An Examination of Educational Resources on Student Performance

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Abstract

This study examined the relationship between educational resources and student performance in mathematics and science on the Program for International Student Achievement (PISA). Many countries face educational inequality and achievement gaps between high- and low-performing students. To a large extent, the resources invested in education determine student performance. This study examined the resources with the greatest potential to increase student performance. The educational resources of time, material, and finance are defined within the study. The measurement of these resources on the international scale uses the PISA questionnaire, which is completed by students, parents, and school principals. Student performance in mathematics and science is also evaluated using the PISA tool. This study used a correlational approach to analyze the relationship between educational resources and student performance. Results identified the optimum areas in which a country should invest their educational resources to increase student performance. Results showed a strong relationship between educational materials, cumulative spending, preprimary school attendance, and student performance on the science and mathematics 2012 PISA. I found no relationship between student performance on the 2012 PISA and the following variables: (a) student learning time in school, (b) class size, (c) participation in extracurricular activities, and (d) teacher salaries. The findings of this study have the potential to support changes in education that could increase student performance and increase the social and economic impacts those students will have in the future.

Keywords: student performance, educational resources, PISA, mathematics, science

AN EXAMINATION OF EDUCATIONAL RESOURCES ON STUDENT PERFORMANCE

This study examined the relationship between educational resources and student performance in mathematics and science on the 2012 Program for International Student Achievement (PISA). By identifying the resources that had the strongest relationship with student performance, I was able to suggest areas of focus for educational leaders and policymakers. Leaders must make decisions prioritizing spending of resources on building repairs and upgrades, access to computers, smaller class size, or increased teacher salaries. Every dollar spent on longer class periods is a dollar not spent on professional development for teachers, increased internet access for students, or extracurricular activities. Leaders need to know which elements have the strongest relationship with student performance. This study examined the relationships among resources and student performance on the 2012 PISA in mathematics and science. By identifying the types of resources that have a significant relationship with student performance, school leaders could potentially maintain spending yet increase student performance. An adjustment of educational resources in such a manner could decrease educational inequality and close the achievement gap. If the achievement gap narrows as a result of increased student performance, more students would become successful in school, and that success may result in a decrease in violent and nonviolent crime, increase the future earned income of individuals, decrease poverty, and increase participation in society. The findings of this study have the potential to increase student performance now and increase the social and economic impact those students will have in the future.

It is not yet known whether considering this much more nuanced understanding of educational resources might uncover useful associations between greater investments in certain kinds of resources and gains in students' performance. Such research is needed to discover whether policymakers and educational leaders should take a much more nuanced approach to allocating not only financial but also other resources in their efforts to improve student learning. The specific educational resources examined in this study come from common themes expressed in the literature. There are three predominant educational resources identified: financial resources, material resources, and the resource of time. In this study, financial resources focus specifically on cumulative expenditure and teacher salaries. For this study, material resources focus specifically on availability of computers at school, instructional use for the internet, and the quality or physical infrastructure and schools' educational resources. Finally, resources associated with time focus specifically on students' learning time in school, class size, preprimary school attendance, and extracurricular activities. This study focused on these three educational resources and their impact on student performance.

Background of the Problem

Educational inequality, the difference in educational opportunities for students, is a problem at the local, national, and global level (Darling-Hammond, 2010; Le Donné, 2014; Mostafa, 2010; Ravitch, 2020; Takayama, 2013). Educational inequality, on the international scale, has led to a significant achievement gap between high- and low-performing students (Le Donné, 2014; Mostafa, 2010; Takayama, 2013). Students who are low performers are more likely to live in poverty (Le Donné, 2014; Mostafa, 2010; Robinson, 2017; Takayama, 2013). According to Levitt and Dubner (2005), mothers who perform at a low educational level have a much higher chance of their children being incarcerated.

Moreover, the achievement gap in many countries is expanding (OECD, 2012, 2013a, 2013b; Ripley, 2013). Mathis (2011) reported 20% of the achievement gap in the United States is attributable to social class. Darling-Hammond (2014) stated the achievement gap on the international stage continues to expand as a result of growing child poverty, increasing segregation, income inequality, and disparities in access to educational resources.

Studies in several countries have shown a link between the greater availability of educational resources and higher student performance (Archibald, 2006; Aztekin & Yilmaz, 2014; Demir, 2012; Greenwal et al., 1996; Kilic et al., 2013; OECD, 2014). The lack of educational resources is a major cause for low student performance; an increase in such resources would improve student performance (Archibald, 2006; Aztekin & Yilmaz, 2014; Demir, 2012; Greenwal et al., 1996; Kilic et al., 2013; OECD, 2014). Though effective resource allocation can maximize the efficiency of investment in education and increase student performance, there are limits. Educational institutions are directed by local and national programs. The direction of leaders may have a significant impact on student performance, perhaps more so than efficiency of educational spending (Ravitch, 2020). Additionally, because many countries have a tradition of democratic elections, they often have political environments filled with new leaders, visions, and policies. Hanushek and Wößmann (2015) stated it might take as many as 40 years to experience the full effect of educational reform. Further, only 2.5% of the educational workforce is exchanged each year with new workers coming in and old workers leaving, so it takes 40 years to fully turn over the workforce with individuals who attended a reformed education. Governments have mandates tied to special education, school certification, civil rights, standardized testing, and various other initiatives that require participation and funding. The problems of educational inequality and the achievement gap could be reduced by more efficient spending, but an effective solution would require other initiatives, resources, and attention from a multifaceted economic and social perspective. The results from this study can be used to inform decisions about educational spending but only within the confines of educational sovereignty.

History of PISA

In this study, student performance was measured by the Program for International Student Assessment (PISA), a test developed in 1997 by Andreas Schleicher, who worked with the Organization for Economic Co-operation (OECD) to develop the PISA. PISA’s assessment of critical thinking, problem solving, and communication skills in science, mathematics, reading, and writing shows the world which countries were teaching students to think for themselves (Ripley, 2013). The PISA assessment was first administered in 2000, followed by 3-year intervals in 2003, 2006, 2009, and 2012 (OECD, 2013a, 2013b, 2014).

PISA focuses on math and science and includes both a survey that examines variables associated with educational resources and an assessment that looks at academic performance. Created by the OECD, a group of nations with a goal of greater economic growth and development, the survey is completed by students, parents, and school principals. Participants from 63 countries completed the 2012 PISA/OECD survey (OECD, 2013). The PISA asks students, parents, and principals questions about their experiences related to the stated resources: financial, material, and time (Gumus, 2011; OECD, 2013a). The survey also collects information regarding student, family, and school characteristics, allowing researchers to investigate the possible interactions between educational resources and student achievement, and the opportunity to compare student performance across many countries (Gumus, 2011; OECD, 2013a, 2013b, 2014). By using data internationally, researchers have the potential to identify various societal variables that impact student performance.

Using data from the PISA 2000 to 2009 results, researchers determined the countries with the highest student performance overall. Finnish students ranked highest on the PISA (OCED, 2014). Students from the country with the highest per-pupil spending, Luxembourg, along with students from the country with the highest teacher salaries, Spain, ranked far below student performance in Finland. Finland's per pupil spending is average for the countries PISA covers and, for comparison, is almost $5,000 USD less than the nearly $12,000 USD the United States spends per pupil (OECD, 2013a, 2013b, 2014; Ripley, 2013).

Some countries allocate substantial resources to their education program, yet many of these systems are outperformed by nations with varying levels of investment (OECD, 2013a). Data collected from PISA show educational institutions, despite their educational resources, have difficulty advancing student performance (OECD, 2013b; Ripley, 2013). A possible explanation is that countries are not investing in the most effective educational resource to improve student performance (OECD, 2013a; OECD, 2013b).

It is possible the PISA score is not connected to the alignment of educational resources; however, that determination cannot be made until such research has been conducted. The mathematics PISA is scored on a scale up to 650 points. In 2013 students from Shanghai, China, scored on average above 600 points, while students from Viet Nam scored slightly above 500 points, and those from Luxembourg scored slightly below 500 (OECD, 2013b). However, the country of Viet Nam spent less than $10,000 USD per pupil; Shanghai-China spent a little less than $50,000 USD per pupil; and Luxembourg spent just under $200,000 USD per pupil (OECD, 2013b). According to the OECD (2013b), Luxembourg spent $190,000 USD per pupil more than Viet Nam, but the students of Luxembourg had an overall lower performance. Additionally, between 2003 and 2012, Mexico started spending almost $5,000 USD less per pupil and increased their mathematics performance almost 30 points, while Sweden increased its per pupil spending more than $25,000 USD and mathematics performance dropped more than 30 points (OECD, 2013b). Overall, however, many educational leaders, politicians, and members of the greater public see educational resources as linked to educational achievement, even though some countries' PISA numbers do not currently reflect those opinions.

Statement of the Problem

Despite similar availability and allocation of educational resources, educational inequality and results in student performance on the 2012 PISA varied widely across the globe. The 2012 PISA installment was the most recent PISA data I could analyze at the time of this study. It appears that the results of later studies are showing similar results to 2012. If leaders could identify resources that had the strongest relationship with student performance on the 2012 PISA, educational leaders could allocate their resources more efficiently. More efficient resource allocation could increase student performance without additional investment, which could close the achievement gap and increase educational equality.

Purpose of the Study

The purpose of this study was to identify the resources with the greatest relationship to student performance on the 2012 PISA. Sixty-three countries participated in the 2012 PISA. In this study, I reviewed the educational resources (financial, material, and time) each country invested in its education program and compared the resource investment to the countries' student performance in science and mathematics on the 2012 PISA. By analyzing the relationship between the countries' resources and student performance, I developed a clearer understanding of those relationships. I compared the impact of a nation's expenditures and distribution of educational resources to the nation's student performance on the PISA to determine if there was a high impact or, any impact at all, that could be determined between these variables. The results of this study indicated there were, indeed, positive correlations between resource allocation and achievement in mathematics and science.

Research Questions

Knowing the identified resources that had the strongest relationship with student performance on the 2012 PISA, educational leaders could allocate their resources more efficiently. To determine these relationships, I developed the following research questions:

- Which of the educational resources of time, financial, and material have the strongest relationships with student performance in science and mathematics on the 2012 PISA?
- What are the most significant resources one can use to consistently increase student performance?

The research questions were developed on the following hypothesis: More efficient resource allocation can increase student performance, without additional investment, which could close the achievement gap and increase educational equality.

Significance of the Study

This study has added to the literature through an examination of the relationship between educational resources and student performance. Although this research is limited to the PISA 2012 data and OECD survey results, researchers can use the most recent data from the PISA and OECD to replicate this study. Additionally, educational leaders and policymakers at the international, national, local, and school levels can use this information when allocating and distributing resources in an effort to prevent social and economic problems in the future by increasing student performance on the PISA in mathematics and science. Educational leaders can use the information from this study to determine the quality and quantity of resources to be spent on cumulative educational expenditure, available computers at school, and student learning time in school. Educational leaders who allocate resources more effectively can improve student performance on the PISA in mathematics and science by focusing on the resources with greatest impact on student performance, which, in turn, may adjust educational inequality and the achievement gap and have a specific impact on student individual future income and participation in society. The most important goal is to close the achievement gap among students, schools, and nations to give more people an equitable education.

Literature Review

In this study I sought to find evidence related what resources have the greatest relationship with student performance on the 2012 PISA. Through my analysis of the data, I found those resources that have the strongest relationships with student performance, showing the possibilities that school leaders have to adjust resource allocation to be more efficient and increase student performance without increasing the need to invest more resources. Researchers (Ripley, 2013) have widely studied educational inequality, educational resources (time, finances, and material), and how resources are used. According to Ripley (2013), some scholars have argued the way in which educational resources are used has a greater impact on student performance than the quantity of resources they have available.

In this study, I sought to construct a global understanding of relationships between resources and achievement, described previously by Engel (2015) and Edwards (2012), within the large pool of available data from PISA. Knowing these data are used to develop reforms, and reforms have yet to significantly reduce educational inequality, educational leaders can return to the raw data to try to create different assumptions and frameworks about how to more effectively lessen, and eventually eliminate, educational gaps in the success of students around the world.

High student performance is important not only for a student to be well educated but also for a student to be successful as an adult. Researchers have found an educated and active citizen body is critical for effective governance in a democratic society (Gutman, 1987; Westheimer & Kahne, 2004). Additionally, student performance is the greatest predictor of individual earned income as an adult and individual participation in society (OECD, 2004, 2013, 2014; OECD/UNESCO, 2003; Ripley, 2013). Hanushek and Wößmann (2015) analyzed international testing data to find the relevance of education in economic growth. There was an assumption that 1 year of schooling in different countries was equivalent; however, Hanushek and Wößmann concluded the knowledge base held by the country's population, what the people know, determined if a country was rich or poor; thus, the quality of education varies in each country. These researchers concluded countries whose members do well on international tests have greater economic growth; additionally, 75% of a country's economic growth rate incorporates the mathematics and science skills of the population (Hanushek & Wößmann, 2015).

Resource of Time

Studies have suggested the educational resource of time impacts student performance (Angrist & Lavy, 1997; Belinski et al., 2009; Bloom, 1977; Eccles & Barber, 1999; Fischer, 1981; Guskey, 2001). The resource of time consists of (a) the amount of individual student–teacher time, (b) students' time spent invested in the school or the greater school community outside of school academic hours, and (c) the amount of time a student spends on learning (e.g., the age at which children start their education, the length of their classes). Similarly, time, as an educational resource, defined by OECD (2013), consists of (a) students' learning time in school, (b) class size, (c) extracurricular activities, and (d) students' attendance at preprimary school. Angrist and Lavy (1997) noted a decrease in class size has a significant increase in student reading and mathematics scores for fourth and fifth graders. Each student receives more individual time with the teacher if there are fewer students in the class. Therefore, Angrist and Lavy suggested these are the reasons for improved performance. Additionally, Bloom (1977) and Guskey (2001) stated, to reduce variation in students' achievement and to have all students learn well, educators must increase learning time. Fisher (1981) also found additional student learning time in school and smaller class sizes increased student performance. Furthermore, student involvement in extracurricular activities has been correlated with increased academic performance (Eccles & Barber, 1999) because the student's time is invested in school and education becomes more of a priority, even if the extracurricular activities are not academic. Berlinski et al. (2009) found preprimary education increased student test scores by 8%; the student's time in school and academics started early, as did their skill development.

Material Resources

Researchers have identified educational material resources (e.g., computers, pencils, books, paper, staplers, copiers, printers) as having a positive impact on student performance (Evans, 2006; Faith, 209; Gouda et al., 2013) According to Evans (2006), Faith (2009), and Gouda et al. (2013), the material resource consisted of (a) the availability of computers, (b) the instructional use of the internet, (c) the quality of the physical infrastructure, and (d) the school's educational resources. Likewise, material resources, defined by OECD (2013), consisted of both physical infrastructure and educational resources. Faith explained physical infrastructure and material educational resources such as computers and internet access have a statistically significant positive impact on student achievement in the fourth and eighth grades. The same study identified between 55.8% and 77.2% of variation in student achievement can be attributed to investment in educational resources.

Financial Resources

Studies by the Education Commission of the States (1992), the Federal Deposit Insurance Corporation (2007), Gius (2013), Husted (2005), Ripley (2013), and Vegas and Coffin (2015) suggested financial educational resources have an impact on student performance; additionally, the OECD (2013) stated that financial resources consisted of the total amount of money spent on education and money spent on teacher’s salary. Financial resources, defined by OECD (2013), consisted of teacher’s salary and expenditures for education. Gius (2013) performed a study that showed positive changes in teacher pay had decreased the district-level dropout rate by 2.36% and increased the graduation rate by 3.04% over a 7-year period. Additionally, Vegas and Coffin (2015) discovered overall expenditure had a positive correlation with student performance, as mean student performance was approximately 14 points higher on the PISA scale for every additional $1,000 USD spent.

The indication that finances are connected to student achievement has been replicated by more recent studies. For example, the Learning Policy Institute found a meta-analysis of research conducted by Baker (2018) from Rutgers Graduate School of Education indicated finances matter to student achievement. According to the LPI Brief, written by Baker (2018), there were three important conclusions from the meta-analysis:

1. An analysis of the relationship between financial resources and student outcomes indicates that money matters in a positive way for student achievement.
2. Educational resources that cost money (e.g., smaller class sizes, salaries for expert teachers) are positively correlated with student achievement.
3. Test scores and graduation rates rise when school districts sustain their efforts to improve educational resources.

There appear to be three issues related to resources: (a) the quantity of resources, (b) the quality of the resources, and (c) how resources are allocated. These issues were at the heart of this study.

Conclusion

Some countries allocate substantial resources to their education programs, yet many of these systems are outperformed by nations with varying levels of investment (OECD, 2013a). Data collected from PISA show educational institutions, despite their educational resources, have difficulty advancing student performance (OECD, 2013b; Ripley, 2013). This study examined the educational inequality and varying results in national student performance on the 2012 PISA despite similar availability and allocation of educational resources. Knowing the identified resources that had the strongest relationship with student performance on the 2012 PISA, educational leaders could allocate their resources more efficiently. More efficient resource allocation could increase student performance without additional investment, which could close the achievement gap and increase educational equality. The resources of time, material, and financial resources have been identified as having a relationship with student performance (OECD, 2013a; OECD, 2013b); however, information is not available regarding which relationships have the greatest impact on student performance. A comparison of the impact these resources have is needed; it is not enough to determine if a relationship exists. A narrow view of one resource relationship with student performance is limited; however, a broader of view of which resources have the greatest relationship with student performance can be more informative.

PISA has collected data on the allocation of educational resources and student performance. Certain resources may be more closely related to improved student performance on the PISA. In the mid-1960s, Finnish students earned a score of 510; by 2010, Finnish students earned a score of 545, gaining 35 points in 50 years, which is a modest but steady improvement (Ripley, 2013). In the same time span, the United States went from 485 to just above 490, and, in 50 years, France's score had no change, Canada's student performance increased from 490 to 525, and Norway's student performance decreased from 490 to just above 465 (Ripley, 2013). The data suggested that, over time, some countries increased student performance, others did not change, and some countries had declining performance.

The impact of educational resources on student performance is not well studied. Research is needed so policymakers and educational leaders can make careful decisions regarding resource allocations. This study addressed part of that gap by focusing on the quantity of a resource and its impact on student performance. The distribution of educational resources is not limited to financial means; education requires talented and dedicated people, facilities to support and advance education, and time dedicated to proper preparation and instruction (OECD, 2012, 2013a, 2013b). I examined the impact educational resources have on student performance, specifically the resources of time, material resources, and financial resources and their impact on student performance in mathematics and science on the 2012 PISA.

Methodology

This study reviewed the 2012 PISA data to determine the educational resources that had the greatest relationship with student performance. If school districts were aware of the resources that had the strongest relationship with student performance, administrators could adjust resource allocation to be more efficient and increase student performance without investing more resources. This section outlines the correlational methodology used to determine the relationship between educational resources and student performance on the 2012 PISA.

Research Design

The research design for this study was a correlational study. A correlational study, according to Gall et al. (2007), allows for an investigation examining the direction and magnitude of the relationship among variables using correlation statistics. Correlational analysis can be used to examine complex relations among many variables. This study used 11 variables for performance in science and 12 for mathematics, for a total of 23 interactions between each resource variable and measures of student performance. The number of variables, with different units of measure, provided a complexity in this study that correlational analysis could manage.

The OECD has collected data from 63 countries around the world. The information collected is in two forms: (a) a test assessing student academic performance in mathematics and science and (b) a survey completed by schoolteachers, principals, parents, and other members of the education community. The survey provides information on the allocation of resources within the educational system. A qualitative or mixed method study would not have been appropriate for analyzing the data collected by the OECD. A correlational analysis study was necessary to determine the strength of the relationship between the educational resources and student performance. With this method, I answered the research question, “Which of the educational resources of time, financial, and material have the strongest relationship with student performance in science and mathematics on the 2012 PISA?” This method allowed me to analyze data even where there were varying units of measure, as there were in this study. It can be difficult to analyze statistics of various, seemingly incomparable, units of measure into something useful and meaningful; in such cases, it is appropriate to employ correlational statistics.

I used a correlational analysis methodology; additionally, I used Intellectus Statistics software for calculations and graphing. I also used Intellectus Statistics software to determine r, the Pearson correlation coefficient, and p, the probability value, with a 95% confidence interval. This methodology (Gall, 2007) can examine the complex relationships between resources and student performance.

Research Method and Rationale

In this quantitative study, I employed correlation analyses to determine the relationship of time, material, and financial educational resources with student performance in science and mathematics on the 2012 PISA. The OECD has already collected data on student performance and resource allocation. The data collection section in this article expands on the specific data harvested from the OECD 2012 PISA. With the data collected from the OECD database, I converted the data to a *z* score. A *z*-score conversion was necessary because some of the survey questions were answered in percentages, others in number of minutes, dollar amount, etc. The units are different, and, in this study, using *z* scores put each element of the educational resource on the same scale, making comparison easier. I used Intellectus Statistics software to convert the data to a *z* score; the formula for a *z* score is (score – mean) / standard deviation. Each resource element needed to be compared to the mathematics and science 2012 PISA scores. I created scatterplot graphs to compare the *z* score of each resource element on one axis and the countries' student performance *z* score in mathematics and science on the other. I used Intellectus Statistics software to create the scatterplot graphs and to subsequently determine the Pearson correlation coefficient, *r,* and *p* value, with a 95% confidence interval. This methodology (Gall et al., 2007) examined the complex relationships between resources and student performance. I calculated and compared the correlation coefficients to understand the magnitude of each suggested resource with student performance.

Participants

The member countries of the OECD and nonmember countries participating in the PISA and OECD research composed the participant pool. The 2012 assessment was administered to 510,000 students who were between 15 years 3 months and 16 years 2 months old (OECD, 2013). Sixty-three countries participated in the 2012 PISA; I used the data collected from those 63 countries in this study. Country participation was voluntary and included: Albania, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Columbia, Costa Rica, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong-China, Hungary, Iceland, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Macao-China, Malaysia, Mexico, Montenegro, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Qatar, Romania, Russian

Federation, Republic of Serbia, Shanghai-China, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taipei-China, Thailand, Tunisia, Turkey, United Arab Emirates, United Kingdom, United States, and Uruguay (OECD, 2013).

The sampling techniques of the OECD and participating countries, along with parental and governmental consent to participate in the PISA, had already been determined, validated, submitted, and approved by the participants or their guardians. According to the OECD (2015), schools are randomly selected in each participating country by the international contractor for participation in PISA, and the selection of schools and students is kept as inclusive as possible, so the sample of students comes from a broad range of backgrounds and abilities. I used the mean scores, by country, to analyze academic student performance in this study. Specific student scores were available; however, data for specific students do not contain identifying information. Each student is referred to only as a number.

Sampling

The OECD's (2014) school sampling process used a cluster model; the target cluster size did not fall below 35 students. According to the OECD, an international contractor used the countries' school sampling frame to select the school sample. Each school prepared a list of eligible students, according to the OECD (2014):

> Each school drawing an additional grade sample was to prepare a list of age and grade-eligible students that included all PISA-eligible students in the designated grade (e.g., Grade 10); and all other 15-year-old students (using the appropriate 12-month age span agreed upon for each participating country) currently enrolled in other grades. This form was referred to as a student listing form. (p. 85)

The following criteria were considered important according to the OECD (2014):

- Age-eligible students were all born in 1996 (or the appropriate 12-month age span agreed upon for the participating country).

- The list was to include students who might not be tested due to a disability or limited language proficiency.
- Students who could not be tested were to be excluded from the assessment after the student sample was selected. Students were to be excluded after the students' sample was drawn, not prior.
- Schools were to retain a copy of the student list in case the national project manager had to contact the school with questions.
- Student lists were to be up to date at the time of sampling rather than a list prepared at the beginning of the school year. Students were identified by their unique student identification numbers.

Once the international contractor received the list of PISA-eligible students from a school, the school was responsible to select the student sample (OECD, 2014). The schools were "required to use KeyQuest, the PISA Consortium sampling software, to select the student samples unless otherwise agreed upon. For PISA 2012, all countries used KeyQuest" (OECD, 2014, p. 85). According to the OECD (2014), the overall response rate for the 2012 PISA was 85%. To select the student particiants and ensure the students participating in the 2012 PISA were representative of their country, the OECD (2014) developed the following framework and guidelines:

> Selected students attending the same school cannot be considered as independent observations as assumed with a simple random sample because they are usually more similar to one another than to students attending other schools. For instance, the students are offered the same school resources, may have the same teachers and therefore are taught a common implemented curriculum, and so on. (p. 186)

The OECD (2014) stated differences among schools can be larger if different educational programs are not consistently available. For example, one would expect to observe greater differences between a vocational school and an academic school rather than between two comprehensive schools. To have more reliable data, the OECD has taken strides to have a diverse sample of schools and students. The OECD (2014) addressed how geographic places of residence could have an impact:

> It is well known that within a country, within sub-national entities and within a city, people tend to live in areas according to their financial resources. As children usually attend schools close to their home, it is likely that students attending the same school come from similar social and economic backgrounds. A simple random sample of 4,000 students is thus likely to cover the diversity of the population better than a sample of 100 schools with 40 students observed within each school. It follows that the uncertainty associated with any population parameter estimate (i.e., standard error) will be larger for a clustered sample estimate than for a simple random sample estimate of the same size. (p. 186)

Within the participating countries, the schools taking the PISA are randomly selected (OECD, 2015). The PISA aims to assess performance at the national level, not an individual student level, so not every student completes the same test (OECD, 2015), providing a broader assessment. Additionally, there are 13 different survey booklets and three different questionnaires distributed randomly to the randomly selected participating students (OECD, 2015). Different assessments are used to gain more data about the general population; a single student would not have enough time to complete all the assessments. The OECD (2013) assesses between 4,500–10,000 students in each participating country.

Variables

This study analyzed which educational resources had the strongest relationship with student performance in mathematics and science on the 2012 PISA. Later in this section, I expand on the educational resource variables and the variables of student performance. To determine the relationship between the two variables, I graphed each resource element against student performance, in both mathematics and science. Each graph had information from all 63 participating countries, allowing a large sample size for determining the relationship strength between the variables.

In this study, I analyzed student performance on the international scale by looking at national scores in science and mathematics. Analyzing national student performance scores requires a tool that can collect data consistently, independently, and without bias while assessing students from many nations. I provide a table with the survey questions used to collect data on each resource in Appendix A.

Financial educational resources, according to the OECD (2013), include:

- cumulative expenditure on education
- teacher salaries, ratio per GDP

Material educational resources, according to the OECD (2013), include:

- physical infrastructure quality
- educational resource quality
- availability of computers at school
- proportion or computers that have access the internet.

Time educational resources, according to the OECD (2013), include:

- student learning time in school: mathematics and science
- class size
- extracurricular activities
- student attendance at preprimary school

Results

In this study, I aimed to determine the educational resources that have the greatest relationship with student performance on the 2012 PISA. By identifying resources that have a strong relationship with student performance in this study, I have provided information to make it possible for school leaders to adjust resource allocation to increase student performance without investing more resources. This information can help guide the decision making of Board of Education members, Superintendents, and other school leaders.

Study Findings

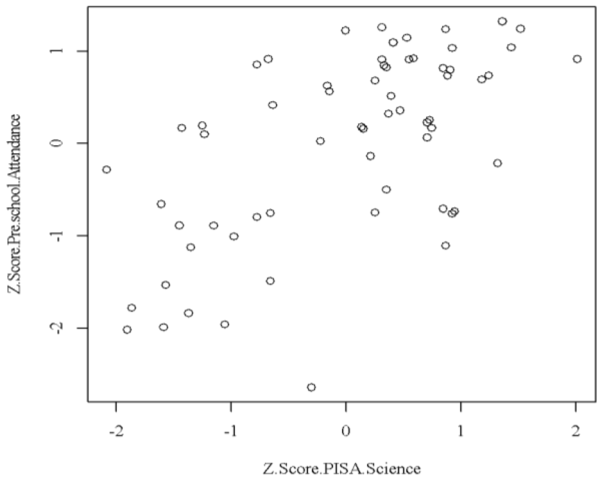
I conducted a Pearson correlation analysis to determine the strength of the relationship between each educational resource and student performance in mathematics and science. I used Cohen's standard to evaluate the strength of the relationship, where coefficients between .10 and .29 represent a small association, coefficients between .30 and .49 represent a moderate association, and coefficients equal to or above .50 indicate a large association (Cohen, 1988). A Pearson correlation requires the relationship between each pair of variables is linear (Conover & Iman, 1981). This assumption is violated if there is curvature among the points on the scatterplot between any pair of variables.

Science and Mathematics Scores and Preprimary school

There was a significant positive correlation between PISA science scores and preprimary school attendance ($r = 0.60$, $p < .001$; see Table 1). The correlation coefficient between PISA science scores and preprimary school attendance was 0.60, indicating a strong relationship. As preprimary school attendance increased, PISA science scores tended to increase (see Figure 1).

Figure 1

Science and Preprimary school Attendance

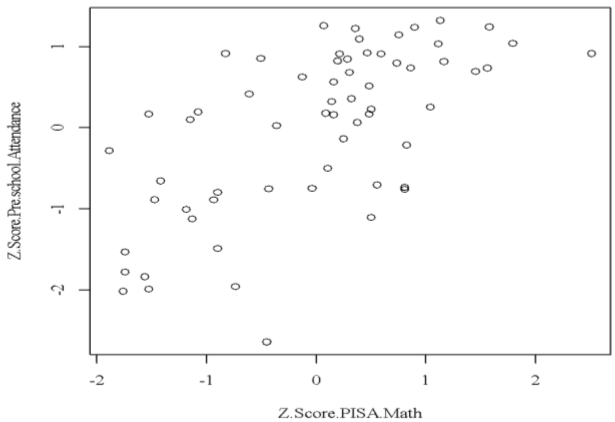


Note. Scatterplot between PISA science scores and preprimary school attendance. Pearson correlation coefficient = 0.60. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

There was a significant positive correlation between PISA mathematics scores and preprimary school attendance (r = 0.64, p < .001; see Table 2). The correlation coefficient between PISA mathematics scores and preprimary school attendance was 0.64 indicating a large relationship (see Figure 2). As preprimary school attendance increased, PISA mathematics scores tended to increase.

Figure 2

Mathematics Scores and Preprimary school



Note. Scatterplot between PISA mathematics scores and preprimary school attendance. Pearson correlation coefficient = 0.64. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

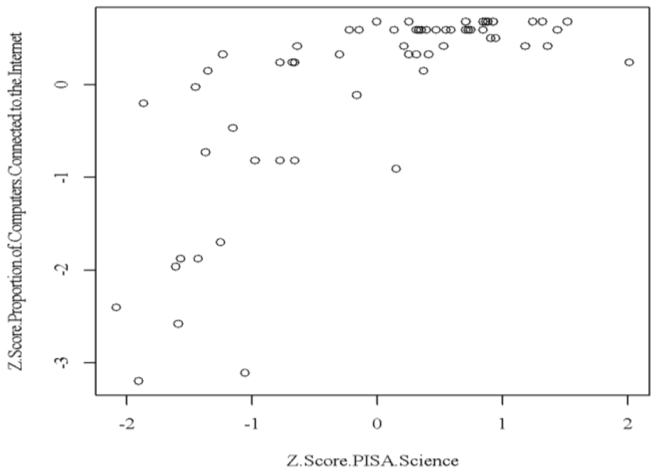
These scores indicated an important correlation between both mathematics and science scores on the PISA and student attendance at preprimary school. Preprimary school may be an important area for educational leaders to consider in terms of closing the achievement gap for young students.

Science and Mathematics Scores and Computers

There was a significant positive correlation (see Figure 3) between the science scores and the proportion of computers connected to the internet ($r = 0.74$, $p < .001$; see Table 1). The correlation coefficient between science scores and the proportion of computers connected to the internet was 0.74, indicating a strong relationship. As the proportion of computers connected to the internet increased, the PISA science scores tended to increase. Figure 3 presents a scatterplot of the correlation.

Figure 3

Science Scores and Internet Computers

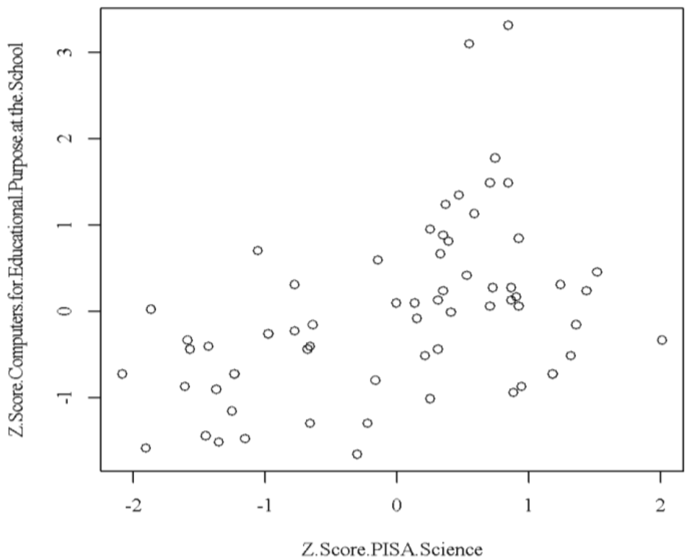


Note. Relationship between PISA science scores and the proportion of computers connected to the internet. Pearson correlation coefficient = 0.74. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

The data also revealed a significant positive correlation between PISA science scores and the number of computers for educational purpose at school (*r* = 0.46, *p* < .001; see Table 1). The correlation coefficient between PISA science scores and the number of computers for educational purpose at school was 0.46, indicating a moderate relationship. As the number of computers for educational purpose at school increased, PISA science scores tended to increase (see Figure 4).

Figure 4

Science Scores and Educational Computers

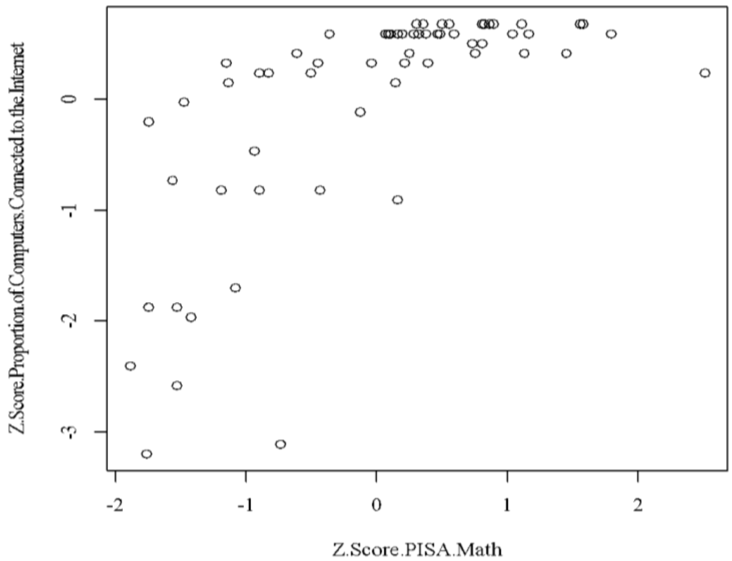


Note. Scatterplot between PISA science scores and the number of computers for educational purpose at school. Pearson correlation coefficient = 0.46. Data retrieved from “Education Spending,” by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

There was a significant positive correlation between PISA mathematics scores and the proportion of computers connected to the internet (r = 0.69, p < .001; see Table 2). The correlation coefficient between PISA mathematics scores and the proportion of computers connected to the internet was 0.69, indicating a large relationship (see Figure 5). As the proportion of computers connected to the internet increased, PISA mathematics scores tended to increase.

Figure 5

Mathematics and Internet Computers



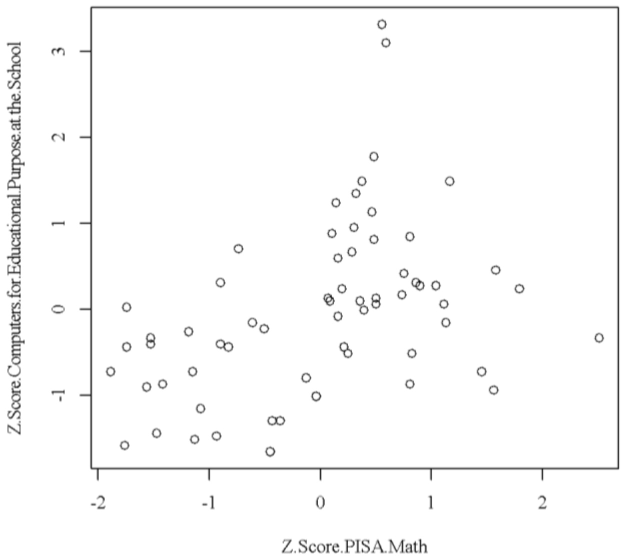
Note. Scatterplot between PISA mathematics scores and proportion of computers connected to the internet. Pearson correlation coefficient = 0.69. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

There was a significant positive correlation between PISA math scores and the number of computers for educational purposes at the school (r = 0.41, p < .001). The correlation coefficient between PISA math scores and the number of computers for educational purposes at the school was 0.41, indicating a moderate relationship (see Table 2). As the number of computers for educational purposes at the school increased, PISA math scores tended to increase (see Figure 6).

The data indicated a significant and strong relationship between the proportion of computers connected to the internet and mathematics and sciences scores on the PISA. In terms of the number of computers dedicated for educational purposes, the relationship with mathematics and science was significant with a moderate correlation size.

Figure 6

PISA Mathematics Scores and Computers



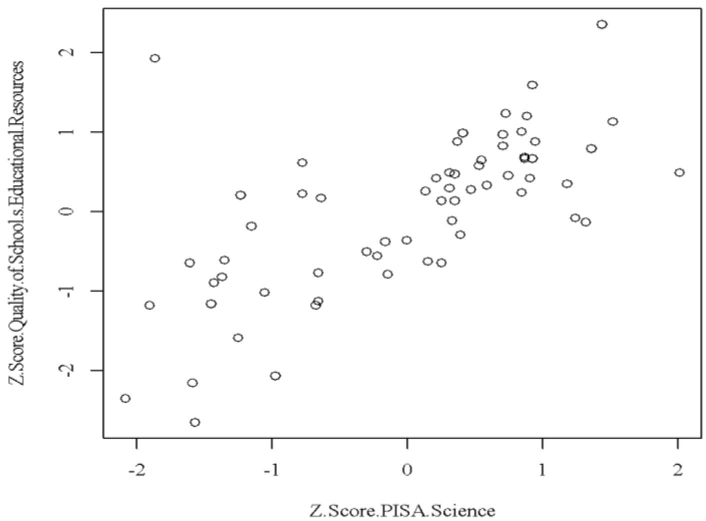
Note. Scatterplot between PISA math scores and the number of computers for educational purposes at the school. Pearson correlation coefficient = 0.41. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

Science and Mathematics Scores and Educational Resources

There was a significant positive correlation between PISA science scores and the quality of school educational resources (r = 0.68, p < .001; see Table 1). The correlation coefficient between PISA science scores and the quality of school's educational resources was 0.68, indicating a strong relationship. As quality of school's educational resources increased, PISA science scores tended to increase (see Figure 7).

Figure 7

Science Scores and Quality of Educational Resources

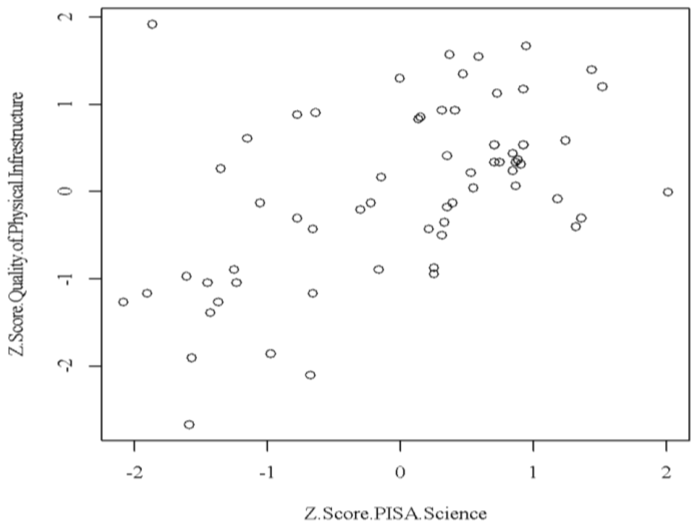


Note. Relationship between PISA science scores and the quality of schools' educational resources. Pearson correlation coefficient = 0.68. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

Additionally, there was a significant positive correlation between PISA science scores and the quality of physical infrastructure ($r = 0.52$, $p < .001$; see Table 1). The correlation coefficient between PISA science scores and the quality of physical infrastructure was 0.52, indicating a large relationship. As the quality of physical infrastructure increased, PISA science scores tended to increase (see Figure 8).

Figure 8

Science Scores and Physical Infrastructure

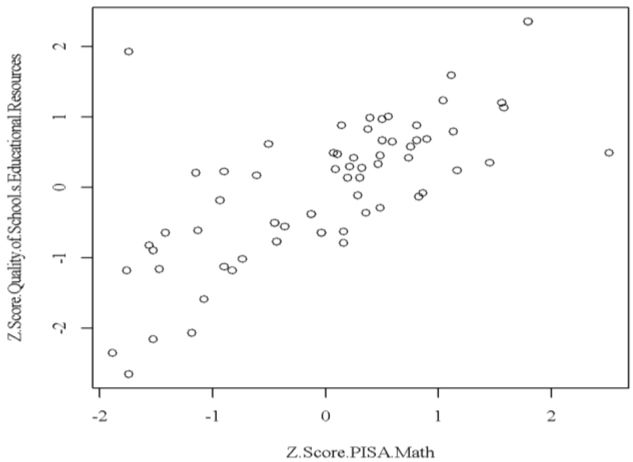


Note. Scatterplot between PISA science scores and quality of physical infrastructure. Pearson correlation coefficient = 0.52. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

There was a significant positive correlation between PISA mathematics scores and the quality of school's educational resources (*r* = 0.69, *p* < .001; see Table 2). The correlation coefficient between PISA mathematics scores and the quality of school's educational resources was 0.69, indicating a large relationship (see Figure 9). As the quality of school's educational resources increased, PISA mathematics scores tended to increase.

Figure 9

Mathematics Scores and Quality of Education Resources

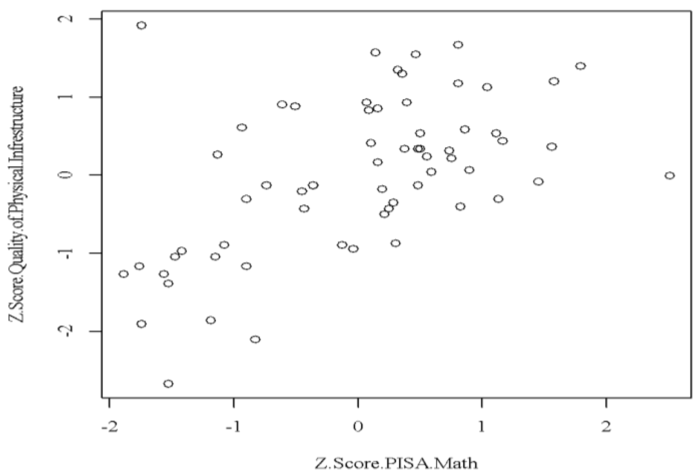


Note. Scatterplot between PISA mathematics scores and the quality of school's educational resources. Pearson correlation coefficient = 0.69. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

There was a significant positive correlation between PISA mathematics scores and the quality of physical infrastructure (r = 0.54, p < .001; see Table 2). The correlation coefficient between PISA mathematics scores and the quality of physical infrastructure was 0.54, indicating a large relationship (see Figure 10) As the quality of physical infrastructure increased, PISA mathematics scores tended to increase.

Figure 10

Mathematics Scores and Physical Infrastructure



Note. Scatterplot between PISA mathematics scores and the quality of physical infrastructure. Pearson correlation coefficient = 0.41. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

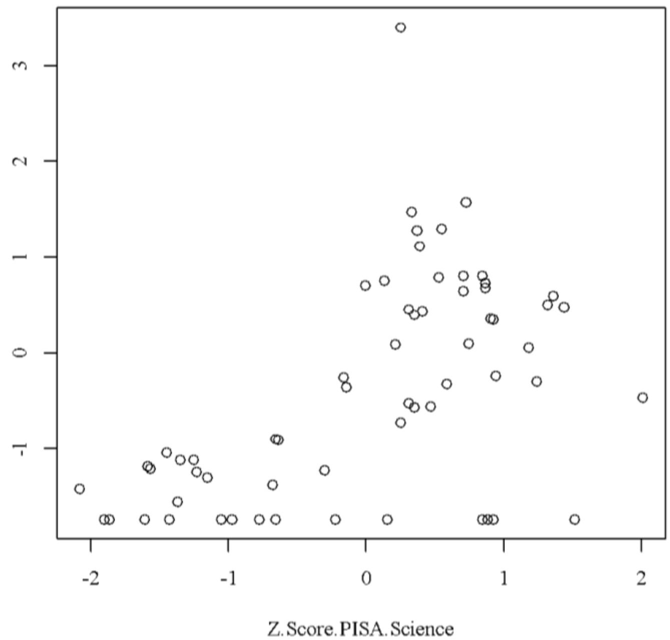
Scores indicate for both mathematics and science a significant and strong positive relationship between student PISA scores and the quality of school resources. The same was true for mathematics and sciences scores and the quality of school infrastructure.

Science and Mathematics Scores and Cumulative Expenditures

A significant positive correlation was also found between PISA science scores and cumulative expenditure ($r = 0.55$, $p < .001$; see Table 1). The correlation coefficient between PISA science scores and cumulative expenditure was 0.55, indicating a large relationship. As cumulative expenditure increased, PISA science scores tended to increase (see Figure 11).

Figure 11

Science Scores and Cumulative Expenditures

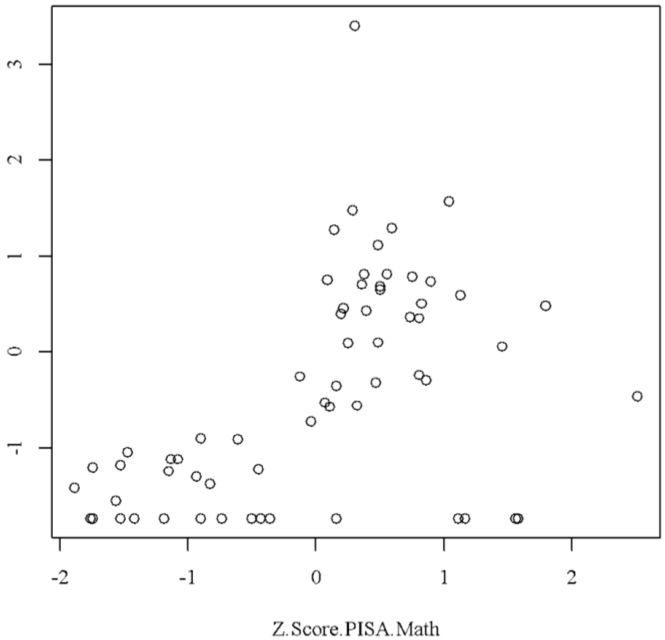


Note. Scatterplot between PISA science scores and cumulative expenditure. Pearson correlation coefficient = 0.55. Data retrieved from "Education Spending," by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

There was a significant positive correlation between PISA mathematics scores and cumulative expenditure (r = 0.50, p < .001; see Table 2). The correlation coefficient between PISA mathematics scores and cumulative expenditure was 0.50, indicating a large relationship As cumulative expenditure increased, PISA mathematics scores tended to increase (see Figure 12).

Figure 12

Mathematics Scores and Cumulative Expenditures



Note. Scatterplot between PISA mathematics scores and cumulative expenditure. Pearson correlation coefficient = 0.50. Data retrieved from “Education Spending,” by OECD, 2012 (https://data.oecd.org/eduresource/education-spending.htm).

The results of this study indicate a strong positive relationship between mathematics PISA scores and cumulative expenditures. The data also indicate a positive and strong relationship between science scores and cumulative expenditures in schools.

Summary

As can be observed in Table 1, six educational resources had significant correlational relationships with science scores of the PISA. The significant correlations between science scores and educational resources included: (a) preprimary school attendance, (b) quality of physical infrastructure, (c) quality of schools' educational resources, (d) quantity of computers for educational purposes, (e) proportion of computers connected to the internet, and (f) cumulative expenditure. Items that did not have significant correlations with science scores included: (a) student learning time in school, (b) class size, (c) extracurricular activities at school, and (d) teacher salaries. The two highest effect sizes were generated by the proportion of computers connected to the internet (*r* = 0.74) and the quality of a school's educational resources (*r* = 0.68). These scores indicate how schools allocate their resources matters.

Table 1

Correlation Between Science and Educational Resources

Resource Variable	*r*	*p*
Time		
Student learning time in school	0.07	.590
Science		
Class size	-0.16	.220
Extracurricular activities at school	0.09	.480
Preprimary school attendance	0.60	< .001
Material		
Quality of physical infrastructure	0.52	< .001
Quality of schools' educational resources	0.68	< .001
Computers for educational purposes	0.46	< .001
Proportion of computers connected to the internet	0.74	< .001
Financial		
Cumulative expenditure	0.55	< .001
Teacher salaries	0.22	.090

Note. Resource table relationship with student performance on Science PISA; this table provides a summary of information.

Table 2 displays the six correlations between mathematics PISA scores and educational resources that were statistically significant. The six significant areas included: (a) preprimary school attendance, (b) quality of physical infrastructure, (c) quality of schools' educational resources, (d) computers for educational purposes, (e) proportion of computers connected to the internet, and (f) cumulative expenditure. These were the same resources that were significant between science and education resources. The highest effect sizes were also related to the science scores: proportion of computers connected to the internet and quality of schools' educational resources. The scores for mathematics and science also indicate the importance of preprimary school attendance for student achievement in mathematics and science.

Table 2

Correlation Between Mathematics and Educational Resources

Resource Variable	*r*	*p*
Time		
Student learning time in school	0.01	.940
Mathematics		
Class size	-0.10	.430
Extracurricular activities at school	0.08	.530
Preprimary school attendance	0.64	< .001
Material		
Quality of physical infrastructure	0.54	< .001
Quality of schools' educational resources	0.69	< .001
Computers for educational purposes	0.41	< .001
Proportion of computers connected to the internet	0.69	< .001
Financial		
Cumulative expenditure	0.50	< .001
Teacher salaries	0.15	.240

Note. Resource table relationship with student performance on Mathematics PISA; this table provides a summary of information.

Summary/Conclusions of Results

I found a significant positive relationship between student performance on the science and mathematics 2012 PISA and six resource variables. These variables included: (a) proportion of computers connected to the internet (mathematics $r = 0.69$, science $r = 0.74$); (b) quality of schools' educational resources (mathematics $r = 0.69$, science $r = 0.68$); (c) preprimary school attendance (mathematics $r = 0.64$, science $r = 0.60$); (d) quality of physical infrastructure (mathematics $r = 0.54$, science $r = 0.52$); (e) cumulative expenditure (mathematics $r = 0.50$, science $r = 0.55$); and (f) computers for educational purposes (mathematics $r = 0.41$, science $r = 0.46$). The scores for mathematics and science were basically consistent. These results indicate resource allocation for mathematics and science could follow along the same resource path when educators are contemplating allocation of resources that will raise achievement in mathematics and science.

Discussion

In this study, I assessed the correlation between 10 resource areas and student achievement in mathematics and science. I evaluated which of the educational resources of time, finances, and/or material had the strongest relationships with student performance in science and mathematics on the 2012 PISA. I suggest as variables such as preprimary school attendance are addressed, student performance will increase, as will the individual student's future economic and social impact. Research has shown (OECD, 2004, 2013, 2014; OECD/UNESCO, 2003; Ripley, 2013) the achievement gap and educational inequality may decrease with increased performance. The ability to be more successful in school will offer individual students opportunities for higher future earned income and greater participation in society.

Performance may increase, but individual students could have a different relationship and the result may not be constant. As student performance continues to increase, student future economic and social impact will also grow. My study attempted to identify optimal areas in which stakeholders can invest educational resources to increase student performance on the PISA, perhaps without increasing cost of education and thereby possibly reducing educational inequality.

Key Findings

My findings suggest educational resources have varying relationships with student performance in science and mathematics, but the resources that were significant were significant for both mathematics and science. Educators who are interested in advancing student achievement in both mathematics and science should seriously consider supporting resources in the following six areas: (a) proportion of computers connected to the internet, (b) quality of school educational resources, (c) preprimary school attendance, (d) quality of the physical structures, (e) cumulative spending, and (f) the number of computers used for educational purposes.

Additionally, my analysis of specific resource strands showed varying relationships within an educational resource, such as time, material, and financial support. As a result, each resource's relationship with student performance in mathematics and science should be looked at individually. By looking on the international level, researchers can analyze a broad range of policies and practices associated with educational resources and their impact on student performance. The results of this study suggest the number of computer connections to the internet for students to use, the quality of educational resources, preprimary school attendance, the physical infrastructure, cumulative expenditure, and the number of computers used for educational purposes have a significant relationship with student performance in mathematics and science. Other disciplines may have different resource needs.

Resources and Student Performance in Science and Mathematics

I found the resource of time has a limited relationship with student performance in mathematics and science. Angrist and Lavy (1997), Belinski et al. (2009), Eccles and Barber (1999), and Fisher (1981) suggested the resource of time has a positive link with student performance; however, I found no relationship between student performance and class size (mathematics r = -0.10, science r = -0.16); students' learning time in school (mathematics r = 0.01, science r = 0.07); and student participation in extracurricular activities at school (mathematics r = 0.08, science r = 0.09). My findings might be a result of looking at the resource of time through an international lens. Hanushek and Wößmann (2015) explained 1 year of schooling can be very different in each country; additionally, they stated time spent in school was not as relevant as the knowledge of the population.

The variables, in order of correlation coefficient, suggest a priority list or resources that should receive support. This might indicate school leaders seeking to increase student performance in mathematics and science should first increase the proportion of computers connected to the internet, increase the quality of schools' educational resources, and increase preprimary school attendance before decreasing class size or increasing the number of available teachers. It is important to remember these variables were compared to each other, and the results are limited to the pool of educational resources. I cannot conclude the proportion of computers connected to the internet is the most important resource because it has the highest coefficient, only that this resource has a higher correlation than the other variables to which it compared in this study.

Educational Materials. The large scale of this study suggests by adjusting the investment in educational materials to find the optimum level of investment before the allocated resources have a diminishing return in student performance, national governments will be able to most efficiently use the benefits of educational materials without continued waste of scarce resources. I found educational materials have a positive relationship with student performance. My results echo those previously found by Evans (2006), Faith (2009), and Gouda et al. (2013). However, neither the literature nor my study determines causation. Educational materials may not have a strong relationship with student performance but instead might only indicate countries with high test scores, which also have growing economies (Hanushek & Wößmann, 2015), have the means to purchase more computers, have a higher proportion of computers with internet capabilities, have the ability to construct and renovate school buildings, and have more resources. Darling-Hammond (2014) suggested child poverty, segregation, income inequality and disparities in access to educational resources will diminish if resources are distributed efficiently. Additional research needs to be conducted to determine if expenditure of educational materials causes increased student performance, or if increased student performance creates a need for more resources.

Cumulative Spending. The relationship between student performance and financial resources varies. My results showed no significant relationship between teacher salaries and student performance (mathematics 0.15, science 0.22) on the 2012 PISA. However, Gius (2013) found competitive teacher salaries and changes in teacher pay had a statistically significant, positive effect on student performance and district-level graduation rate. Other variables may have contributed to positive outcomes instead of the adjustment in teacher salaries. Hanushek and Wößmann, (2015) found teacher salaries and other pay incentives only have a positive relationship with student performance when students need to pass an external exam to graduate.

Along with the Education Commission of the States (1992), the Federal Deposit Insurance Corporation (2007), Husted (2005), Ripley (2013), and Vegas and Coffin (2015), I found cumulative spending impacts student performance (mathematics 0.50, science 0.55). According to Hanushek and Wößmann (2015), spending on education does not have a direct relationship with student performance, but they also maintain such a resource is not completely irrelevant. Cumulative spending impacts student performance only to the point that cumulative spending impacts the resources and variables that directly impact student performance (OECD, 2014). This explanation might apply to students in countries with high cumulative expenditure, such as Lichtenstein, who are being outperformed by students in Finland who receive much less spending (OECD, 2013a, 2013b, 2014; Ripley, 2013).

Preprimary School Attendance. Time spent in school, class size, and extracurricular activities might impact student performance only as far as they affect student confidence, interest in subject, and perceived relationship with the teacher or even the quality of instruction the student receives. I determined correlation, not causation, and found no relationship between student performance and class size, students' learning time in school, and student participation in extracurricular activities at school. I found a positive relationship between preprimary school attendance and student performance (mathematics 0.64, science 0.60). Angrist and Lavy (1997) and Fisher (1981) found increased time between students and teachers led to higher student performance. I found a similar relationship with preprimary school attendance but not with increased learning time in the classroom.

Research of preprimary school attendance (Fisher, 1981; OECD 2013) suggests its importance for students' future growth and success. By increasing preprimary school availability and attendance, national governments will be able to increase student performance with the most desirable rate of return for expenditure and performance. Additional research needs to be conducted to specifically identify and better define the student and teacher time together that correlates with increased student performance.

Limitations

The information collected from the OCED database originated as student or principal self-reporting and may not be as accurate, as conscious and subconscious factors may cause inaccurate self-reporting. The analysis of the correlations was limited to linear relationships between variables; even if the correlation coefficient was zero, a nonlinear relationship might exist. Additionally, the PISA items selected for each resource category are proxies and may not be the best proxies available. This study may suggest positive or negative interactions between variables; however, this study is unable to prove causation and can only suggest such a link exists. This study focused on the educational resources in terms of quantity and not the quality of resources. The distinction has no impact for the financial resource strand of cumulative spending; however, all the other resource strands have no measure of the quality of the educational resource. Given these limitations, I recommend that educational leaders should confirm my findings before adjusting policy.

Recommendations for Future Research

The results of this study suggest the need for future research in several areas. We know educational materials have a relationship with student performance, but we do not know the point of investment where educational materials yield maximum results. By understanding the investment and the return of this resource, educational leaders will be able to reach the highest potential of student performance through educational materials before the relationship dissipates. When school leaders can maximize the resources invested in educational materials, leaders have opportunities to more effectively control the cost of education. This will allow educators to become financially more transparent and more likely to develop mechanisms to effectively meet student needs.

Preprimary school attendance and availability is important because of its relationship with student performance. Educators do not know how long a student needs to attend preprimary school, what happens during this learning opportunity, and how to maximize performance efficiency. This study did not identify the ways in which resources spent on teachers and teacher professional development can best reach their maximum efficiency. The literature asserts teachers and teacher professional development has a significant relationship with student performance (Afterschool Alliance, 2007; Althauser, 2015; Hattie, 2009; Ripley, 2013; Ross & Begeny, 2014). Additional research needs to be done to determine how this study could be designed to specifically target those resources.

Final Thoughts

Ultimately, this study showed the relationship between educational resources and student performance in science and mathematics on the 2012 PISA. This study should be replicated in the subsequent PISA installments; the 2015 PISA results are now available to verify the results and expand the data set. Additional research should be done to determine the degree to which investment and preprimary school attendance increase student performance on the PISA. Additional research could confirm that increased student performance on the PISA directly improves or is correlated to students' future economic and social impact. When educational leaders consider the relationship between educational resources and student performance, and where that relationship is strongest upon allocation of those resources, the potential exists for educators to efficiently reduce the achievement gap and decrease educational inequality. A more efficiently resourced education may also be a better education.

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