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Outside school time: an examination of science achievement and non-cognitive characteristics of 15-year olds in several countries†

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ABSTRACT

Elementary and secondary students spend more hours outside of class than in formal school and thus have more time for interaction with everyday science. However, evidence from a large international survey, Program of International Student Assessment (PISA) (OECD 2012), found a negative relationship between number of hours attending after-school science and science assessment scores in many countries, raising questions about why. The secondary analysis of the 2006, 2009, and 2012 PISA surveys found that in most Western countries the longer students attended after-school science programs (in a typical week), the lower their PISA standardized science test score, but the higher their positive attitudes toward future science careers, interest in science, and self-confidence in science. Several potential hypotheses for this relationship are examined and rejected. Further analysis of a causal relationship between frequent attendance in after-school programs and student achievement and attitudes should clearly identify the content of the program so that the analysis could distinguish experiences closely related to regular school curricula from the informal science activities that are not. A new analysis also should include carefully designed longitudinal surveys to test the effectiveness of informal experiences on later life choices in career and study.

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Out-of-school time; international comparisons; science achievement; science attitudes

Introduction

Informal science education researchers have estimated that elementary and secondary students spend more than five times as many waking hours outside of class than in formal school (Banks Au et al., 2007; National Research Council, 2009, p. 29), and thus have more time for interaction with everyday science. International studies have sought to account for all sources of variation in learning levels across countries and thus have obtained estimates of student use of time in regular school and outside of school (Third International Mathematics and Science Study (TIMSS) in 1995 and 1999; Organization for Economic Cooperation and Development (OECD, 2011): Foshay, Thorndike,

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Hotyat, Pidgeon, & Walker, 1962). The assumption of these studies was that more time spent on a subject would lead to higher scores on standardized tests of that subject (OECD, 2011). However, the survey evidence of 15-year-old-students in the 2006 Program of International Student Assessment (PISA) found that the aggregate country average standardized score in science achievement was lower in countries in which average student time in after-school science programs during a typical week was higher (OECD, 2011 and Figure 1).

The term 'out-of-school-time' (OST) will be used in this paper rather than 'after-school'. OST is defined by Shaw and Noam as

> programs that offer activities that may or may not align with school curricula, that focus on youth development and enriching learning activities, and that can take place in a school setting, local community center or museum, on weekdays, weekends or during the summer. (Noam & Shah, 2013)

The survey measurement of OST in the PISA survey comes close to this definition.

Although the average number of hours in OST and the aggregate science achievement scores for 28 countries are related negatively in the 2006 PISA survey as shown in Figure 1, the aggregate scores for countries do not necessarily imply that a negative relationship would exist for individuals within each country (nor, of course, does the relationship imply a causal relationship because many factors are not yet accounted for). The association between individual science scores and number of hours in OST science in a

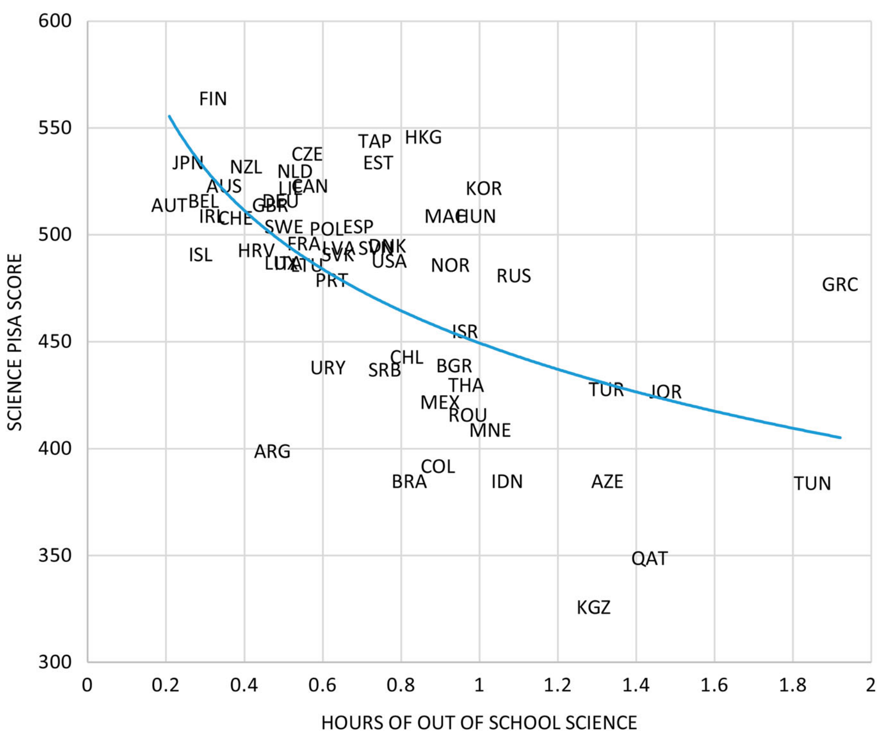

Figure 1. Aggregate country average science achievement by average number of hours attending out-of-school science in a typical week: 28 OECD countries in PISA 2006.

typical week was calculated from PISA data and the results are shown in Figure 2 for 28 OECD countries in 2006. The associations for individual students were negative in 23 OECD member countries, not significant in 3 countries, and positive for 4 countries (Scotland was shown separately from the UK to be consistent with analyses later in this paper and because it has unique relationships). The fact that the negative relationship between hours of OST and science test scores is found in a large number of countries suggests that some general factor about what type of student attends OST might be responsible for this relationship.

The following analysis will investigate several competing hypotheses for the observation that the frequency of attending after-school science is negatively associated with standardized test scores in science at both the country and individual student levels. Possible explanations include factors such as the selectivity of students who choose to attend after-school programs with different family backgrounds or the selectivity of students who hold particular attitudes toward science. Other explanations may include the methods of data collection used in self-reported surveys of students as suggested by Bray (2013). A detailed

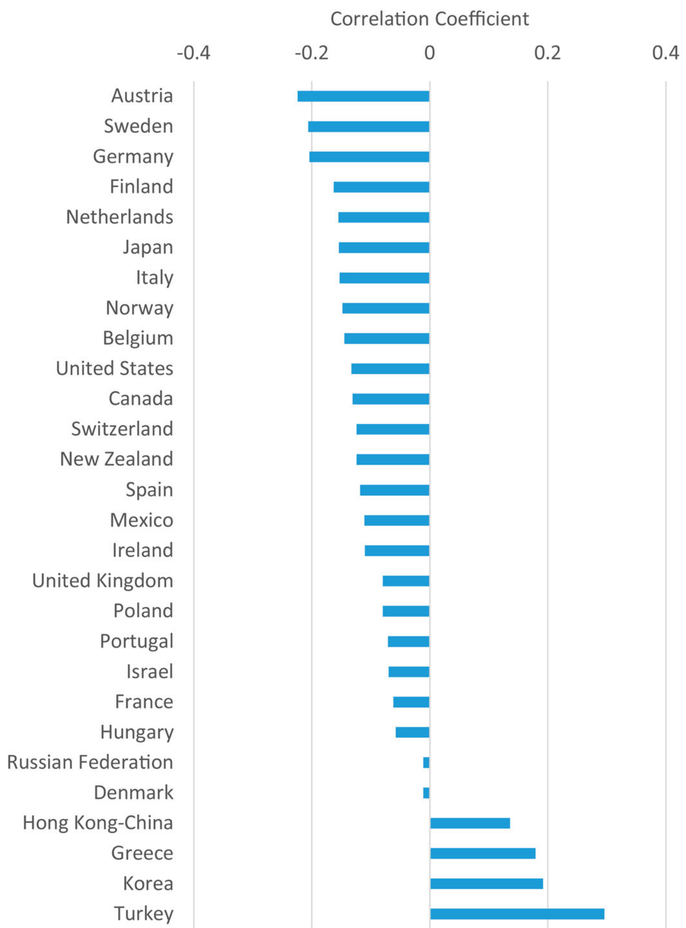

Figure 2. Correlation coefficient between number of typical hours in an after-school science activity and student achievement: 28 OECD member countries: PISA 2006.

analysis of relationships within all 61 PISA countries for the 3 surveys available would not be possible within the space for this paper; therefore, a detailed analysis will be conducted for a smaller number of countries with similar language and history.

PISA survey items on OST

No US ongoing national surveys could be identified that measured OST in science. However, two international surveys, TIMSS and PISA, have included items in their surveys to gauge how frequently students participate in such informal OST activities (Bray, 2013; Martin et al., 2000; Mullis et al. 2000, figures 4.6 and 4.7). International surveys seek to include a wide number of measurements of student experiences that might help account for country to country differences in student achievement. The 2006 PISA survey was chosen as a source of detailed survey data for this analysis because it was specifically designed as an analysis of science learning and is well suited for a detailed analysis of background and attitudinal factors. Other PISA surveys in 2009 and 2012 also included brief standardized tests for science and mathematics and an expanded set of questions about OST that will provide some useful information, but they do not include significant measures of attitudes toward science. The PISA items in each of the survey years identify student participation in science, mathematics, and reading in regular school, in out-of-school-time, and doing homework. The wording of the items is as follows:

<u>2006</u>
Q31. For each subject, please indicate separately:
· the time spent attending regular lessons at your school;
· the time spent attending out-of-school-time lessons (at school, at home, or somewhere else);
· the time spent studying or doing homework by yourself.
(Please tick only one box in each row) <An hour here refers to 60 minutes, not to a class period>
· No time
· Less than 2 hours a week
· 2 or more but less than 4 hours a week
· 4 or more but less than 6 hours a week
· 6 or more hours a week
a) Regular lessons in <school science> at my school
b) Out-of school-time lessons in <school science>
c) Study or homework in <school science> by myself Mathematics
d) Regular lessons in mathematics at my school
e) Out-of school-time lessons in mathematics
f) Study or homework in mathematics by myself Language
g) Regular lessons in language at my school
h) Out-of school-time lessons in Language
i) Study or homework in Language by myself
<u>2009 and 2012</u>
Q32 How many hours do you typically spend per week attending out-of- school-time lessons in the following subjects (at school, at home, or somewhere else)?
These are only lessons ***in subjects that you are also learning at school****, that you spend learning extra time outside of normal school hours. The lessons may be given at your school, at your home or somewhere else. <language> <mathematics> <science> <other subjects>*

Table 1. Percent reported attending OST science program by year for Ireland, the United Kingdom, and the United States by year: PISA.

	Percent of total			Standard error		
Country and hours reported attending OST science	2006	2009	2012	2006	2009	2012
Ireland						
None	78.8	79.3	88.2	0.6	0.7	0.6
1–2 hours	16.7	14.8	6.3	0.6	0.6	0.4
3 or more	4.5	5.9	5.5	0.3	0.4	0.4
United Kingdom						
None	68.8	75.6	65.5	0.4	0.4	0.5
1–2 hours	24.6	13.4	15.0	0.4	0.3	0.3
3 or more	6.6	10.9	19.5	0.2	0.3	0.4
United States						
None	55.9	78.5	75.6	0.7	0.6	0.6
1–2 hours	31.0	11.0	13.2	0.6	0.4	0.5
3 or more	13.1	10.5	11.2	0.5	0.4	0.4

a I do not attend <OUT-of-school-time lessons> in these subjects
b Less than 2 hours a week
c 2 or more but less than 4 hours a week
d 4 or more but less than 6 hours a week
e 6 or more hours a week

The slight changes in wording, and perhaps the location of the items in the questionnaire (the 2006 items were within a series of questions about time use) altered the response rates in different ways for each country (Table 1). The 2006 survey question stem did not specify 'hours' as the later surveys did. Also, the 2006 survey did not separate as clearly where the OST lessons were held as did the later surveys. While the definitions appear to be similar, the distinctions of place of participation almost certainly led to differences in response rates for some countries. The rates of participating in OST science programs for three countries is shown in Table 1.

While the US and Irish students reported less frequent attendance in OST science classes, the UK students reported more frequent attendance. Most of the changes between 2006 and later years are greater than four times the sampling error (with $p < .01$) and thus cannot be dismissed as errors of sampling. While the purpose of this paper is not to conduct a detailed analysis of reporting errors, this table is a reminder that definitions of OST practices for purposes of sample surveys require further experimentation and clarification.

Hypotheses and analysis framework

The main subject matter for the analysis is science attendance in OST science programs, science achievement, and attitudes toward science. The analysis will include some examination of the relationships of achievement to OST attendance in other subject areas (mathematics and reading) to establish a broad set of norms of participation and relationships for comparison to science.

The paper will also raise issues about student responses to large national surveys of students' use of time. In particular, self-reported responses about past behavior and attitudes, especially in a cross cultural context, should be closely examined for potential biases of reporting. Also, the surveys available for this analysis are all cross sectional and therefore prohibit any possibility for measurement of changes in individual attitudes or performance over a period of time thereby reducing the power of conducting adequate analysis of causal relationships. In order to reduce the number of possible explanations for observed differences, a detailed analysis will be conducted for four 'countries' (or regional areas) with a common language and heritage in education. Based on the recent thorough review of research in England and the United States by the Wellcome Trust fund (Falk et al., 2012; Lloyd, Neilson, King, & Dyball, 2012; Matterson & Holman, 2012) I have chosen to examine the PISA surveys for England, Wales, and Northern Ireland (as a group), Scotland, the Republic of Ireland, and the USA. While this is not intended to be a comprehensive comparative study of all world systems of after-school education, it will allow a closer examination of differences and similarities of student relationships between these countries to explore possible student and program characteristics that affect the relationship between attending after-school programs and science achievement scores and allow the testing of conjectures about differences in culture behavior. To do the same for all countries in PISA would require a longer analysis. An in-depth analysis of four systems with common measurement tools could provide new insights about whether after-school experiences reported in a survey of 15-year-old students can be generalized to all countries or whether different countries have unique after-school effects on students.

The following specific conjectures and research questions are based on the previous review of academic publications in OST:

(1) Many US (and other country) programs in OST are attended by students with few family resources. Is the relationship of attendance in OST to science performance mainly due to the selectivity of students into OST from under-resourced schools? Are the students more likely to be in lower income households or require remedial assistance?
(2) OST programs in most countries provide a wide variety of opportunities for experiences with science. Therefore, is the relationship between OST science attendance and science achievement a function of social and psychological characteristics, interests, and content of the OST program?
(3) Time use in OST is different from other forms of study, in that OST students are more engaged with science as a practical activity rather than receiving direct instruction about science content included in standardized tests. Therefore, some direct hypotheses are as follows:
    (a) Achievement levels in science will be higher for students who spend more time in school science programs or science homework study than in OST.
    (b) Students who attend OST science programs dislike the formal school science classes because they hold a stronger interest in more practical aspects of science than is found in classroom science.
    (c) Many students attend OST for social and emotional reasons to gain benefits from the interactions with other students; therefore, they may be less likely to benefit from the cognitive content of the programs as measured by standardized tests in science.

Table 2. Types of personal and educational factors that may affect OST relationships to learning and non-cognitive behavior.

Hours of study	Attitudes	Instruction	Cognitive (measured by standardized test scores)
Hours in OST science	Enjoyment of science	Science teaching—hands-on activities	Standardized science score
Hours in regular science	Future-oriented science motivation	Science teaching—interaction	Standardized math score
Hours self-study science	General interest in learning science	Score of explaining phenomena scientifically	Score of support for scientific inquiry
Hours studying other subjects	General value of science	Score of identifying scientific issues	Score of using scientific evidence
	Instrumental motivation in science	Teaching—focus on applications or models	Student information on science-related careers
	Personal value of science		
	School preparation for science-related careers		
	Science activities		
	Science self-concept		
	Science self-efficacy		
	Score of interest in science		

(4) Development of self-reported sample surveys of OST behavior is relatively new and the PISA results for the 3 years are likely to contain some types of reporting error (Bray, 2013).
   (1) Survey developers have not yet clearly defined the OST activities that are related to psychological attributes of developing children or to development of content knowledge in science as a subject area.
   (2) The policy of some countries is that all time spent on a subject outside of school is conducted for the purpose of improving regular school performance (Bray, 2013).
   (3) Survey items may be interpreted differently in different settings and may include such things as private tutoring as well as informal experiences (Bray, 2013).

A structure for examining the relationship between attendance in OST, student attitudes, the forms of formal instruction, and cognitive measurements is displayed in Table 2. This table does not include background factors of students' families such as wealth, and educational resources in the home which will be included in the analysis.

Distributions of time use in four settings

Figure 3 shows that the number of total study hours per week reported in 2006 is approximately 25 hours in each of the English-speaking countries: (England, Wales and Northern Ireland; Scotland; Ireland; and the United States). The averages were calculated by including responses from all students; therefore, non-attendance in OST is counted as zero hours. The average number of hours in self-study is about 7 hours per week, while the number of hours in OST is less than 2 hours in each country (Figure 3). The graph shows that many more hours are spent in formal school classes than in other forms of study. The total number of hours in OST for all subjects (science, mathematics,

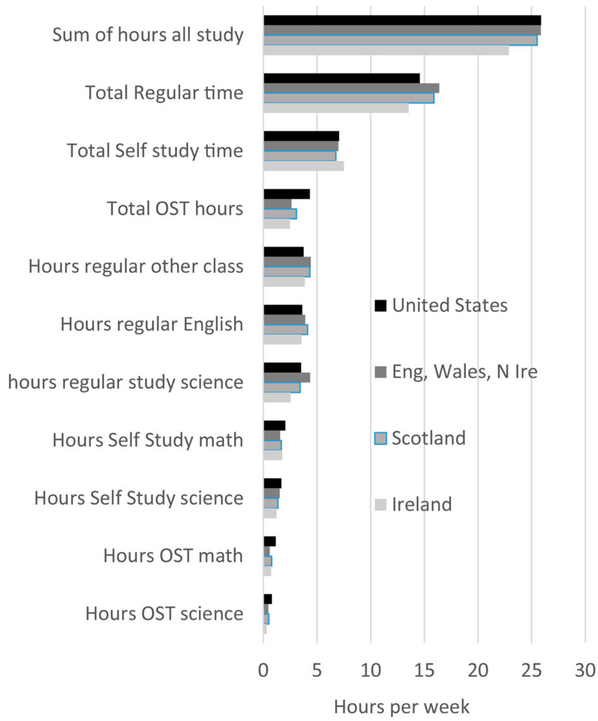

Figure 3. Average number of hours of study in regular class, self study, or in after-school for four countries: PISA 2006.

English, and other) among these countries is between 2 and 4 hours a week in these four countries.

The correlation between standardized science test scores and hours of study in each type of activity during a typical week shows that OST is unlike any other reported type of study time in the four countries (Figure 4). Students with higher hours of study in formal school and self-study had higher science scores in all four countries. But, students with higher hours of OST science had lower science scores in three countries. Scotland stands out as having little or no relationship of achievement with hours of science OST. Ireland has some unique characteristics that affect the size of the relationships. For example, Ireland has the lowest average number of hours of regular school (Figure 3) and the lowest association between hours spent in regular school and science performance (Figure 4). These comparisons indicate that the school systems differ slightly in how daily hours are reported and thus the distributions of time use are not equivalent between countries, which affect the size of the relationship to OST. Ireland stands out as having a low association between achievement measures and formal school hours, whereas Scotland tends to have high levels of association for all forms of hours of study and a less negative association with OST in the four reported subjects than the other countries (Figure 4). The strength of the relationship between time spent in OST and other types of study differs between the four countries; but, in general it can be said that this analysis adds credence to the original OECD observation that students who are in OST programs for the longest periods (in any subject) have the lowest achievement in science (Figure 4).

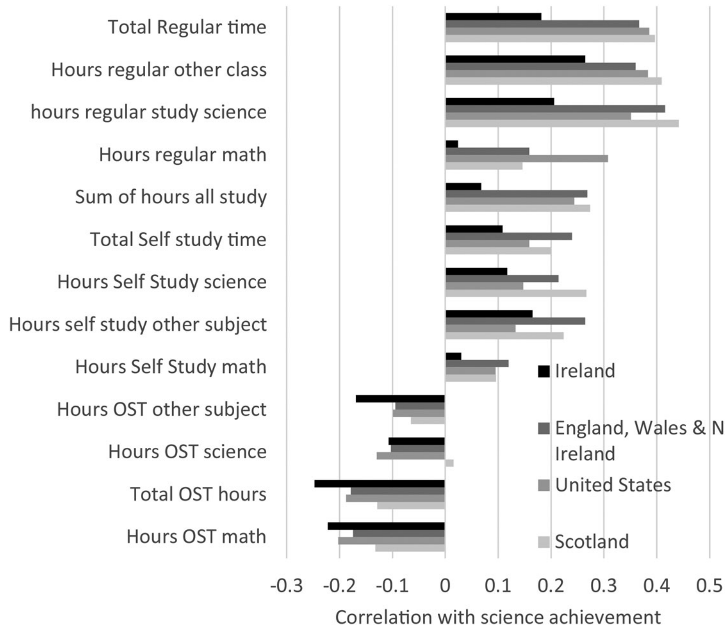

Figure 4. Correlation between science assessment and hours of class time, home study, and after-school science in a typical week 4 countries: PISA 2006.

Review of research on after-school learning

What do we know from previous academic studies about the relationship between OST attendance and test performance and other student characteristics? According to surveys by the United States. After School Alliance, approximately 10 million US students are estimated to attend after-school programs annually (AfterSchool Alliance, 2009). What do these students do in these programs? In the United States at least, some of the OST activities are intentionally focused away from direct learning even though the programs may occur in a school setting or other venue (Noam & Shah, 2013). Noam points out that OST programs may incorporate blocks of time devoted to (1) homework help and tutoring, (2) enriched learning experiences that may not be directly tied to the school-day, and (3) nonacademic activities, such as sports, arts, or play (Noam, Biancarosa, & Dechausay, 2003, p. 3). Some OST programs are intended only to help students connect with their surroundings, better connect their lives to science, and extend the more formal school science experiences beyond textbook memorization and test-taking (Noam & Shah, 2013, p. 12). This view of OST was also adopted by a committee of The National Research Council (2009) which stated that, 'Out-of-school-time programs have the potential to provide large-scale enrichment opportunities that were once reserved for wealthier families' (National Research Council, 2009, p. 175; National Research Council, 2015).

Mahoney, Larson, Eccles, and Lord

A comprehensive analysis of after-school activities and their potential effect on students was produced by Mahoney, Larson, Eccles, and Lord (2005). In their summary of the status of research on student after-school 'organized activities', they acknowledged that non-school activities may have been viewed by some policy makers as counterproductive but that with the increase in women's participation in the labor force, a greater need for safe organized activities for children is evident. Their comprehensive list of organized activities is useful to recite here:

> They include nationally sponsored youth organizations and federally funded after-school programs (e.g., Boys and Girls Clubs, YMCA, YWCA, 21st Century Community Learning Centers, 4-H, Boy/Girl Scouts, Camp Fire). They involve community, school, and locally organized programs: autonomous grassroots youth developmental organizations, faith based youth organizations, and activities provided by parks and recreation services, museums, libraries, youth centers, youth sports organizations and amateur leagues (e.g., little league) , school-sponsored extracurricular and after-school activities, and community service programs. They also include specific types of activities (e.g., sports, music, hobby clubs, social dubs, religious, service activities) that can be differentiated on the basis of activity-related goals, atmosphere, and content (Roth & Brooks-Gunn, 2003). (Mahoney et al., 2005, p. 5.)

Their report cites the benefits of organized activities as including improvements in educational attainment, reduction in behavioral problems, and heightened psychosocial competencies (p. 6) that had been noted by a National Research Council committee on Community-Level programs for Youth' (National Research Council and Institute of Medicine 2002). Authors acknowledged that although the mechanisms of potential positive effects on youth could be identified and were persuasive to the authors, empirical research to support the conjectures was rare (p. 12). Most importantly, the authors point out that the effectiveness of a particular program is most certainly affected by the quality and content of the program (Mahoney et al., p. 16).

Establishing reliable expectations for predicting results of participation in OST programs based on prior research is difficult because the existing academic literature on the subject is not orderly and is based almost entirely on small-scale individual programs (Lloyd et al., 2012) rather than regularly conducted surveys. A recent review of the quality of after-school research commissioned by the Wellcome Trust Fund found that the after-school community in England has 'limitations in its use of theory and research, its need to garner evidence more effectively and its need to become more professional in its sharing of knowledge and expertise'. (Falk et al., 2012; Lloyd et al., 2012; Matterson & Holman, 2012). Although many case studies of individual after-school programs have identified positive influences of extra-curricular activities on students' psychological and academic performance (Mahoney et al., 2005; National Research Council, 2015), none of these studies have been based on national samples of youth. Moreover, those studies of informal learning that do exist have identified only weak or negative associations between attitudes or cognitive (standardized test) learning with after-school program participation (OECD, 2011).

One possible reason for the status of research in after-school time is that conceptual frameworks for after-school measurement are not consistent or are not consistently applied across different studies, making it difficult to accumulate knowledge. That nearly all studies are unique case studies of single programs rather than across a large number of programs in a state, across states, or across nations reduces the possibility of generalization. Research studies about after-school effects on students are not the responsibility of any single agency, foundation, or professional association, so that knowledge of how to conduct valid studies has not been centrally accumulated. While federal funding may be provided through competitive grants in the United States from some federal agencies (such as the National Science Foundation, the Department of Education, and the Department of Health and Human Services), the topic of after-school learning is not a high priority for national policy-making (the budget for the twenty-first century program was reduced in 2005), although it is a growing concern in states and local school districts such as California (California Department of Education, 2014). Furthermore, the types of after-school science experiences vary greatly from program to program; they are often brief, random, voluntary, and frequently occur in settings that lack planning and structure (Friedman, 2008; Lemke, Lecusay, Cole, & Michalchik, 2012; Moore & Hamilton, 2010). Also, many studies of OST, including the current study of PISA, use measurement methods, such as cognitive assessments and attitude measures, designed for formal education which may or may not fit the student's after-school experiences.

The reviews of research in England for the Wellcome Trust fund claim that a thorough description and analyses of who the OST students are and why they chose to attend after-school programs are needed to develop an appropriate framework for measuring outcomes (Falk et al., 2012). Little descriptive information about the content of activities of after-school programs in the UK is available in research centers or associations and little information about the nature of those activities was provided in the international PISA reports. Some US researchers and associations have made efforts to provide general guidance of what to expect after-school programs to accomplish and they tend to downplay the direct connection between OST participation and direct increases in standardized science test scores. For example, a US association of after-school programs stressed that OST programs are more likely to be places where 'students engage with the world in authentic ways, grapple with real-world problems, and develop conceptual understanding through interactions with peers and adults' (Coalition for Science After School, 2004).

Another point of view about experiences in informal settings is that the OST experiences are purposefully centered away from the goals of formal school, which emphasize higher performance on cognitive exams (Arena & Schwartz, 2013). Instead of directly leading to improvements in achievement, as measured by standardized tests of science content, the experience in OST is expected to provide activities with science materials, positive relationships to others, and opportunities to relate formal school knowledge to the real world as experienced naturally. For example, papers by Arena and Schwartz and Noam have argued that formal school cognitive tests are not necessarily appropriate for assessing informal experiences because those tests require direct knowledge of scientific vocabulary and the domain of informal settings is in providing students with opportunities for emotionally compelling experiences that help them 'make sense' out of the abstractions learned elsewhere (Arena & Schwartz, 2013; Noam & Shaw, 2014). Many OST programs focus on intellectual and academic dimensions of Science, Technology, Engineering and Mathematics (STEM) learning, including conceptual understandings and epistemic practices of STEM, but the influence of these program activities may not appear on standardized testing (National Research Council, 2015).

On the other hand, national reviews of after-school programs supported by the US Department of Education have applied a standard of expectation of high cognitive performance as measured by school standardized tests from an OST program. For example, a major effort to evaluate the effectiveness of existing programs and studies was conducted at the request of the Department of Education (Beckett et al., 2009). That report recommended that after-school programs be organized rigorously so that they would produce students with higher achievement levels on standardized tests (Beckett et al., 2009). Additionally, some program administrators have predicted that student performance on tests would be increased if they spent more time on a subject matter (Farbman, 2012). In a similar vein, some researchers in informal learning have argued that better use of the free time available to students after formal school would have a significant effect on their attitudes toward subjects such as science (Falk et al., 2012; National Research Council (2009)). For example, the US National Research Council report on informal learning says:

> Programs, especially during out-of-school time, afford a special opportunity to expand science learning experiences for millions of children. These programs, many of which are based in schools, are increasingly folding in disciplinary and subject matter content, but by means of informal education. (National Research Council, 2009, p. 5)

The report furthermore says:

> Public discussions of learning usually focus on the experiences and outcomes associated with schooling. Yet a narrow focus on traditional academic activities and learning outcomes is fundamentally at odds with the ways in which individuals learn across various social settings: in the home, in activities with friends, on trips to museums, in potentially all the places they experience and pursuits they take on. The time that children spend pursuing hobbies of their own choosing—in such activities as building, exploring, and gaming—often provides them with experiences and skills relevant to scientific processes and understanding.

Thus, the researchers in OST appear to agree that time spent with science content in informal settings may not necessarily lead toward increases in standardized science learning, as in school directed instruction. But they do believe that such time spent builds interest, capacity, and commitment to STEM that indirectly lead toward such learning (Krishnamurthi, Ballard, & Noam, 2014).

Research and evaluation efforts to understand the role of student exposure to science in OST settings on student achievement on standardized tests may require a more precise specification of how time is used (Bray, 2013). Carroll's theory of student learning and use of time points out that adding additional time to a student's exposure to science may not always be sufficient to increase science learning (Carroll, 1963; Carroll, 1989; OECD, 2011). He carefully pointed out that other conditioning factors such as prior abilities, quality of instruction, and engagement are all a part of the total equation of student attention and retention. Additional time spent with a topic may be a necessary but not a sufficient condition for greater student learning.

The analysis of survey data will not be able to untangle all of the issues raised in this brief review of after-school research, but it should provide some concrete observations from reliable national surveys that can point the direction toward future improvements in assessing the effects of OST on student learning and achievement.

Source of data

The statistical evidence gathered by PISA's tri-annual survey of 15-year olds in 2006, 2009, and 2012 provides the source for a detailed exploration of the social, psychological, and cognitive learning characteristics of students outlined in Table 2 within and across countries. The basic purpose of PISA is to explain country differences in student performance through evidence of differences in student background; school and classroom experiences, use of time in and out of formal school settings, tests of performance in science, mathematics, and reading; and psychological characteristics such as achievement motivation, efficacy, and self-identity. This exploratory study will not focus on country differences as much as the OECD reports would, but it will seek to identify sources of any influence of OST on student cognitive, social, and psychological skills.

Hypothesis testing

OST students are selective of those who have a propensity for lower performance

One way to test this hypothesis of student selectivity is to examine the relationship between student hours in different forms of study and indicators of family status. In PISA 2006, Family resources of students were measured with five indicators (cultural possessions at home; family wealth, home educational resources; index of economic, social, and cultural status; and an index of home possessions). The strongest predictor of student achievement is the general index of social status which is a combination of the other indices. The measure of home educational resources is moderately related to achievement while the least strong indicator is a measure of family wealth, except in the United States where wealth and home resources have about the same association with achievement (Table 3).

If family background is a factor in the selection of students attending OST, then the correlations between amount of time in OST and family background factors should be as high as time spent in other forms of study. Figure 5 shows that for all four countries, the association of any of the PISA family background factors with time spent in OST is lower than the association with time spent in regular school or self-study of science. The strength of each indicator's association with study time (cultural possessions, family wealth, educational resources, social status, or home possessions) varies somewhat between countries. Home educational and cultural resources are consistently associated with frequency of attending OST. This relationship, supports the conceptualization that OST students are likely to seek educational experiences on their own, including at home. It might even be conjectured that the availability of home resources in education influences the orientation of students to seek outside experiences in science; however,

Table 3. Correlation between science achievement and five measures of family resources: PISA 2006.

Country	Index of economic, social and cultural status	Index of home possessions	Cultural possessions at home	Family wealth	Home educational resources
Ireland	.355	.277	.267	.094	.215
England, Wales and N. Ire	.373	.290	.264	.097	.224
Scotland	.407	.321	.305	.143	.232
United States	.419	.346	.269	.235	.229

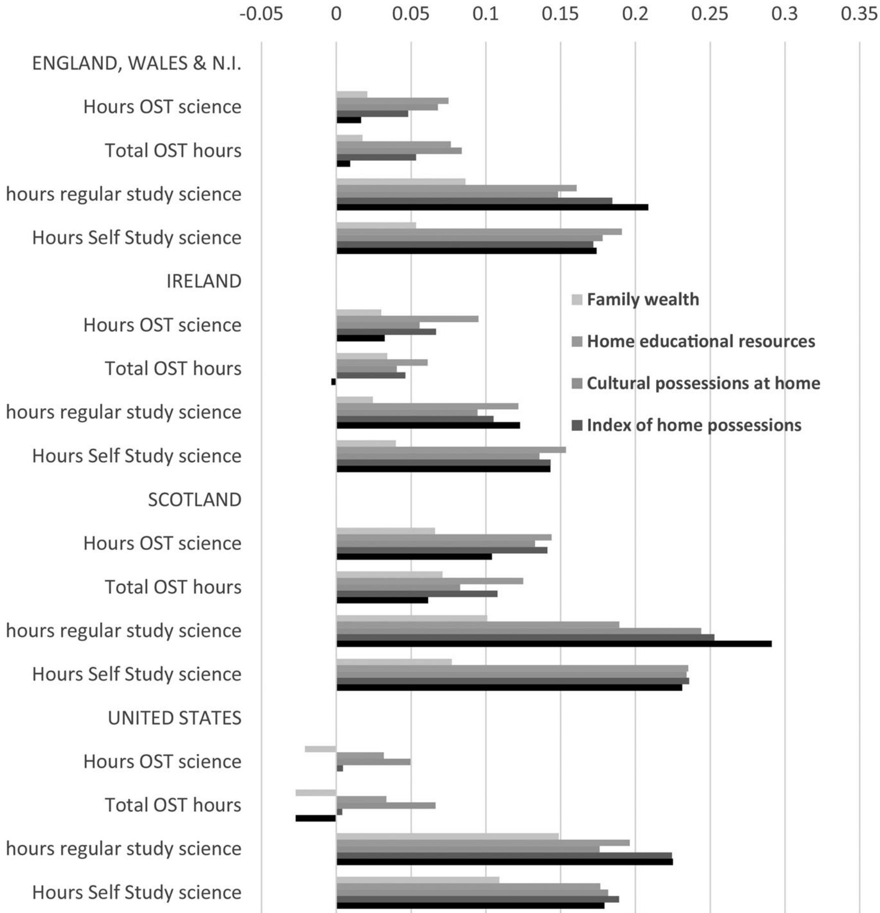

Figure 5. Correlation between hours of study of science with five measures of Family Status: PISA 2006.

that conjecture cannot be directly tested without further evidence. The zero (or slightly negative) association of hours in OST attendance with family wealth in the United States, England, and Ireland clearly indicates that in OST students are neither rich nor poor. The same is not true in Scotland however where family status and wealth are positively associated with student attendance at OST (as well as all other forms of science study). The higher influence of status and educational performance in Scotland likely explains the overall lack of a negative association between OST science time in Scotland compared with the other countries. The students who attend OST in Scotland are more likely than in other countries to have a higher status background and higher achievement.

The possibility that the association between family status and OST practices is curvilinear or due to an non-normal distribution of family status by time in after school was tested and rejected for the United States.

The question of whether students in OST programs had lower achievement because they tended to be attending remedial courses is tested (see Table 4 and Figure 6) with data in the 2009 PISA survey for the United States, the United Kingdom, and Ireland (Scotland has been combined with England, Wales, and Northern Ireland). The analysis

Table 4. Percent of 15 year-olds who attended after OST course in science or mathematics for remedial or enrichment purposes.

Country and subject	Percent of all students in remedial lessons	Percent of all students in enrichment lessons	Percent reporting both reasons	Percent of all remedial in OST program
Science				
United Kingdom	17.5	11.1	5.7	30.0
Ireland	1.8	3.7	1.1	22.7
United States	6.9	10.7	4.8	41.5
Mathematics				
United Kingdom	22.4	17.3	9.3	74.6
Ireland	8.1	16.0	5.5	85.2
United States	8.7	14.8	6.1	62.6

shows that the three countries had no consistent pattern in participation in remedial or enhancement of science (Figure 6). Either the students in each country interpreted the item differently, or the after-school programs in each country differ significantly. The proportion of OST science or mathematics students who reported a reason of either remedial or enrichment was only between 2 and 18% of the total (Table 4). A higher percentage of all students in the UK said that they were attending some form of remedial science class than those from the other two countries. And a higher percentage of students reported that they were taking OST classes for enhancement in Ireland and the United States than in UK, especially in mathematics. Thus it appears that without adjusting for family status that reasons for taking OST classes (remedial or enhancement) do not easily explain the observed lower science and mathematics performance of OST mathematics and science students in these three countries.

However, following up on a comment by a reviewer a further analysis of reasons for attending OST by family background provides a different set of possibilities. Do students at higher family status levels attend for enrichment purposes? Oddly, perhaps, the 2009 PISA survey (the only year that questions of remedial or enrichment purposes were asked) shows that 15-year-olds at lower socioeconomic status (SES) levels who attended OST in science were more likely to report that their participation was either 'remedial'

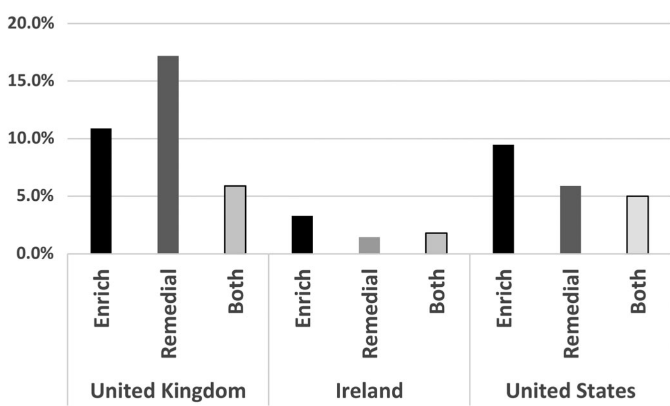

Figure 6. Percent of 15 year olds in 3 countries who reported taking OST science for remedial or enrichment purposes: PISA 2009.

or ‘enrichment’ than those students at higher SES levels (Chi square = 22, $p < .01$). This negative relationship between status and enrichment-remedial purpose suggests that students from lower status families were the most likely to report attending after-school programs for advancement. Although the relationship is not strong and the number of cases that allow a detailed analysis of purpose of attending does not permit a detailed analysis this initial analysis does suggest that the purpose of attending OST along with family background may help explain the differences in performance.

Attitudes toward science

Hypothesis 3b: Students attend OST for social and emotional reasons and have established socio-emotional benefits from the interactions with other students. Evidence for this hypothesis is presented in Table 5 by comparing the association of OST hours with 10 scales of student motivation to learn science and the association of hours of self-study in science with those attitudes.

Attendance in OST programs is positively related to many positive attitudes toward science in all four countries with Scotland having a somewhat higher association for attitudes such as value of science and school preparation for science. The attitude scales presented in Table 5 include future-oriented science motivation, interest in science, instrumental motivation in science, general interest in learning science, enjoyment of science, personal value of science, science self-concept, school preparation for science-related careers, general value of science, and science self-efficacy. The relationships of these attitude scales with OST hours are all more positive than the relationship

Table 5. Correlation between number of hours in OST or Self-Study for nine attitudes toward science: four countries PISA 2006 (items ranked by size of correlation to OST science in the USA).

	Eng. W and Northern Ireland		Ireland		Scotland		United States	
Attitude toward science scales	Hours OST science	Hours self study science	Hours OST science	Hours self study science	Hours OST science	Hours self study science	Hours OST science	Hours self study science
Future-oriented science motivation	.171	.302	.178	.314	.190	.360	.190	.236
Plausible value in interest in science	.154	.234	.136	.229	.133	.254	.180	.169
Instrumental motivation in science	.157	.299	.158	.308	.193	.361	.175	.255
General interest in learning science	.162	.294	.167	.312	.191	.366	.157	.226
Enjoyment of science	.143	.328	.159	.342	.202	.394	.146	.253
Personal value of science	.159	.281	.146	.307	.195	.346	.132	.222
Science self-concept	.139	.267	.125	.284	.162	.317	.131	.181
Science self-efficacy	.058	.236	.105	.208	.122	.320	.082	.196
School preparation for science-related careers	.086	.254	.089	.255	.133	.337	.074	.197
General value of science	.076	.202	.086	.203	.137	.283	.047	.161

to science standardized achievement in each country. Students who attend OST science programs most frequently have the most positive attitudes toward science and science careers. However, the relationship of these attitudes to number of hours per week in self-study of science is about half as large in all countries showing that the students who spend most hours in direct study of science are even more positively oriented toward science.

The measure of self-efficacy is an indicator of how confident students are in their understanding of science. It is interesting that the relationship of self-efficacy to hours attending OST is slightly positive, unlike the relationship of the test score in science. Apparently, students who attend OST frequently like science, like science activities, and are somewhat more likely to believe that they understand science, but they do not perform well on standardized tests. Perhaps this indicator of self-efficacy in science helps solve the puzzle of how it could be that students who attend OST have positive attitudes but low achievement. The answer is that they believe that they understand science, and they like science, they just do not perform well on standardized tests. It would be interesting to know what choices these interested and confident but low performing students will choose to do later in their educational and work careers. Perhaps they are the ones who are likely to become scientists in the future by ignoring the formal pathways. The retrospective questions asked in National Center for Education Statistics longitudinal surveys does give some clue that adults who become scientists remember their informal activities as children (Maltese & Tai, 2010).

PISA students were asked how much they agree that they would like to work in a science career (response options were strongly agree to strongly disagree). In Figure 7 shows the percent of 15-year-olds by whether attending an OST science program by negative attitudes toward a science career. Those students who attend science OST are less likely to report that a science career is not a good thing in all four countries. The orientation toward a science career is consistent with other attitudes about liking science activities. Apparently, OST students are more serious about their orientation toward science than are students who do not attend science OST.

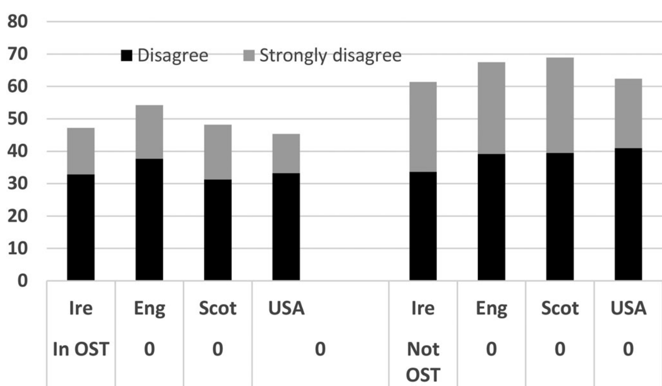

Figure 7. Percent of PISA 15-year-olds who disagree that a Science Career is a good thing by whether in OST science program or not: PISA 2006.

School characteristics

We proposed to examine the relationships between student reports of their relationship with science teachers and science classes and their attendance in OST programs. The PISA survey asked students to report how often their science classes conducted 17 different types of activities. These 17 items were used to create 5 scales of student responses on how frequently these activities occurred in the classroom:

- Focused on applications or models.
- Conducted hands-on activities.
- Conducted science activities.
- Held classroom interactions (explanations, discussions, and debates).
- Conducted student investigations.

Hypothesis 3a: Students who attend OST science programs are more likely to dislike the formal school science classes because they hold a stronger interest in more practical aspects of science than is found in classroom science.

The correlation of hours spent in OST classes and attitudes toward regular classroom activities in science is compared with hours of self-study in Figure 8. This comparison is intended to illustrate the particular significance of OST attendance on school efficacy. Coefficients for Self-study are in the top half of the table and OST hour correlations are in the lower half. The evidence indicates that the more time students spend in OST science, the more likely they are to have positive attitudes toward science instruction that involves student investigations, student to student interaction, application of models, or hands-on activities. The relationship of self study and

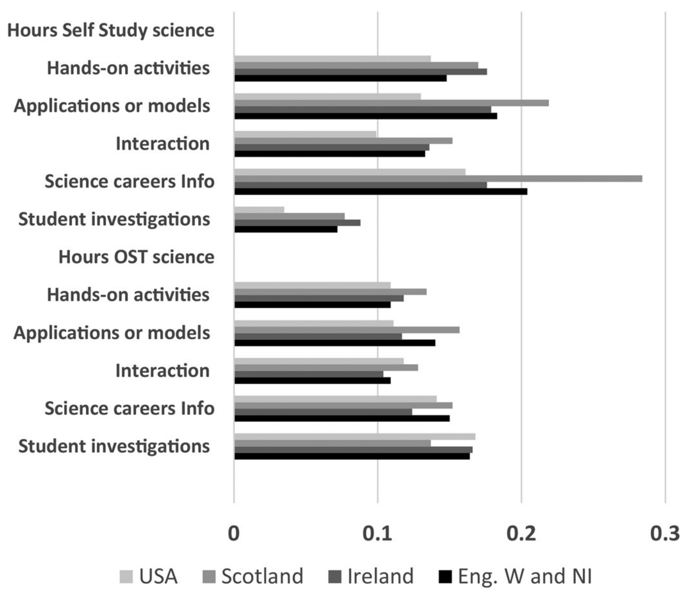

Figure 8. Correlation between number of hours in typical week of OST science or hours of self-study with attitudes toward regular class activities: PISA 2006.

classroom activities is not the same. Those who do more hours of self study do not appreciate hands-on classroom activities as much as the OST students and they are much more likely to like discussions of science careers. The country to country differences for OST students are not particularly significant. However, the self-study associations stand out as particularly strong in Scotland for activities regarding science careers and application of models, but as in other countries, more hours of self-study in Scotland are not highly associated with classroom student-investigation activities.

The correlations between these attitude scales with number of hours in OST science programs and hours of self-study (Figure 8) do not strongly support the hypothesis that students in OST classes 'dislike' classroom activities. Notice however that the difference in size of relationships of hours of study and liking student investigations is higher for OST students than for self-study students in each country. This is further evidence for the thesis that OST students are more oriented toward life-like science activities than are other students. One scale that did not perform as expected is the scale of liking science classrooms that emphasized hands-on activities. The relationship of that scale to hours in OST is the lowest of all the attitude items toward science teaching and much lower than among self-study students in each country. Perhaps this relationship can be interpreted as an indicator of OST student's general responses to formal school practices as not suitable to their personal interests.

Summary and conclusions

The findings of this study are consistent with recent studies by US researchers who have identified that factors such as the effectiveness of OST experiences and the quality of student experience appear to play a larger role on the student outcomes than does the quantity of time spent in a program (Bray, 2010; Moore & Hamilton, 2010; Vaughan, Manning, Kochman, & Goodman, 2009; Shernoff, 2010). In recognition of the importance of the quality of instruction, the Program in Education, Afterschool and Resiliency (PEAR) group at Harvard has developed an observational tool to measure the quality of instruction in the OST setting for science learning to inform practitioners and improve their practices (Noam, Robertson, Papazian, & Guhn, 2012). Thus both theory (Carroll, 1963) and empirical evidence consistently indicate that exposure to science content may not be the significant factor in itself to affect the relationship between attending OST programs and student cognitive performance or attitudes. The measures of engagement of students with the content of the program would form a stronger basis for establishing a broader conceptual framework for the role of OST in science and math learning.

The paper initially made a number of conjectures based on readings of OST research:

(1) That OECD's reporting of a negative relationship between attending OST and student achievement occurs because frequent OST students are selective of students in remedial classes.
(2) That students who attend OST frequently are selective of students with high interest and low achievement in the subject (science, math, or reading) because of a personal interest in more practical aspects of science that is not represented in classroom science.

(3) That students who attend OST programs for long periods are more selective of students from poor family backgrounds.
(4) That students attend OST for social and emotional reasons and have established socio-emotional benefits from the interactions with other students.
(5) That the relationship between OST attendance and achievement is a complex relationship of student selectivity and content of the OST program.
(6) That field surveys of student self-response on OST programs are newly established and contain reporting errors that need to be examined.

Findings

These conjectures were explored with two PISA data bases. The 2006 survey which focused on science learning and contained an extensive battery of scales about student motivation as well as achievement and attendance in after-school programs. The 2009 survey did not contain the motivation measures but did add a question for after-school attendees about their purpose of attending (remedial or enrichment).

(1) The 2009 PISA survey clearly showed that OST students in the USA and Ireland were as equally likely to attend science OST for either remedial or enhancement purposes. The Students of Great Britain (GBR) were most likely to report that they attended after-school programs for remedial purposes. Therefore, program differences in each country may contribute differently to student experiences.
(2) A compelling result of this analysis is that students in OST programs are highly interested in aspects of science. They are not especially interested in the science of the regular school. Therefore, the inference that after-school programs provide some students with positive life-like hands-on science experience (probably accompanied by leaders and other students with a like mind) is supported by the evidence from this analysis.
(3) National level survey data find that students of all income levels attend OST programs in all three countries. The relationship of attendance in OST to family background was not significant except in Scotland which has unique values compared with the other countries.
(4) Each PISA survey is administered only once during the school year, and few questions were asked about previous behaviors; therefore it was not possible to establish a causal or time link between attendance and changes in student learning or interest in science. Future longitudinal surveys are needed to answer that question.
(5) The analysis found that estimates of participation in each country varied from year to year in inconsistent ways (the USA went down while GBR went up). These variations are probably the result of random events, different contexts of questionnaire design, and differences in student interpretation of the items.

Conclusion

This paper presented an exploratory and descriptive study of existing survey data to understand and provide new explanations for student achievement in science obtained from after-school programs. The cross sectional nature of the PISA surveys permitted a rich description of the learning and attitudes of students who reported various uses of time of study, but did not permit an effective analysis of causal factors in student achievement. Some potential rival hypotheses for explaining the negative relationship of time spent in OST and achievement were ruled out. The fact that students who report they attended several hours of after-school programs a week in science have lower standardized test science achievement and higher positive attitudes toward liking science has been firmly established by this re-analysis of individual responses in four English-speaking countries. The analysis addressed possible competing hypotheses such as whether the students were attending after-school programs for remedial purposes, whether they were selective of low-income families, and whether the students held more negative views toward formal school science. None of these factors completely explained the higher level of positive attitudes toward future orientation toward science yet having lower science test performance.

The analysis of factors that are known to be associated with student achievement such as family background and access to educational materials did not provide strong support to the hypotheses that lower status background was responsible for the observed relationships between cognitive and non-cognitive factors of OST students. However, the possibility of complex interactions between student backgrounds and their participation rates in OST needs to be examined in a more nuanced manner. The new PISA survey for 2015 will provide an opportunity for such extensive analysis.

The findings of this study that more time in after-school programs with science content may not necessarily lead to higher test scores are consistent with recent studies by US researchers who have identified factors in the programs themselves such as the effectiveness of OST experiences and the quality of the student experience that play a larger role on the student outcomes than does the quantity of time spent in a program (Bray, 2013; Moore & Hamilton, 2010; Vaughan et al., 2009; Shernoff, 2010). Thus both theory (Carroll, 1963) and empirical evidence consistently indicate that extending the time students spend with a subject may not by itself be the significant factor in seeking explanations for the relationship between attending OST programs and student cognitive performance and attitudes.

Many after-school programs that include the subjects of science, such as scouting, boys and girls clubs, and community centers, do not seek to advance student achievement, but they do focus on interesting activities. Therefore, the finding that student interest in science is higher for those who attend longer is consistent with that goal. While some organizations such as the US Department of education (Beckett et al., 2009) expect after-school programs to lead to higher achievement levels, this study suggests that such an expectation is unrealistic.

Recommendations for future investigation of OST

This exploratory analysis of OST participation of national samples of the 15-year-old student population in 4 English-speaking countries in 2006 and 2009 provides a source of generalization and it raises new questions about how such surveys should define educational activities in after-school settings. The main purpose of measuring experiences with out-of-school study by the PISA to identify all potential sources of differences in opportunity to learn science, mathematics, and reading in different countries and evidence from Eastern countries that practice after school 'cramming' suggests that such opportunities may occur in other countries (see Figure 2). However, the result that more frequent participation is associated with lower standardized test scores in Western countries suggests that OST is attended for different purposes (OECD, 2011).

Future research should identify more precisely in questionnaire items what students expected to obtain from their participation in OST. The content of the programs themselves should be classified into content coverage areas and goals for students. Perhaps the general content areas defined in the Science Standards (NGSS Lead States, 2013) or the National Assessment of Education Progress could be used for such a classification. Of course, knowing more about the qualifications of instructors in after-school programs would be an important element in describing the actual experiences of attending students. Surveys should measure the educational levels of the instructors, their formal and informal training in instructional methods, and their attitudes toward the program they are participating in. Since many studies of OST are case studies of single studies (Falk et al., 2012; Lloyd et al., 2012; Matterson & Holman, 2012; National Research Council, 2015) a collaboration between those creating large scale studies of student performance and those who conduct evaluations of individual programs might result in improved national measures of the effect of OST on student achievement. Lastly, the measure of student achievement itself should be designed to conform to the student experiences with science in OST settings. Measures of student achievement could be expanded from the current NAEP framework based on required school content areas or the PISA framework which was defined by skills necessary for employment in highly technical occupations to include areas such as knowledge of working together with others to solve a common problem, problem solving while engaged in non-formal activities, or combining skills of science with other subjects such as art. Such a program of study would involve a comprehensive analysis of the expertise of program leaders and instructors with science content areas and an accompanying framework of scientific practices that extend the experiences of formal schooling for adolescents attending after-school programs. Other research agencies and foundations are encouraged to seek further understanding of the role of OST in students' lives.

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Disclosure statement

No potential conflict of interest was reported by the author.

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Larry E. Suter is an independent consultant on education research living is Woodstock, Maryland. He retired from the National Science Foundation in 2011 after 21 years. He is a Visiting Scholar at the University of Michigan and a Lecturer (Part-time) at Harvard Medical School. He received his

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References

Afterschool Alliance. (2009). *America after 3pm: A household survey on afterschool in America*. Washington, DC: Afterschool Alliance. Retrieved from researchconnections.org/location/ccrca3769

Arena, D. A., & Schwartz, D. L. (2013). Experience and explanation: Using videogames to prepare students for formal instruction in statistics. *Journal of Science Education Technology*. doi:10.1007/s10956-013-9483-3

Banks Au, K. H., Ball, A. F., Bell, P., Gordon, E. W., Gutierrez, K. D., Heath, S. B., … Zhou, M. J. A. (2007). *Learning in out of school in diverse environments: Life-long, life-wide, lifedeep*. Seattle: University of Washington, The LIFE Center the Center for Multicultural Education.

Beckett, M., Borman, G., Capizzano, J., Parsley, D., Ross, S., Schirm, A., & Taylor, J. (2009). *Structuring out-of-school time to improve academic achievement: A practice guide (NCEE #2009-012)*. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from ies.ed.gov/ncee/wwc/publications/practiceguides

Bray, M. (2010). Researching shadow education: Methodological challenges and directions. *Asia Pacific Education Review*, *11*(1), 3. doi:10.1007/s12564-009-9056-6

Bray, M. (2013). Benefits and tensions of shadow education: Comparative perspectives on the roles and impact of private supplementary tutoring in the lives of Hong Kong students. *Journal of International and Comparative Education*, *2*(1), 18–30.

California Department of Education. (2014). Background information, program objectives, and requirements for the After School Education and Safety program. Retrieved from http://www.cde.ca.gov/ls/ba/as/pgmdescription.asp

Carroll, J. B. (1963). A model for school learning. *Teachers College Record*, *64*, 723–733.

Carroll, J. B. (1989). The Carroll model: A 25-year retrospective and prospective view. *Educational Researcher*, *1*(18), 26–31.

Coalition for Science After School. (2004). *Report of the national conference on science after school*. Cambridge, MA: TERC.

Falk, F., Osborne, J., Dierking, L., Dawson, E., Wenger, M., & Wong, B. (2012). *Analysing the UK science education community: The contribution of informal providers*. Welcome Trust Foundation publication. Retrieved from wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtp040860.pdf

Farbman, D. (2012). *The case for improving and expanding time in school: A review of key research and practice*. Retrieved from http://www.timeandlearning.org/case-improving-and-expanding-time-school

Foshay, A. W., Thorndike, R. L., Hotyat, F., Pidgeon, D. A., Walker, D. A. (1962). *International studies in education educational achievements of thirteen-year-olds in twelve countries: Results of an international research project, 1959–61*. Hamburg: Unesco Institute of Education.

Friedman, A. (Ed.). (2008). *Framework for evaluating impacts of informal Science education projects*. National Science Foundation Workshop Report. Retrieved from http://insci.org/resources/Eval_Framework.pdf

Krishnamurthi, A., Ballard, M., & Noam, G. G. (2014). Examining the impact of afterschool STEM programs commissioned by the Noyce foundation. Retrieved from http://www.afterschoolalliance.org/ExaminingtheImpactofAfterschoolSTEMPrograms.pdf

Lemke, J., Lecusay, R., Cole, M., & Michalchik, V. (2012). Media-rich environments: A Report to the MacArthur Foundation. Retrieved from http://lchc.ucsd.edu/MacArthur-Learning-Report_2012-12.pdf

Lloyd, R., Neilson, R., King, S., & Dyball, M. (2012). Review of informal science learning. London: Welcome Trust. Retrieved from http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtp040863.pdf

Mahoney, J. L., Larson, R. W., Eccles, J. S., & Lord, H. (2005). Organized activities as developmental contexts for children and adolescents. In J. L. Mahoney, R. W. Larson, & J. S. Eccles (Eds.), *Organized activities as contexts of development* (pp. 3–22). Mahwah, NJ: Lawrence Erlbaum Associates.

Maltese, A. V., & Tai, R. H. (2010, March 15). 5289 online /10/050669–17, (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), , 669–685. ISSN 0950-0693 print /ISSN 1464.

Martin, M. O., Mullis, I. V., Gonzalez, E. J., Gregory, K. D., Smith, T. A., Chrostowski, S. J., … O'Connor, K. M. (2000). *TIMSS 1999 International Science report findings from IEA's repeat of the third International Mathematics and Science study at the Eighth Grade*. IEA International Study Center, Boston College, USA.

Matterson, C., & Holman, J. (2012). *Informal science learning review: Reflections from the Wellcome Trust*. Retrieved from wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtp040859.pdf

Moore, K., & Hamilton, K. (2010). *How out-of-school time program quality is related to adolescent outcomes. Child Trends Research Brief*. Retrieved March 3, 2012 from http://www.childtrends.org/Files/Child_Trends-2010_08_02_RB_OSTProgramQuality.pdf

Mullis, I. V., Martin, M. O., Gonzalez, E. J., Gregory, K. D., Garden, R. A., O'Connor, K. M., … Smith, T. A. (2000). *TIMSS 1999 International Mathematics report findings from IEA's repeat of the third International Mathematics and Science study at the Eighth Grade*. IEA International Study Center, Boston College, USA.

National Research Council. (2009). P. Bell, B. Lewenstein, A. W. Shouse, & A. W. Feder (Eds.), *Learning science in informal environments: People, places, and pursuits*. Committee on Learning Science in Informal Environments. Washington, DC: The National Academies Press.

National Research Council. (2015). *Identifying and supporting productive programs in out-of-school settings*. Committee on Successful Out-of-School STEM Learning, Board on Science Education, Division of Behavioral and Social Science and Education. Washington, DC: The National Academies Press.

National Research Council and Institute of Medicine. (2002). Community programs to promote youth development. Committee on community-level programs for youth. In J. Eccles & J. A. Gootman (Eds.), *Board on children, youth, and families, division of behavioral and social sciences and education* (p. 79). Washington, DC: National Academy Press.

NGSS Lead States. (2013). *Next generation Science standards: For states, by states*. Washington, DC: The National Academies Press.

Noam, G., Biancarosa, G., & Dechausay, N. (2003). *Afterschool education: Approaches to an emerging field*. Cambridge: Harvard Education Press.

Noam, G., & Shah, A. (2013). *Informal science and youth development: Creating convergence in out-of-school time*. Chapter to appear in the National Society for the Study of Education (NSSE). Yearbook 2013.

Noam, G. G., Robertson, D. L., Papazian, A., & Guhn, M. (2012). *The common instrument: Background and summary information about the assessment tool: Report for national aeronautics and space administration: Program in education*, Afterschool and Resiliency (PEAR).

Noam, G. G., & Shaw, A. (2014). *Informal science and youth development: Creating convergence in out-of-school time*. Chapter in Informal Science and Youth Development.

OECD. (2011). *Quality time for students: Learning in and out of school*. OECD Publishing. Retrieved from http://dx.doi.org/10.1787/9789264087057-en. Francesca Borgonovi, Miyako Ikeda &Soojin Park authors

Roth, J. L., & Brooks-Gunn, J. (2003). What is a youth development program? Identifying defining principles. In F. Jacobs, D. Wertlieb, & R. M. Lerner (Eds.), *Enhancing the life chances of youth and families: Public service systems and public policy perspectives: Vol. 2. Handbook of applied developmental science: Promoting positive child, adolescent, and family development through research, policies, and programs* (pp. 197–223). Thousand Oaks, CA: Sage.

Shernoff, D. J. (2010). Engagement in after-school programs as a predictor of social competence and academic performance. *American Journal of Community Psychology*, *45*, 325–337.

Vaughan, P., Manning, C. F., Kochman, M. A., & Goodman, I. (2009). *An Evaluation of NPASS—National Partnerships for Afterschool Science Year 3 Final Report*, Submitted to Charlie Hutchison and Bernie Zubrowski Center for Science in Education. Education Development Center. Retrieved from: http://informalscience.org/reports/0000/0225/NPASS_FINAL_EVALUATION_REPORT.pdf.