JOURNAL OF EDUCATIONAL RESEARCH & PRACTICE

Journal of Educational Research & Practice
2021, Volume 11, Issue 1, Pages 345–358
DOI: 10.5590/JERAP.2021.11.1.25

Original Research

WALDEN UNIVERSITY

Teacher Instructional Practices and Student Mathematics Achievement

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Abstract

Using the nationally representative sample from the United States in the 2012 Programme for International Student Assessment (N = 7,429 students from 240 schools), I examined the relationship between teacher instructional practices and student mathematics achievement. To account for the multilevel structure of the data with students nested within schools, I used a two-level hierarchical linear model in the data analysis. Teacher instructional practices showed statistically significant effects on student mathematics achievement, even after controlling for socioeconomic status (SES) and sex at the student level and school mean SES and whether the school is public or private at the school level. Furthermore, I found that the relationship between teacher instructional practices and student mathematics achievement varied statistically significantly across schools.

Keywords: *teacher instructional practices, teacher-directed instruction, student-centered instruction, mathematics achievement, Programme for International Student Assessment (PISA)*

Date Submitted: May 26, 2021 | Date Published: December 4, 2021

Recommended Citation

Osborne, M. C. (2021). Teacher instructional practices and student mathematics achievement. *Journal of Educational Research and Practice, 11(1)*, 345–358. https://doi.org/10.5590/JERAP.2021.11.1.25

Introduction

Despite the vast educational resources that have been invested into K–12 education in the United States, students in the U.S. are continually outperformed by their international peers in mathematics achievement (see remarks of then U.S. Secretary of Education Arne Duncan, https://tylershepard1991.files.wordpress.com/2017/01/duncan-article.pdf). According to the 2012 Programme for International Student Assessment (PISA), even though the U.S. spends more money per student than all but four of the 34 Organisation for Economic Co-operation and Development (OECD) countries, it ranks only 27th in mathematics (OECD, 2013). Numerous educational reforms centered around curriculum and instruction have been implemented with the aim of improving the performance of U.S. students in mathematics (Dossey et al., 2016).

For example, in the year 2000, the National Council of Teachers of Mathematics (NCTM), having worked hand-in-hand for decades with the mathematical community at large, released its Principles and Standards for School Mathematics (NCTM, 2000). This effort by NCTM sought to lay out in detail what curriculum and instruction (as well as assessment) should include when it comes to K–12 mathematics education in the U.S. Being a key player in mathematics education, NCTM emphasizes 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).

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). One of the primary ideas 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 2010 (NGA Center & CCSSO, 2010). The CCSSM lay out in-depth grade-by-grade standards for grades K–8 and standards organized according to mathematical topics for grades 9–12, as well as a set of eight Standards for Mathematical Practice, which describe practices that play a critical role in cultivating an understanding of mathematics across all grades. The underlying 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.

Review of Literature

Teacher Instructional Practices

Unfortunately, thus far, none of the reforms aimed at improving the mathematical performance of U.S. students have proven to be sustainably effective, so the search goes on. My study joined these national efforts by examining the relationship between teacher instructional practices and student mathematics achievement. 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 et al., 2002). The topic of teacher 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 academic achievement, with the general consensus being that teacher instructional practices do make a difference in terms of student academic achievement. However, there continues to be disagreement among educational researchers as to which types of 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 (NMAP), having teachers implement effective instructional practices is a necessary, though not sufficient, component of improving student mathematics achievement (NMAP, 2008). 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 some other variables, such as sex, 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).

Teacher-Directed Instructional Practices

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 tend to be few interactions, especially among students (Schenke et al., 2015).

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 et al., 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 et al., 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 (Salihu & Räsänen, 2018). 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 oriented to performance, 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 to appear intelligent (Skaalvik & Federici, 2016). In performance-oriented classrooms, the teacher sets goals for the students and publicly rewards those students who successfully achieve the goals (Park et al., 2016). As an example, if a student makes the highest grade in the class for an assignment, the teacher might display that student’s work on a bulletin board in the classroom or hallway.

Student-Centered Instructional Practices

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).

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 pupils 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 (Wilkins, 2008). For example, when introducing 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 eighth-grade students 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 (McKinney & Frazier, 2008).

Student-centered instructional practices tend to be oriented to mastery rather than to performance, 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. Elementary school students whose classrooms focus on mastery have been found to experience higher levels of learning, as well as more enjoyment of mathematics, than students whose classrooms focus on performance (Stipek & Byler, 2004).

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 (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 opportunities to discuss their own thoughts and strategies with their classmates when encountered with 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).

Summary

Although individual instructional methods can be categorized as being either teacher-directed or student-centered practices, it is not necessary for a particular teacher's instructional procedures to all fall into the same category. This is due, in part, 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 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 practices, most teachers tend to include both types of instructional practices in their classrooms (Jong, 2016). Since both teacher-directed 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).

Method

To explore the relationship between teacher instructional practices and student mathematics achievement, I sought to address the following research questions:

1. Are teacher instructional practices associated with student mathematics achievement, with control over student and school background characteristics?

2. Does the association between teacher instructional practices and student mathematics achievement vary across schools?

3. If the association between teacher instructional practices and student mathematics achievement does vary across schools, do teacher education and class size contribute to the variation?

PISA 2012 provided sufficient data that could be used to answer these research questions.

Data

PISA is an international assessment of 15-year-old students conducted every 3 years by OECD. While seeking to measure students' mathematics, reading, and science literacy, the intent of PISA is not as focused on assessing students' knowledge of content-related facts as it is on how well students can apply their content knowledge to real-world problem-solving situations (OECD, 2014a). PISA implemented a two-stage, stratified, random probability sampling procedure. At the first stage, a random sample of schools was selected in proportion to school enrollment size from all public and private schools containing 15-year-old students in grade 7 or higher. At the second stage, within each sampled school, a random sample of students was selected from a list of all eligible students. In addition to the standardized paper-and-pencil achievement tests, students and their school principals completed questionnaires to provide information about background characteristics of the students and the school. For this study, I used the national sample of the U.S. with 7,429 students from 240 schools from PISA 2012 because it is the latest cycle with a focus on mathematics.

Dependent Variable

PISA 2012 contained 85 items in its assessment of mathematics measuring student mathematical literacy (OECD, 2013). These items measured four mathematical literacy areas: change and relationship; space and shape; uncertainty and data; and quantity. Change and relationship involve 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 involve using geometry and measurement to understand the visual and physical world. Uncertainty and data involve using probability and statistics to produce models, interpret data, 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.

The dependent variable I used in this study to measure student mathematics achievement was the score on the overall mathematical literacy (a combination of the four literacy areas). It is worth noting that "there is theoretically no minimum or maximum score in PISA; rather, the results are scaled to fit approximately normal distributions, with means around 500 score points and standard deviations around 100 score points" (OECD, 2019, p. 43).

Independent Variables

The independent variables came from the student and school questionnaires (Kastberg et al., 2014). The key independent variables (at the student level) were the aforementioned categories of teacher instructional practices: teacher-directed instruction and student-centered instruction.

Teacher-Directed Instruction

PISA 2012 used information obtained from several items included on the student questionnaire to measure the degree to which the classroom instruction involves teacher-directed practices (Table 1). Based on student responses to these items, PISA created a composite standardized variable of teacher-directed instruction, with one score for each student (Cronbach's α = .76; OECD, 2014b).

Student-Centered Instruction

PISA 2012 used information obtained from several items included on the student questionnaire to measure the degree to which the classroom instruction involves student-centered practices (Table 1). Based on student responses to these items, PISA created a composite standardized variable of student-centered instruction, with one score for each student (Cronbach's α = .68; OECD, 2014b).

Teacher Education

PISA 2012 used information obtained from the school questionnaire to determine, for each school, the proportion of mathematics teachers with a bachelor's or master's degree with a major in mathematics, statistics, physics, or engineering. The variable of teacher education was included at the school level.

Class Size

PISA 2012 used information obtained from the school questionnaire to determine, for each school, the average number of students in each class. The variable of class size was included at the school level.

Student-Level Control Variables

Students are viewed as bringing into their schools different individual and family characteristics, commonly referred to as student background characteristics. Individual differences in student mathematics achievement have been shown to be attributable to some of these characteristics, including sex and SES (Ma et al., 2008).

Consequently, sex (1 = male, 0 = female) and SES (continuous index) were included in this study as control variables (at the student level).

School-Level Control Variables

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 some of these characteristics, including school mean SES (determined by averaging the SES of all students in the school) and whether the school is public or private (Ma et al., 2008). Consequently, school mean SES (continuous index) and whether the school is public or private (1 = public, 0 = private) were included as control variables (at the school level).

Table 1. *Description of Items for Construction of Composite Variables*

Variable	Possible Responses
Teacher-Directed Instruction	
How often do these things happen in your mathematics lessons?	1 = never or hardly ever
• The teacher sets clear goals for our learning.	2 = some lessons
• The teacher asks me or my classmates to present our thinking or reasoning at length.	3 = most lessons 4 = every lesson
• The teacher asks questions to check whether we have understood what was taught.	
• At the beginning of a lesson, the teacher presents a summary of the previous lesson.	
• The teacher tells us what we have to learn.	
Student-Directed Instruction	
How often do these things happen in your mathematics lessons?	1 = never or hardly ever
• The teacher gives different work to classmates who have difficulties learning and/or to those who can advance faster.	2 = some lessons 3 = most lessons
• The teacher assigns projects that require at least 1 week to complete.	4 = every lesson
• The teacher has us work in small groups to come up with solutions to a problem or task.	
• The teacher asks us to help plan classroom activities or topics.	

Note. For each bulleted item, students were instructed to choose one of the possible responses.

Statistical Analyses

A two-level hierarchical linear model (HLM) was used to account for the multilevel structure of the U.S. data with students nested within schools. The HLM analysis was performed in three stages. The first stage was the null model, which included no independent variables at either level. This model was used to estimate the grand mean student mathematics achievement and to show how its variance is partitioned between the student level and the school level.

At the second stage, the variables of teacher-directed instruction and student-centered instruction, along with all student-level and school-level control variables, were added to the model to examine the effects of teacher-directed instruction and student-centered instruction on student mathematics achievement (at the student level). Additionally, teacher-directed instruction and student-centered instruction were treated as random at the school level to examine whether their effects on student mathematics achievement vary across schools.

The results obtained at this stage were used to address the first and second research questions.

Finally, at the third stage, teacher education and class size were added to the model (at the school level) to examine whether they contribute to the between-school variance in the effects of teacher-directed instruction and student-centered instruction on student mathematics achievement. The results obtained at this stage were used to address the third research question.

Results

Descriptive Statistics

Descriptive statistics were calculated to examine the key features of all variables of interest.

Student-Level Variables

Teacher-directed instruction had a mean of 0.27 with a standard deviation (*SD*) of 1.07. The teacher-directed instruction index was standardized based on all participating countries, meaning the average U.S. student received slightly more teacher-directed instruction than the average OECD student (OECD, 2014b). Student-centered instruction had a mean of 0.28 with an *SD* of 0.93. The student-centered instruction index was standardized based on all participating countries, meaning the average U.S. student received slightly more student-centered instruction than the average OECD student (OECD, 2014b). In terms of sex, 51% of U.S. students were male and 49% were female. The average SES for the U.S. students was 0.19, with an *SD* of 0.97. The SES index was standardized based on all participating countries, meaning the average U.S. student had a slightly higher SES than the average OECD student (OECD, 2014b).

School-Level Variables

On average, about two-thirds (66%) of the mathematics teachers in the U.S. schools had at least a bachelor's degree in mathematics or a related discipline. The average class size for the U.S. schools was 25.71 students per class with an *SD* of 5.70. The average school mean SES for the U.S. schools was 0.17 (*SD* = 0.56), slightly higher than the average school mean SES for all OECD countries (OECD, 2014b). Nearly all (90%) of the U.S. schools were public schools.

Grand Mean and Partition of Variance for Student Mathematics Achievement

Although student mathematics achievement was the dependent variable, descriptive statistics for this variable are omitted because PISA measures it using multiple plausible values.

Instead, the grand mean and variance for student mathematics achievement were estimated using a two-level HLM, specifically the null model. For student mathematics achievement, the estimated grand mean for the U.S. students was 480.58 ($p < .001$). The partition of variance for student mathematics achievement showed that approximately 76% of the variance is attributable to students, while approximately 24% is attributable to schools ($\hat{\sigma}^2 = 6114.95$, $\hat{\tau} = 1963.60$). The variance at the school level was statistically significant ($p < .001$), indicating that U.S. schools are significantly different in terms of student mathematics achievement.

Effects of Teacher Instructional Practices

While controlling for sex and SES at the student level and school mean SES and whether the school is public or private at the school level, the teacher instructional practice of teacher-directed instruction was found to have a statistically significant effect on student mathematics achievement ($p < .001$). Specifically, a 1-point increase in teacher-directed instruction is associated with an increase of 9.27 points in student mathematics achievement. That is, this study found a positive association between teacher-directed instruction and student mathematics achievement.

The teacher instructional practice of student-centered instruction also was found to have a statistically significant effect on student mathematics achievement ($p < .001$). In this case, however, a 1-point increase in student-centered instruction is associated with a decrease of 25.43 points in student mathematics achievement. That is, this study found a negative association between student-centered instruction and student mathematics achievement.

Because the PISA mathematics achievement has a mean of 500 and an *SD* of 100 (OECD, 2014b), it is easy to convert these effects into effect size measures. Specifically, the (positive) effect size for teacher-directed instruction is 9.27% of an *SD*, while the (negative) effect size for student-centered instruction is 25.43% of an *SD*.

Between-School Variance in Effects of Teacher Instructional Practices

In addition to examining the effects of teacher instructional practices on student mathematics achievement, HLM was also used to examine whether these effects vary across schools. The between-school variance in the effect of teacher-directed instruction was found to be statistically significant ($p < .001$). That is, the (positive) effect of teacher-directed instruction on a student's mathematics achievement is dependent upon which school the student attends.

The between-school variance in the effect of student-centered instruction also was found to be statistically significant ($p < .001$). That is, the (negative) effect of student-centered instruction on a student's mathematics achievement is dependent upon which school the student attends.

Contribution of Teacher Education and Class Size to Effects of Teacher Instructional Practices

Since the between-school variance in the effects of both types of teacher instructional practices on student mathematics achievement was found to be statistically significant, the variables of teacher education and class size were added to the model at the school level to examine whether they contribute to the school-level variance. Teacher education was not found to make a statistically significant contribution to the effects of either teacher-directed instruction ($p = .987$) or student-centered instruction ($p = .955$). Similarly, class size was not found to make a statistically significant contribution to the effects of either teacher-directed instruction ($p = .649$) or student-centered instruction ($p = .120$).

HLM Model Performance

The proportion of variance explained was used to assess the HLM model performance. The final model accounted for approximately 47% of the total variance in student mathematics achievement at the student level and approximately 48% of the total variance in student mathematics achievement at the school level. Overall, the final model accounted for approximately 47% of the total variance in student mathematics achievement. According to the common standards in social sciences (Gaur & Gaur, 2006), these numbers indicate a sound performance of the final HLM model, providing confidence for the analytical claims that follow.

Discussion

Revisit the Research Literature

The topic of teacher instructional practices, specifically when comparing and contrasting teacher-directed instructional practices with student-centered instructional practices, has been and continues to be one of major interest among educational researchers, K–12 teachers and administrators, and even parents of school-age children (Jong, 2016; Remillard & Jackson, 2006). This engagement from so many groups is not surprising since teacher instructional practices play such a major role in influencing student mathematics achievement, while at the same time, no clear consensus has been reached as to which specific instructional practices are best (McKinney & Frazier, 2008).

Although some studies involving teacher instructional practices and student mathematics achievement have involved national random samples (e.g., Byrnes and Wasik, 2009), most have been more limited in their scope by involving nonrandom samples that were either small in size or selected from small geographical regions (or both). Thus, having employed a large, nationally representative random sample to assess the issues, this study allows for more generalizable results than many other studies. Further, unlike most previous studies, I made use of HLM to account for the fact that students are nested within schools. Without this multilevel statistical technique, the effects of student-level variables such as teacher instructional practices on student mathematics achievement can be confounded with the effects of school-level variables, such as school mean SES (Ma et al., 2008).

Considering these advantages of my study, three key contributions to the research literature can be made with confidence. First, I found that 15-year-old students in the United States in general, not just in a specific location, who were exposed to teacher-directed instructional practices demonstrate a positive association with their mathematics achievement, even after controlling for some student-level and school-level variables. With many recent studies focusing on the benefits of student-centered instructional practices (and rightly so), this finding that provides strong evidence that the benefits of teacher-directed instructional practices are critical, since past studies have shown that students need aspects of both types to become proficient in mathematics (NMAP, 2008).

Second, I found that 15-year-old students in the United States (again, in general) exposed to student-centered instructional practices demonstrate a negative association with their mathematics achievement, even after controlling for some student-level and school-level variables. This finding is, admittedly, surprising and stands in contrast to much of the recent research (e.g., Yu & Singh, 2018; Lerkkanen et al., 2016). To further complicate the matter, the negative effect size for student-centered instruction (25.43% of an *SD*) in my present study was nearly three times as large as the positive effect size for teacher-directed instruction (9.27% of an *SD*). This finding, however, provides opportunity and motivation for future research.

Third, I found that the effects of teacher instructional practices on the mathematics achievement of 15-year-old students in the United States varies statistically significantly from school to school. In other words, the relationship between teacher instructional practices and student mathematics achievement is dependent upon which schools students attend. This finding, which was made possible by the multilevel modeling technique used in the study, provides further evidence that school-level variables make a difference, i.e., it matters which school a student attends (Ma et al., 2008).

Educational Implications

The finding that teacher instructional practices are associated with student mathematics achievement calls for efforts to reinforce to teachers that how they deliver the mathematics content in their classrooms does play a role in their students' success. Further, the finding that teacher-directed instructional practices are positively associated with student mathematics achievement brings to the forefront the danger of swinging the pendulum too far in either direction in terms of being a teacher-directed or student-centered classroom. As noted by McKinney and Frazier (2008), striking the right balance is key, and, thus, school administrators should caution their teachers not to emphasize student-centered instructional practices so much that they neglect to provide to their students the crucial benefits of teacher-directed practices (NMAP, 2008). With this in mind, the issue of teacher instructional practices, particularly in the mathematics classroom, should be an integral component of teacher professional development. Such professional development opportunities should compare and contrast teacher-directed and student-centered instructional practices, while emphasizing to teachers the important role that both types play in their students' success in the mathematics classroom.

The finding that the relationship between teacher instructional practices and student mathematics achievement varies across schools is concerning due to the nature of school-level variables, particularly those related to the school context (e.g., location, available resources, socioeconomic and racial-ethnic compositions of the student body, and education and experience levels of the teacher body) or climate (e.g., administrative policies, instructional organization, and attitudes and expectations of students, parents, and teachers) (Ma et al., 2008). Although changing a school's context or climate presents a challenge, efforts must be made to do so in order that schools will be more equitable for all students.

Limitations and Future Research

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 (McKinney & Frazier, 2008) or students (this study; 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 conducted by the researchers (Crosnoe et al., 2010). 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, possibly due to differences in how the curriculum is used or differences in the teachers' knowledge and beliefs about mathematics (Jong et al., 2010). Future research could involve measuring teacher instructional practices in multiple ways in the same study to examine if the results are similar across the various measures. In addition, although the internal consistency values of PISA's composite variables used for measuring teacher-directed instructional practices (Cronbach's $\alpha = .76$; OECD, 2014b) and student-centered instructional practices (Cronbach's $\alpha = .68$; OECD, 2014b) in this study were acceptable, there is still room for improvement.

Another issue of concern in this study is the way in which student and school characteristics were controlled. With secondary data analysis, my study was limited to the data collected by PISA. Ideally, the study would have included more control variables at both the student and school levels in hopes of improving the performance of the models. For example, PISA does not provide (or even collect) data on students' race or ethnicity. As a result, it was not possible to control for the racial-ethnic composition of the student body. Such an omission is not desirable, especially given the research on the importance of racial-ethnic differences in student mathematics achievement (McGraw et al., 2006; Parks & Schmeichel, 2012). Further research that seeks to improve control over student and school characteristics has the potential to better explain the relationship between teacher instructional practices and student mathematics achievement.

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