to <the student who brought this questionnaire home>.

Q10 In the last twelve months, about how much would you have paid to educational providers for services?

In determining this, please include any tuition fees you pay to your child's school, any other fees paid to individual teachers in the school or to other teachers for any tutoring your child receives, as well as any fees for cram school.

Do **not** include the costs of goods like sports equipment, school uniforms, computers or textbooks if they are not included in a general fee (that is, if you have to buy these things separately).

(Please tick only one box.)

Nothing 1

<More than \$0 but less than \$W> 2

<\$W or more but less than \$X> 3

<\$X or more but less than \$Y> 4

<\$Y or more but less than \$Z> 5

<\$Z> or more 6

Notes: <\$> - This symbol denotes the national currency.

<\$Z> is a suitably rounded value representing an amount of money that could be spent on an expensive education, including tutoring etc. About 5% of parents should choose this option in a national sample.

<\$W> is a suitably rounded value for a public education without any extra tutoring. Where public education is absolutely free, this would be set at a low nominal value but above zero (e.g. 50 or 100 Euro) to take account of incidental fees that might be paid.

After determining <\$Z> and <\$W>, equal categories are created between these figures by using increments of $(\langle \$Z \rangle - \langle \$W \rangle) / 3$.

Attitudes to child's school

We are interested in what you think about your child's school.

Q11 How much do you agree or disagree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

- a) Most of my child's school teachers seem competent and dedicated 1 2 3 4
- b) Standards of achievement are high in my child's school 1 2 3 4
- c) I am happy with the content taught and the instructional methods used in my child's school 1 2 3 4
- d) I am satisfied with the disciplinary atmosphere in my child's school 1 2 3 4
- e) My child's progress is carefully monitored by the school 1 2 3 4
- f) My child's school provides regular and useful information on my child's progress 1 2 3 4
- g) My child's school does a good job in educating students 1 2 3 4

Parents' involvement with school

Q12 During the last <academic year>, have you participated in any of the following school-related activities?

(Please tick one box in each row.)

1-Yes 2-No

- a) Discussed my child's behaviour with a teacher on my own initiative 1 2
- b) Discussed my child's behaviour on the initiative of one of his/her teachers 1 2
- c) Volunteered in physical activities, e.g. building maintenance, carpentry, gardening or yard work 1 2
- d) Volunteered in extra-curricular activities, e.g. book club, school play, sports, field trip 1 2
- e) Volunteered in the school library or media centre 1 2
- f) <Assisted a teacher in the school> 1 2
- g) Appeared as a guest speaker 1 2
- h) Participated in local school <government>, e.g. parent council or school management committee 1 2
- i) Discussed my child's progress with a teacher on my own initiative 1 2
- j) Discussed my child's progress on the initiative of one of their teachers 1 2
- k) Volunteered in the school <canteen> 1 2

Note: <Academic year> refers to the year of schooling which is not necessarily the calendar year.

School choice

We are interested in the options you had as parents when choosing the school your child is currently attending.

Q13 Which of the following statements best describes the schooling available to students in your location?

(Please tick only one box.)

There are two or more other schools in this area that compete with the school my child is currently attending 1

There is one other school in this area that competes with the school my child is currently attending 2

There are no other schools in this area that compete with the school my child is currently attending 3

Q14 How important are the following reasons for choosing a school for your child?

(Please tick only one box in each row.)

1-Not important 2-Somewhat important 3-Important 4-Very important

a) The school is at a short distance to home 1 2 3 4

b) The school has a good reputation 1 2 3 4

c) The school offers particular courses or school subjects 1 2 3 4

d) The school adheres to a particular <religious philosophy> 1 2 3 4

e) The school has a particular approach to <pedagogy/didactics, e.g. example> 1 2 3 4

f) Other family members attended the school 1 2 3 4

g) <Expenses are low> (e.g. tuition, books, room and board) 1 2 3 4

h) The school has < financial aid> available, such as a school loan, scholarship, or grant 1 2 3 4

i) The school has an active and pleasant school climate 1 2 3 4

j) The academic achievements of students in the school are high 1 2 3 4

k) There is a safe school environment 1 2 3 4

Q15 How often do you or someone else in your home do the following things with your child?

(Please tick only one box in each row.)

1-Never or hardly ever 2-Once or twice a year 3-Once or twice a month

4-Once or twice a week 5-Every day or almost every day

a) Discuss how well my child is doing at school 1 2 3 4 5

b) Eat <the main meal> with my child around a table 1 2 3 4 5

c) Spend time just talking to my child 1 2 3 4 5

d) Help my child with his/her mathematics homework 1 2 3 4 5

e) Discuss how my child is performing in mathematics class 1 2 3 4 5

f) Obtain mathematics materials (e.g., applications, software, study guides etc) for my child 1 2 3 4 5

g) Discuss with my child how mathematics can be applied in everyday life 1 2 3 4 5

Mathematics in child's career and job market

We are interested in what you think about the need for mathematics skills in the job market today.

Q16 How much do you agree with the following statements?

(Please tick only one box in each row.)

1-Strongly agree 2-Agree 3-Disagree 4-Strongly disagree

a) It is important to have good mathematics knowledge and skills in order to get any good job in today's world 1 2 3 4

b) Employers generally appreciate strong mathematics knowledge and skills among their employees 1 2 3 4

c) Most jobs today require some mathematics knowledge and skills 1 2 3 4

d) It is an advantage in the job market to have good mathematics knowledge and skills 1 2 3 4

Academic and professional expectations in mathematics

The following questions refer to <mathematics-related careers>. A <mathematics-related career> is one that requires studying

a mathematics course at a university level.

Examples of <mathematics-related careers> include Mathematics Teacher, Economists, Financial Analyst and Computer scientist.

<Mathematics-related careers> also include many science-related careers, such as Engineers, Weather Forecasters, and Medical doctors. All of these can also be considered as <mathematics-related careers>.

Q17 Please answer the questions below.

(Please tick only one box in each row.)

1-Yes 2-No

- a) Does anybody in your family (including you) work in a <mathematics-related career>? 1 2
- b) Does your child show an interest in working in a <mathematics-related career>? 1 2
- c) Do you expect your child will go into a <mathematics-related career>? 1 2
- d) Has your child shown interest in studying mathematics after completing <secondary school>? 1 2
- e) Do you expect your child will study mathematics after completing <secondary school>? 1 2

Child's past academic performance

Q18 Has your child ever repeated a <grade>?

(Please tick only one box in each row.)

1-No, never 2-Yes, once 3-Yes, twice or more

- a) At < ISCED 1> 1 2 3
- b) At < ISCED 2> 1 2 3
- c) At < ISCED 3> 1 2 3

Notes: <Grade> refers to the administrative level of the student in the school. In many countries, the number of years in schooling is the usual measure of grade.

For a definition of <ISCED 1> see the note in Q6 of the student questionnaire.

For a definition of <ISCED 2> and <ISCED 3> see the note in Q7 of the student questionnaire.

Child's career interests

Q19 Which of the following do you expect your child to complete?

(Please tick as many as apply.)

- a) <ISCED 2> 1
- b) <ISCED 3B or C> 2
- c) <ISCED 3A> 3
- d) <ISCED 4> 4
- e) <ISCED 5B> 5
- f) <ISCED 5A or 6> 6

Notes: For a definition of <ISCED 2> and <ISCED 3> see the note in Q7 of the student questionnaire.

For a definition of <ISCED 4> to <ISCED 6> levels see the note in Q14 of the student questionnaire.

Q20 What occupation do you expect your child to have when they are about 30 years old?

Please write in the job title:

Parents' migration background**Q21 In what country were the following people in the child's family born?***(Please tick one answer per column.)***Mother Father****Maternal****Grandmother****Maternal****Grand-father****Paternal****Grandmother****Paternal****Grand-father**

<Test Country> 1 1 1 1 1 1

<Country A> 2 2 2 2 2 2

<Country B> 3 3 3 3 3 3

<Country C> 4 4 4 4 4 4

<Country D> 5 5 5 5 5 5

<Country E> 6 6 6 6 6 6

<Country F> 7 7 7 7 7 7

Notes: <Test Country> refers to the country being tested.

<Country X>, each country or economy may choose certain countries for this question.

Q22 If the child's father was NOT born in <country of test>, how old was he when he arrived in <country of test>?*(If less than 12 months old, please write zero (0).)**Years*

Note: <Country of test> refers to the country being tested.

Q23 If the child's mother was NOT born in <country of test>, how old was she when she arrived in <country of test>?*(If less than 12 months old, please write zero (0).)**Years*

Note: For a definition of <Country of test> see Q20.

Q24 In what country are the father and mother of the child legal citizens? If they are dual citizens, you may tick more than one country.*(Please tick as many as apply.)***1-Mother 2-Father**

a) <Test Country> 1 1

b) <Country A> 2 2

c) <Country B> 3 3

d) <Country C> 4 4

Note: For a definition of <Test country> see Q19.

Q25 What language do the father and mother of the child speak at home most of the time?*(Please tick one answer per column.)***1-Mother 2-Father**

<Test language> 1 1

<Other official national languages> 2 2

<Other national dialects or languages> 3 3

< Other language 1> 4 4

< Other language 2> 5 5

< Other language 3> 6 6

Other language 7 7

Note: <**Test language**> refers to the language of instruction in which you would administer the PISA reading assessment.