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STUDENT HELP-SEEKING BEHAVIORS AND TEACHER INSTRUCTIONAL PRACTICES: EXAMINING THEIR RELATIONSHIP WITH U.S. STUDENT MATHEMATICS ACHIEVEMENT

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STUDENT HELP-SEEKING BEHAVIORS AND TEACHER INSTRUCTIONAL PRACTICES: EXAMINING THEIR RELATIONSHIP WITH U.S. STUDENT MATHEMATICS ACHIEVEMENT

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Education in the College of Education at the University of Kentucky

By

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2019

ABSTRACT OF DISSERTATION

STUDENT HELP-SEEKING BEHAVIORS AND TEACHER INSTRUCTIONAL PRACTICES: EXAMINING THEIR RELATIONSHIP WITH U.S. STUDENT MATHEMATICS ACHIEVEMENT

Even though the United States (U.S.) spends, on average, more money per student than most Organisation for Economic Co-operation and Development (OECD) countries, it continues to lag behind its international peers in mathematics achievement. This study, which responded to the call for educational reforms that improve the mathematics achievement of U.S. students, aimed to examine the issue of student help-seeking behaviors and teacher instructional practices as they interact to affect student mathematics achievement. The Programme for International Student Assessment (PISA) defines student help-seeking behaviors as the ways in which students have a propensity to depend on the knowledge and intellect of others, including both their peers and teachers, when attempting to solve problems.

Because mathematics is perhaps the most difficult school subject, student help-seeking behaviors should be a critical component of mathematics learning and teaching. Unfortunately, the research literature is barren concerning this important educational issue. This study attempted to produce the first wave of empirical evidence and open up an avenue for future research in this less-charted academic field, with the ultimate goal being to use students' help-seeking behaviors to improve their mathematics achievement.

Using the U.S. sample of 15-year-old students from PISA 2012 (the most recent PISA assessment in which the main area of focus was mathematical literacy), this study intended to determine whether students' help-seeking behaviors play a significant role in their mathematics achievement, whether this relationship varies from school to school, and whether teacher instructional practices contribute to the school-level variation. Due to the multilevel structure of the data, with students being nested within schools, a two-level hierarchical linear model (HLM) was employed in the analysis of the data. Multiple measures of mathematics achievement were used as the dependent variables for separate analyses. Student help-seeking behavior was used as the key student-level independent variable, while three teacher instructional practices were used as the key school-level independent variables. In addition, several student and school background characteristics were used as control variables.

The findings from this study indicate that student help-seeking behavior has a statistically significant effect on all measures of student mathematics achievement, even after controlling for various student background characteristics. On the other hand, the study did not find statistically significant evidence that the effects of student help-seeking behavior on any measure of student mathematics achievement vary from school to school. Overall, the issue of student help-seeking behaviors should be considered a worthy topic to pursue in future educational research. From a practical standpoint, since students' mathematics achievement is positively associated with their help-seeking behaviors, efforts should be made to educate mathematics teachers on how to encourage their students to be more proactive in seeking help in the learning of mathematics.

KEYWORDS: Student Help-Seeking Behavior, Student Mathematics Achievement, Teacher Instructional Practices, Programme for International Student Assessment (PISA), Student and School Background Characteristics

Michael C. Osborne

April 19, 2019
Date

STUDENT HELP-SEEKING BEHAVIORS AND TEACHER INSTRUCTIONAL PRACTICES: EXAMINING THEIR RELATIONSHIP WITH U.S. STUDENT MATHEMATICS ACHIEVEMENT

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Introduction

Despite the vast amounts of resources that have been poured into K-12 education in the United States (U.S.), students in the U.S. continue to lag behind their international peers in mathematics achievement, as measured by the Organisation for Economic Co-operation and Development's (OECD) 2012 Programme for International Student Assessment (PISA). PISA is an international comparative study conducted every three years that aims to measure in rotation the academic achievement of 15-year-old students in the content areas of mathematics, reading, and science (Kastberg, Roey, Lemanski, Chan, & Murray, 2014). In fact, even though the U.S. spends, on average, more money per student than all but 4 of the 34 OECD countries, it ranks only 27th in mathematics (OECD, 2013). Numerous educational reforms have been made and programs have been designed with the aim of improving the performance of U.S. students in mathematics, but thus far none have proven to be sustainably effective, so the search goes on.

Many educational reform efforts in the U.S. have been centered around curriculum and instruction (e.g., NCTM, 2000; NGA Center & CCSSO, 2010). For example, in the year 2000 the National Council of Teachers of Mathematics (NCTM) released its Principles and Standards for School Mathematics, which sought to lay out in detail what curriculum and instruction (as well as assessment) should consist of when it comes to K-12 mathematics education in the U.S. (NCTM, 2000). This study (dissertation) joins these national efforts by examining a unique issue of the interaction between student help-seeking behaviors and teacher instructional practices in relation to student mathematics achievement.

Definition and Discussion of Terms

Student help-seeking behaviors. Regardless of their knowledge or ability level, students undoubtedly will encounter problems that are too difficult for them to solve on their own, and external assistance will become necessary in order for the learning process to continue. Having the wherewithal to recognize when external assistance is needed and then seeking the most appropriate assistance out of the available options are integral components of self-regulated learning (Newman, 1998). In the context of student learning, help-seeking behaviors are defined as the ways in which students search for and make use of external resources during the learning process or when attempting to solve problems (Ogan et al., 2015). These behaviors could be positive or negative and include such actions as asking a teacher or classmate for help, reading a textbook, conducting an internet search for example problems or instructional videos, or even copying an answer from another student's paper.

Unfortunately, despite the potential that appropriate help-seeking behaviors have to facilitate student learning, the research literature is generally quite thin in this area. In the relatively few existing studies, the results are often discouraging in that they reveal that students are deficient in this critical area of self-regulation. To exacerbate the situation, low-achieving students, who potentially would benefit the most from seeking help, tend to be the least likely to actually seek it; further, when these students do make the decision to seek help, their help-seeking behaviors are often ineffective (Roll, Aleven, & Koedinger, 2004).

Unlike other skills involved in the process of cognitive development such as goal-setting and time management, help-seeking is unique in that it is not only a self-regulation strategy but typically involves social interaction as well. Upon determining that help is needed and then deciding to act upon that determination by actively pursuing help, it is natural for students to look to other people for assistance; in the mathematics classroom environment, the most appropriate people to look to would be the teacher and more knowledgeable peers. This social dimension of help-seeking behaviors has the added benefit of improving the cognitive and social abilities of the helpers in addition to the seekers (Ryan, Pintrich, & Midgley, 2001).

Teacher instructional practices. In general, teacher instructional practices refer to the methods and strategies teachers use within their classrooms to promote student learning and improve student academic achievement (Stipek & Byler, 2004). The classroom environment that teachers establish as a result of their instructional practices both explicitly and implicitly conveys information to the students related to learning in specific and education in general (Kaplan, Middleton, Urdan, & Midgley, 2002). The topic of teachers' classroom instructional practices has long been of interest to educational researchers; consequently, there exists an extensive body of literature regarding this important issue. In particular, many studies have examined the relationship between teacher instructional practices and student achievement, with the general consensus being that teacher instructional practices do have a significant effect on student achievement. However, there continues to be a nontrivial amount of disagreement among educational researchers as to which types of classroom instructional practices teachers should use, especially when the subject being taught is mathematics (U.S. Department of Education, 2013).

According to the National Mathematics Advisory Panel (2008), having teachers implement effective instructional practices is a necessary, though not sufficient, component of improving student mathematics achievement. In fact, some research has provided evidence that student mathematics achievement is affected by teacher instructional practices more than by any other variable (McKinney & Frazier, 2008). One advantage to identifying teacher instructional practices as a key variable for influencing student mathematics achievement is that, unlike other variables such as gender, race, and socioeconomic status (SES), teacher instructional practices are controlled at, and thus can be changed at, the local school level. Interestingly, despite the ongoing debate among educational researchers over which teacher instructional practices are most effective at increasing student mathematics achievement, convincing individual classroom teachers to implement, or even experiment with, meaningful changes in their instructional practices continues to be challenging (McKinney & Frazier, 2008).

A thorough review of the research literature involving a wide variety of teacher instructional practices revealed an overarching theme that permits each instructional practice to be placed into one of two primary categories: teacher-directed instructional practices or student-centered instructional practices. Teacher-directed instructional practices can be traced back to the traditional theory of learning, which maintains that the best way for learning to occur is for the teacher to actively transmit knowledge to the students, who remain primarily passive throughout the process (Stipek & Byler, 2004). As a result, in a teacher-directed classroom, there tends to be a small number of teacher-to-student interactions and essentially an absence of student-to-student interactions (Artzt & Armour-Thomas, 1999).

Unlike teacher-directed instructional practices, which make the teacher the center of attention with the students functioning primarily as an audience, student-centered instructional practices delegate most of the responsibility for learning to the students themselves, while the teacher assumes the role of facilitator (NMAP, 2008). With student-centered instructional practices, the students are regarded as active participants who construct their own knowledge through exploration and reasoning, while the teacher's responsibility is to guide the students' thinking by asking thought-provoking questions and encouraging discussions (Lerkkanen et al., 2016).

PISA specific definitions. Since this study used data from PISA 2012, it is necessary not only to present the definitions given in the general body of literature for student help-seeking behaviors and teacher instructional practices, but also to present the specific characterizations that PISA uses when measuring these issues, as well as PISA's definition of student mathematical literacy. PISA defines student help-seeking behaviors as the ways in which students have a propensity to depend on the knowledge and intellect of other people, including both their peers and teachers, when attempting to solve problems (OECD, 2014b). This definition fits well with the previously discussed definition and characteristics of student help-seeking behaviors.

According to PISA, teacher instructional practices refer to a broad range of processes, from the way in which classrooms are organized and resources are used to the daily activities engaged in by teachers and students to facilitate learning (OECD, 2010). In PISA's view, the current research does not explicitly support the promotion of any particular method of teaching as being the most effective for improving student mathematics achievement. On the contrary, PISA notes there is evidence, including that from PISA 2003 (the only year prior to PISA 2012 that the focal subject area of the PISA assessment was mathematics), that certain characteristics of teacher-directed instructional practices are positively associated with student mathematics achievement and certain characteristics of student-centered instructional practices are positively associated with student mathematics achievement (OECD, 2013). This view is consistent with the recommendation given by McKinney and Frazier (2008) that teachers need to achieve a proper balance between these two main categories of classroom instructional practices.

Finally, PISA defines student mathematical literacy as “how well 15-year-old students can understand, use, and reflect on mathematics for a variety of real-life problems and settings that they may not encounter in the classroom” (Kastberg et al., 2014, p. 2). PISA measures student mathematical literacy by using the student achievement (scores) on the mathematics component of the PISA 2012 assessment, which was designed to measure literacy in four mathematical areas: change and relationship, space and shape, uncertainty and data, and quantity (OECD, 2013).

A minimal amount of research has been published that examines the relationship between student help-seeking behaviors and student mathematics achievement. Mehdizadeh, Nojabaee, and Asgari (2013) analyzed the effects of cooperative learning on student mathematics anxiety and student help-seeking behaviors, concluding that invoking cooperative learning opportunities in mathematics classrooms reduces the students’ anxiety and increases their willingness to seek help, with the goal being to eventually improve the students’ mathematics achievement. Newman and Schwager (1993) examined the relationship between student perceptions of the mathematics teacher, as well as student perceptions of classmates, and student willingness to seek help. In general, the authors concluded that students are more likely to seek help from the teacher than from their classmates; further, the students are more likely to seek help from the teacher if they perceive the teacher as being encouraging of asking questions. These two studies function to illustrate the research premise (hypothesis) of this study that (a) seeking help in mathematics learning has positive effects on mathematics achievement and (b) teacher instructional practices either facilitate or hinder these effects.

Purpose of the Study

The primary purpose of the current study was to examine the issue of student help-seeking behaviors and teacher instructional practices as they interact to affect mathematics achievement. To do this, the study used the U.S. data from PISA 2012 in which the main area of focus was mathematical literacy. More specifically, this study sought to address the following three research questions:

- At the student level, do student help-seeking behaviors have any statistically significant effects on student mathematics achievement, with control over student background characteristics?
- At the school level, do the effects of student help-seeking behaviors on student mathematics achievement vary statistically significantly from school to school?
- If the effects of student help-seeking behaviors on student mathematics achievement do vary from school to school, do teacher instructional practices contribute statistically significantly to this variation, with control over school background characteristics?

Significance of the Study

Academic importance. Since minimal research has been done that examines the relationship between student help-seeking behaviors and student mathematics achievement, this study attempted to open up an avenue for future research. If it can be argued that mathematics is the most difficult school subject for students of all ages to learn, then student help-seeking behaviors should naturally be a critical component of mathematics learning and teaching; unfortunately, the research literature is barren concerning this important educational issue. This study aimed to venture into this less-charted academic field in order to produce the first wave of empirical evidence. As a byproduct, this study also provided an opportunity to examine the effects of teacher instructional practices on student mathematics achievement, thus adding more information to the relatively rich literature on this topic.

Practical importance. This study aimed to inform interested stakeholders such as educational policymakers, school administrators, classroom teachers, parents, and students, as to the effectiveness of student help-seeking behaviors and teacher instructional practices, as well as to help guide the development of educational policies and practices that will assist in providing optimal opportunities for all students to receive a high-quality education. For example, if student help-seeking behaviors were found to have significant effects on student mathematics achievement, then teachers should be educated on how to encourage their students to be more proactive in seeking help in the mathematics classroom, with the goal being to improve the students' mathematics achievement. In addition, if teacher instructional practices were found to positively facilitate the effects of student help-seeking behaviors on student mathematics achievement, then teachers should receive professional development training on which instructional practices are most likely to be beneficial to their students.

Organization of the Study

Going forward, the second chapter provides a review of the research literature situated in the context of current mathematics education. This literature review examines previously published research studies involving student help-seeking behaviors and teacher instructional practices, with an emphasis on their relationship with student mathematics achievement. The third chapter describes the data used for the present study and provides information concerning the independent, dependent, and control variables. Further, this chapter gives a detailed description of the statistical methodologies that were used to analyze the data and address the research questions. The fourth chapter presents the findings from the study, uses them to answer the research questions, and makes appropriate statistical inferences. The fifth (and final) chapter summarizes the findings from the study, relates them back to the literature, and addresses limitations of the study. In addition, this chapter discusses potential implications for educational policy and practice, as well as for future educational research.

Chapter 2: Review of the Literature

Overview of Current Mathematics Education

In 1989, the National Council of Teachers of Mathematics (NCTM), having worked hand-in-hand for decades with the larger mathematical community including mathematicians, mathematics educators, and mathematics teachers, released its Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989). These standards targeted the mathematics content and curriculum for grades K-12, with a particular focus on the processes of problem solving, communication, reasoning, and connections. What is often referred to as the "standards movement" began in mathematics education. Over the course of the next several years, NCTM released its Professional Standards for Teaching Mathematics (NCTM, 1991) and Assessment Standards for School Mathematics (NCTM, 1995). Taken together, these three sets of standards gave a complete picture of what the K-12 mathematics curriculum should look like in terms of content, pedagogy, and assessment. Unfortunately, despite the efforts by NCTM to help minimize the state-to-state differences in K-12 mathematics education, particularly the differences in grade-level content, state mathematics standards continued to exhibit a nontrivial amount of variability among states, as many states did not heed the recommendations given by NCTM (Dossey, McCrone, & Halvorsen, 2016).

As the turn of the 20th century drew near, with hopes of convincing more states to bring their K-12 mathematics standards in line with the NCTM recommendations, as well as to reflect more current research concerning mathematics learning and teaching, NCTM began to revise and update its standards. As a result of this endeavor, NCTM published its Principles and Standards for School Mathematics, which combined its previous three sets of standards (content, teaching, and assessment) into a single set (NCTM, 2000). In addition, Principles and Standards for School Mathematics advocated for distributing the content across four grade bands (PreK-2, 3-5, 6-8, and 9-12) rather than just three (K-4, 5-8, and 9-12). As a key player in mathematics education, NCTM continues to emphasize that “all students need access each year to a coherent, challenging mathematics curriculum taught by competent and well-supported mathematics teachers” (NCTM, 2000, p. 12).

In order to hold school districts more accountable for their students’ academic achievement and to further promote the goal shared by NCTM that all students receive a high-quality education, the U.S. government passed into law the No Child Left Behind Act (NCLB) of 2001 (U.S. Department of Education, 2002). NCLB provided financial incentives for high-performing schools and financial penalties for low-performing schools. In particular, NCLB set the goal that every student in the U.S. would be proficient in mathematics (as well as reading) by the year 2014. NCLB held school districts accountable to this goal by implementing a measure called Adequate Yearly Progress (AYP) to determine if schools were staying on-track to reach the goal. The primary idea behind NCLB was to use an accountability system based on high-stakes standardized testing as a way to stimulate growth in student mathematics (and reading) achievement. Not only did NCLB lead to an increase in standardized testing for assessment, but essentially every aspect of K-12 education was affected by it, including content, pedagogy, and the allocation of financial resources (Hollingsworth et al., 2007).

In keeping with the mathematics standards movement started by NCTM, the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) released the Common Core State Standards for Mathematics (CCSSM) in the year 2010 (NGA Center & CCSSO, 2010). The CCSSM lay out detailed grade-by-grade standards for grades K-8 and standards organized according to mathematical topics for high school. In addition to these standards, the CCSSM include a set of eight Standards for Mathematical Practice, which describe practices that play a critical role in cultivating an understanding of mathematics across all ages. The primary purpose of creating the CCSSM was to unify the existing state mathematics standards into a common set of standards that could be used by all states, with the goal being for students eventually to become college or career ready by developing an in-depth conceptual understanding of mathematics rather than viewing mathematics as simply a set of rules and procedures to follow.

National and International Assessments

There are several large-scale national and international assessments used to gauge the mathematics achievement and progress of students in the U.S. (and beyond). In addition to measuring student mathematics achievement, these assessments produce data from large, nationally representative samples that can be used to drive policies and practices related to K-12 mathematics education. One such assessment, started in 1969 by the U.S. Department of Education's National Center for Education Statistics (NCES) in conjunction with the National Assessment Governing Board (NAGB), is the National Assessment of Educational Progress (NAEP). The NAEP assessment in mathematics uses a random sample of students in grades 4, 8, and 12 to measure not only the students' mathematical content knowledge, but also the students' ability to apply their knowledge to solve problems that are situated in a real-world context (NAGB, 2014). Designed to examine trends over time, the NAEP mathematics assessment revealed no recent significant change in mean mathematics achievement between 2015 and 2017 for students in grades 4 and 8 (NCES, 2017). On the other hand, NAEP revealed a decrease in mean mathematics achievement between 2013 and 2015 for students in grade 12 (NCES, 2015). National assessment results like these are intended to inform educational reforms in policies and practices relevant to mathematics education nationwide.

In 1995, the International Association for the Evaluation of Educational Achievement (IEA) established the Trends in International Mathematics and Science Study (TIMSS), an international comparative study involving a random sample of fourth grade and eighth grade students from more than 50 countries. In addition to measuring students' knowledge in the mathematical content areas, TIMSS also includes a variety of problem solving situations that require students to use cognitive thinking skills such as applying and reasoning (Mullis & Martin, 2013). Like NAEP, TIMSS also seeks to identify trends over time. The TIMSS mathematics assessment revealed no recent significant change in mean mathematics achievement between 2011 and 2015 for U.S. students in grade 4, while U.S. students in grade 8 saw an increase in mean mathematics achievement over that same time period. Internationally, U.S. students in grade 4 tied for 14^{th} out of 49 countries on the 2015 TIMSS mathematics assessment, while U.S. students in grade 8 tied for 10^{th} out of 39 countries (Mullis, Martin, Foy, & Hooper, 2016).

The Programme for International Student Assessment (PISA) was first launched in the year 2000 by the Organisation for Economic Co-operation and Development (OECD), an international organization consisting of 34 member countries across the globe. PISA, an international assessment that involves a random sample of 15-year-old students, seeks to measure mathematics, reading, and science literacy, as well as problem solving skills. Differing from TIMSS, the focus of PISA is not so much on assessing students' knowledge of content-related facts, but more so on how well students can apply their content knowledge to real-world problem solving situations (OECD, 2014a). In PISA 2012, the most recent year that mathematics was the focal subject of PISA, the U.S. ranked only 27th out of the 34 OECD countries in mean mathematics achievement (OECD, 2013). All international assessment results like those from TIMMS and PISA are intended to create a comparative platform for the U.S. so as to promote national (as well as local) educational reforms in policies and practices relevant to mathematics education.

Student Help-Seeking Behaviors

With the national and international contexts as the background, educational reforms in the U.S. have flourished over the past few decades. For example, the Appalachian Mathematics and Science Partnership (AMSP), funded by a five-year grant from the National Science Foundation (NSF) and centered at the University of Kentucky, began in 2002 as an effort to reform mathematics and science education in the Appalachian region (Ma & Ma, 2009). AMSP aimed to achieve its goal of improving the mathematics and science learning opportunities for students in this poverty-stricken area by bringing together the expertise of, and building relationships between, K-12 teachers and post-secondary educators and researchers.

As another example, in 1985 the University of Chicago School Mathematics Project began its development of Everyday Mathematics, a national reform-based curriculum for K-6 students (http://everydaymath.uchicago.edu/). Everyday Mathematics, which is still widely used throughout the U.S. today, is designed to promote a conceptual understanding of mathematics as opposed to a procedural understanding. To accomplish this goal, Everyday Mathematics focuses its curriculum on real-world problem solving, reasoning, and application, unlike more traditional textbooks which place the primary emphasis on rote procedures and memorization.

Among these educational reforms in the U.S. are efforts to change student cognitive and affective behaviors in the learning of mathematics (Ma, 2006; Ni et al., 2018). With increasing evidence that constructive help-seeking behaviors have a positive effect on student learning and academic achievement (Schenke, Lam, Conley, & Karabenick, 2015), efforts should be made to facilitate students to employ effective help-seeking behaviors as an essential element of the mathematics learning process. The research points to a seemingly obvious but often overlooked explanation for why some students are not seeking help when they need it: These students have yet to come to the realization that an internally insurmountable obstacle has been reached and external assistance is needed (Webb, 1991). For example, students might watch the mathematics teacher work a problem on the board during class and assume they understand how to work that problem, as well as similar problems, independently without ever attempting to do so. As a consequence, those students who, in actuality, do not have the skills and knowledge necessary for solving the problem, will not be aware that the need for help-seeking exists. Therefore, the determination is made that developing a habit of utilizing help-seeking behaviors must be preceded by having the capacity to recognize that outside help is needed.

By early adolescence, most students have developed the cognitive skills necessary for determining when they need to seek help and which help-seeking behaviors are applicable. Unfortunately, for various reasons such as personal autonomy concerns, perceptions of cognitive and social incompetence, and classroom environment, many of these students choose to keep to themselves and avoid the help-seeking process (Ryan, Patrick, & Shim, 2005).

Initial studies considered help-seeking behaviors as impediments to the learning process because they produced dependency on external resources (Ames & Lau, 1982; Nelson-LeGall, 1985). This view of help-seeking behaviors might be short-sighted, as more recent research has revealed that help-seeking is actually a fundamental aspect of cognitive development (Ogan et al., 2015). Unfortunately, the attitude that help-seeking creates dependency and should be avoided in favor of personal autonomy continues to subsist (Ryan et al., 2001). Instead of seeking help upon recognizing that a barrier exists, students with autonomy concerns resist help-seeking and choose to continue on their own, even if it means they will be unsuccessful. On the upside, when students who are concerned with being autonomous do decide to seek help, they tend to engage in effective help-seeking behaviors (Ryan et al., 2005).

Another common reason that students who are aware of the need for help avoid seeking it is the concern that asking for assistance from other people will be considered evidence of incompetence. These students see help-seeking as involving a risk/reward scenario, where they must decide if the reward of (or for) solving the problem outweighs the risk of appearing incompetent in front of their peers (Stipek et al., 1998). Whereas high-achieving students are likely to view help-seeking behaviors as worthwhile courses of action involved in the learning process, low-achieving students are more likely to view them as having the potential to expose their inability to solve the problem on their own.

As a consequence of deriving their own self-worth primarily from other people's opinions of them, these students tend to avoid help-seeking even when they realize it is needed (Ryan et al., 2005). On the other hand, some students may be so confident in their ability to communicate with other people and have such a strong desire to do so that they are willing to ignore the possibility of revealing their lack of content knowledge in exchange for the opportunity to demonstrate their social skills that comes about as a result of seeking help (Ryan et al., 2001). These scenarios further emphasize the importance of viewing help-seeking behaviors not only as learning strategies but also as methods of social interaction.

Still another reason some students choose not to seek external assistance despite recognizing the need for it is that they believe no one available is capable of providing the help they need and, therefore, seeking help would be ineffective and a waste of time. This type of thinking is referred to as an expedient concern (Webb, 1991). For example, some students overestimate their own intelligence and see themselves as being smarter at mathematics than all of their peers, thereby concluding that if they are unable to solve the problem then no one else could solve it, either.

When students with expedient concerns do decide to seek help, they tend to demonstrate executive help-seeking behaviors, that is, behaviors that will lead to the correct answer as quickly as possible but with little to no regard as to whether learning actually takes place. Executive help-seeking behaviors are inappropriate due to their inclination to lead to a dependency on external resources (Ryan et al., 2005). For example, some students always use the available help features in online mathematics homework systems, copy their friends' mathematics homework answers, or seek help immediately without first attempting to understand and solve the mathematics problems independently.

As opposed to using executive help-seeking behaviors, some students seek help only when they truly need it, an approach that stems from their desire to develop an understanding of the content. When these students do decide to seek help, they tend to choose instrumental help-seeking behaviors, that is, behaviors that are aimed at learning and not just producing correct answers. Instrumental help-seeking behaviors are appropriate because they lead to the cultivation of transferrable knowledge and skills that can be applied to future problems (Roll, Aleven, McLaren, & Koedinger, 2011). For example, students who use instrumental help-seeking behaviors might work on a mathematics problem independently for an extended period of time before finally going to the teacher to ask for guidance in the right direction, whereas students who use executive help-seeking behaviors might go to the teacher immediately in hopes of being given the right answer.

Classroom goal structure (i.e., a mastery-goal orientation or a performance-goal orientation) has also been shown to play a critical role in influencing students' help-seeking behaviors (Schenke et al., 2015). A classroom with a mastery-goal orientation emphasizes that there is an intrinsic value to learning and leads students to recognize the need to develop an understanding of the content and skills that are applied in addition to solving the task at hand (Newman, 1998). In this approach, effort is considered to be productive and worthwhile even if it fails to lead to a correct answer. Because the focus in a classroom with a mastery-goal orientation is on gaining understanding and not just getting the right answers, these students tend to employ instrumental help-seeking behaviors (Ryan et al., 2001).

A classroom with a performance-goal orientation emphasizes individual performance relative to peer performance, creating an atmosphere of competition in which students continually compare themselves to their peers and judge their own accomplishments against what their peers have accomplished on similar tasks (Newman, 1998). Students in these environments perceive that being smart is demonstrated not by recognizing internally that learning has occurred, but instead by such external factors as scoring well on tests, being the first to answer the teacher's questions, making A's on their report cards, and having their peers refer to them as the smart kids. As a result of this need to constantly prove they are smarter than their peers because they know all of the answers and to repeatedly receive praise from their teacher and peers, these students tend to employ executive help-seeking behaviors that will quickly produce correct answers at the expense of learning (Ryan et al., 2001).

It is reasonable to assume that the appropriateness of certain help-seeking behaviors may be dependent upon the cultures in which they are expressed (Ogan et al., 2015; Vatrapu, 2008). For example, one culture could stress individualism and the need for self-reliance, while another culture might stress collectivism and the need to work together. In this case, the two cultures would have differing opinions on how and when students should seek help from their teacher or peers. In fact, the research suggests that, while help-seeking behaviors are generally transferrable across different subject areas, they are generally not transferrable across different cultures. For example, Stanton-Salazar, Chavez, and Tai (2001) examined the help-seeking behaviors of high school students in an urban public high school in a culturally and racially diverse area of the U.S. and found that students whose primary language is English, including both non-Hispanic students as well as English-speaking Hispanic students, are more likely to seek help than Hispanic students whose primary language is Spanish. Another study of U.S. students in a similar geographical location found that Vietnamese students are more likely to display executive rather than instrumental help-seeking behaviors, while Hispanic students are more likely to display instrumental (Schenke et al., 2015).

Finally, an international study by Ogan, Walker, Baker, Rebolledo, and Jimenez-Castro (2012) analyzed the help-seeking behaviors of students within the context of using a computer-based tutoring system in the mathematics classroom and found that students in Brazil, Costa Rica, and Mexico work together significantly more than students in the U.S. In this case, although the study was designed to provide software as the primary source of help on an individual level, the extent of the cooperation between students was such that other classmates ended up being the primary source with the software being secondary.

Student Help-Seeking Behaviors in Mathematics

Help-seeking is considered an important aspect of the learning process in general and self-regulation in particular. If it can be argued that mathematics is the most difficult school subject for students of all ages to learn, then student help-seeking behaviors should naturally be a critical component of mathematics learning and teaching. While an extensive amount of research has demonstrated the association between general self-regulated learning strategies and mathematics achievement, a minimal amount of research has been done that examines the more specific relationship between student help-seeking behaviors and student mathematics achievement. In addition, the research that has been done regarding this important educational issue has been limited in both its scope and generalizability.

Mehdizadeh et al. (2013) analyzed the effects of cooperative learning on student mathematics anxiety and help-seeking, concluding that invoking cooperative learning in mathematics classrooms reduces the students' anxiety and increases their willingness to seek help, with the goal being to eventually improve the students' mathematics achievement. This study is limited in its scope in that it only measured mathematics anxiety and not mathematics achievement. Further, the study is extremely limited in its generalizability due to the fact that the sample only included ninth grade females in one particular school in Iran.

Newman and Schwager (1993) examined the relationship between students' perceptions of the mathematics teacher, as well as perceptions of classmates, and students' willingness to seek help. In general, the authors concluded that students are more likely to seek help from the teacher than from their classmates; further, the students are more likely to seek help from the teacher if they perceive the teacher as being encouraging of asking questions. This study is also limited in that it did not measure mathematics achievement, and all of the students sampled were from the same general area of southern California and either in third, fifth, or seventh grade. Newman (1998) studied a similar group of students and found that help-seeking behaviors fail to mediate the relationship between student goals and student performance in mathematics problem solving. In this case, the study did measure mathematics achievement but not its dependency on help-seeking behaviors.

A study by Ryan and Pintrich (1997) used exploratory factor analyses to examine the relationship between students' prior mathematics achievement and their help-seeking behaviors and found that students who have performed poorly in mathematics in the past are more likely to avoid seeking help in the future than students who have a track record of achieving at a high level. Concerning limitations of the study, the sample of 203 seventh and eighth graders included primarily white students from working-class and middle-class families who all attended the same junior high school in Michigan.

Another study (Beal, Qu, & Lee, 2008) examined students' prior mathematics achievement and their help-seeking behaviors in the context of geometry problem solving while using instructional software and found an unanticipated relationship between the two variables: Students with low levels of prior mathematics achievement are just as likely as high-achievers to engage in effective help-seeking behaviors, while both low-achievers and high-achievers are more likely to seek appropriate help than average-achievers. This finding is in conflict with prior research such as that conducted by Ryan and Pintrich (1997) and Newman (2002), which found that low-achieving students are the least likely to seek help. It is worth noting, however, that the differences in findings could be attributable to the fact that computer software, rather than the teacher and peers, provided the help resources in the Beal et al. (2008) study.

Unlike previous studies that used self-assessments and questionnaires to measure students' help-seeking behaviors, a study by Ryan et al. (2005) had the teachers report the students' help-seeking behaviors and examined their effects on the students' mathematics achievement. After controlling for prior achievement, this study found that students who utilize instrumental help-seeking behaviors score higher than students who utilize executive help-seeking behaviors or avoid help-seeking altogether. On the downside, all of the students in this study were sixth graders in urban elementary schools and most were from families of low socioeconomic status (SES).

Despite their limitations, the findings from Ryan et al. (2005) were further supported by a study by Schenke et al. (2015) involving an ethnically diverse group of southern California middle school and high school students. This study found that students who employ instrumental help-seeking behaviors, including seeking instrumental help from the teacher, experience significantly larger gains in mathematics achievement over the course of a year than students who employ executive help-seeking behaviors. However, most of the students in this study were also from families of low SES, thus limiting its generalizability.

Finally, Ogan et al. (2015) conducted an international study involving students in Costa Rica, the Philippines, and the U.S. that was designed primarily to assess the cross-cultural effectiveness of student help-seeking behaviors within the context of an online learning environment. In addition to addressing the main research questions of the study, the data also produced an interesting finding: Students' help-seeking behaviors, as measured by a computer-based tutoring system, are more useful than their mathematics pretest scores at predicting their mathematics posttest scores.

PISA's Perspective on Student Help-Seeking Behaviors

To measure student help-seeking behaviors, PISA included Situational Judgment Tests (SJTs) as part of the PISA 2012 student questionnaire (OECD, 2014b). SJTs present students with a real-world scenario involving a problem to be solved and require students to assess a variety of possible responses to the problem. The three SJTs included in the PISA 2012 student questionnaire involved the following problematic situations: 1) fixing a mobile phone that will no longer send text messages, 2) determining the most efficient route to take to get to a zoo, and 3) operating an unfamiliar ticket machine at a train station. Each of the three prompts was followed by four statements related to addressing the problem. For example, here is the SJT involving the mobile phone:

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. What would you do?

- I press every button possible to find out what is wrong.
- I think about what might have caused the problem and what I can do to solve it.
- I read the manual.
- I ask a friend for help.

For each item, the students were instructed to choose one response from the following options: I would definitely do this; I would probably do this; I would probably not do this; I would definitely not do this.

Since PISA is relatively new in measuring student help-seeking behaviors, having first included relevant items in PISA 2012 (OECD, 2014b), the PISA literature seems to be virtually non-existent in terms of its perspective on this issue. On the other hand, PISA has long recognized that students may cultivate a variety of learning strategies that influence their learning behavior and that these learning strategies are important components of the learning process. PISA defines student learning strategies as the processes, both cognitive and metacognitive, used by students when making an effort to increase their learning (OECD, 2010). PISA is particularly interested in the effect that individual students' learning strategies have on their academic achievement, as well as the way in which student learning strategies vary from school to school, with PISA's goal being to inform interested stakeholders such as educational policymakers, school administrators, classroom teachers, parents, and students, as to which student learning strategies are most effective (OECD, 2010).

As a result, PISA has been measuring student learning strategies since its inception with PISA 2000 by including items involving these topics within the student questionnaire as well as the school questionnaire (OECD, 2002). PISA 2003 was the only year prior to PISA 2012 that the focal subject area was mathematics (OECD, 2005), and that assessment data provided evidence that, in general, an association exists between student learning strategies and student mathematics achievement (OECD, 2010). Knowing that this relationship exists, PISA is now interested in determining if a more specific relationship exists between a particular student learning strategy, namely help-seeking, and student mathematics achievement.

Unfortunately, despite the evidence demonstrating that effective learning strategies do play an important role in overcoming the difficulties students face when learning mathematics, PISA has found that typical mathematics classroom instruction continues to stress primarily the execution of step-by-step procedures and memorization at the expense of other higher-order thinking skills and cognitive processes (OECD, 2013). Notwithstanding, PISA continues to press on in its effort to improve the quality of education for all students.

Teacher Instructional Practices

Specifically in the mathematics classroom, teacher-directed instructional practices mainly involve the teacher disseminating content-related information such as definitions, rules, and examples to the students, with the goal being for the students to acquire basic facts and skills (Morgan, Farkas, & Maczuga, 2015). In a typical teacher-directed mathematics lesson, the teacher incorporates procedural instruction to demonstrate the mathematical procedures required to solve each type of problem. This generally fast-paced direct instruction is followed by the students repeatedly practicing the procedures on their own with similar problems, often using worksheets, while the teacher walks around the classroom to monitor the students and offer assistance when the students ask for help (Herbel-Eisenmann, Lubienski, & Id-Deen, 2006).

Acquiring procedural fluency, which involves not only the ability to carry out the procedures but also the knowledge of when to use them, is particularly helpful for low-achieving students, who often lack the basic knowledge and skills necessary for implementing higher-order approaches to solving problems, as well as the ability to reason abstractly (Kroesbergen & Van Luit, 2003). In fact, the study by Morgan et al. (2015) found that first grade students with mathematics difficulties perform better on mathematics achievement tests when the classroom instruction is teacher-directed than they do when it is not. In addition to achievement level, some studies have found that age itself is a factor in the effectiveness of teacher-directed classrooms. For example, a study by Georges (2009) found that kindergarten students whose teachers focus on procedural skills experience larger gains in mathematics achievement than students whose teachers do not focus on such skills, while Crosnoe et al. (2010) found a negative association between the amount of procedural instruction used by the teacher and the mathematics achievement of fifth grade students.

Teacher-directed instructional practices tend to be performance-oriented, where the teacher treats learning as a competition and stresses to the students the importance of answering questions correctly and getting good grades; in turn, the students seek to outperform their classmates in order to appear intelligent (Stipek et al., 1998). In classrooms that are performance-oriented, the teacher sets goals for the students and publicly rewards those students who successfully achieve the goals (Park, Gunderson, Tsukayama, Levine, & Beilock, 2016). As an example, if a student makes the highest grade in the class for a particular assignment, the teacher might display that student's work on a bulletin board in the classroom or in the hallway.

By requiring the students to connect their prior knowledge with new experiences, student-centered instructional practices assist the students in cultivating a conceptual understanding of mathematics as opposed to just memorizing and repeating procedures (Jong, 2016). For example, a mathematics teacher might ask the students to draw a square and then describe its features, with the goal being for the students to eventually develop a mathematical definition for a square. A recent study of ninth grade students by Yu and Singh (2018) found that a more frequent use of conceptual classroom instruction by the teacher is associated with higher student mathematics achievement. Also, despite the fact that student-centered instructional practices emphasize conceptual understanding rather than the acquisition of basic skills, there is evidence that students in student-centered classrooms still attain higher levels of proficiency in using basic skills and procedures than students in teacher-directed classrooms (Lerkkanen et al., 2016).

Student-centered instructional practices may involve the use of mathematical manipulatives to stimulate higher-order thinking and help students develop a conceptual understanding of the mathematical content (McKinney & Frazier, 2008; Wilkins, 2008). For example, when introducing one of the four basic arithmetic operations on fractions, the teacher might distribute pattern blocks to the students and then allow them to create their own physical representations of the problems and develop the algorithms themselves. Wenglinsky (2002) found that students in eighth grade who are exposed to more hands-on learning experiences such as using manipulatives generally have higher levels of mathematics achievement than those students who are not afforded these types of experiences. An activity-based approach to classroom instruction has been shown to be particularly effective in increasing the mathematical knowledge of students in geographical regions with high rates of poverty (Berry, 2003).

Student-centered instructional practices tend to be mastery-oriented rather than performance-oriented, with students being encouraged to strive for personal improvement and progress toward mastery as opposed to simply outperforming their classmates (Schenke et al., 2015). When the teacher defines student success in terms of making progress and achieving mastery, every student has an opportunity to be successful. On the other hand, when success is defined in terms of performance and competition with classmates, some students necessarily will fail. In a mastery-oriented classroom environment, incorrect answers are not treated as failures but as a normal and beneficial component of the learning process. A study of fourth, fifth, and sixth graders by Stipek et al. (1998) found that students who focus on mastery experience higher levels of learning, as well as more enjoyment of mathematics, than students who focus on performance.

Since student-centered instructional practices do not pit students against one another in a competitive atmosphere, the classroom environment becomes like that of a close-knit community in which student-to-student interactions, as well as student-initiated student-to-teacher interactions, become the norm (Lerkkanen et al., 2016). Without the fear of feeling embarrassed or being ridiculed for making a mistake, students in student-centered classrooms are more willing to explain their ideas and learning strategies to both their classmates and teachers (Morgan et al., 2015). In addition, when the teacher encourages students to ask questions and take risks, students are more likely to seek help when they encounter difficulties, thus demonstrating that teacher instructional practices are also associated with student help-seeking behaviors (Ryan & Shim, 2012).

This social interaction, which is a key feature of student-centered instructional practices, plays a critical role in the area of problem solving. By the time they reach middle school, the majority of students know basic mathematical facts and can perform standard mathematical procedures; however, even these students continue to struggle with applying their mathematical knowledge to situations that involve problem solving (McKinney & Frazier, 2008). Through the use of student-centered instructional practices that promote inquiry-based learning, students are provided with the opportunity to discuss their own thoughts and strategies with their classmates when encountered by problems that are situated in real-world contexts. A classroom environment that encourages students to collaborate with their peers and exposes them to multiple approaches during situations that require problem solving is associated with higher levels of mathematics achievement for students in elementary school, particularly those students who struggle with mathematics (McCaffrey et al., 2001).

In addition to prior research demonstrating the existence of a relationship between teacher instructional practices and student mathematics achievement, a number of studies involving elementary school students have further determined that the strength of this relationship may vary depending upon the age of the students (Lerkkanen et al., 2016). Although age has been identified as a moderator variable, in comparison to the abundance of studies involving young students, relatively few studies have considered the relationship between teacher instructional practices and student mathematics achievement at the high school level (Yu & Singh, 2018).

One issue that arises in comparing the results from various studies involving teacher instructional practices is the discrepancy in the ways in which the instructional practices are measured or reported. In some cases, the classroom teacher (e.g., McKinney & Frazier, 2008) or students (e.g., Ryan & Shim, 2012) complete a questionnaire designed to gauge the teacher's instructional practices, while in other cases the teacher's instructional practices are measured based on in-person classroom observations and teacher interviews conducted by the researchers (e.g., Artzt & Armour-Thomas, 1999). In still other cases, teacher instructional practices are categorized based on which mathematics curriculum the school has adopted. However, there is evidence that, even when two teachers are using the same curriculum, their individual instructional practices may vary significantly (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010), possibly due to differences in how the curriculum is used or differences in the teachers' knowledge and beliefs about mathematics.

Although individual instructional practices can be categorized as being either teacher-directed or student-centered, it is not necessary for a particular teacher's instructional practices to all fall into the same category. This is due to the realization that students need to have a firm grasp on basic skills and procedures as well as a conceptual understanding of the content in order to become proficient in mathematics (NMAP, 2008). Further, a study by Byrnes and Wasik (2009) involving a national sample of early elementary-age students found that student mathematics achievement is typically higher when the teacher employs a combination of teacher-directed and student-centered instructional practices. As it turns out, while teachers generally consider their approach to be either teacher-directed or student-centered, most teachers do tend to include both types of instructional practices in their classrooms (Jong, 2016). Since both teacher-directed instructional practices and student-centered instructional practices are potentially valuable, it is recommended that teachers occasionally reflect upon their own instructional practices to ensure they are maintaining a proper balance (McKinney & Frazier, 2008).

PISA's Perspective on Teacher Instructional Practices

Since teacher instructional practices are associated with student mathematics achievement, PISA is interested in examining the magnitude of this association. In addition, PISA is also interested in examining the extent to which teacher instructional practices vary from school to school, as PISA 2003 provided evidence that this variation is significant, even among schools within the same school district (OECD, 2010). The goal of PISA's endeavors regarding this issue is to be able to inform interested stakeholders such as educational policymakers, school administrators, classroom teachers, parents, and students, as to which teacher instructional practices are most effective, as well as to help guide the development of educational policies that will assist in providing optimal opportunities for all students to receive a high-quality education (OECD, 2010).

PISA does not directly survey classroom teachers; however, PISA is still able to collect data on teacher instructional practices by including a variety of items related to those practices on the questionnaire completed by students (OECD, 2014b). On the other hand, because the sampling design used by PISA involves taking a random sample of students from within each randomly selected school as a whole rather than from within individual classrooms, it is not possible to analyze the effects of teacher instructional practices on student mathematics achievement at the classroom level. Instead, PISA produces an aggregated measure of teacher instructional practices at the school level (OECD, 2014b).

Although PISA has been measuring various characteristics of teacher instructional practices since its inception in the year 2000, the specific indices used in PISA 2012 had not been included in any of PISA's previous studies (OECD, 2014b). On a series of items included in the PISA 2012 student questionnaire, students were asked to record how frequently their mathematics teacher uses certain practices, behaviors, and strategies in the classroom. From the students' responses to these items, PISA constructed the following three indices related to teacher instructional practices: teacher-directed instruction, student orientation, and formative assessment (OECD, 2014b).

PISA's index of teacher-directed instruction is aimed at measuring the extent to which the mathematics teacher directly structures the classroom learning experience for the students without their input, and involved items such as how often the teacher sets clear goals for student learning and how often the teacher tells the students what they have to learn (OECD, 2014b). Overall, the five items used to construct PISA's teacher-directed instruction index center around the teacher as the primary player during the learning process; therefore, this index fits into the aforementioned category of teacher-directed instructional practices.

PISA's index of student orientation is aimed at measuring the extent to which the mathematics teacher encourages students to participate and work together in the classroom, and involved items such as how often the teacher asks students to help plan classroom activities and how often the teacher has students work in small groups (OECD, 2014b). Overall, the four items used to construct PISA's student orientation index emphasize student involvement and social interaction among students during the learning process; therefore, this index fits into the aforementioned category of student-centered instructional practices.

PISA's index of formative assessment is aimed at measuring the extent to which the mathematics teacher tracks the progress of the students and provides each student with personalized feedback, and involved items such as how often the teacher tells students how well they are doing in mathematics class and how often the teacher tells students what they need to do to become better in mathematics (OECD, 2014b). Overall, even though the four items used to construct PISA's formative assessment index involve the teacher as the initiator, the information obtained through formative assessment can be used to tailor future classroom instruction to individual student needs; therefore, this index also fits into the aforementioned category of student-centered instructional practices.

Student and School Background Characteristics

Students are viewed as bringing into their schools different individual and family characteristics, commonly referred to as student background characteristics, which have the potential to affect their academic performance (Ma, Ma, & Bradley, 2008). Individual differences in student mathematics achievement have been shown to be attributable to several student background characteristics, including gender, socioeconomic status (SES), number of parents living in the home, and primary language spoken in the home. For example, the Early Childhood Longitudinal Study—Kindergarten Class of 1998-99 (ECLS-K) examined mathematics achievement (along with other variables) by gender of approximately 21,000 students and found that, while mathematics achievement does not differ significantly by gender at the beginning of kindergarten, a significant gap favoring boys becomes evident by the end of kindergarten, and the gap continues to widen throughout elementary school (Lubienski, Robinson, Crane, & Ganley, 2013). The positive correlation between SES and mathematics achievement has been well-documented for quite some time (Ma, 2005). Pong, Dronkers, and Hampden-Thompson (2003) analyzed data from the Trends in International Mathematics and Science Study (TIMSS) and found that students who live with only one parent are significantly disadvantaged in terms of mathematics achievement when compared to students who live with both parents. Relative to U.S. students whose families primarily speak English in the home, English language learners (ELLs) are at a high risk for low achievement in mathematics (Guglielmi, 2012).

Like student background characteristics, there are also school background characteristics that have the potential to affect students' academic performance.

Individual differences in student mathematics achievement have been shown to be attributable to several school background characteristics, including school enrollment size, school location (determined by the population of the city or area within which the school is located), and school mean SES (determined by averaging the SES of all students in the school). For example, a study by Kuziemko (2006) involving students in public elementary schools in Indiana found a negative relationship between school enrollment size and student mathematics achievement. Ma et al. (2008) analyzed data from the U.S. sample of PISA 2000 and found that students in rural schools generally outperform students in urban schools in terms of mathematics achievement. In addition, this study also found that, on average, students attending schools with above-average school mean SES tend to experience significantly higher levels of mathematics achievement than students attending schools with below-average school mean SES.

Roles of Variables in This Study

In the present study, the outcome variable was student mathematics achievement and the main predictor variable was student help-seeking behavior. This relationship was examined in terms of the moderating function of teacher instructional practices while also allowing teacher instructional practices to function as a predictor of student mathematics achievement. This whole analytical framework also contained some control over student and school background characteristics as briefly discussed earlier. From the selection of variables and the specification of analysis, the research practices used in this study fall well in line with Ma et al. (2008) as a study of individual differences in, and school effects on, the core content area of mathematics. Finally, this study took advantage of the nationally representative data from PISA 2012. All of these aspects of the study help to fill in various gaps in the current research literature, especially those gaps related to student help-seeking behaviors.

Chapter 3: Method

Sample and Data

For each participating OECD country, PISA 2012 implemented a two-stage, stratified, random probability sampling procedure (OECD, 2014b). At the first stage, a stratified random sample of schools was selected from the school sampling frame, which consisted of all public and private schools containing 15-year-old students in grade 7 or higher, in proportion to school enrollment size. In a limited number of cases, some schools were excluded from the sampling frame, such as schools in remote areas, special education schools, and very small schools. More specifically, before sampling, with the aim of obtaining results that better reflect the country's population, PISA 2012 assigned the schools in the sampling frame to mutually exclusive groups, called strata, based on certain shared school characteristics. Next, a random sample of schools was selected from each stratum in direct proportion to the relative size of the stratum (OECD, 2014b).

At the second stage of the sampling design, within each of the randomly sampled schools, a random sample of students was selected from a list of all eligible students. Schools that were sampled were permitted to exclude some of their students from the sampling frame for reasons such as mental, emotional, and physical disabilities, as well as language deficiencies. PISA 2012 aimed to randomly select at least 35 students from each sampled school; for a sampled school whose sampling frame contained fewer than 35 students, all of the students in the school's sampling frame were selected (OECD, 2014b).

Worldwide, approximately 510,000 randomly selected students from 65 educational systems participated in PISA 2012 (OECD, 2014b). To collect data in PISA

2012, in addition to the standardized paper-and-pencil based achievement tests and the optional computer-based assessment, participating students and their school principals completed questionnaires to provide information about student and school background characteristics. For the purposes of data analysis, this study utilized only the data collected from the U.S. sample. In the U.S., there were 240 schools randomly selected to participate, from which 7,429 students were randomly selected (Kastberg et al., 2014).

The PISA 2012 assessment data for the U.S. has a hierarchical (or multilevel) structure, with students being nested within schools. Therefore, this study used a two-level hierarchical linear model (HLM) to analyze the data. With this modeling technique, this study was able to estimate the effects that student-level variables and school-level variables have on student mathematics achievement simultaneously, as well as the effects that school-level variables have on the effects of student-level variables on student mathematics achievement.

Dependent (Outcome) Variables

The dependent variable for this study was student mathematics achievement on the mathematics component of the PISA 2012 assessment. PISA 2012 created a total of 85 distinct items to be used in its assessment of mathematics, with the items' intended purpose being to measure mathematical literacy, which PISA defines as "how well 15-year-old students can understand, use, and reflect on mathematics for a variety of real-life problems and settings that they may not encounter in the classroom" (Kastberg et al., 2014, p. 2). In particular, these items were designed to measure literacy in four mathematical literacy areas: change and relationship, space and shape, uncertainty and data, and quantity (OECD, 2013). Change and relationship involves using equations, inequalities, functions, and graphs to model changes that occur over time, as well as how one object changing affects another object. Space and shape involves using geometry and measurement to understand the visual and physical world. Uncertainty and data involves using probability and statistics to produce models, give interpretations, and make inferences in situations involving uncertainty, chance, and variation. Quantity involves applying knowledge of numbers and number operations, along with quantitative reasoning, to a broad range of real-world scenarios.

In addition, these test items also tap into three mathematical process areas: formulating, employing, and interpreting (OECD, 2013). The mathematical process of formulating involves identifying real-world problems that can be solved using mathematics and then developing mathematical structures that can be used to determine solutions. The mathematical process of employing involves applying mathematical reasoning and concepts to produce solutions to mathematically-formulated problems. The mathematical process of interpreting involves reflecting upon mathematical solutions and then interpreting them in view of the context of the real-world problems.

More specifically, the outcome (dependent) measures for this study were student scores on (a) the overall mathematical literacy, (b) the four mathematical literacy areas (change and relationship, space and shape, uncertainty and data, and quantity), and (c) the three mathematical process areas (formulating, employing, and interpreting).

In PISA, seven versions of the mathematics test were created using matrix sampling. In matrix sampling, a set of items that spans the curriculum is divided into subsets, and each student is given one subset of items. The goal of matrix sampling is to minimize the testing time per student while not sacrificing the broadness of the content covered by the test. In the case of PISA 2012, matrix sampling divided the 85 mathematics items into seven subsets called clusters (or units), for an average of about 12 items per mathematics cluster, where each student worked on only one of the clusters (Kastberg et al., 2014).

Due to the use of matrix sampling, not every student takes the same test; therefore, mathematics achievement cannot be determined through the traditional use of test scores. Instead, PISA determines mathematics achievement through the use of plausible values (Kastberg et al., 2014). To obtain plausible values, PISA uses the observed values on individual student tests, as well as information collected on student background variables, to estimate a probability distribution for a student's ability parameter. Then, for each student, plausible values are randomly selected from the distribution (see Ma et al., 2008).

Independent (Predictor) Variables

The student questionnaire administered in PISA 2012 contained 56 questions (Kastberg et al., 2014). These questions were designed to provide information about student background characteristics such as family, home, school, learning strategies, and mathematical and problem solving experiences. The school questionnaire contained 39 questions (Kastberg et al., 2014). These questions were designed to provide information about school background characteristics such as demographics and learning environment. The independent variables in this study came from student and school questionnaire data.

The key student-level predictor (independent) variable for this study was student help-seeking behavior, which PISA defines as the ways in which students have a propensity to depend on the knowledge and intellect of others, including both their peers and teachers, when attempting to solve problems (OECD, 2014b). For the first time in PISA's history, PISA 2012 constructed a composite variable to measure student help-seeking behavior based on student responses to situational judgment tests (SJTs) included in the student questionnaire. Specifically, PISA's help-seeking index was constructed using a total of four items from the text message and ticket machine SJTs (OECD, 2014b). Here is the text message SJT and the items from it that were used:

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. What would you do?

- I read the manual.
- I ask a friend for help.

Here is the ticket machine SJT and the items from it that were used:

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. What would you do?

- I ask someone for help.
- I try to find a ticket office at the station to buy a ticket.

Ultimately, PISA decided not to include this index in the PISA 2012 database due to its low internal consistency (Cronbach's α = .54; OECD, 2014b).

In light of PISA's decision not to include its help-seeking index, the present study constructed a composite variable for measuring student help-seeking behavior that differs from that constructed by PISA. Specifically, this study's help-seeking index used a total of three items from the text message and ticket machine SJTs. Here is the text message SJT and the item from it that was used:

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. What would you do?

- I ask a friend for help.

Here is the ticket machine SJT and the items from it that were used:

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. What would you do?

- I ask someone for help.
- I try to find a ticket office at the station to buy a ticket.

For each item, the students were instructed to choose one response from the following four options: 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. PISA 2012 gave each student separate scores for their responses to each of the three statements; however, for this study the three scores provided by PISA were aggregated to create a composite variable for measuring student help-seeking behavior, with one (composite) score for each student. The items were recoded (i.e., responses reversed) so that a higher value indicates more proactive seeking of help.

Although the help-seeking index constructed for the current study resulted in a slightly higher internal consistency (Cronbach's $\alpha = .58$) than the index constructed by PISA (Cronbach's $\alpha = .54$), the alpha level is still not optimal. Despite this finding, the help-seeking index was used in this study because, conceptually, the three items used to construct the index are measuring exactly students' help-seeking behaviors. In particular, unlike the other items from the SJTs, the three items selected to form the composite variable all involve an individual seeking help by interacting with another person. Therefore, this composite variable is conceptually clear and consistent from a theory-driven perspective, even though from a data-driven perspective, the internal consistency was not as strong as one would want. Other student-level variables were used as control variables (to be discussed later).

The key school-level predictor (independent) variables for this study were the following three teacher instructional practices (as named by PISA): teacher-directed instruction, student orientation, and formative assessment (OECD, 2014b). PISA 2012 used information obtained from the following items included on the student questionnaire to create a composite variable for measuring teacher-directed instruction (Cronbach's $\alpha = .76$; OECD, 2014b), with one (composite) score for each student:

How often do these things happen in your mathematics lessons?

- The teacher sets clear goals for our learning.
- The teacher asks me or my classmates to present our thinking or reasoning at some length.
- The teacher asks questions to check whether we have understood what was taught.
- At the beginning of a lesson, the teacher presents a short summary of the previous lesson.
- The teacher tells us what we have to learn.

PISA 2012 used information obtained from the following items included on the student questionnaire to create a composite variable for measuring student orientation (Cronbach's $\alpha = .68$; OECD, 2014b), with one (composite) score for each student:

How often do these things happen in your mathematics lessons?

- The teacher gives different work to classmates who have difficulties learning and/or to those who can advance faster.
- The teacher assigns projects that require at least one week to complete.
- The teacher has us work in small groups to come up with joint solutions to a problem or task.
- The teacher asks us to help plan classroom activities or topics.

PISA 2012 used information obtained from the following items included on the student questionnaire to create a composite variable for measuring formative assessment (Cronbach's α = .79; OECD, 2014b), with one (composite) score for each student:

How often do these things happen in your mathematics lessons?

- The teacher tells me about how well I am doing in my mathematics class.
- The teacher gives me feedback on my strengths and weaknesses in mathematics.
- The teacher tells us what is expected of us when we get a test, quiz, or assignment.
- The teacher tells me what I need to do to become better in mathematics.

For each of the 13 items listed, students were instructed to choose one response from the following four options: 4 = every lesson, 3 = most lessons, 2 = some lessons, 1 = never or hardly ever.

For this study, each of the three teacher instructional practices were aggregated within each school to generate three school-level measures that describe the school environment of teachers' instructional practices under which students pursue mathematics learning. Other school-level variables were used as control variables (see the following discussion).

Control Variables

In order to combat the effects that certain confounding variables might have on a student's score on the PISA mathematics test, there is a need to control for such variables. This approach enabled the present study to demonstrate the "pure" effects that student help-seeking behavior has on student mathematics achievement while interacting with teacher instructional practices. The key student-level control variables for this study were gender (1 = male, 0 = female), socioeconomic status (SES; continuous index), family structure (1 = single parent, 0 = other structure), and home language (1 = English, 0 = other language). The key school-level control variables for school context in this study were school enrollment size (continuous); proportion of girls; school location (1 = city or large city; 0 = village, small town, or town); school mean SES (aggregated from students' SES); public versus private school (1 = public, 0 = private); and proportion of mathematics teachers with a bachelor's or master's degree with a major in mathematics, statistics, physics, or engineering. Both student-level variables and school-level variables are exogenous in nature, with the goal having been to emphasize the key independent (predictor) variables of both levels.

Statistical Procedures and Analyses

As stated earlier, since the PISA 2012 assessment data for the U.S. has a hierarchical (or multilevel) structure, with students being nested within schools, this study used a two-level hierarchical linear model (HLM) to analyze the data. In particular, the HLM analysis needed to address the research questions was performed by building models in three stages. Although "MATH" appears as the dependent variable in the following models, these models were used for each of the specified outcome (dependent) measures, which were student PISA scores on (a) the overall mathematical literacy, (b) the four mathematical literacy areas (change and relationship, space and shape, uncertainty and data, and quantity), and (c) the three mathematical process areas (formulating, employing, and interpreting), by replacing MATH with the particular dependent variable of interest.

The first stage in the HLM analysis was the null model, which included no independent variables at either the student level or the school level. This model is equivalent to a one-way random-effect analysis of variance (ANOVA), and it was used to show how much variation in student mathematics achievement exists at both the student level and the school level. Here is the null model:

$$\mathrm{MATH}_{ij} = \beta_{0j} + r_{ij}$$

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

where MATH_{ij} is the mathematics achievement for student i in school j, β_{0j} is the mean mathematics achievement for school j, r_{ij} is the error term representing the unique effect associated with student i in school j, γ_{00} is the grand (overall) mean mathematics achievement, and u_{0j} is the error term representing the unique effect associated with school j.

At the second stage in the HLM analysis, student-level variables were added to the null model developed at stage one to determine whether student help-seeking behavior, with the adjustment of the control variables, has any statistically significant effects on student mathematics achievement. The variable of student help-seeking behavior was treated as a random variable for the examination of variance in the effects of student help-seeking behavior on student mathematics achievement across schools. Here is the model at this stage:

$$\mathrm{MATH}_{ij} = \beta_{0j} + \beta_{1j}(\mathrm{HSB})_{ij} + \sum_{p=1}^{m} \beta_{(p+1)j} X_{pij} + r_{ij}$$

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

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

where MATH_{ij} is the mathematics achievement for student i in school j, β_{0j} is the mean mathematics achievement for school j, $(\mathrm{HSB})_{ij}$ is the help-seeking behavior score for student i in school j, β_{1j} is the slope associated with $(\mathrm{HSB})_{ij}$, r_{ij} is the error term unique to student i in school j, γ_{00} is the grand (overall) mean mathematics achievement, u_{0j} is the error term of school j unique to the intercept, γ_{10} is the effect of $(\mathrm{HSB})_{ij}$, and u_{1j} is the error term of school j unique to the slope of $(\mathrm{HSB})_{ij}$. Control variables at the student level were collected within the sigma, with coefficients indicating the effects of each control variable on student mathematics achievement. The results obtained at this stage were used to address the following research question:

- At the school level, do the effects of student help-seeking behaviors on student mathematics achievement vary statistically significantly from school to school?

At the third stage, school-level variables were added to the model developed at stage two, with the goal having been to use variables descriptive of teacher instructional practices to model the effects of student help-seeking behaviors on student mathematics achievement (as well as the direct effects of teacher instructional practices on student mathematics achievement). Here is the model at this stage:

$$\mathrm{MATH_{ij}} = \beta_{0j} + \beta_{1j}(\mathrm{HSB})_{ij} + \sum_{p=1}^{m} \beta_{(p+1)j} X_{pij} + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\mathrm{TDI})_j + \gamma_{02}(\mathrm{STOR})_j + \gamma_{03}(\mathrm{FA})_j + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\mathrm{TDI})_j + \gamma_{12}(\mathrm{STOR})_j + \gamma_{13}(\mathrm{FA})_j + u_{1j}$$

where $\mathrm{MATH_{ij}}$ is the mathematics achievement for student i in school j, β_{0j} is the mean mathematics achievement for school j, $(\mathrm{HSB})_{ij}$ is the help-seeking behavior score for student i in school j, β_{1j} is the slope associated with $(\mathrm{HSB})_{ij}$, r_{ij} is the error term unique to student i in school j, γ_{00} is the grand (overall) mean mathematics achievement, $(\mathrm{TDI})_j$ is the teacher-directed instruction score for school j, γ_{01} is the effect of $(\mathrm{TDI})_j$ on β_{0j}, $(\mathrm{STOR})_j$ is the student orientation score for school j, γ_{02} is the effect of $(\mathrm{STOR})_j$ on β_{0j}, $(\mathrm{FA})_j$ is the formative assessment score for school j, γ_{03} is the effect of $(\mathrm{FA})_j$ on β_{0j}, u_{0j} is the error term of school j unique to the intercept, γ_{10} is the average slope of $(\mathrm{HSB})_{ij}$, γ_{11} is the effect of $(\mathrm{TDI})_j$ on β_{1j}, γ_{12} is the effect of $(\mathrm{STOR})_j$ on β_{1j}, γ_{13} is the effect of

$(FA)_j$ on β_{1j}, and u_{1j} is the error term of school j unique to the slope of $(HSB)_{ij}$. The results obtained at this stage were used to address the following two research questions:

- At the student level, do student help-seeking behaviors have any statistically significant effects on student mathematics achievement, with control over student background characteristics?
- If the effects of student help-seeking behaviors on student mathematics achievement do vary from school to school, do teacher instructional practices (as aggregated measures at the school level) contribute statistically significantly to this variation, with control over school background characteristics?

Chapter 4: Results

Descriptive Statistics for Student-Level and School-Level Variables

The key student-level independent variable for this study was student help-seeking behavior, which had a mean score of 2.21 (on a 4-point scale) with a standard deviation (*SD*) of 0.73 (see Table 1). Four control variables were included at the student level: gender, socioeconomic status (SES), family structure, and home language. Approximately half of the students in the study were male and half were female (see Table 1). The average SES for the students in this study was 0.22 with an *SD* of 0.97 (see Table 1). The SES index was standardized based on all the participating countries, meaning the U.S. students had a slightly higher SES than the average SES for all OECD students (OECD, 2014b). About 21% of the students in the study were from a single-parent home, while roughly 90% spoke English as their primary language at home (see Table 1). Although student mathematics achievement was the key student-level dependent variable for this study, descriptive statistics for this variable are omitted in Table 1 because PISA measures it using multiple plausible values. Nonetheless, means and variances of multiple measures of mathematics achievement were estimated using the two-level hierarchical linear model (HLM) discussed in Chapter 3 (specifically the null model). Estimated descriptive statistics from the model (as opposed to calculated descriptive statistics from the data as in Table 1) are included in Table 3 and discussed later.

The key school-level independent variables for this study were the following three teacher instructional practices: teacher-directed instruction, student orientation, and formative assessment, which had mean scores of 0.30 (*SD* = 0.52), 0.26 (*SD* = 0.47), and

0.32 (*SD* = 0.48), respectively (see Table 2). Six control variables were included at the school level: school enrollment size; proportion of girls; school mean SES; school location; public versus private school; and proportion of mathematics teachers with a bachelor's or master's degree with a major in mathematics, statistics, physics, or engineering. On average, the U.S. schools had an enrollment of about 1337 students (*SD* = 870), with approximately 49% of the students being female (see Table 2). The average school mean SES for the U.S. schools was 0.21 (*SD* = 0.54) (see Table 2), slightly higher than the average school mean SES for all OECD countries (OECD, 2014b). Around 38% of the schools were located in cities with a population size of at least 100,000 people, while nearly all (91%) of the schools were public schools (see Table 2). Finally, on average, about two-thirds (67%) of the mathematics teachers in the U.S. schools had at least a bachelor's degree in mathematics or a related discipline (see Table 2).

Grand Means and Partition of Variance for Mathematics Achievement Measures

The outcome (dependent) measures for this study included eight measures of student mathematics achievement on the mathematics component of the PISA 2012 assessment. Specifically, these measures pertained to (a) the overall mathematical literacy, (b) the four mathematical literacy areas (change and relationship, space and shape, uncertainty and data, and quantity), and (c) the three mathematical process areas (formulating, employing, and interpreting). The first stage in the HLM analysis was the null model, which included no independent variables at either the student level or the school level. The purpose of this step was to determine the grand means for the eight measures of student mathematics achievement and to show how much variation in these outcome measures exists at both the student level and the school level.

Table 3 presents model estimated means and variances (descriptive in nature) for all eight measures of student mathematics achievement. For overall mathematical literacy, the grand mean score for the U.S. students was 486.32. The total variance in overall mathematical literacy was 7895.09. Partition of variance showed that 78% of the variation was attributable to students (6123.07) and 22% was attributable to schools (1772.02). The variance at the school level was statistically significant, $\chi^2(137) = 951.48$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of overall mathematical literacy.

For change and relationship, the grand mean score for the U.S. students was 492.03. The total variance in change and relationship was 8691.35. Partition of variance showed that 78% of the variation was attributable to students (6816.64) and 22% was attributable to schools (1874.71). The variance at the school level was statistically significant, $\chi^2(137) = 905.02$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of change and relationship.

For space and shape, the grand mean score for the U.S. students was 468.72. The total variance in space and shape was 9324.18. Partition of variance showed that 78% of the variation was attributable to students (7247.03) and 22% was attributable to schools (2077.15). The variance at the school level was statistically significant, $\chi^2(137) = 932.88$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of space and shape.

For uncertainty and data, the grand mean score for the U.S. students was 494.41. The total variance in uncertainty and data was 7685.26. Partition of variance showed that 76% of the variation was attributable to students (5845.28) and 24% was attributable to schools (1839.98). The variance at the school level was statistically significant, $\chi^2(137) = 1030.46$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of uncertainty and data.

For quantity, the grand mean score for the U.S. students was 484.69. The total variance in quantity was 9621.73. Partition of variance showed that 77% of the variation was attributable to students (7420.53) and 23% was attributable to schools (2201.20). The variance at the school level was statistically significant, $\chi^2(137) = 962.08$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of quantity.

For formulating, the grand mean score for the U.S. students was 481.22. The total variance in formulating was 9640.73. Partition of variance showed that 77% of the variation was attributable to students (7410.57) and 23% was attributable to schools (2230.16). The variance at the school level was statistically significant, $\chi^2(137) = 970.86$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of formulating.

For employing, the grand mean score for the U.S. students was 485.45. The total variance in employing was 7914.74. Partition of variance showed that 79% of the variation was attributable to students (6232.59) and 21% was attributable to schools (1682.15). The variance at the school level was statistically significant, $\chi^2(137) = 898.39$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of employing.

For interpreting, the grand mean score for the U.S. students was 494.02. The total variance in interpreting was 8727.10. Partition of variance showed that 78% of the variation was attributable to students (6806.72) and 22% was attributable to schools (1920.38). The variance at the school level was statistically significant, $\chi^2(137) = 927.68$, $p < .001$. This indicated that the U.S. schools were significantly different in terms of interpreting.

Relationship Between Student Help-Seeking and Mathematics Achievement

Student help-seeking behavior was added to the null model to examine its absolute relationship with student mathematics achievement. Table 4 presents model estimated effects of student help-seeking behavior on each of the eight measures of student mathematics achievement prior to the inclusion of all other variables in the model. Because PISA mathematics achievement measures have a mean of 500 and a standard deviation (*SD*) of 100, it is easy to convert an effect of student help-seeking behavior into a proportion (or percentage) of an *SD* as an effect size measure for practical importance.

Student help-seeking behavior was found to have a statistically significant effect on overall mathematical literacy. The model predicts an average increase of 8.17 points in the overall mathematical literacy score for each 1-point increase in the student help-seeking behavior score. The effect size was 8.17% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on overall mathematical literacy did not vary statistically significantly from school to school, $\chi^2(135) = 122.25$, $p > .500$. In other words, the effects of student help-seeking behavior on overall mathematical literacy were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on change and relationship. The model predicts an average increase of 7.24 points in the change and relationship score for each 1-point increase in the student help-seeking behavior score. The effect size was 7.24% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on change and relationship did not vary statistically significantly from school to school, $\chi^2(135) = 120.14$, $p > .500$. In other words, the effects of student help-seeking behavior on change and relationship were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on space and shape. The model predicts an average increase of 8.37 points in the space and shape score for each 1-point increase in the student help-seeking behavior score. The effect size was 8.37% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on space and shape did not vary statistically significantly from school to school, $\chi^2(135) = 141.85$, $p = .326$. In other words, the effects of student help-seeking behavior on space and shape were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on uncertainty and data. The model predicts an average increase of 7.42 points in the uncertainty and data score for each 1-point increase in the student help-seeking behavior score. The effect size was 7.42% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on uncertainty and data did not vary statistically significantly from school to school, $\chi^2(135) = 141.39$, $p = .336$. In other words, the effects of student help-seeking behavior on uncertainty and data were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on quantity. The model predicts an average increase of 9.35 points in the quantity score for each 1-point increase in the student help-seeking behavior score. The effect size was 9.35% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on quantity did not vary statistically significantly from school to school, $\chi^2(135) = 136.52$, $p = .447$. In other words, the effects of student help-seeking behavior on quantity were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on formulating. The model predicts an average increase of 10.18 points in the formulating score for each 1-point increase in the student help-seeking behavior score. The effect size was 10.18% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on formulating did not vary statistically significantly from school to school, $\chi^2(135) = 120.72$, $p > .500$. In other words, the effects of student help-seeking behavior on formulating were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on employing. The model predicts an average increase of 7.93 points in the employing score for each 1-point increase in the student help-seeking behavior score. The effect size was 7.93% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on employing did not vary statistically significantly from school to school, $\chi^2(135) = 132.70$, $p > .500$. In other words, the effects of student help-seeking behavior on employing were similar for all schools.

Student help-seeking behavior was found to have a statistically significant effect on interpreting. The model predicts an average increase of 9.13 points in the interpreting score for each 1-point increase in the student help-seeking behavior score. The effect size was 9.13% of an *SD*, indicating a small effect. Meanwhile, the effects of student help-seeking behavior on interpreting did not vary statistically significantly from school to school, $\chi^2(135) = 128.81$, $p > .500$. In other words, the effects of student help-seeking behavior on interpreting were similar for all schools.

Relative Estimates of Student Help-Seeking on Mathematics Achievement

In addition to the student-level independent variable student help-seeking behavior, the full model also included four control variables at the student level: gender, SES, family structure, and home language. Further, three teacher instructional practices (teacher-directed instruction, student orientation, and formative assessment) were included as independent variables at the school level, along with six school-level control variables: school enrollment size; proportion of girls; school mean SES; school location; public versus private school; and proportion of mathematics teachers with a bachelor's or master's degree with a major in mathematics, statistics, physics, or engineering.

Originally, the inclusion of the three teacher instructional practice variables aimed to use them to model the effects of student help-seeking behavior on student mathematics achievement across schools. However, because the effects of student help-seeking behavior on mathematics achievement were shown to be similar for all schools (see Table 3), this modeling purpose became unnecessary. Nonetheless, by including student-level and school-level variables as controls in the model, the study was able to examine the relative or "pure" effects that student help-seeking behavior has on student mathematics achievement. In addition, some interesting findings regarding the effects of teacher instructional practices on student mathematics achievement also surfaced. These findings are summarized in Table 6 and will be discussed later.

Table 5 presents model estimated effects of student help-seeking behavior on each of the eight measures of student mathematics achievement after the inclusion of all other variables in the model. Strictly speaking, all interpretations related to Table 5 need to include the phrase "controlling for all other variables in the model." However, to avoid repetition, this phrase was omitted from many of the following interpretations.

For overall mathematical literacy, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 6.61 points in the overall mathematical literacy score for each 1-point increase in the student help-seeking behavior score (effect size = 6.61% of an *SD*). It is worth emphasizing that this relative effect of 6.61 is not dramatically different from the absolute effect of 8.17 (see Table 4), indicating a robust effect.

For change and relationship, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 5.99 points in the change and relationship score for each 1-point increase in the student help-seeking behavior score (effect size = 5.99% of an *SD*). It is worth emphasizing that this relative effect of 5.99 is not dramatically different from the absolute effect of 7.24 (see Table 4), indicating a robust effect.

For space and shape, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 7.41 points in the space and shape score for each 1-point increase in the student help-seeking behavior score (effect size = 7.41% of an *SD*). It is worth emphasizing that this relative effect of 7.41 is not dramatically different from the absolute effect of 8.37 (see Table 4), indicating a robust effect.

For uncertainty and data, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 6.02 points in the uncertainty and data score for each 1-point increase in the student help-seeking behavior score (effect size = 6.02% of an *SD*). It is worth emphasizing that this relative effect of 6.02 is not dramatically different from the absolute effect of 7.42 (see Table 4), indicating a robust effect.

For quantity, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 7.52 points in the quantity score for each 1-point increase in the student help-seeking behavior score (effect size = 7.52% of an *SD*). It is worth emphasizing that this relative effect of 7.52 is not dramatically different from the absolute effect of 9.35 (see Table 4), indicating a robust effect.

For formulating, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 8.63 points in the formulating score for each 1-point increase in the student help-seeking behavior score (effect size = 8.63% of an *SD*). It is worth emphasizing that this relative effect of 8.63 is not dramatically different from the absolute effect of 10.18 (see Table 4), indicating a robust effect.

For employing, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 6.59 points in the employing score for each 1-point increase in the student help-seeking behavior score (effect size = 6.59% of an *SD*). It is worth emphasizing that this relative effect of 6.59 is not dramatically different from the absolute effect of 7.93 (see Table 4), indicating a robust effect.

For interpreting, the full model still found student help-seeking behavior to have a statistically significant effect on this measure of student mathematics achievement, even after the inclusion of the control variables at different levels in the model. Specifically, the full model predicts an average increase of 6.92 points in the interpreting score for each 1-point increase in the student help-seeking behavior score (effect size = 6.92% of an *SD*). It is worth emphasizing that this relative effect of 6.92 is not dramatically different from the absolute effect of 9.13 (see Table 4), indicating a robust effect.

Relative Estimates of Teacher Instructional Practices on Mathematics Achievement

Since the effects of student help-seeking behavior were not found to vary statistically significantly from school to school for any of the eight measures of student mathematics achievement, it was not possible to examine how the three teacher instructional practices (teacher-directed instruction, student orientation, and formative assessment) at the school level contribute to the variation. However, the full model still enabled the examination of the relationship between teacher instructional practices and student mathematics achievement.

Table 6 presents model estimated effects from the full model of the three teacher instructional practices (at the school level) on each of the eight measures of student mathematics achievement. Strictly speaking, all interpretations related to Table 6 need to include the phrase "controlling for all other variables in the model." However, to avoid repetition, this phrase was omitted from the following interpretations.

Teacher-directed instruction as a teacher instructional practice had a statistically significant effect on only one of the eight measures of student mathematics achievement. For uncertainty and data, a 1-point increase in the teacher-directed instruction score at the school level is associated with an increase of 17.13 points in student achievement. The effect size was 17.13% of an *SD*, indicating a small effect. More specifically, teacher-directed instruction showed a very limited benefit in a mathematical area where procedural knowledge tends to be dominant (i.e., probability and statistics).

Student orientation as a teacher instructional practice had a statistically significant effect on five of the eight measures of student mathematics achievement. For overall mathematical literacy, a 1-point increase in the student orientation score at the school level is associated with a decrease of 15.58 points in student achievement. The effect size was 15.58% of an *SD*, indicating a small effect. For uncertainty and data, a 1-point increase in the student orientation score at the school level is associated with a decrease of 18.12 points in student achievement (effect size = 18.12% of an *SD*). For quantity, a 1-point increase in the student orientation score at the school level is associated with a decrease of 20.77 points in student achievement (effect size = 20.77% of an *SD*). For employing, a 1-point increase in the student orientation score at the school level is associated with a decrease of 20.08 points in student achievement (effect size = 20.08% of an *SD*). For interpreting, a 1-point increase in the student orientation score at the school level is associated with a decrease of 17.84 points in student achievement (effect size = 17.84% of an *SD*). The straightforward (or normal) interpretation of these negative effects tends to be counterintuitive and, therefore, may not be appropriate. It is likely that a more reasonable interpretation would be that in schools where student mathematics achievement was low, there appeared to be more adoption of student orientation as a teacher instructional practice.

Lastly, formative assessment as a teacher instructional practice did not have a statistically significant effect on any of the eight measures of student mathematics achievement.

Proportion of Variance Explained by the Model

Table 7 presents the proportion of student-level, school-level, and overall variance in each of the eight measures of student mathematics achievement explained by the full model, as well as by the full model with student help-seeking behavior removed from the model. In general, student help-seeking behavior uniquely accounts for no more than 1%

of the variance in student mathematics achievement. This unique effect is calculated as the difference between the proportion of variance explained by the full model and the proportion of variance explained by the full model with student help-seeking behavior removed from the model. Specifically, student help-seeking behavior uniquely accounts for 1% of the student-level variance in the following measures of student mathematics achievement: overall mathematical literacy, change and relationship, formulating, and employing. Student help-seeking behavior uniquely accounts for 1% of the school-level variance in the following measures of student mathematics achievement: overall mathematical literacy, space and shape, uncertainty and data, quantity, and interpreting. Student help-seeking behavior uniquely accounts for 1% of the overall variance in the following measures of student mathematics achievement: change and relationship, space and shape, formulating, and interpreting.

The proportion of variance uniquely accounted for by student help-seeking behavior was trivial, which fell in line with the small effect sizes of student help-seeking behavior across all eight measures of student mathematics achievement (the maximum absolute effect size was 10.18% of an *SD*; the maximum relative effect size was 8.63% of an *SD*). Nonetheless, taken as a whole, the model accounts for rather adequate proportions of variance in student mathematics achievement. More specifically, the proportion of variance accounted for by the full model ranged from 8% to 11% at the student level, 60% to 73% at the school level, and 20% to 25% overall.

Table 1

Means and Standard Deviations for Student-Level Variables: Student Help-Seeking and Control Variables

Variable	*M*	*SD*
Student help-seeking	2.21	0.73
Gender (1 = male, 0 = female)	0.50	0.50
Socioeconomic status	0.22	0.97
Family structure (1 = single parent, 0 = other structure)	0.21	0.41
Home language (1 = English, 0 = other language)	0.88	0.33

Note. Because each measure of mathematics achievement is represented with multiple (5) plausible values, descriptive statistics on mathematics achievement are not included in this table.

Table 2

Means and Standard Deviations for School-Level Variables: Teacher Instructional Practices and Control Variables

Variable	*M*	*SD*
Teacher instructional practice		
Teacher-directed instruction	0.30	0.52
Student orientation	0.26	0.47
Formative assessment	0.32	0.48
School enrollment size (in hundreds)	13.37	8.70
Proportion of girls	0.49	0.07
School mean socioeconomic status	0.21	0.54
Location (1 = city or large city; 0 = village, small town, or town)	0.38	0.49
Public vs private (1 = public, 0 = private)	0.91	0.29
Proportion of mathematics teachers with math-related degree	0.67	0.37

Table 3

Grand Means and Partition of Variance for Multiple Measures of Mathematics Achievement: Results From the Unconditional (Null) Model

	Fixed Effects			
Variable	Coefficient	*SE*	*t*	*p*
Intercept (mathematics achievement)				
Overall	486.32	4.52	107.51	< .001
Change & relationship	492.03	4.59	107.16	< .001
Space & shape	468.72	5.01	93.49	< .001
Uncertainty & data	494.41	4.46	110.89	< .001
Quantity	484.69	5.07	95.63	< .001
Formulating	481.22	5.13	93.86	< .001
Employing	485.45	4.41	110.14	< .001
Interpreting	494.02	4.60	107.42	< .001
	Random Effects			
	Variance	*df*	χ^2	*p*
Between-school variability				
Overall	1772.02	137	951.48	< .001
Change & relationship	1874.71	137	905.02	< .001
Space & shape	2077.15	137	932.88	< .001
Uncertainty & data	1839.98	137	1030.46	< .001
Quantity	2201.20	137	962.08	< .001
Formulating	2230.16	137	970.86	< .001
Employing	1682.15	137	898.39	< .001
Interpreting	1920.38	137	927.68	< .001
Within-school variability				
Overall	6123.07			
Change & relationship	6816.64			
Space & shape	7247.03			
Uncertainty & data	5845.28			
Quantity	7420.53			
Formulating	7410.57			
Employing	6232.59			
Interpreting	6806.72			

Note. For the fixed effects, each *p*-value has *df* = 137.

Table 4

Absolute Estimates of the Relationship Between Student Help-Seeking and Multiple Measures of Mathematics Achievement

	Fixed Effects			
Variable	Coefficient	*SE*	*t*	*p*
Intercept (mathematics achievement)				
Overall	486.29	4.50	108.17	< .001
Change & relationship	492.02	4.57	107.61	< .001
Space & shape	468.64	4.98	94.05	< .001
Uncertainty & data	494.34	4.43	111.65	< .001
Quantity	484.66	5.04	96.17	< .001
Formulating	481.20	5.09	94.45	< .001
Employing	485.43	4.39	110.70	< .001
Interpreting	494.02	4.56	108.43	< .001
Student help-seeking slope				
Overall	8.17	2.37	3.45	< .001
Change & relationship	7.24	2.37	3.05	.003
Space & shape	8.37	2.80	2.98	.004
Uncertainty & data	7.42	2.42	3.06	.003
Quantity	9.35	2.56	3.65	< .001
Formulating	10.18	2.70	3.77	< .001
Employing	7.93	2.39	3.32	.001
Interpreting	9.13	2.40	3.80	< .001
	Random Effects			
	Variance	*df*	χ^2	*p*
Between-school variability				
Intercept				
Overall	1750.11	135	881.12	< .001
Change & relationship	1857.54	135	838.67	< .001
Space & shape	2051.21	135	871.02	< .001
Uncertainty & data	1811.97	135	946.26	< .001
Quantity	2179.84	135	896.06	< .001
Formulating	2205.72	135	905.65	< .001
Employing	1665.95	135	833.31	< .001
Interpreting	1888.29	135	860.84	< .001
Student help-seeking slope				
Overall	27.46	135	122.25	> .500
Change & relationship	15.80	135	120.14	> .500
Space & shape	79.24	135	141.85	.326
Uncertainty & data	64.72	135	141.39	.336

Table 4 (continued)

Absolute Estimates of the Relationship Between Student Help-Seeking and Multiple Measures of Mathematics Achievement

Quantity	57.02	135	136.52	.447
Formulating	38.72	135	120.72	> .500
Employing	24.57	135	132.70	> .500
Interpreting	38.29	135	128.81	> .500
Within-school variability				
Overall	6078.82			
Change & relationship	6784.64			
Space & shape	7173.04			
Uncertainty & data	5785.31			
Quantity	7348.38			
Formulating	7342.22			
Employing	6190.20			
Interpreting	6748.76			

Note. For the fixed effects, each *p*-value associated with an intercept has *df* = 137. For the fixed effects, *p*-values associated with the slopes for Change & Relationship, Uncertainty & Data, Quantity, Employing, and Interpreting have *df* = 137; *p*-values associated with the slopes for Overall, Space & Shape, and Formulating have *df* = 88, *df* = 71, and *df* = 50, respectively.

Table 5

Relative Estimates of the Relationship Between Student Help-Seeking and Multiple Measures of Mathematics Achievement

	Fixed Effects			
Variable	Coefficient	*SE*	*t*	*p*
Intercept (mathematics achievement)				
Overall	476.23	11.48	41.47	< .001
Change & relationship	484.24	13.48	35.92	< .001
Space & shape	465.06	13.93	33.39	< .001
Uncertainty & data	476.02	12.41	38.36	< .001
Quantity	484.72	14.53	33.35	< .001
Formulating	467.21	13.98	33.41	< .001
Employing	486.02	11.88	40.91	< .001
Interpreting	474.82	14.45	32.86	< .001
Student help-seeking slope				
Overall	6.61	2.17	3.05	.003
Change & relationship	5.99	2.43	2.47	.015
Space & shape	7.41	2.73	2.72	.009
Uncertainty & data	6.02	2.36	2.55	.012
Quantity	7.52	2.49	3.02	.003
Formulating	8.63	2.90	2.98	.006
Employing	6.59	2.36	2.80	.006
Interpreting	6.92	2.32	2.99	.003
	Random Effects			
	Variance	*df*	χ^2	*p*
Between-school variability				
Overall	504.61	128	376.01	< .001
Change & relationship	635.35	128	403.34	< .001
Space & shape	838.10	128	458.68	< .001
Uncertainty & data	504.95	128	384.87	< .001
Quantity	732.44	128	421.06	< .001
Formulating	688.96	128	397.59	< .001
Employing	532.27	128	381.41	< .001
Interpreting	518.90	128	361.21	< .001
Within-school variability				
Overall	5467.50			
Change & relationship	6095.04			
Space & shape	6637.54			
Uncertainty & data	5329.37			
Quantity	6677.79			

Table 5 (continued)

Relative Estimates of the Relationship Between Student Help-Seeking and Multiple Measures of Mathematics Achievement

Formulating	6775.06
Employing	5637.21
Interpreting	6068.94

Note. Student-level and school-level variables are present in the model as control variables to "purify" the relationship between student help-seeking behavior and student mathematics achievement. Appendices A through H contain full results of the model with all independent variables. For the fixed effects, each *p*-value associated with an intercept has *df* = 128, with the exception of Interpreting (*df* = 99). For the fixed effects, *p*-values associated with the slopes for Overall, Change & Relationship, Space & Shape, Uncertainty & Data, Quantity, Formulating, Employing, and Interpreting have *df* = 174, *df* = 92, *df* = 57, *df* = 107, *df* = 234, *df* = 25, *df* = 86, and *df* = 186, respectively.

Table 6

Relative Estimates of the Relationship Between Teacher Instructional Practices and Multiple Measures of Mathematics Achievement

	Fixed Effects			
Variable	Coefficient	*SE*	*t*	*p*
Teacher-directed instruction				
Overall	7.06	7.97	0.89	.377
Change & relationship	9.78	8.30	1.18	.241
Space & shape	-6.55	11.60	-0.57	.573
Uncertainty & data	17.13	8.26	2.08	.040
Quantity	15.12	9.94	1.52	.131
Formulating	5.64	9.48	0.59	.553
Employing	14.82	8.11	1.83	.070
Interpreting	9.43	8.36	1.13	.261
Student orientation				
Overall	-15.58	6.98	-2.23	.027
Change & relationship	-8.61	7.49	-1.15	.252
Space & shape	-13.73	9.90	-1.39	.168
Uncertainty & data	-18.12	6.81	-2.66	.009
Quantity	-20.77	8.77	-2.37	.019
Formulating	-12.22	9.07	-1.35	.180
Employing	-20.08	7.54	-2.66	.009
Interpreting	-17.84	6.66	-2.68	.008
Formative assessment				
Overall	3.25	9.44	0.34	.731
Change & relationship	-1.64	8.16	-0.20	.841
Space & shape	11.76	13.68	0.86	.391
Uncertainty & data	-3.49	9.71	-0.36	.720
Quantity	-4.88	11.87	-0.41	.682
Formulating	6.11	10.98	0.56	.579
Employing	1.98	10.48	-0.19	.850
Interpreting	2.80	9.07	0.31	.758

Note. Each *p*-value has *df* = 128.

Table 7

Proportion of Variance Explained (R^2) Calculated as Overall and at Student and School Levels for the Full Model and the Model With Student Help-Seeking (SHS) Removed From the Full Model

	R^2 (Full Model)		
Mathematics achievement	Student level	School level	Overall
Overall	.107	.715	.244
Change & relationship	.106	.661	.226
Space & shape	.084	.597	.198
Uncertainty & data	.088	.726	.241
Quantity	.100	.667	.230
Formulating	.086	.691	.226
Employing	.096	.684	.221
Interpreting	.108	.730	.245
	R^2 (Without SHS)		
Mathematics achievement	Student level	School level	Overall
Overall	.104	.709	.240
Change & relationship	.104	.656	.223
Space & shape	.081	.589	.194
Uncertainty & data	.086	.718	.237
Quantity	.096	.664	.226
Formulating	.081	.687	.221
Employing	.092	.678	.217
Interpreting	.105	.723	.241

Chapter 5: Discussion and Conclusion

Summary of Principal Findings

In response to the call for educational reforms that improve the mathematics achievement of U.S. students, this study aimed to examine the issue of student help-seeking behaviors and teacher instructional practices as they may interact to affect student mathematics achievement. More specifically, using the U.S. sample of 15-year-old students from PISA 2012 (the most recent PISA assessment in which the main area of focus was mathematical literacy), this study intended to determine whether students' help-seeking behaviors play a significant role in their mathematics achievement, whether this relationship varies from school to school, and whether teacher instructional practices contribute to the school-level variation. Due to the multilevel structure of the data, with students being nested within schools, a two-level hierarchical linear model (HLM) was employed in the analysis of the data.

As background information for the current study, both students and schools were found to be responsible for variation in student mathematics achievement. For the eight measures of mathematics achievement, between 76% and 79% of the variation is attributable to the student level, while 21% to 24% is attributable to the school level (see Table 3). For example, for overall mathematical literacy, 78% of the variation is attributable to students, while 22% is attributable to schools.

Student help-seeking behavior at the student level was found to have a statistically significant effect on all eight measures of student mathematics achievement, even after the inclusion of various student and school background characteristics as control variables, as well as the three teacher instructional practices as school-level independent variables. For the eight measures of mathematics achievement, a 1-point increase in the student help-seeking behavior score is associated with an average increase of between 5.99 points and 8.63 points in mathematics achievement (see Table 5); the corresponding effect sizes ranged from 5.99% of a standard deviation (*SD*) to 8.63% of an *SD*. For example, for overall mathematical literacy, a 1-point increase in the student help-seeking behavior score is associated with an average increase of 6.61 points in mathematics achievement, corresponding to an effect size of 6.61% of an *SD*. Effect sizes of these magnitudes are considered small.

On the other hand, the study did not find any statistically significant evidence that the effects of student help-seeking behavior vary from school to school for any of the eight measures of student mathematics achievement (see Table 4). Overall, the study found that student help-seeking behavior (at the student level) uniquely accounts for no more than 1% of the variation in student mathematics achievement (see Table 7).

The three teacher instructional practices (teacher-directed instruction, student orientation, and formative assessment) were originally selected to model the variation in the effects of student help-seeking behavior on student mathematics achievement across schools. Given the lack of evidence that such variation exists, the teacher instructional practices were only examined for their direct effects on student mathematics achievement. This study indicated that teacher-directed instruction at the school level had a statistically significant effect on only one of the eight measures of student mathematics achievement. For uncertainty and data, a 1-point increase in the teacher-directed instruction score at the school level is associated with an increase of 17.13 points in student achievement (see Table 6), corresponding to an effect size of 17.13% of an *SD*.

An effect size of this magnitude is considered small. Student orientation had a statistically significant effect on five of the eight measures of student mathematics achievement (overall mathematical literacy, uncertainty and data, quantity, employing, and interpreting). For these five measures of mathematics achievement, a 1-point increase in the student orientation score at the school level is associated with an average decrease of between 15.58 points and 20.77 points in student achievement (see Table 6); the corresponding effect sizes ranged from 15.58% of an *SD* to 20.77% of an SD. For example, for overall mathematical literacy, a 1-point increase in the student orientation score at the school level is associated with an average decrease of 15.58 points in student achievement, corresponding to an effect size of 15.58% of an *SD*. Effect sizes of these magnitudes are considered small. Formative assessment did not have a statistically significant effect on any of the eight measures of student mathematics achievement.

The models containing student help-seeking behavior as the primary predictor of student mathematics achievement indicated satisfactory model performance. In other words, adequate proportions of variance in student mathematics achievement were accounted for by the models. Specifically, the proportion of variance accounted for by the models ranged from 8% to 11% at the student level, 60% to 73% at the school level, and 20% to 25% overall (see Table 7). For example, for overall mathematical literacy, the full model accounted for 11% of the student-level variance, 72% of the school-level variance, and 24% of the overall variance. Considering the proportions of variances explained, these models were deemed adequate in performance, and especially so at the school level.

Revisit of Research Literature

As discussed earlier, the research literature concerning the relationship between student help-seeking behavior and student mathematics achievement is very thin. However, the small number of previous empirical studies addressing these issues (e.g., Ryan et al., 2005; Schenke et al., 2015; Ogan et al., 2015) all concluded that there is a positive association between student help-seeking behavior and student mathematics achievement. The populations for these studies involved students between the ages of 12 and 17 from primarily low SES families in urban neighborhoods in the U.S., although one of the studies also involved students from Costa Rica and the Philippines. The statistical methods used in these studies included multiple regression analysis and analysis of variance (ANOVA), with one study employing multilevel modeling (i.e., HLM).

The present study provides stronger evidence than the previous studies that student help-seeking behavior is positively associated with student mathematics achievement. The term "stronger" is worth emphasizing in that a thorough review of the literature revealed that the previous studies involving these issues have attempted to address them by using nonrandom samples that were either relatively small in size or selected from small geographical regions (or both). Therefore, by using a large, nationally representative, random sample to assess student mathematics achievement, the present study makes unique contributions to the research literature with far more precise generalizability concerning the issues at hand.

Further, the present study differs from all but one of the previous studies involving these issues in that it employed multilevel modeling (i.e., HLM) for the analysis of data to account for the fact that students are nested within schools. This adoption of multilevel techniques reflects the intent of the present study to assume and test whether the effects of student help-seeking behavior on student mathematics achievement are potentially affected by school-level factors in addition to student-level factors. Not only is this approach to data analysis a substantial improvement in research methodology, but it also revealed some unique (and interesting) findings.

In light of the aforementioned advantages of the present study, two major conclusions can be made with confidence. First, the help-seeking behaviors of 15-year-old students in the U.S. have a positive (though relatively small) effect on a variety of measures of mathematics achievement. In other words, for a wide range of mathematical domains, an increase in student help-seeking behavior matters in that it is associated with a positive effect on student mathematics achievement. Second, although students' help-seeking behaviors do have positive effects on their mathematics achievement, these effects do not vary statistically significantly in the U.S. from school to school. In other words, the relationship between a student's help-seeking behavior and the student's mathematics achievement is independent of which school the student attends.

The first finding (conclusion) gives further support to the relatively small number of previous studies involving these issues. In particular, the present study provides statistically significant evidence that the help-seeking behavior of 15-year-old students in the U.S. is positively associated with their mathematics achievement, even after adjusting for several important student-level and school-level variables. Consequently, the present study suggests that this association is rather robust (or stable). Further, these positive effects of student help-seeking behavior hold across a wide range of mathematical content areas, including number operations, quantitative reasoning, functions, graphing, geometry, measurement, probability, statistics, and problem solving. Consequently, the present study suggests that this association is rather comprehensive (or systematic). The second finding (conclusion), that the effects of a student's help-seeking behavior on the student's mathematics achievement are independent of which school the student attends, has rarely been reported and is thus very unique in the research literature.

Implications for Educational Policy and Practice

From a practical standpoint, this study aimed to contribute to the national discussions regarding educational reforms that center around the teaching and learning of mathematics, with the practical goal of helping to guide the development of K-12 educational policies and practices that will assist in providing optimal opportunities for all students to receive a high-quality mathematics education. Since the present study found that students' mathematics achievement is positively associated with their help-seeking behaviors, efforts should be made to educate mathematics teachers on how to encourage their students to be more proactive in seeking help in the learning of mathematics. To accomplish this, it is recommended that educational policies be implemented that would make student help-seeking behavior an integral component of teacher professional development for the specific purpose of improving the help-seeking behavior of students in the mathematics classroom. Such professional development opportunities may emphasize a sound understanding of help-seeking behavior (e.g., its nature, its unique relationship with mathematics as opposed to other school subjects, individual and cultural differences, related affective and cognitive conditions, and the role of technology) and effective techniques for creating a classroom environment that invites students to seek help in the learning of mathematics.

The finding that the relationship between a student's help-seeking behavior and the student's mathematics achievement is independent of which school the student attends is a piece of positive news. Schools have a context. School context refers to the "hardware" of a school such as location, available resources, socioeconomic and racial-ethnic compositions of the student body, and education and experience levels of the teacher body (see Ma et al., 2008). Schools have a climate. School climate refers to the "software" of a school such as administrative policies, instructional organization, and attitudes and expectations of students, parents, and teachers (see Ma et al., 2008). It is challenging for educators to change school climate and nearly impossible for them to change school context. With that in mind, it is encouraging to find that the positive benefits of effective help-seeking behaviors are available to all students, regardless of school contextual and climatic characteristics.

Finally, although the present study supports the robust importance of student help-seeking behavior to student mathematics achievement, the effect size is small. This finding implies that improving student help-seeking behavior by itself in an isolated fashion may not matter much in terms of improving student mathematics achievement. Instead, it should be more beneficial to combine efforts at improving student help-seeking behavior with other educational reforms aimed at improving student mathematics achievement. For example, Everyday Mathematics, a national reform-based curriculum that is widely used throughout the U.S. (http://everydaymath.uchicago.edu/), provides a good opportunity for mathematics educators to emphasize student help-seeking. In particular, specially designed student help-seeking activities can be implemented within the Everyday Mathematics curriculum as instructional strategies to address specific topics in mathematics, especially those that are traditionally considered to be difficult (e.g., fractions).

Limitations

Since the current study involved a very specific age group of students, namely, 15-year-olds, any generalizations applied to students of other ages should be made with caution. Further, this study involved students in the U.S. only; therefore, the results of the study may not reflect those that would be observed in other countries, even when using students of the same age. Of course, these concerns are not unique to the present study, as all empirical studies are conditional on when and where and whom.

Another issue of concern is the way in which student characteristics and school characteristics were controlled. The present study involved secondary data analysis and thus was limited to the data collected and made available by PISA. Ideally, more student and school control variables would be considered to potentially improve the performance of the model. For example, PISA 2012 collected information on race in the student questionnaire but did not make the data available. Consequently, race could not be controlled at the student level, and the racial-ethnic composition of the student body could not be factored in as a school contextual variable. Given the research on the importance of racial-ethnic differences in student mathematics achievement (e.g., Parks & Schmeichel, 2012; McGraw, Lubienski, & Strutchens, 2006), such an omission is not desirable. Further, PISA did not collect sufficient data on school climatic variables such as administrative policies and instructional organization. Because school characteristics may show effects on student mathematics achievement that are over and above the effects of student help-seeking behaviors, the inclusion of more school climatic variables may create additional opportunities for meaningful comparisons to help drive educational policy and practice.

The primary weakness of the current study is the relatively low internal consistency of the composite variable used for measuring student help-seeking behavior. Although the student help-seeking index constructed for the current study did result in a slightly higher internal consistency (Cronbach's $\alpha = .58$) than the corresponding index that had been constructed by PISA (Cronbach's $\alpha = .54$), the alpha level is still not optimal. Nonetheless, as explained in detail in Chapter 3, the decision ultimately was made to use the student help-seeking index constructed for this study because it is conceptually clear and consistent from a theory-driven perspective. In particular, this index of student help-seeking behavior emphasized interaction with other people, which fits well with PISA's definition of student help-seeking behaviors. This emphasis is good in the sense that interacting with other people is a common way to seek help; however, this emphasis omits other potentially useful avenues of help-seeking such as reading books or watching online instructional videos. Overall, the present study seems to have focused on a very specific or very unique aspect of student help-seeking behavior. Such a limit on the scope of student help-seeking behavior is the primary concern of the present study.

Suggestions for Further Research

Overall, the findings from this study indicate that the issue of student help-seeking behavior and its relationship with student mathematics achievement is a worthy topic to pursue in educational research. However, the PISA experience suggests that student help-seeking behavior may be a multidimensional construct that would require the design of a measurement instrument far more complex than the one used in PISA 2012. More specifically, to capture the complexity of student help-seeking behavior, the conceptual structure of this variable needs to be determined theoretically and tested empirically.

One area of concern in attempting to measure student help-seeking behavior is that the modern forms of communication brought about by continual advances in technology may have fundamentally changed the primary ways in which people seek help. Previously, help-seeking concerning mathematics relied heavily on the availability of physical resources such as textbooks and classroom teachers. Now, in addition to these physical resources, help-seeking has a growing reliance on the availability of electronic resources such as online homework systems and instructional videos, adding further complexity to the conceptual structure of student help-seeking behavior. Additionally, this issue is directly related to the implications for educational policy and practice as discussed earlier.

Measurement error is a potential problem with all large-scale assessment data (Cole & Preacher, 2014). In order to account for any measurement error related to student help-seeking behavior as well as student mathematics achievement, future research could employ statistical techniques that make appropriate adjustments for measurement error. The primary benefit of this approach is that it tends to increase the effect sizes, although the downside is that it also tends to increase the standard errors (Woodhouse, Yang, Goldstein, & Rasbash, 1996).

Finally, the present study adopted the statistical concept of control (e.g., controlling for student background characteristics) in order to “purify” the relationship between student help-seeking behavior and student mathematics achievement. Another approach to understanding the complexity of student help-seeking behavior would be the use of moderation, in which the interactions between student help-seeking behavior and other student background characteristics are considered. For example, race could be used as a moderator variable to examine how it interacts with student help-seeking behavior to affect student mathematics achievement.

Appendix A

Relative Estimates of the Relationship Between Overall Mathematical Literacy and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	6.61	2.17	3.05	.003
Gender (1 = male, 0 = female)	9.17	3.38	2.72	.007
Socioeconomic status	26.19	2.73	9.58	< .001
Family structure (1 = single parent, 0 = other structure)	-5.22	4.45	-1.17	.243
Home language (1 = English, 0 = other language)	-10.83	5.93	-1.83	.068
School-level				
Teacher-directed instruction	7.06	7.97	0.89	.377
Student orientation	-15.58	6.98	-2.23	.027
Formative assessment	3.25	9.44	0.34	.731
School enrollment size (in hundreds)	0.46	0.36	1.29	.199
Proportion of girls	7.04	29.78	0.24	.814
School mean socioeconomic status	34.58	6.08	5.69	< .001
Location (1 = city or large city; 0 = village, small town, or town)	-2.03	6.40	-0.32	.752
Public vs private (1 = public, 0 = private)	23.28	9.07	2.57	.011
Proportion of mathematics teachers with math-related degree	20.29	7.04	2.88	.005

Appendix B

Relative Estimates of the Relationship Between Change and Relationship and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	5.99	2.43	2.47	.015
Gender (1 = male, 0 = female)	10.48	3.75	2.79	.006
Socioeconomic status	29.50	2.78	10.60	< .001
Family structure (1 = single parent, 0 = other structure)	-3.07	4.24	-0.72	.470
Home language (1 = English, 0 = other language)	-19.91	6.85	-2.91	.005
School-level				
Teacher-directed instruction	9.78	8.30	1.18	.241
Student orientation	-8.61	7.49	-1.15	.252
Formative assessment	-1.64	8.16	-0.20	.841
School enrollment size (in hundreds)	0.24	0.38	0.64	.526
Proportion of girls	35.46	25.99	1.36	.175
School mean socioeconomic status	34.44	6.13	5.61	< .001
Location (1 = city or large city; 0 = village, small town, or town)	2.05	6.87	0.30	.766
Public vs private (1 = public, 0 = private)	26.62	11.88	2.24	.027
Proportion of mathematics teachers with math-related degree	21.68	8.04	2.70	.008

Appendix C

Relative Estimates of the Relationship Between Space and Shape and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	7.41	2.73	2.72	.009
Gender (1 = male, 0 = female)	11.31	4.10	2.76	.009
Socioeconomic status	25.50	3.14	8.12	< .001
Family structure (1 = single parent, 0 = other structure)	-14.66	4.81	-3.05	.002
Home language (1 = English, 0 = other language)	-17.04	7.75	-2.20	.032
School-level				
Teacher-directed instruction	-6.55	11.60	-0.57	.573
Student orientation	-13.73	9.90	-1.39	.168
Formative assessment	11.76	13.68	0.86	.391
School enrollment size (in hundreds)	0.80	0.43	1.86	.066
Proportion of girls	0.82	41.01	0.02	.984
School mean socioeconomic status	34.50	7.31	4.72	< .001
Location (1 = city or large city; 0 = village, small town, or town)	0.52	7.28	0.07	.944
Public vs private (1 = public, 0 = private)	22.15	12.67	1.75	.084
Proportion of mathematics teachers with math-related degree	20.92	8.61	2.43	.017

Appendix D

Relative Estimates of the Relationship Between Uncertainty and Data and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	6.02	2.36	2.55	.012
Gender (1 = male, 0 = female)	8.75	3.41	2.57	.011
Socioeconomic status	22.13	2.81	7.89	< .001
Family structure (1 = single parent, 0 = other structure)	-4.01	4.05	-0.99	.323
Home language (1 = English, 0 = other language)	-3.90	6.39	-0.61	.544
School-level				
Teacher-directed instruction	17.13	8.26	2.08	.040
Student orientation	-18.12	6.81	-2.66	.009
Formative assessment	-3.49	9.71	-0.36	.720
School enrollment size (in hundreds)	0.38	0.35	1.08	.284
Proportion of girls	25.37	24.62	1.03	.306
School mean socioeconomic status	37.87	6.29	6.03	< .001
Location (1 = city or large city; 0 = village, small town, or town)	-3.86	6.33	-0.61	.543
Public vs private (1 = public, 0 = private)	25.82	10.83	2.38	.019
Proportion of mathematics teachers with math-related degree	15.57	7.02	2.22	.028

Appendix E

Relative Estimates of the Relationship Between Quantity and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	7.52	2.49	3.02	.003
Gender (1 = male, 0 = female)	12.32	3.68	3.34	< .001
Socioeconomic status	29.15	3.16	9.23	< .001
Family structure (1 = single parent, 0 = other structure)	-1.50	4.61	-0.32	.746
Home language (1 = English, 0 = other language)	-12.59	7.16	-1.76	.082
School-level				
Teacher-directed instruction	15.12	9.94	1.52	.131
Student orientation	-20.77	8.77	-2.37	.019
Formative assessment	-4.88	11.87	-0.41	.682
School enrollment size (in hundreds)	0.82	0.41	1.99	.049
Proportion of girls	17.30	44.68	0.39	.699
School mean socioeconomic status	28.60	7.17	3.99	< .001
Location (1 = city or large city; 0 = village, small town, or town)	-9.43	7.52	-1.25	.212
Public vs private (1 = public, 0 = private)	14.66	12.81	1.14	.256
Proportion of mathematics teachers with math-related degree	24.41	8.93	2.73	.007

Appendix F

Relative Estimates of the Relationship Between Formulating and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	8.63	2.90	2.98	.006
Gender (1 = male, 0 = female)	14.18	3.68	3.86	< .001
Socioeconomic status	26.75	3.11	8.59	< .001
Family structure (1 = single parent, 0 = other structure)	-5.76	4.83	-1.19	.234
Home language (1 = English, 0 = other language)	-13.00	7.24	-1.79	.075
School-level				
Teacher-directed instruction	5.64	9.48	0.59	.553
Student orientation	-12.22	9.07	-1.35	.180
Formative assessment	6.11	10.98	0.56	.579
School enrollment size (in hundreds)	0.57	0.42	1.34	.183
Proportion of girls	-6.06	37.72	-0.16	.873
School mean socioeconomic status	42.08	6.76	6.23	< .001
Location (1 = city or large city; 0 = village, small town, or town)	2.01	7.43	0.27	.787
Public vs private (1 = public, 0 = private)	25.49	11.74	2.17	.032
Proportion of mathematics teachers with math-related degree	21.04	8.25	2.55	.012

Appendix G

Relative Estimates of the Relationship Between Employing and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	6.59	2.36	2.80	.006
Gender (1 = male, 0 = female)	7.07	3.58	1.98	.050
Socioeconomic status	25.09	3.06	8.21	< .001
Family structure (1 = single parent, 0 = other structure)	-8.16	4.16	-1.96	.050
Home language (1 = English, 0 = other language)	-16.30	6.22	-2.62	.009
School-level				
Teacher-directed instruction	14.82	8.11	1.83	.070
Student orientation	-20.08	7.54	-2.66	.009
Formative assessment	1.98	10.48	-0.19	.850
School enrollment size (in hundreds)	0.37	0.35	1.06	.293
Proportion of girls	22.45	32.52	0.69	.492
School mean socioeconomic status	28.87	5.90	4.89	< .001
Location (1 = city or large city; 0 = village, small town, or town)	-3.96	6.65	-0.60	.553
Public vs private (1 = public, 0 = private)	19.69	9.48	2.08	.040
Proportion of mathematics teachers with math-related degree	17.75	7.31	2.43	.017

Appendix H

Relative Estimates of the Relationship Between Interpreting and All Independent (Including Control) Variables: Results From the Full Model

Variable	Coefficient	*SE*	*t*	*p*
Student-level				
Student help-seeking	6.92	2.32	2.99	.003
Gender (1 = male, 0 = female)	14.10	3.66	3.85	< .001
Socioeconomic status	27.34	2.85	9.59	< .001
Family structure (1 = single parent, 0 = other structure)	-4.10	4.24	-0.97	.334
Home language (1 = English, 0 = other language)	-5.60	6.18	-0.91	.364
School-level				
Teacher-directed instruction	9.43	8.36	1.13	.261
Student orientation	-17.84	6.66	-2.68	.008
Formative assessment	2.80	9.07	0.31	.758
School enrollment size (in hundreds)	0.51	0.33	1.53	.127
Proportion of girls	18.23	32.82	0.56	.580
School mean socioeconomic status	33.92	6.33	5.36	< .001
Location (1 = city or large city; 0 = village, small town, or town)	-2.05	6.39	-0.32	.749
Public vs private (1 = public, 0 = private)	25.55	12.51	2.04	.044
Proportion of mathematics teachers with math-related degree	26.55	7.47	3.55	< .001

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