Global Pattern of Extended Education and Its Impact on Educational Outcomes: The Case of Science Education

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Abstract: Science education as a part of STEM education is becoming important not only for the future success of the individual but also for the economic development of the nation. This study explores the global pattern of extended education and its impact on learning outcomes in the area of science. First, the study found substantial national differences in access to afterschool science programs. Children and youth in developing countries generally lack opportunities to learn science after school, which was found to predict PISA 2015 science achievement in this study. The study suggests that inequality in extended education among countries requires urgent attention, as does inequality within countries. Second, the study found a negative relationship between additional study time for science and PISA science performance at the national level. Regarding this finding, it is speculated that the content of learning during additional study time differs from that of higher-order learning experiences measured by the PISA science test. The result may also be explained by the argument that the purpose of additional afterschool study is usually remedial lessons and/or test preparation. This cross-national research will provide insights to policy makers who intend to find global patterns in extended education, develop policy direction at the global level, and offer advice to national governments.

Keywords: extended education, PISA 2015, afterschool science program, additional study time

Introduction

It is increasingly important that children have opportunities to learn after school. Many researchers have revealed that participation in extended education, also called “afterschool,” “all-day school,” “extracurricular activities,” and “out-of-school time-learning activities,” contributes to improving cognitive and socio-emotional development of children and youth (Afterschool Alliance, 2009; Durlak & Weissberg, 2007; Lauer et al., 2006). Attending quality afterschool programs was also found to have positive effects on student health and well-being (Little, Wimer, & Weiss, 2008). It is widely agreed that extended education provides considerable social benefits in that it keeps children safe while their parents still work, helps students engaged in significant learning experiences that may not be offered by the regular classes, and contributes to cultivating future talents who will play important

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roles in certain fields such as arts and STEM. Finally, extended education has contributed to reforming public schools, particularly the less-open, less-flexible, and teacher-driven aspects of the regular curriculum. It functions as a place where innovative and creative teaching strategies are implemented based on learners' interests (Bae & Jeon, 2013; Noam & Triggs, 2018). In many countries like South Korea, Japan, and the United Kingdom, extended education has been used to build bridges between public schools and the local communities (Dyson & Jones, 2014; Kanefuji, 2017). On the one hand, the educational capacities of schools are extended to solve the problems of local towns. On the other hand, extended education becomes a platform where educational resources of the local communities are employed for better education.

In this context, extended education is gaining popularity among the public and policy makers in many countries. It is spotlighted as an effective attempt to fix the problems that public schooling has faced, respond to diverse social needs such as childcare and education for immigrants, and develop a skillful workforce in certain areas. Accordingly, substantial financial and physical resources are provided to improve the quality of extended education and enhance opportunities to learn after school, especially for underserved and underrepresented children and youth.

However, most efforts have been made to promote the quality and equality of extended education in the context of a certain country. Public attention has also been given to domestic education issues. During the past decade, extended education research has kept increasing, but the focus of the research was primarily on the issues within the country. Only a few comparative qualitative studies have been done to explore differences and similarities between two selected countries (e.g., Bae & Kanefuji, 2018; Klerfelt & Stecher, 2018; Schuepbach & Huang, 2018). The exception is those studies that investigate private supplementary tutoring, also known as shadow education, across countries (e.g., Bray, 2013; Bray, Kwo & Jokic, 2015).

Fueling this study is the lack of empirical comparative research on extended education at the international level – in other words, cross-national comparative research. A primary focus of this exploratory research is to examine the global pattern of extended education provision and participation at the national level. In addition, the study examines whether national differences, if any, are related to learning outcomes of the students aggregated at the national level. The aim of this cross-national research is to provide researchers and policy makers with information about how the national context influences extended education. In addition, this study aims to suggest what the policy implications of achieving quality and equality of extended education at the global level are.

In the context of extended education, this research concerns "science education," which is the core subject of STEM (Science, Technology, Engineering, and Math) and is considered a powerful predictor of national competitiveness. A great deal of research (National Research Council, 2010) has pointed out that STEM education plays a significant role in the educational and career success of the individual as well as the competitiveness of the nation. Studies (Brophy et al. 2008; National Science Board, 2008; White, 2014) suggest that participation in well-designed STEM education helps students develop problem-solving skills, critical and creative thinking, and collaboration skills that are all necessary for the knowledge-based economy and jobs of the present and future. Furthermore, higher

STEM scores are associated with a greater tendency by students to enroll in higher education in STEM fields and become professionals in these areas. There is no doubt that more graduates and professionals in the area of STEM will lead to stronger high-tech industries and advanced innovative businesses. In line with research findings suggesting the importance of STEM education, many countries have made greater efforts to improve the quality of STEM programs and offer more opportunities for afterschool learning, particularly to disadvantaged students (National Science Board, 2007). Nonetheless, little research has been conducted to reveal the global pattern of STEM education in the context of extended education. This cross-national exploratory study was conducted to fill that void.

The research questions are as follows:

1. Do national differences exist in the provision of school-based afterschool science programs and additional study time on science by students?
2. Are the percentage of the nation's schools offering afterschool science programs and the average of additional study time on science spent by students associated with the average science performance of the students at the national level?
3. What determines how many schools offered afterschool science programsand how much additional study time for science is spent by students at the national level?

Review of the Related Literature

Extended Education

Extended education refers to the intentionally structured learning and development programs and activities that are not part of the regular classes and generally offered before and after school and at locations outside the school. However, the term or name used varies across different countries – in other words, afterschool programs, all-day school, extracurricular activities, out-of-school time learning, extended schools, expanded learning, and leisure-time activities. The features of extended education are closely related to social, political, and educational contexts of the society where it has been developed and implemented. Given the variety of names and features across nations, "extended education" was created as an umbrella term (for more information, see Bae, 2018).

In addition, Bae (2018) suggested a typology based on the purpose of extended education programs: a) extended education programs from child development-based conception, b) extended education programs from the role of the school-based conception, and c) extended education programs from family-reproduction conception. Given the availability of cross-national data[1], the current study involves the analysis of the data about the "school-based afterschool programs," which are based on child-development conception and "additional study after school of the student" that relates to family-reproduction conception. "School-based afterschool programs" have been developed to solve the problems of the

1 The OECD PISA (Program for International Student Assessment) 2015 survey collected national data about the provision of afterschool programs and additional afterschool study time spent by students across subjects.

regular curricular activities, which tend to be standardized and are not flexible enough to respond to the diverse needs of the students (Bae & Jeon, 2013).
Worldwide, these programs are implemented to promote student creativity, problem-solving skills, and socio-emotional skills by adopting innovative teaching approaches and experimental learning strategies (Noam & Triggs, 2018). "Additional study after school," often called "supplementary private tutoring" and "shadow education," is becoming globally popular and institutionalized (Bray, 2013; Mori & Baker, 2010). Bray (2013) suggested that the institutional features of shadow education include supplementation, privateness, and academic subject-focus.

Afterschool Programs

Studies (Afterschool Alliance, 2008; Durlak & Weissberg, 2007; Lauer et al., 2006; Little, Wimer, & Weiss, 2008) have found that afterschool programs affect student emotional development, which in turn affects academic performance. In addition, afterschool programs were found to promote youth development including self-esteem, positive attitudes (e.g., self-perception), and social behavior. Students who participate in afterschool programs tend to show a significant improvement in attitudes such as self-perception and bonding with their school and decreased problem behaviors. Furthermore, these positive effects of afterschool program participation can be expanded to improve academic performance.

The effects of participation in afterschool programs on academic achievement can be moderated by certain conditions such as the focus of the programs (e.g., academic-focused *vs.* enrichment-focused), socio-economic status (SES) of participants (e.g., low-income *vs.* higher-income families), and participation time. For instance, in the case of afterschool programs in Korea, it was found that as the afterschool program becomes more academic-centered, participants tend to register better achievement levels (Bae, Kim, & Yang, 2010). The study (Pierce, Auger, & Vandell, 2013) also found that underprivileged students tend to benefit more from afterschool program participation.

While previous studies have paid much attention to the effect of afterschool program participation on student outcomes, few studies have examined what determines the provision of afterschool programs by the school. Considering the factors that were found to influence educational investment and achievement at the individual and national levels, this study involves variables at the school, the community, and student levels in examining the determinants of provision of afterschool science programs by the school. More specifically, the study assumed that the educational resources of the school, the number of full-time teachers with certification in this study, is related to the school's capacity to provide afterschool programs. Next, the study investigated whether the active participation of parents in school events, the percentage of parents who volunteered in extracurricular school activities in this study, is associated with the availability of afterschool programs. Finally, the study posited that a school in which students are more motivated is more likely to offer afterschool programs.

Additional Study Time

In this study, "additional study time" is a general term for additional afterschool study including homework as well as private supplementary education, also called "shadow education." The term "shadow education" conveys the image of outside-school learning activities compared to officially provided public education that students buy to increase their educational opportunities (Baker et al., 2001). These activities tend to go beyond doing routinely assigned homework. Instead, they consist of organized and structured learning, often by private vendors, in order to supplement regular school learning and/or take advantage of examinations in which they compete with peers – particularly in East Asian countries like South Korea, Japan, and Hong Kong (for more information, see Bae & Jeon, 2013; Bray, 2013; Mori & Baker, 2010; Sivan & Siu, 2017).

Many researchers have suggested that shadow education has grown and become institutionalized, and have sought to examine its impact on academic performance. For instance, Farbman (2012) suggests that afterschool study time is related to higher school performance. However, some researchers (Husen, 1972) questioned the positive effects of additional afterschool study on academic achievement. Suter (2016) suggests a negative association between additional study hours and science achievement. In relation to the findings above, Cooper, Robinson, and Patall (2003) synthesized the results of studies from 1987 to 2003. They found no relationship between afterschool study time and academic achievement. According to the researchers, excessive study time may cause burnout for certain students, which in turn negatively affects academic performance.

Meanwhile, the negative impact of additional study or shadow education on academic achievement should be interpreted with caution, since the result may not be a consequence. This means that lower student achievement could be a motivator for additional study. Moreover, Baker et al. (2001) explained the negative relationship between additional study time and academic achievement in terms of the different purposes students had for participating. According to them, in many cases, students participate in shadow education for remedial reasons rather than for enrichment. In this context, as will be seen later, this study included student motivation as an independent variable in the model to investigate the predictors of additional study time by the student.

STEM Education and Afterschool Program

Worldwide, STEM education in the K-12 setting is gaining popularity since it is believed to enhance 21st-century skills such as adaptability, non-routine problem solving, and systems thinking (National Research Council, 2010). Moreover, higher achievement in STEM education leads to increased enrollment in post-secondary education in STEM fields (Merrill & Daugherty, 2010), and therefore a greater possibility for students to become professionals in these fields. The increased interest in STEM education led to the provision of various programs at the national level. The programs not only include regular STEM classes, but also a variety of extended education programs and activities. In addition, the government and individual schools make efforts to promote STEM outcomes, particularly science performance. The efforts are not limited to improving the quality of regular science classes, but also include quality afterschool programs.

Science is at the forefront of STEM education (Bybee, 2010). With the growing interest in STEM education, what determines science achievement has been called into question. What affects science performance may be categorized into two factors – the individual and school levels. First, the study found that individual-level factors include demographic characteristics, motivation level, self-perception and awareness, parental support, and study time (Areepattamannil & Kaur, 2013; Ing, 2014). Among these factors, demographic characteristics (e.g., gender and socio-economic status and language) and self-perception are found to be the two major determinants of science achievement (Shen & Pedulla, 2000; Wang, Oliver, & Straver, 2008). Interestingly, the studies found that study time is inconsistent in its relationship with academic achievement. A negative effect was found after a certain level (Karwiet, 1984). The factors at the school level include school context, teacher quality, and their belief in their students (Areepattamannil & Kaur, 2013). Among the school-level factors, teacher subject-area certification is the most consistent predictor of science achievement by the student (Darling-Hammond, 2000; Tuerk, 2005). Nonetheless, the findings above mainly relate to the regular classes and may be applicable to the extended education context.

In this sense, it is notable that PISA conducted surveys to collect national data about the provision of school-based afterschool science programs and additional student study time spent on science. PISA attempted to measure the current state of afterschool programs by asking students, teachers, and school principals. Although some critics contend that PISA does not measure the full aspect of afterschool programs, cross-national data collected serves a pivotal role in capturing the global trend of afterschool programs in this area. This study, therefore, analyzed the PISA 2015 data to explore the global pattern of extended education and its impact on science performance of the students at the national level.

Methodology

Data and Sample

The study involves analysis of secondary data. The data was collected from the database of the 2015 version of PISA, which is a triennial international survey administered by the OECD (Organization for Economic Cooperation and Development). PISA primarily aims to evaluate the quality and equality of education systems by testing 15-year-old students. The tested subjects include mathematics, science, and reading. For PISA 2015, approximately 540,000 students participated in the test, representing about 29 million students from 73 countries and economies—35 members *vs.* 38 non-members[2] (OECD, 2018a). Specifically, this study used the results of the PISA 2015 science test and the information about the country provided by OECD statistics.

2 The Republic of Cyprus is opted-out in the official document due to political issues related to the United Nations. However, the data for the Republic of Cyprus was included in this study as the data was available.

Variables

Dependent Variables

To answer the research questions, five dependent variables were selected. Detailed information about the dependent variables is shown in Table 1.

Table 1. Item and Scale of Dependent Variable

Dependent Variable	Item and Scale
PISA science score (average score)	– PISA 2015 science mean score of a country – PISA 2015 scientific question categories are as follows: • scientific competencies that explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically • knowledge categories including content knowledge, procedural knowledge, and epistemic knowledge • content areas pertaining to physical systems, living systems, and earth and space systems
Percentage of top performers (%)	– Percentage of students with science scores of level 5 or above (above 633.33 score points) in the country
Percentage of low performers (%)	– Percentage of students with science scores of below level 2 (less than 409.54 score points) in the country
Afterschool program provision (%)	– Percentage of schools that provide afterschool programs (i.e., science club and competition) – PISA asked school principals the following yes-or-no question: • This academic year, which of the following activities does your school offer to students in the national modal grade for 15-year-olds? • Among ten choices, this study used two choices (i.e., science club and science competitions) that match research questions – The means of the answer "yes" for each choice were calculated to make one variable
Additional study time (hour)	– Additional study time after school per week – PISA asked the following question in relation to science learning participation after school: • This school year, approximately how many hours per week do you spend learning in addition to your required school schedule in the following subjects? • Please include the total hours for homework, additional instruction, and private study.

Source: OECD (2014a; 2014b; 2016a; 2016b; 2018b).

Independent Variables

To examine the relationships between the average national PISA science performance and two extended education variables—afterschool program provision and additional study time (RQ2)—two control variables were chosen at the national and school levels. The first variable is the amount the nation spends on education, and the other is the allotted regular classes for science.

To explore what factors determine which percentage of the nation's schools offer afterschool science programs and additional study time spent on science per student, aggregated at the national level (RQ3), three independent variables were selected from the school, the parent, and the student levels. They are the percentage of full-time teachers at the school, the degree of parental volunteering, and student motivation. The variables in the model were chosen based on the results of previous studies. The simplicity of the model and availability of the data were also considered.

Table 2. Item and Scale of Independent Variable

	Independent variable	Item and Scales
RQ2	Education expenditure (Thousands USD)	– Cumulative expenditure per student between 6 and 15 years of age – Equivalent USD converted using PPP
	Regular classes (hours)	– Hours per week allotted for science classes in regular lessons
RQ3	Full-time teachers (%)	– Percentage of full-time teachers in the school – A full-time teacher is employed at least 90% of the time as a teacher for the full school year.
	Parental volunteering (%)	– Percentage of parents who volunteered in physical or extracurricular activities
	Student motivation (%)	– Percentage of students who agreed or strongly agreed with the following statements: – How much do you agree with the statements below? • Making an effort in my school science subject(s) is worth it because this will help me in the work I want to do later on. • What I learn in my school science subject(s) is important for me because I need this for what I want to do later on. • Studying my school science subject(s) is worthwhile for me because what I learn will improve my career prospects. • Many things I learn in my school science subject(s) will help me to get a job.

Source: OECD (2014a; 2014b; 2016a; 2016b; 2018b)

Data Analysis

To answer the research questions, the study conducted descriptive and inferential statistics. First, means, standard deviations, and the ranges of all variables were calculated to investigate the general characteristics of the data and samples. The unit of analysis are individual countries.

Second, to explore the global pattern of extended education (RQ1), this study conducted descriptive statistics of three variables by country – PISA science score, afterschool program provision, and additional study time. Results are displayed in a world map with the mean and frequency values of the variables by country. The maps showed a snapshot of the global pattern of extended education in the context of science. The maps also suggest insights on the relationships among the variables at the national level. This study also presented quadrant graphs with the selected variables, which shows a snapshot of the correlations between the two variables of interest.

Finally, multiple regression analyses were conducted to examine the relationships between PISA science score and the two extended education variables (RQ2) and explore what determines the above two variables (RQ3). Microsoft Excel 2015 and the software Bing were used to create maps and graphs. SPSS 18.0 was used to conduct multiple regression analyses.

Findings

Descriptive Statistics

Table 3 shows descriptive statistics of variables used for analysis. There exist considerable national disparities in average national PISA science performance (*SD*=49.13). The gap among countries is wider in afterschool program provision (*SD*=19.46) than it is in additional study time of students (*SD*=1.17).

Table 3. Descriptive Statistics

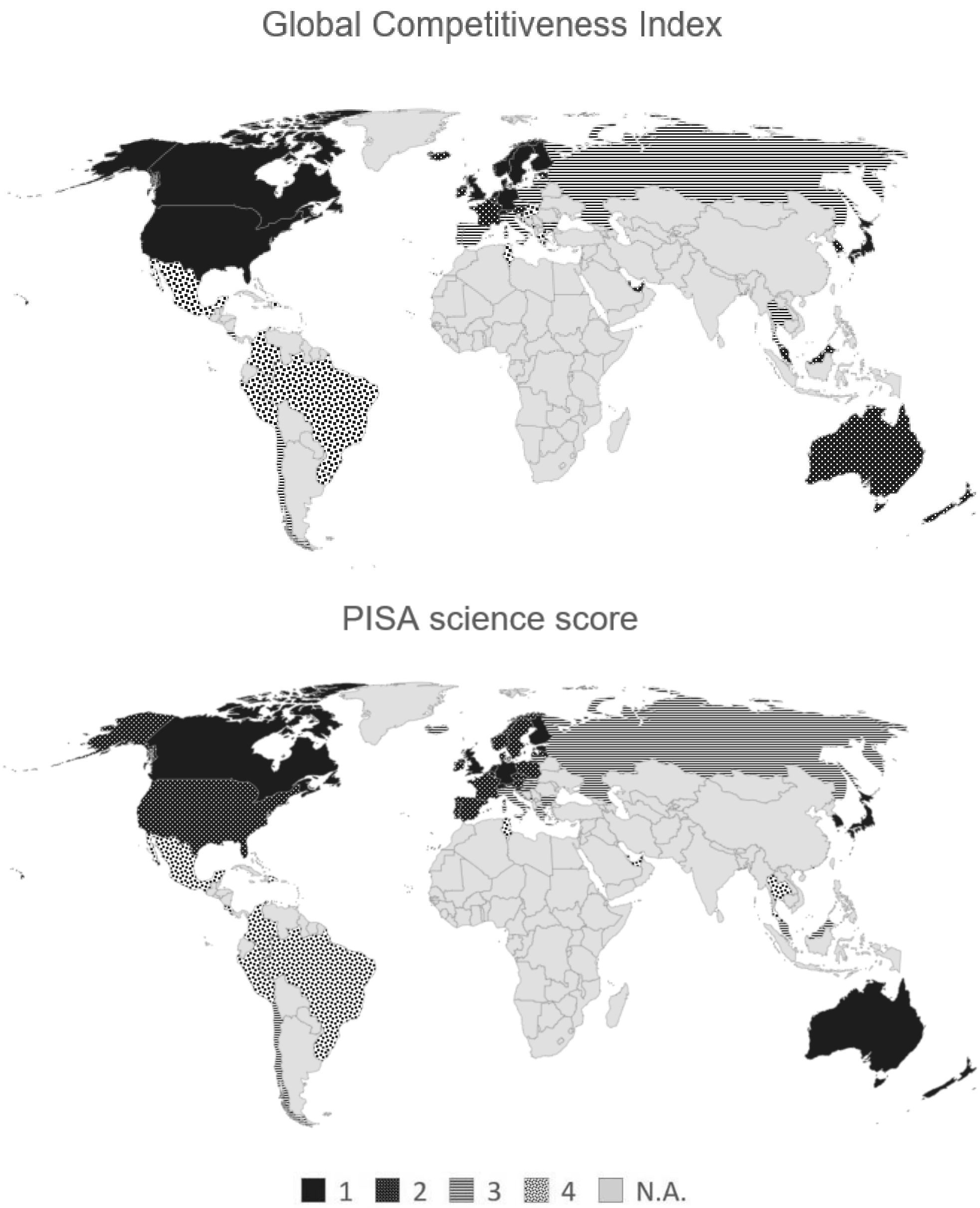
	M	*SD*	*N*	*Min.*	*Max.*
PISA science performance					
PISA science mean score	465.30	49.13	73	331.64	555.57
Percentage of top performers	5.36	5.10	73	0.01	24.19
Percentage of low performers	31.36	18.02	73	5.91	85.74
Extended education					
AS program provision	59.03	19.46	73	7.02	92.20
Additional study time	3.66	1.17	57	1.69	7.19
Other variables					
Education expenditure	75	40	53	12	187
Regular classes	3.66	0.90	57	1.66	5.83
Full-time teachers	80.82	17.53	73	16.09	99.45
Parental volunteering	16.48	9.37	57	4.80	48.30
Student motivation	72.00	10.62	73	48.22	93.60

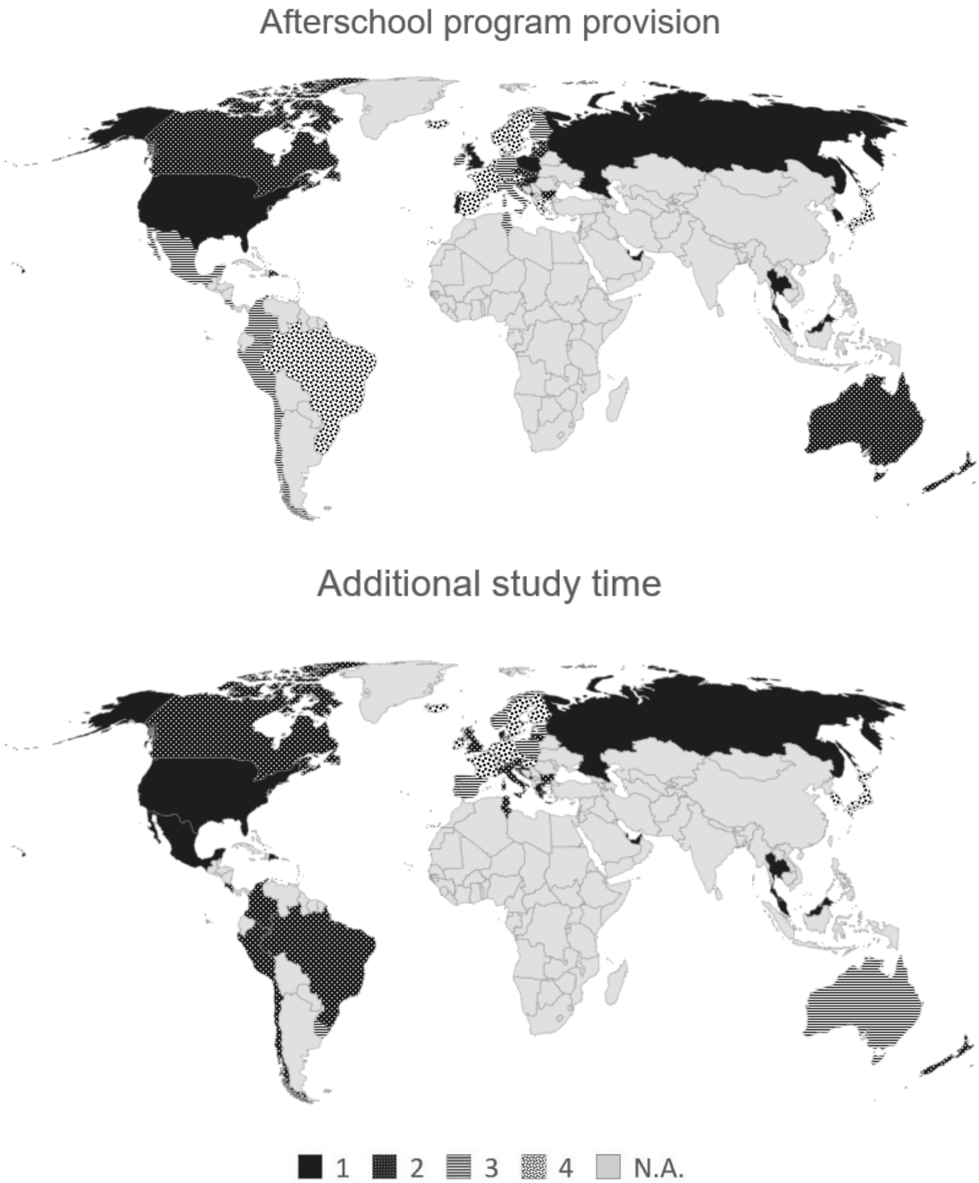
Note: the unit of education expenditure = thousand

Global Pattern of Extended Education (RQ 1)

As shown in Figure 1, student science performance measured by the national mean score in the PISA 2015 science test varies across nations. In general, countries in North America, Europe, East Asia, and Oceania tend to show higher levels of achievement than countries from other regions. A similar pattern was found for the percentage of the schools providing afterschool science programs. Synthesizing the two patterns, the study suggests that afterschool science programs flourish in economically advanced countries with support from public schools. Regarding the findings above, the following speculative reasoning may be possible. First, countries seeking economic growth and development tend to employ technology-driven development strategies that can be driven by talented people in the science field. Second, public schools are encouraged to provide more science-learning opportunities not only during regular classes but also through afterschool science programs and activities —science clubs and competitions in this study. Finally, the cross-national pattern of additional study time for science is slightly different from the other two patterns—PISA science score and afterschool program provision. The information from the maps (see Figure 1) and the national rankings on the selected variables (see Appendix 1) suggest that students from some economically advanced countries and higher-achieving countries spend less additional time studying for science.

Figure 1. Distribution of Global Competitiveness Index, PISA Science Score, AS Program Provision, and Additional Study Time





Note 1. For comparison purposes, the data of 54 countries (OECD members and non-members) was divided into quartiles with quartile 1 being the highest and quartile 4 being the lowest. Countries with no data available are marked as N.A. (Not Applicable).

Note 2. In the case of China, the data does not represent the whole country; thus, this study excluded China from the map and marked it as N.A.

Source: World Economic Forum; Global Competitiveness Report 2015–2016, Table 1.
OECD, PISA 2015 Database, Table I.2.3, Table II.6.46 and Table II.6.3.

The Relationships Between Extended Education and PISA Science Score (RQ2)

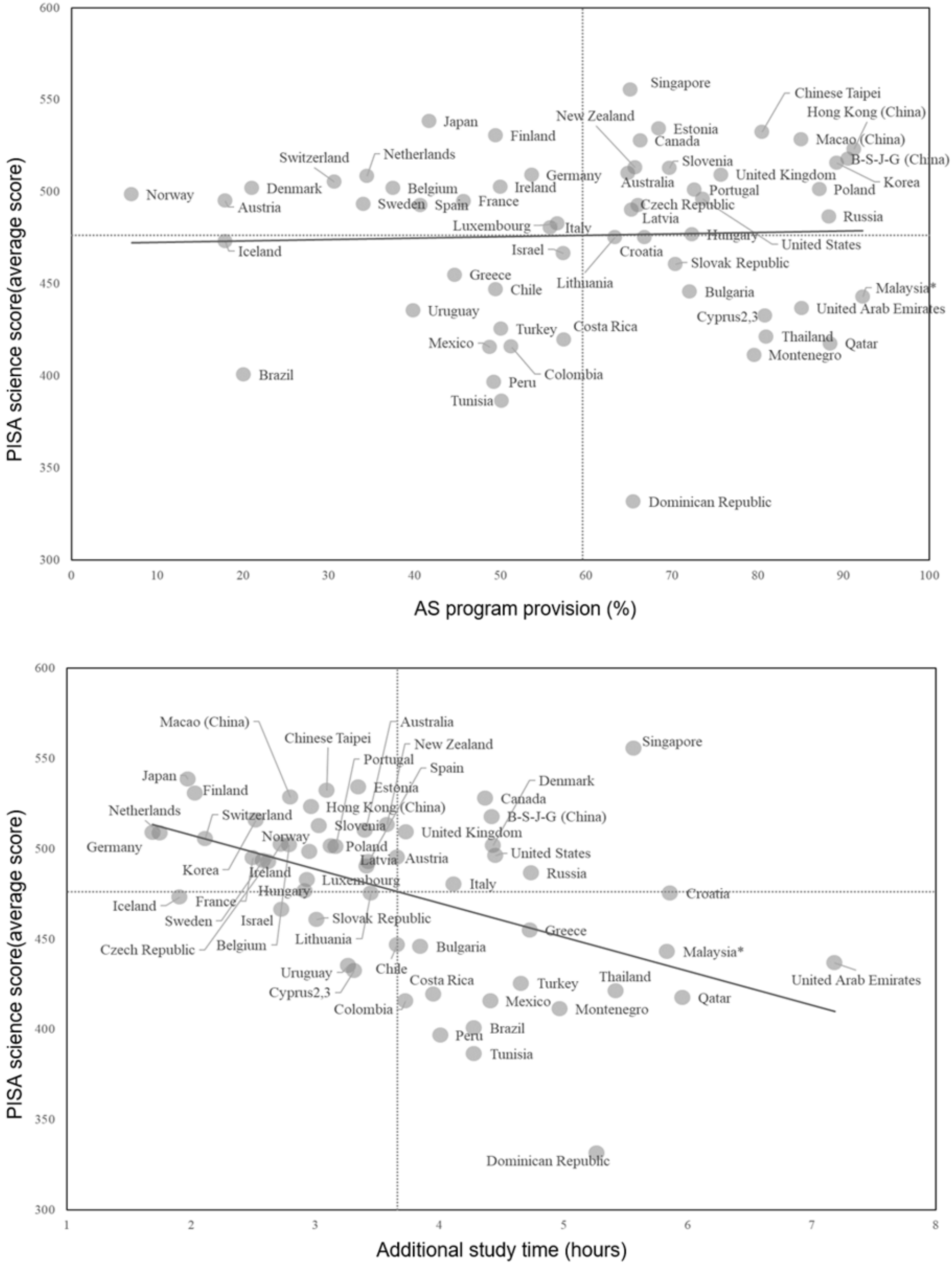
Correlations

In order to have thumbnail views of the relationships between the independent and dependent variables, two-dimensional scatter plots were created. The two charts in Figure 2 show the correlations between the average national PISA science score and the two extended education variables. The result suggests that countries in which more schools offer afterschool science programs are more likely to achieve higher PISA science scores aggregated at the national level. In other words, a positive correlation was found. Unexpectedly, however, a negative correlation was discovered between additional study time and PISA science scores. Specifically, countries in which students spent more time studying for science after school tend to record lower PISA science scores at the national level.

Given the unexpected negative correlation between additional study time and PISA science scores, the study speculated that some variables may moderate the relationship between the two variables. To explore moderators, the study used in turn a couple of third variables on the bottom chart of Figure 2.

The upper chart of Figure 3 shows the three-dimensional scatter plot with three national-level variables. In this chart, the horizontal axis is additional study time (independent variable), the vertical axis is PISA science score (dependent variable), and finally the size of the circle refers to the accumulated national educational expenditure per person (the third variable). Interestingly, a positive correlation was found between the independent and dependent variables in the case of the sample countries that spent more money for public education—the top 17 out of 49 countries (see the bottom chart of Figure 3). In other words, for countries that have greater educational investment, additional study time for science leads to higher PISA science scores at the national level. This result implies that the relationship between additional study time and PISA science scores may depend on national levels of educational expenditure. However, due to the small size of the sample, interpretation should be made with caution.

Figure 2. Correlation Between Extended Education and PISA Science Score



Note. N=49, dotted lines show the mean of each variable.
Source: OECD (2014a; 2014b; 2016a; 2016b; 2018b)

Figure 3. Relationship Between Additional Study Time, PISA Science Score, and National Educational Expenditure

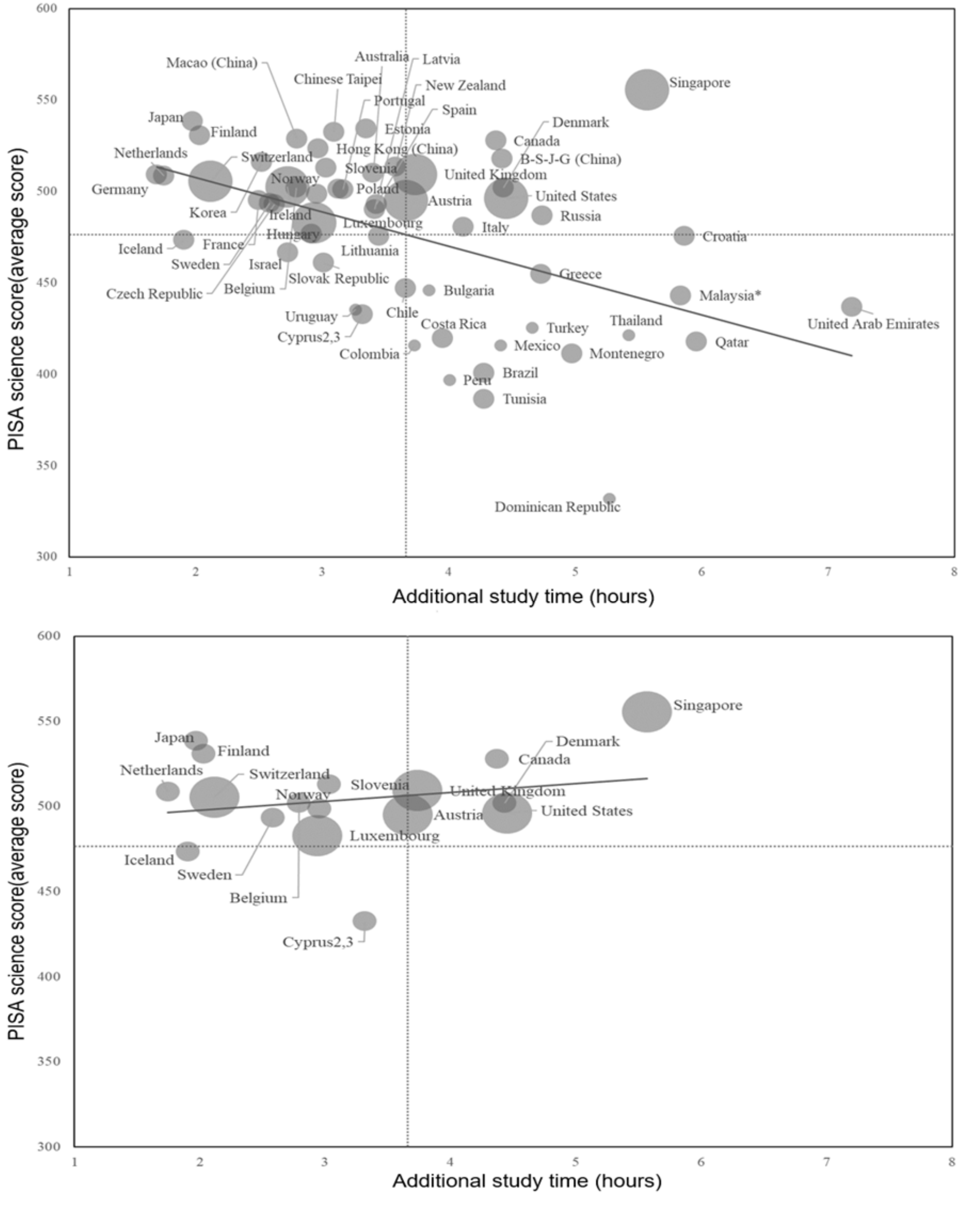


Figure3. The relationship between additional study time, PISA science scores, and national educational expenditure

Note. N=54, Three groups were classified by education expenditure and displayed as bubbles. This study analyzed the top one-third of countries among them.

Source: OECD (2014a; 2014b; 2016a; 2016b; 2018b)

The Relationships Between Extended Education and PISA Science Score

As shown in Table 4, the accumulated national educational investment per student was found to be positively associated with the average national PISA science achievement (β = .58) and the percentage of top performers (β = .60). However, it was negatively related to the percentage of low performers (β = -.55, p<.001). These findings suggest that a nation's educational investment that may influence the quality of education has the strongest impact on PISA science achievement at the national level. Second, the study found that countries in which more schools offer afterschool science programs are more likely to have higher national PISA science scores (β = .26), more top performers (β = .25), and few lower performers (β = -.26) (p<.05). Finally, when controlling for other variables, additional study time spent on science was negatively related to the average national PISA science score (β = -.34, p<.01).

Furthermore, additional study time was found to have a positive influence on the national percentage of low performers. This finding means that countries in which students spent more time on science after school tend to have greater numbers of lower-performing students (p<.01, β = .36). Although this is the finding from the national-level analysis, it appears to contradict the common notion that "more study time leads to higher achievement." Methodologically speaking, the results of multiple regression analysis do not suggest a causational relationship between independent and dependent variables.

Therefore, one can only interpret the findings based on the relevant theories and previous studies. First, the interaction effect may lead to speculation that national social and educational contexts may affect the relationship between additional study time and the nation's average PISA science score. For instance, as shown in Figure 3, the relationship between additional study time and the PISA science score may differ with the level of national educational investment. However, due to the problem of sample size, it is recommended that future research be conducted using a larger sample.[3] Second, it may also be assumed that what the students learn during additional study time is different from what the PISA test is intended to measure. As suggested by previous studies (Bae & Jeon 2013; Bray, 2013; Sivan & Siu, 2017), the purpose of additional study may be supplementary and remedial learning. However, the PISA 2015 science test measures higher-level competencies and knowledge in relation to scientific phenomena. That is, the content of additional afterschool study may have little to do with what the PISA 2015 science test measures. Finally, since the results from multiple regression analysis only suggest that a relationship exists between variables, one can interpret the result in the opposite way. Therefore, it may be argued that students who perform worse at science might take supplementary science tutoring—more study time spent for afterschool science.

3 Considering the relationship among the three variables shown in Figure 3, the interaction effect was examined by including national educational expenditure as the moderator in the multiple regression model. However, the value of variance inflation factors (VIF) was high, indicating the multicollinearity issue. Future studies may be conducted using other variables as moderators.

Table 4. Relationship Between Extended Education and PISA Science Score by Group

	Mean scores			**% of Top performers**			**% of Low performers**		
	B	*S.E*	*β*	*B*	*S.E*	*β*	*B*	*S.E*	*β*
Intercept	460.08	24.92		2.25	3.13		31.49	9.07	
Education expenditure	0.67***	0.13	0.58	0.08***	0.17	0.60	-0.22***	0.05	-0.55
Regular classes	10.08†	5.82	0.19	1.18	0.73	0.20	-3.43	2.12	-0.19
Extended education AS program provision	0.59*	0.25	0.26	0.07*	0.03	0.25	-0.20*	0.09	-0.26
Additional study time	-15.04**	5.34	-0.34	-1.05	0.67	-0.21	5.60**	1.94	0.36
R^2		0.49			0.39			0.45	

Note: N=49, *** p<0.001, ** p<0.01, *p<0.05, †p<0.1, unit of education expenditure = thousand

Determinants of Afterschool Program Provision and Additional Study Time (RQ 3)

As shown earlier, the study found that afterschool program provision and additional study time are associated with national PISA science achievement, either positively or negatively, which raises the question of what determines these two variables—the percentage of schools offering afterschool science programs and additional study time spent on science.

The study found that the ratio of full-time teachers in the school is associated with national provision of school-based afterschool programs (β = .39, p<.001). The degree of parental volunteering in school activities was associated with afterschool program provision at the 0.1 level. These findings imply that full-time teachers and parents may be important resources of the school in implementing afterschool science programs.

Student motivation was found to be positively related to the dependent variable of additional study time (β = .61, p<.001). Considering the theory that suggests that lower performers might have higher motivation, the negative relationship between additional study time and PISA science score at the national level appears to be reasonable.

Table 5. Determinants of Afterschool Program Provision and Additional Study Time

	AS program provision			***Additional study time***		
	B	***S.E***	***β***	***B***	***S.E***	***β***
Intercept	-10.78	18.59		-1.97	0.89	
Full-time teachers	0.50**	0.15	0.39	0.01	0.01	0.12
Parental volunteering	0.50†	0.30	0.22	0.01	0.01	0.11
Student motivation	0.31	0.27	0.15	0.07***	0.01	0.61
R^2		0.30			0.47	

Note: N=57, $^{***}p$<0.001, $^{**}p$<0.01, $^{*}p$<0.05, $^{†}p$<0.1

Conclusion and Implications

Extended education flourishes in many parts of the world. The same is true of school-based afterschool science programs as part of STEM education, which is becoming increasingly critical not only for individual educational and career success, but also for national economic development. However, as this study reveals, the problem is that there are substantial national differences in access to afterschool science programs. In general, afterschool science programs offered by schools are more likely to thrive in developed countries. In other words, children and youth in developing countries are disadvantaged in terms of opportunities to learn science after school, which is not good for global sustainable development.

Because of increased Official Development Assistance (ODA) by developed countries and education-aid programs by international organizations such as UNESCO and the World Bank, the quality of public schooling, particularly basic education, in developing countries has been steadily enhanced (Heyneman & Lee, 2016). However, due to the lack of resources at the international level, most efforts have been devoted to promoting the quality and equality of formal and regular public schooling in developing countries. As a great deal of research has revealed, participation in extended education is becoming enormously important for the growth and development of children and youth—particularly participation in STEM education. In this sense, inequality in extended education among countries requires urgent attention, as does inequality within countries. This study found international disparity in access to school-based afterschool science programs and its impact on science achievement. Moreover, the current study revealed the percentage of full-time teachers in the school, showing the importance of education investment for securing devoted educators in the school, and that the culture of parental volunteering is partially critical in providing school-based afterschool programs. Future research may be conducted to find the determinants of afterschool program provision at the national level with larger samples and more variables.

The second meaningful finding is that there is a negative relationship between additional study time for science and PISA science performance at the national level, which is contradictory to the common notion. Due to the constraints of the exploratory study analyzing secondary data with the simple research modeling, the results of the study are not enough to explain why such an unexpected relationship is found. Moreover, the PISA 2015 survey may have measurement issues. In other words, it does not capture the full aspect of extended education including shadow education. Nonetheless, it may be clear that the content that the students learn during additional study time differs from higher-order learning experiences that the PISA science test is intended to measure. Supporting this argument, researchers (Bae & Jeon, 2013; Bray, 2013; Mori & Baker, 2010; Sivan & Siu, 2017) have suggested that the purpose of shadow education, additional study after school in this study, is remedial lessons and/or test preparation. Future studies may be conducted to investigate students' afterschool learning experiences and whether they differ among nations. In addition, the current study concerns extended education in the science area. Future research may be extended to other subject areas.

This study is a cross-national comparative study, of which the unit of analysis are individual countries. All variables are calculated into country-level means. The nature of the mean as a variable in social science excludes the dynamics within the research context. Nevertheless, it should be noted that comparative research has the potential to help researchers better understand the national and regional context that influences the patterns of individual behaviors and attitudes as well as the policy direction of the national institutions, either public or private. Cross-national research also provides insights to policy makers who intend to find global patterns and standards, develop the direction of education around the world, and finally offer advice to national governments. The same holds true for extended education.

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Appendix 1. Rankings of selected variables

Ranking	Global Competitiveness Index	PISA science score	Afterschool program provision	Additional study time	Edu. expenditure
	N=68	*N=73*	*N=73*	*N=57*	*N=53*
1	**Switzerland**	Singapore	Malaysia*	U.A.E.	**Luxembourg**
2	Singapore	**Japan**	Hong Kong	Qatar	**Switzerland**
3	**United States**	**Estonia**	B-S-J-G (China)	Croatia	**Norway**
4	**Germany**	Chinese Taipei	**Korea**	Malaysia*	**Austria**
5	**Netherlands**	**Finland**	Qatar	Singapore	Singapore
6	**Japan**	Macao (China)	Russia	Thailand	**United States**
7	Hong Kong	**Canada**	Kazakhstan*	Dominican Rep.	**United Kingdom**
8	**Finland**	Viet Nam	**Poland**	Montenegro	Malta
9	**Sweden**	Hong Kong	U.A.E.	Russia	Cyprus
10	**United Kingdom**	B-S-J-G (China)	Macao (China)	**Greece**	**Sweden**
11	**Norway**	**Korea**	Thailand	**Turkey**	**Belgium**
12	**Denmark**	**New Zealand**	Cyprus	**United States**	**Iceland**
13	**Canada**	**Slovenia**	Chinese Taipei	**Denmark**	**Denmark**
14	Qatar	**Australia**	Montenegro	B-S-J-G (China)	**Finland**
15	**New Zealand**	**United Kingdom**	**United Kingdom**	**Mexico**	**Netherlands**
16	U.A.E	**Germany**	**United States**	**Canada**	**Canada**
17	Malaysia*	**Netherlands**	**Portugal**	Tunisia	**Japan**
18	**Belgium**	**Switzerland**	**Hungary**	Brazil	**Slovenia**
19	**Luxembourg**	**Ireland**	Bulgaria	**Italy**	**Australia**
20	**Australia**	**Belgium**	**Slovak Rep**	Peru	**Germany**
21	**France**	**Denmark**	Malta	Costa Rica	**Ireland**
22	**Austria**	**Poland**	**Slovenia**	Bulgaria	**France**
23	**Ireland**	**Portugal**	Indonesia	**United Kingdom**	**Italy**
24	**Korea**	**Norway**	**Estonia**	Colombia	**Portugal**
25	**Israel**	**United States**	Croatia	**Austria**	**New Zealand**
26	China	**Austria**	**Canada**	**Chile**	**Korea**
27	**Iceland**	**France**	Albania	**New Zealand**	**Spain**
28	**Estonia**	**Sweden**	**Czech Rep**	Lithuania	**Poland**
29	**Czech Rep**	**Czech Rep**	**New Zealand**	**Spain**	**Israel**
30	Thailand	**Spain**	Dominican Rep.	**Latvia**	**Estonia**
31	**Spain**	**Latvia**	**Latvia**	**Australia**	**Czech Rep**

Ranking	Global Competitive-ness Index	PISA science score	Afterschool program provision	Additional study time	Edu. expenditure
32	**Chile**	Russia	Singapore	**Estonia**	**Latvia**
33	Lithuania	**Luxembourg**	**Australia**	Cyprus	**Slovak Rep**
34	**Portugal**	**Italy**	Lithuania	Uruguay	Russia
35	Indonesia	**Hungary**	Georgia	**Portugal**	Croatia
36	**Poland**	Lithuania	Moldova	**Poland**	Argentina*
37	Kazakhstan*	Croatia	Costa Rica	Chinese Taipei	Lithuania
38	**Italy**	Buenos Aires	**Israel**	**Slovenia**	**Hungary**
39	**Latvia**	**Iceland**	**Luxembourg**	**Slovak Rep.**	Costa Rica
40	Russia	**Israel**	**Italy**	Hong Kong	Chinese Taipei
41	Malta	Malta	Romania	**Norway**	**Chile**
42	**Turkey**	**Slovak Rep.**	North Macedonia	**Luxembourg**	Brazil
43	Costa Rica	Kazakhstan*	Kosovo	**Hungary**	**Turkey**
44	Romania	**Greece**	**Germany**	Macao (China)	Uruguay
45	Bulgaria	**Chile**	T.A.T.	**Belgium**	Bulgaria
46	Viet Nam	Bulgaria	Buenos Aires	**Israel**	**Mexico**
47	**Mexico**	Malaysia*	Colombia	**Ireland**	Thailand
48	**Slovenia**	U.A.E.	Lebanon	**Czech Rep.**	Montenegro
49	Colombia	Uruguay	Tunisia	**Sweden**	Colombia
50	**Hungary**	Romania	**Turkey**	**Korea**	Dominican Rep.
51	Jordan	Cyprus	Argentina*	**France**	Kazakhstan*
52	Cyprus	Argentina*	**Ireland**	**Switzerland**	Peru
53	Georgia	Moldova	**Finland**	**Finland**	Georgia
54	**Slovak Rep.**	Albania	**Chile**	**Japan**	–
55	Peru	**Turkey**	Peru	**Iceland**	–
56	Montenegro	T.A.T.	Algeria	**Netherlands**	–
57	Uruguay	Thailand	**Mexico**	**Germany**	–
58	Brazil	Costa Rica	**France**	–	–
59	Croatia	Qatar	Viet Nam	–	–
60	**Greece**	Colombia	**Greece**	–	–
61	Moldova	**Mexico**	**Japan**	–	–
62	Algeria	Montenegro	**Spain**	–	–
63	T.A.T.	Georgia	Uruguay	–	–
64	Tunisia	Jordan	Jordan	–	–
65	Albania	Indonesia	**Belgium**	–	–
66	Dominican Rep.	Brazil	**Netherlands**	–	–
67	Lebanon	Peru	**Sweden**	–	–
68	Argentina*	Lebanon	**Switzerland**	–	–
69	–	Tunisia	**Denmark**	–	–
70	–	North Macedonia	Brazil	–	–
71	–	Kosovo	**Austria**	–	–
72	–	Algeria	**Iceland**	–	–
73	–	Dominican Rep.	**Norway**	–	–

Note. *Argentina, Kazakhstan and Malaysia: coverage is too small to ensure comparability. U.A.E.= United Arab Emirates, T.A.T.= Trinidad and Tobago. OECD(*N*=35) countries have been shaded.

Source: World Economic Forum; Global Competitiveness Report 2015–2016, Table 1.

OECD. (2016a; 2016b), PISA 2015 Database, Table I.2.3, Table II.6.46, Table II.6.37 and Table II.6.58.