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Introduction

The education system budget in Israel is the second-largest budgetary allocation after defense. The size of the budget is influenced by four main factors: teachers' salaries, the number of teaching positions, class size, and teachers' working hours (which are highly correlated with the number of instructional hours received by students).[1] Thus, a discussion of each of these components is important. This paper focuses on the interrelationship between the latter two components and their impact on academic achievements, while holding the first two components (teachers' salaries and number of teaching positions) constant. Using data from the international PISA and TIMSS exams, the objective is to examine the feasibility of reducing class size while

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1 At times, confusion arises between the terms "instructional hours" and "class work hours." The term "instructional hours" refers to the actual hours the class spends learning, whereas the term "class work hours" encompasses all the hours allocated to the class, including split hours, private hours, preparation hours, mentoring hours, etc., all of which ultimately reflect the quality of the actual instructional hours the students receive. Hence, it would be preferable to use the term "student work hours," which expresses the total work hours assigned to the class, divided by the number of students. The data in OECD publications pertain to the minimum compulsory instruction time, non-compulsory hours, and intended instruction time. In Israel, the first and last are identical. In this paper in the absence of data on student work hours, we use the number of instructional hours as presented in the *Education at a Glance 2015* publication, which represents the minimum compulsory instruction time (OECD, 2015).

simultaneously reducing instructional hours without altering educational budgets and without compromising students' academic achievements.[2]

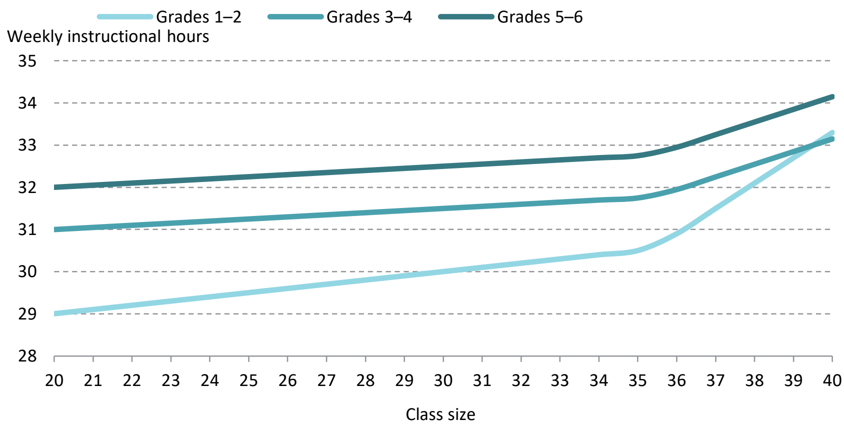
Two budgeting methods are widely accepted in global educational systems. Under one approach, the class is the budgetary unit. According to this method, a school's budget is determined on the basis of the number of classes in the school, without considering the number of students in the school or in each class. Under the second approach, the budgetary unit is the individual student, and therefore, at the school level, the number of students determines the allocated budget. In the first method, the budget per class is uniform, while in the second method, the budget per student is uniform. Each of these approaches is typically complemented by various adjustments based on student characteristics and other variables. These adjustments — such as additional budget allocation for students from disadvantaged socioeconomic backgrounds, for those who are not native speakers of the language of instruction, or for the inclusion of students with special needs — to a great extent, reflect the educational and social values prevailing in the country.

In Israel, the budget allocation for primary and middle school education is primarily determined on a per-class basis. However, aside from the aforementioned adjustments, it also includes additional factors, chief among them being class size. As shown in Figure 1, each class in primary school education is allocated a basic budget by the Ministry of Education at a relatively uniform level (between 29 and 32 hours). However, a specific number of additional hours is added for each student beyond the 20th student.[3] Initially, these additions are minor but gradually increase with the number of students, particularly for each student beyond the 35th student. The underlying assumption reflected in this graph is that additional instruction hours need to be allocated to prevent a decline in students' achievements due to class size. Analogously, it is also possible to reduce the number of students per class without exceeding the given budget — by reducing instructional hours, especially around the "critical threshold" of 35 students per class.

2 It is equally possible to ask whether both class size and the number of instructional hours can be increased without increasing the budget and without harming academic achievements. We do not ask this question because most educators see reducing class size as having many other benefits beyond contributing to academic achievements.

3 The situation in middle school is similar.

Figure 1. Basic standard (minimum instructional hours) for classes of various sizes in primary school education, by age group, academic year 2021/2022



Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: Ministry of Education

In our opinion, this explicit reference to class size in the budget formula — assuming that one of the goals of the Ministry of Education is to achieve equity in academic achievements across classes of varying sizes — signifies a clear recognition of the trade-offs between class size and the number of instructional hours (or alternatively, teachers' working hours). The problem is that this recognition of trade-offs is not based on empirical data — i.e., how many instructional hours per class may be eliminated to enable a reduction of one student per class without increasing expenditure or compromising achievements. Hence, the current budget formula expresses, at best, a combination of educational expertise and experience on the one hand, and budgetary and administrative constraints on the other.

In this paper we aim to examine, based on available data on class size and instructional hours per class, whether class size and instructional hours can be traded off in a way that enables similar academic achievements.[4] The analysis is for countries participating in the international PISA and TIMSS tests with available relevant data. Specifically, we seek to explore whether there are

4 The formal analysis controls for expenditure per student as a percentage of GDP.

countries where academic achievements are comparable despite different combinations of instructional hours and class size, and how changes in the number of instructional hours and class size have affected student performance in countries that have made such adjustments.

This paper does not presume to propose a formula to determine the number of hours per class that can be reduced when the class size is reduced by one student without compromising academic and educational achievements or changing the budget. Such a formula would require a controlled trial tailored to the unique characteristics of Israel's education system and its diverse sectors.

General background and literature review

The issue of the effect of class size and instructional hours on educational outcomes is one of the most popular topics in educational research. The prevailing conclusion from the majority of studies is that class size has a negative impact on academic achievement (and other educational variables, such as discipline or satisfaction with the learning environment). That is, larger classes are associated with lower performance, particularly among younger students or those from disadvantaged backgrounds, although the effect is usually not great.[5] Reducing the number of students in the average class requires a substantial increase in the number of teachers and classrooms, which entails considerable budgetary investment. Furthermore, increasing the number of teachers may potentially lead to a decline in their quality, particularly affecting disadvantaged populations, as the heightened competition for teachers might result in experienced and proficient educators moving to schools serving more privileged populations. As such, many researchers, mostly those in the field of economics, have reached the general consensus that the costs do not justify an overall reduction in the average class size, and that resources are better invested in other initiatives.[6]

5 It should be emphasized that most of the studies related to classes of between 20 and 30 students, while in Israel, the average class size is about 28 students, and in some cases even reaches 40.

6 Generally, as studies looked at larger systems or wider age ranges and time scales, the effect of class size on student achievement was smaller, less statistically significant, or disappeared altogether. In addition, most studies examined the effect of class size for much smaller classes than in Israel.

The relationship between instructional hours and academic achievements has also been examined numerous times. In general, one might expect that increasing instructional hours would lead to improved academic performance. The considerable weight of instructional hours within total education expenditure further reinforces this logic. However, Gromada and Shewbridge (2016) found that while there is generally a positive correlation between instructional hours and achievements, this relationship is weak and often statistically insignificant. In other words, the time devoted to instruction plays a central role, but how it is utilized is of greater importance. Moreover, the researchers discovered that the improvement in achievements resulting from each additional instructional hour increases when the initial number of hours is small, and beyond a certain threshold, not only does it stop increasing, but it decreases and even becomes negative. Economists who have examined this issue concluded that adding instructional hours is a less efficient way to improve achievements relative to other approaches (e.g., Levin, 1984; 1986).

Against the backdrop of these findings, the perception has evolved over the years, both in Israel and around the world, that as long as reducing the number of students in a class is not accompanied by a reduction in instructional hours per class, it will invariably necessitate an increase in the number of teachers and the addition of classes, proportional to the extent of the reduction in the number of students (Blass, 2008; Shafrir et al., 2016).

The intentional reduction in class size (as opposed to reduction resulting from demographic changes) typically occurs in two scenarios: during periods of economic prosperity when the educational system has access to substantial resources, and there is no necessity to concomitantly decrease the number of instructional hours; or during periods of educational crisis when there is a willingness to reallocate resources from other sectors to the education system. Similarly, instances of increasing class sizes and reducing instructional hours have taken place during economic downturns with the need for budgetary cutbacks. We are not aware of situations like the ones that occurred in Israel during the academic year 2020/2021, where in extensive parts of the education system, the number of students per class was drastically reduced, and simultaneously, the number of weekly instructional hours was diminished.[7]

7 To the best of our knowledge, even during COVID-19, reducing classes in most countries in order to maintain physical distancing between students was not accompanied by a reduction in the number of hours as a way to deal with the shortage of teachers. Most countries responded to the state of emergency created by the pandemic by canceling school days. Countries that sought to reduce class size did so by introducing a second shift (when there was no physical alternative in terms of buildings) or by dividing existing classes and adding staff.

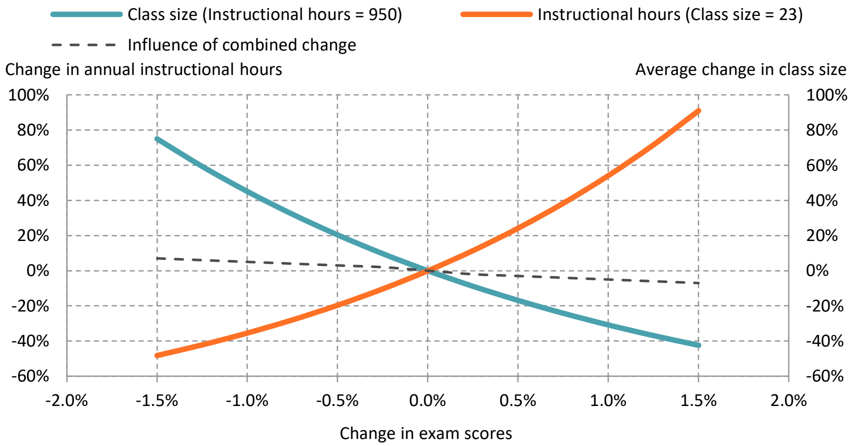
This paper disregards the two fundamental assumptions noted above and attempts to examine the substitutionality between class size and teacher work hours and their theoretical impact on educational outcomes, based on empirical data from international exams. This will be done through a thought experiment involving a simultaneous reduction in the number of students and instructional hours.[8]

Figure 2 depicts the substitutionality between instructional hours and class size and its effect on academic achievements. The horizontal axis represents the expected change in the average international exam scores, while the vertical axes on the right and left show the percentage change in the number of students per class and the number of instructional hours received by the class, relative to the starting point (the intersection of the curves). The blue curve represents the effect of the change in the number of students on the scores, and the orange curve represents the effect of the change in instructional hours on the scores. The point (0, 0) indicates the initial state, which we calibrated as the average of both variables in our international sample (to be further elaborated below). The black dashed line roughly indicates the vertical difference between the two curves, thus representing the result of the simultaneous effect of modifying both variables by the same relative amount.[9] In the graph, the curves slope almost symmetrically, and accordingly, the impact of any change in one of the variable on academic achievements is almost entirely offset by the equal-sized relative change in the other variable.

8 The need for optimal utilization of study spaces in schools and the addition of classrooms is discussed at length in another paper (see Blass, 2020).

9 The graph is predicated on the simplifying assumption that there is no interrelationship between the various educational factors. However it is reasonable to contend that this assumption is likely inconsistent with reality. For example, reducing class size and reducing the number of instructional hours cannot only have a direct effect as observed in hours of study per student, but also indirect ones. For example, it can affect the quality of teachers due to reduced retirement rates, result in reduced disciplinary problems, reduce the demand for teaching personnel (when the effect of reducing the number of hours is greater than that of reducing classes), and enable more rigorous screening of new teachers.

Figure 2. The impact of class size and number of study hours on test scores



Note: The graph is intended for the purpose of illustration only, whereby the values depicted are based on estimates that are not statistically significant. These estimates are derived from the results presented in column 5 of Table 4 in the Appendix). Had we focused solely on statistically significant estimates (as in Figure 1 in the Appendix), both curves would slope downwards from left to right (indicating that both reducing class size and reducing the number of instructional hours improve performance) and the effect would have been much more substantial.

Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

The possible trade-offs between class size and instructional hours are influenced to a considerable extent by the slopes of each curve, which are contingent upon a range of variables, such as students' age, the subject of study, students' socioeconomic background, learning environment, and similar factors. While specific effects of each and every variable are not discussed in-depth in this paper, it is worth noting that accumulated educational experience indicates a negative relationship between class size and academic achievements, whereas the relationship between the number of instructional hours and academic achievements tends to be positive, with both slopes being small (in their absolute value).

The graph illustrating the interrelationships between the two variables allows for the theoretical possibility of "performance isoquants" — scenarios where reducing class size while simultaneously decreasing instructional hours do not affect academic achievements.[10] The empirical challenge lies in calculating the slopes of each curve that represents the relationship between class size and instructional hours with academic achievements, which can only be achieved through a controlled interventional study (see Appendix) or a natural experiment. This type of natural experiment occurred in Israel during COVID-19, in which there was a reduction in class size and instructional hours (albeit under exceptional circumstances), but the data required to conduct the necessary analysis were not collected.

In an earlier study (Blass, 2020), we demonstrated that in the reality that occurred in Israel during the COVID-19 period, reducing class size — when accompanied by a reduction in the number of instructional hours per class — is feasible in terms of human resource and educational infrastructure available to the education system. In the current study, we seek to determine whether this can be achieved without compromising academic and educational achievements.

Our research draws on the results of the international PISA and TIMSS exams, conducted between 1999 and 2019, which focused on reading comprehension, mathematics, and science, and on data on average class sizes and instructional hours in countries that participated in these assessments. These data enabled us to measure the slopes of the curves linking class size and the number of instructional hours to academic achievements.

The slopes of the curves obtained in our analysis are very moderate, indicating weak effects of class size and the number of instructional hours on academic achievements. Despite the limitations of the aggregate data, given the collective experience of numerous countries that participated in international exams, it seems reasonable to suggest that both factors can be reduced without risking significant adverse effects on academic outcomes.

Regardless of the widespread popularity of investigating the influence of class size or the number of instructional hours on academic attainments (see, for example, Ayalon et al., 2019; Gromada & Shewbridge, 2016), only a few studies have explored the simultaneous reduction of class size and instructional hours (or vice versa, the simultaneous increase of both factors). One possible

10 In educational research, it is commonly assumed that additional instructional hours enhance academic achievements while increasing the number of students adversely affects academic achievements. The change does not have to be identical, and in most cases the absence of a change is achieved by different relative changes in class size and the number of hours of instruction.

explanation for the scarcity of such research is that this combination is exceptionally rare.[11]

A study conducted in Chicago found that the amount of time devoted to instruction has a positive effect on academic achievements, and this effect increases as class size decreases (Coates, 1998). In Israel, a study examining the impact of changes in the funding principles of the primary education system following the recommendations of the Shoshani Committee on academic achievements, found that adding instructional hours as a policy for improving achievements was more efficient than reducing class size (Lavy, 2012). According to the researcher's estimation, the improvement achieved by reducing class size by 20% could also be attained by adding 4.2 hours per class (approximately 15%). At that time, the cost of this alternative was significantly lower than the cost of reducing class size.[12]

In a study based on data from the German PISA exam in 2000 examining the substitutionality between instructional hours and class size in the German education system, Wiermann (2005) showed that class size had a negative effect on academic achievements, and that except in biology, instructional hours had a positive effect. The researcher found that simultaneously reducing class size and instructional hours could have a positive impact on achievements (p. 15).

Flores (2017) linked the relationship between academic achievements in the 2012 PISA test to a number of educational expenditure variables in European countries. Specifically, she investigated the association between the number of instructional hours per year and class size, creating a new variable termed "instructional hours per student," defined as the quotient of annual instructional hours divided by the number of students in each class. The researcher poses a question that is the same as ours: Do students require a substantial number of instructional hours, or can they achieve better results with fewer hours in smaller groups, providing more personalized attention (p. 165)?

11 Generally, a reduction in the number of students in a class is not accompanied by a reduction in instructional hours, and an increase in the number of students in a class is not accompanied by an increase in instructional hours. The situation that occurred in Israel (and perhaps in other countries) during the COVID-19 period is rare and unique, and its outcomes have not yet been thoroughly researched.

12 It is essential to emphasize that the research examined a very short time frame — one year from the day the decision to change the funding method was made — and that during this period, the actual changes were very minor and only affected a small portion of the education system. See Blass et al., 2016; Blass & Kraus, 2014, for more details.

Her findings suggest there is no direct relationship between education expenditure per student and the number of students in a class and instructional hours, as education expenditure is essentially a consequence of educational and budgetary policies in a country. Thus, she concludes that the assertion that insufficient budget hinders increasing instructional hours for students is erroneous, as it is always possible to modify the ratio between instructional hours and class size (p. 166). Furthermore, the study determined that there is no clear connection between either class size or instructional hours on the one hand, and academic achievements on the PISA exam on the other.

In another study that examined the impact of instructional hours and class size on student achievements in Denmark, one of the secondary findings was that the effect of an increase in instructional hours is smaller than that of a reduction in the number of students in a class, though the former is more administratively feasible (Bingley et al., 2018).

Another factor influenced by class size is the time dedicated to actual learning. In the OECD's *Education at a Glance 2015* publication, it was reported that as class size increases, the allocated instructional time for non-learning activities also grows (OECD, 2015, pp. 418–419, Chart D2.a). The significance of this finding is that any reduction in the number of students in a class results in additional time devoted to actual learning, and a reduction in time wasted on discipline and non-academic activities (such as taking attendance and various administrative tasks).

Finally, from the data published in *Education at a Glance 2020*, insights can be drawn regarding the efficiency of increasing instructional hours independently, regardless of other variables, as a means of improving academic achievements. In Israel's formal education system (excluding Haredi education), the required instructional hours in grades 1–9 are 12% higher than the OECD average and 17% higher than the European Union average. The gap in primary school education is 20% and 26%, respectively. In middle school the gap is slightly smaller (OECD, 2020, p. 351, Figure D1.1). However, despite Israeli students spending significantly more hours studying than their OECD peers — especially in primary school education — their achievements in all subjects tested in international exams do not surpass those of their counterparts in other countries.

In conclusion, most studies have not investigated, and certainly not through controlled experiments, whether a reduction in instructional hours coincided with changes in the number of students in the class. This remains an empirical question that, at this stage, lacks a definitive answer.

Descriptive findings

In order to examine the statistical relationship between class size and instructional hours with achievements on international exams — which is not necessarily causal — we collected national-level data for most countries participating in TIMSS and PISA exams from 1999 to 2019. This data includes the country's overall score on the exams, alongside data on the country's educational inputs (class size, annual instructional hours, and expenditure per student as a percentage of GDP).[13] Previous research had a narrower scope than our current study. While previous studies focused on a specific educational stage (primary or secondary), a particular exam (e.g., PISA 2006), or a specific subject (e.g., mathematics), our study also considered the TIMSS tests administered in primary schools and the PISA tests administered in secondary schools. We looked at 13 exams covering a wide range of years and subjects.

At this point it is important to note that using national-level data complicates the identification of the causal relationship between educational inputs (class size and instructional hours) and academic achievements for two main reasons. First, there is a loss of the variance among students and schools within each country. Second, countries differ not only in their measured educational inputs, but also in other (unobserved) aspects, such as pedagogical approaches, economic conditions, and additional factors which also impact academic achievements. Nevertheless, due to the lack of comprehensive data at the student or class level for each of the countries participating in the international exams, we had to suffice with generalizations based on country-level data.[14]

Using the available data, a database comprising 31 countries that participated in at least one of the 13 TIMSS or PISA exams conducted during the time period (1999–2019), totaling 168 observations, or 197 observations excluding expenditure data per student, was constructed. Based on this database, we focused on the impact of the total instructional hours allocated

13 This study includes seven PISA exams (2000, 2003, 2006, 2009, 2012, 2015, 2018) and six TIMSS exams (1999, 2003, 2007, 2011, 2015, 2019). PISA data were obtained from the OECD (Organization for Economic Cooperation and Development), while TIMSS data were obtained from the IEA (International Association for the Evaluation of Educational Achievement).

14 Our approach is supported by the work of Hanushek and Woessmann on the relationship between international exam scores and future growth, which also relies on aggregate country-level data. They argue that while there is no definitive evidence of a causal link between the two, existing evidence supports the hypothesis that improving skills of the population leads to higher rates of economic growth. See Hanushek & Woessmann, 2021, p. 1.

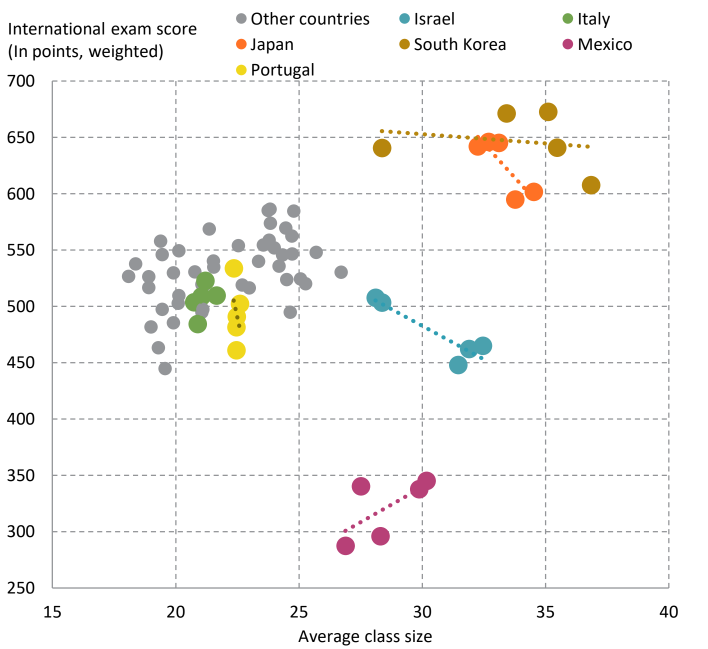
per class on academic achievements across all subjects, assuming a close relationship between instructional hours across subjects. This approach, though overlooking important aspects such as differential allocation of resources to students at varying proficiency levels and student preferences for specific subjects which could contribute to variations in achievements across different subjects, reinforces, in our opinion, the existence of a relationship between resource allocations (inputs) and outcomes.[15]

Figures 3–6 depict the relationship between class size and the number of annual instructional hours and composite scores in international middle school exams between 1999 and 2019, as well as the relationship between the changes in each of the inputs and the change in scores in both Israel and five selected countries (Portugal, Mexico, South Korea, Japan, and Italy). All these countries consistently participated in the exams throughout the entire period, and their input patterns and achievements on the international exams differ from those of Israel. The period was divided into five four-year sub-periods (with 2–3 exams in reading comprehension, mathematics, and science in each sub-period). Consequently, the data represent the four-year average for each of the variables.

15 For added certainty, we also conducted tests where the dependent variable is the score in a specific subject (mathematics or science). The results are presented in Table 3 in the Appendix.

Figure 3 presents the relationship between average class size in middle school and exam scores for both Israel and the comparison countries. A quick glance suffices to show that the correlation lines for different countries diverge significantly, and there is no clear correlation between the two variables.[16] A more in-depth analysis reveals that the different observations of the same country (scores on different exams) tend to cluster or be relatively close together, while the countries themselves are relatively distant from each other. This implies that differences between countries across time, both in class size and exam scores, are much greater than the changes that have occurred within countries over time. Moreover, it is quite clear that any line-of-best-fit extending across the entire graph will be highly sensitive to the presence of specific countries, such as Japan and South Korea with their large classes but high exam scores, or Mexico and early-21st-century-Israel characterized by large class sizes and low achievement levels.

Figure 3. Class size and exam scores on international exams, 1999–2019



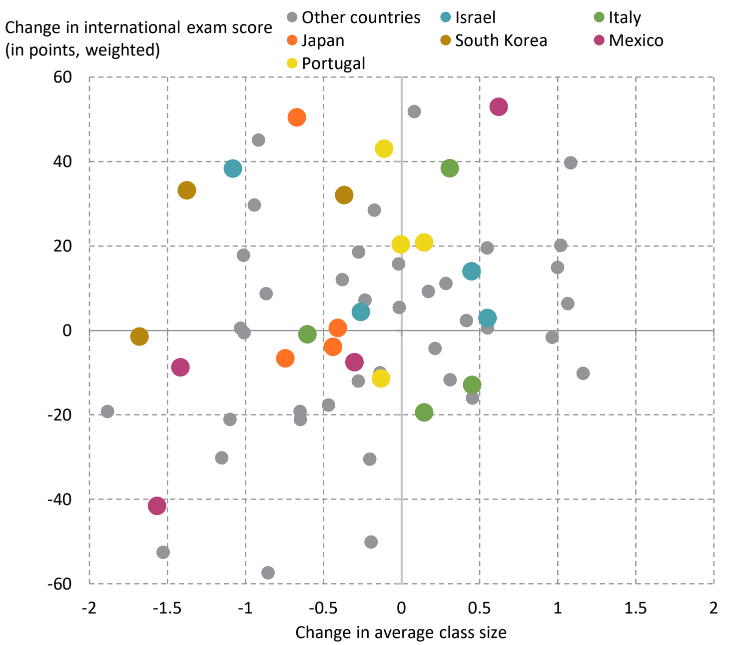
Note: The data presented in the graph represent the four-year average of the mean class size and the composite scores on the international exams for middle school grades.

Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

16 Since each country's trend line is based on only five observations, caution must be exercised when interpreting it.

Figure 4 presents the correlation between the change in class size and the change in scores. Here, too, there is no clear correlation, especially since in most countries, class size has hardly changed over the entire sample period, and in most countries the change in scores was not dramatic either — less than half of a standard deviation, which is 100 points.

Figure 4. Change in class size and the change in scores on international exams, 1999–2019

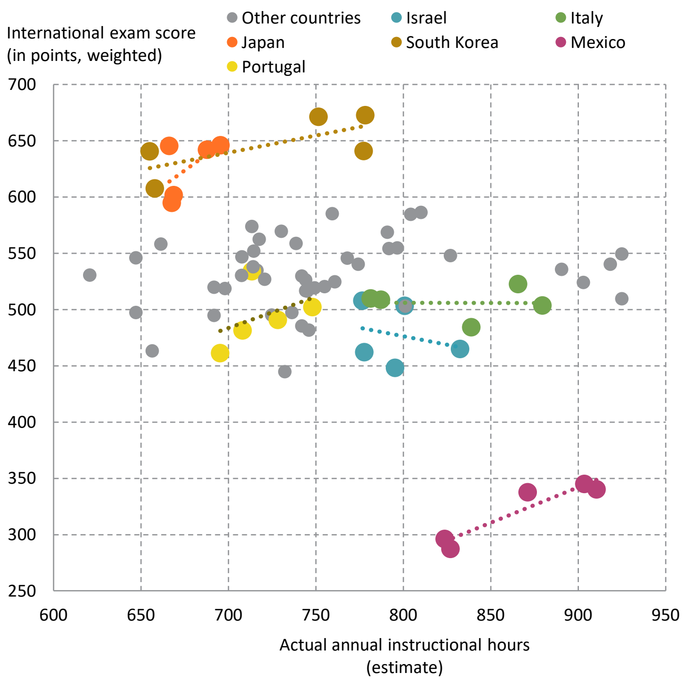


Note: The data presented in the graph represent the four-year average of the mean class size and the composite scores on the international exams for middle school grades.

Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

Figure 5 presents the correlation between actual annual instructional hours (as noted, this is an estimate based on the findings of the TALIS study — the OECD Teaching and Learning Survey) and exam scores. Here too, a clear international correlation cannot be identified, and as we observed in Figure 3 which dealt with class size and scores, the main variation is among countries. For example, the average difference between Mexico and Japan is immeasurably greater than the changes observed within each country over the period.

Figure 5. Actual annual instructional hours and international exam scores, 1999–2019

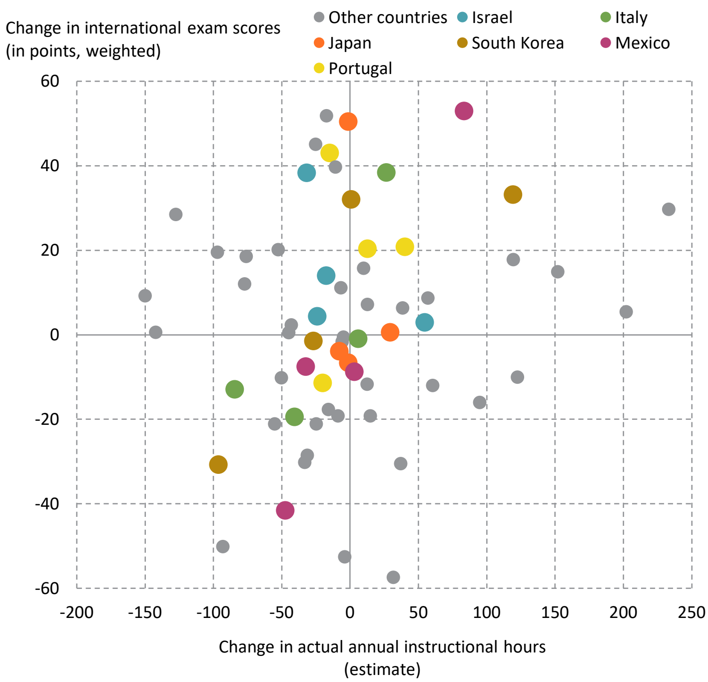


Note: The data presented in the graph represent the four-year average of actual instructional hours (estimate) and the composite scores on the international exams for middle school grades.

Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

Figure 6 illustrates the correlation between change in annual instructional hours and the changes in exam scores, similar to Figure 4, which focused on changes in class size and exam scores. However, unlike that figure, here it is evident that many countries have increased or decreased instructional hours significantly over the years, allowing us to identify an international trend whereby changes in instructional hours correspond to a modest change in exam scores in the same direction. However, this correlation is far from universal, as can be observed in the changes over the period in Israel.

Figure 6. Change in actual annual instructional hours and the change in international exam scores, 1999–2019



Note: The data presented in the graph represent the four-year average of changes in actual instructional hours (estimate) and changes in the composite scores on the international exams for middle school grades.

Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Source: OECD; IEA; TALIS

Even if additional instructional hours do indeed contribute to student achievements, the absence of a positive relationship between the two variables in an international cross-section may be indicative of inverse causality. It is possible that countries determine the amount of inputs based on past scores, especially in countries where student achievements do not meet expectations. In such cases, when the country responds to inadequate exam scores by increasing instructional hours (and possibly decreasing class size), the positive impact may be obscured, and one may even measure what appears to be a negative effect. In any case, the graph does not provide evidence supporting a significant positive relationship between instructional hours and exam scores across countries, which echoes a familiar assertion presented in the literature (e.g., Baker et al., 2004).[17]

Another possible explanation for the absence of a positive relationship in the international comparison is the between-country variation on two key variables: the number of instructional hours in primary and middle school education (both in the year of the PISA or TIMMS exam and also cumulatively) and the number of hours devoted to out-of-school learning, such as homework and private tutoring, which are not included in the estimates for the year of the exam.[18]

Table 1 presents countries according to their change in scores (in points) from 1999 to 2019. The eight countries marked in blue reduced both instructional hours and class size (a group including Israel). A notable outlier in this group is Slovakia, which experienced a dramatic decrease in average scores. However, in five of these countries, including Israel, the average scores increased. As clearly evident from Figures 3 and 5 and Table 1, various trends concerning class size and instructional hours in secondary education were observed in

17 Attempting to estimate the relationship between the number of instructional hours and academic scores while controlling for past scores within a continuous panel framework yields similar findings in terms of magnitude, as shown in Table 4 in the Appendix, but lacks statistical significance — both with and without lags.

18 The exceptional performance of East Asian countries such as China, Japan, South Korea, and Singapore in international tests is commonly attributed to the phenomenon of private tutoring, which is particularly prominent in these countries. However, Rappleye and Komatsu (2020) refrain from making such a definitive assertion, (at least regarding Japan). Additionally, Bray and Kobakhidze (2014) found that this phenomenon is progressively expanding and thriving in many other countries, which differ significantly from each other in their achievements. In any case, we do not observe any semblance of this phenomenon in our data, and its correlation with instructional hours on one hand and scores on the other may bias the correlation we attempt to estimate.

different countries over the past two decades (similar variations are also evident in other educational stages). For instance, Denmark and the United States, which increased both class size and instructional hours, demonstrated improvements in academic achievements. In contrast, Spain, which also increased both variables, experienced a decline in academic performance. Moreover, some countries that increased instructional hours and decreased class size saw improving achievements (e.g., Japan), while others experienced declines (e.g., Finland, Czechia, and Mexico).

Given these diverse trends, we conclude that in addition to budgetary variables — such as class size and instructional hours, which may be important but clearly do not determine scores on their own — there are non-budgetary variables, such as pedagogical and organizational factors, that also influence academic achievements (as asserted in Blass, 2020).

Table 1. Changes in class size, the number of instructional hours, and the average exam score, 1999–2019

Country	Change in instruction hours	Change in class size	Change in average exam score
Slovakia	-56.94	-4.55	-110.58
Australia	-18.35	-1.28	-32.26
France	-13.09	0.93	-25.47
Finland	80.59	-0.51	-20.56
Czechia	19.44	-0.54	-12.86
Spain	77.25	0.24	-7.08
Mexico	6.90	-2.67	-4.83
Hungary	-95.52	-0.77	-4.22
Italy	-92.21	0.30	5.09
US	52.77	2.34	7.85
Austria	-111.01	-2.92	8.93
Denmark	180.78	1.22	22.98
South Korea	-2.93	-8.48	32.92
Japan	18.97	-2.27	40.46
Russia	-139.65	-0.72	55.15
Germany	-10.26	-0.65	57.04
ISRAEL	-18.54	-3.35	59.64
Portugal	18.06	-0.11	72.78

Note: The countries that decreased both class size and instructional hours are highlighted in blue.
Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

Multivariate analysis

In an attempt to formulate broader conclusions regarding the relationship between student achievements and variables such as class size, instructional hours, and other determinants (e.g., expenditure per student), we conducted multivariate analyses of several "production function" models using the available international data.[19] When these models include the countries' "fixed effects" (long-term average scores that correspond to unobserved time-invariant local characteristics), the between-country variance — which constitutes the lion's share of variance in our data — is neutralized, and the explanatory power of the model is significantly diminished. The independent variables were not consistently significant, and the models as a whole explained very little of the variation in student achievements.

Nontheless, we conducted several estimations that did not include country fixed effects, exploiting as much of the variation in the sample as possible. It is worth noting, however, that in this specification, it is possible that the differences in the explanatory variables correspond to unobserved country-specific characteristics. This possibility complicates the interpretation of the statistical estimation results. Nonetheless, in all of these estimations, the effect of class size had a marginal statistical significance, with a consistently negative coefficient. Surprisingly, the effect of the number of instructional hours was negative and of greater statistical significance.

19 For the empirical estimation, we adopted two distinct models employing different data pooling methods: single-year averaging and multi-year averaging. The first model, which utilizes all 197 observations, exhibits higher statistical power but it does not allow for the study of effects over time due to its non-continuous nature (tests are not conducted at fixed time intervals). For the second model we divided the years 1999–2019 into five consecutive and equally spaced sub-periods, and then averaged all the variables for each country in each of the periods. This approach allowed us to investigate temporal effects (such as the relationship between past scores and current educational inputs). However, the dataset was reduced to 116 observations (and even fewer when accounting for temporal disparities). The descriptive statistics of the dataset employed in our analysis are presented in Table 2 in the Appendix, and the results of the models are displayed in Tables 3 and 4. In all models, the estimated equation for country *i* in year *t* is as follows:

$$(score)_{i,t} = \alpha_i \left(class\ size_{i,t}\right)^{\beta_1} \left(instruction\ hours_{i,t}\right)^{\beta_2} \left(expenditure_{i,t}\right)^{\beta_3}$$

In addition to examining the relationship between the differences in the inputs and student achievements, we estimated the relationship between the *changes* in the inputs and *changes* in student achievements. This model, with its complete results presented in Table 5 in the Appendix, explored the link between changes in the country's average scores over time and changes in the average class size and instructional hours. Again, this model did not yield statistically significant evidence of a clear-cut relationship. Changes in average class size or instructional hours (both nominal or actual) did not correspond to changes in scores, even after controlling for expenditure per student (as a rough proxy for the "quality" of inputs), the previous score, class size, and for instructional hours during the previous period — the starting point from which all changes were measured. On the contrary, a higher previous score, smaller class size, and more instructional hours all predict a smaller change (a smaller increase or a larger decrease) in the score. This finding likely reflects the diminishing marginal returns of educational inputs.

Summary

In a previous study (Blass, 2020), we demonstrated that within the Israeli education system, reducing the number of teacher work hours per class allows for a similar reduction in the maximum number of students per class, without necessitating additional budget allocation for additional teaching staff. In the same study we explored potential strategies to address the need to increase the number of classes due to the decrease in the maximum number of students per class.

In this study, our objective was to construct an integrated dataset that would enable us to examine the substitutionality between class size and instructional hours, and to investigate whether it was possible to reduce class size and instructional hours simultaneously without adversely impacting academic achievements. To achieve this, we analyzed the average scores of countries that participated in international exams between 1999 and 2019, using available data on the average class size in those countries, the number of instructional hours allocated to students in each country, and the expenditure per student as a percentage of the per capita GDP.[20] Relying solely on these educational

20 There are certainly other variables that influence student achievements, such as teacher quality, curriculum design, school environment, and more. However, since relevant data on these factors were not available for all countries, we did not include them in our study.

inputs, as important as they may be, imposes limitations on the analysis and complicates the assessment of the "educational production function" — the relationship between inputs and outcomes within an education system. Nevertheless, examining the statistical relationship between these inputs and test scores (even without considering other outcome variables) across multiple countries over an extended time period can indicate the *sign* of the causal relationship if it exists or, conversely and equally important, cast doubt on its existence.

The analysis of the statistical models — the 1-year averaged model (discontinuous/with gaps) and the 4-year averaged model (continuous), divided into five-year periods — presents a somewhat similar picture to that depicted in the descriptive graphs. In both cases, a weak yet significant relationship is found between class size, actual instructional hours, and academic achievements. The less anticipated finding is that the direction of the relationship of instructional hours is negative, suggesting the possibility that an increase in instructional hours may not only be unrelated to improved academic achievement but could also potentially hinder it.[21] Even when accounting for previous instructional hours and academic achievements, the negative relationship persists. This finding appears counterintuitive and contradicts educational experience; however, it reinforces the assertion that a reasonable reduction in instructional hours allocated to each class may not necessarily harm academic achievements (for example, see Figure 1 in the Appendix). Accumulating evidence suggests that in many cases, the significant loss of instructional hours due to the lockdowns during the COVID-19 period did not coincide with a decline in academic achievements, and even when there was a decline, it was not substantial.[22] This finding justifies at least

21 This phenomenon can be explained by several possible factors, (for instance, beyond a certain threshold, the addition of extra instructional hours might have a negative impact because students become less receptive to further learning, or the increase in instructional hours, similar to the reduction in class size, may predominantly occur in classes with weaker students), but it is worthwhile to investigate this more thoroughly.

22 In the "Imagine" conference hosted by the Trump Foundation in Tel Aviv in November 2022, Prof. John Hattie referenced research findings indicating that the significant loss of instructional hours during the COVID-19 lockdowns did not result in a substantial decline in academic achievements (usually between 0.03 to 0.07 standard deviations) (Hattie, 2022). According to data from the National Assessment of Educational Progress (NAEP) in the United States, there was a decline of 5 points in the average reading score (from 220 to 215) and a decline of 7 points in the average mathematics score (from 241 to 234) during the pandemic. Some sources mentioned that this was the largest drop in reading scores since 1990 and the first in mathematics since records began (NAEP, 2022).

discussing whether it is worthwhile to “sacrifice” a certain degree of decline in academic achievements to gain more significant benefits in other essential educational areas.

Our findings indicate that comparing the achievements of numerous countries in international exams does not allow for a clear causal relationship to be established between changes in class size or instructional hours and academic achievements. Even substantial changes in class size, when made in parallel with changes in instructional hours, do not provide definitive evidence of a clear direction of changes in academic achievements. Moreover, even in countries where changes in both or one of these variables coincided with parallel changes in academic achievements, the direction of the effect is not conclusive. Some countries improved student performance when reducing class sizes and instructional hours, while others with the same policy experienced opposite results (see Table 1). It appears that changes in class size or in the number of instructional hours are not necessarily linked to changes in academic achievements, and that a significant and persistent improvement in academic achievements can only be obtained if such changes are contingent upon pedagogical approaches tailored to the unique realities of each specific situation — whether at the level of school, region, or country.

At first glance, this finding may seem disappointing, as researchers typically hope to find clear and significant statistical correlations — and, if possible, causal links — between independent and dependent variables. Nonetheless, in practice, this crucial finding should inform those in charge of national educational systems. Its importance lies in the possibility that reducing instructional hours alongside decreasing class size may not necessarily negatively impact academic achievements. This finding shifts the focus to a great extent away from the debate over reducing class size which involves the associated budgetary costs of increasing the number of teachers and classes on the one hand, and the concerns of potential severe negative consequences on academic outcomes on the other hand.[23] As a result, the discussion shifts to focus on the educational, social, and professional advantages and disadvantages associated with reducing class sizes and the pedagogical and organizational steps needed to accompany such changes.[24]

23 In the Israeli reality, this argument is based on findings by Blass (2020).

24 It is reasonable to assume that such a process would entail specific expenditures for construction and foregoing various components of the current school activities performed using non-frontal teacher work hours in a full class setting.

Accordingly, the true critical question is not whether reducing class size is feasible from a budgetary perspective. The question now pertains to *whether reducing class size alongside a decrease in instructional hours is a valid and advisable course of action*, considering all the educational, social, and professional implications, including on academic achievements. The fact remains that at least five countries have improved their students' achievements concurrently with reducing class size along with the number of instructional hours in one way or another.[25] The caveat is that over the 20-year period under examination, there may have been other developments and events that have facilitated these outcomes, but this does not undermine the argument. On the contrary, it reinforces it by turning the spotlight away from the debate on class size and instructional hours and towards other educational and organizational variables that need to be considered.

As noted earlier, until a large-scale controlled trial is conducted to assess the advantages and disadvantages of such an approach (see the proposal in the Appendix), factoring in the magnitude of changes in each of the variables, we will not be able to provide a definitive answer to this question. However, given the practical, budgetary, and methodological challenges associated with such a large-scale trial, it may be initially worthwhile to analyze the natural experiment that occurred in Israel during the COVID-19 period. During that time, different age groups studied in diverse settings with varying numbers of instructional hours and class sizes. To do so, this analysis would require a thorough investigation of the academic achievements of Israeli students on international exams.[26] At a later stage, it is worthwhile to thoroughly study the feasibility of conducting a controlled trial to assess the impact of reducing class sizes and working hours (not necessarily instructional hours) on academic achievements, as well as other important variables such as teacher and parent satisfaction, improved inclusion of students with special needs in integrated classes, reduced school violence, and more.

25 Countries such as Austria, South Korea, Russia, Germany, and Israel have been mentioned in Table 1 above.

26 Due to significant changes in the format of high school matriculation exams and the cancellation of the Meitzav exams during the COVID-19 period, it is not possible to conduct a comprehensive study.

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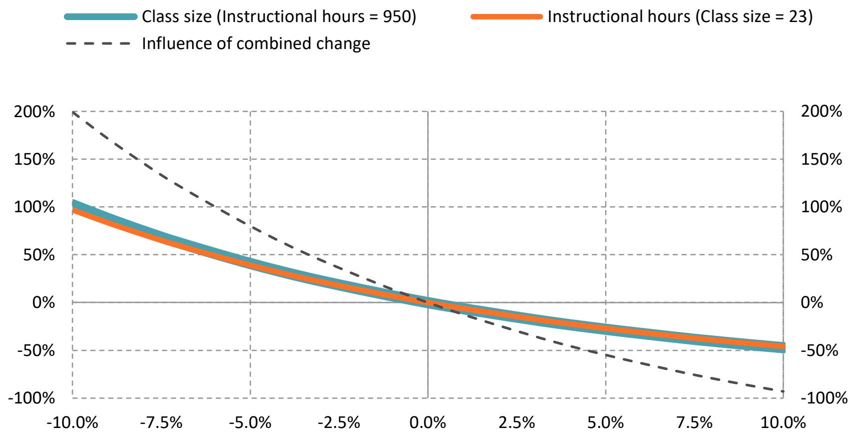
Appendix

Appendix Figure 1. The effect of the change in class size and number of instructional hours on scores



Note: The graph presented here corresponds to Figure 2 in the main body of the paper, but it is based on statistically significant estimates of score elasticity with regards to class size and instructional hours, as shown in column (8) of Table 3 in the Appendix. The graph suggests that reducing class size concurrent with a decrease in instructional hours would yield a positive impact on attainments (assuming that the reduction in hours is proportional to the class size reduction).

Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD: IEA; TALIS

Appendix Table 1. The OLS regression: The relationship between class size and percentage of hours devoted to actual learning

	Dependent variable: Percent of instructional hours devoted to frontal instruction, national average	
	Full sample	Full sample, no class size outliers
Explanatory variable		
Average class size (number of students, middle school)	-0.0035***	-0.0038***
	(0.001)	(0.002)
Intercept	0.8670***	0.8732***
	(0.035)	(0.039)
R^2	0.138	0.143
Number of observations	42	39

Note: The full sample includes 42 observations (country-year) for which data on both the instructional hours devoted to actual learning in 2013 or 2018 and the average class size in that year or in a year adjacent to it. The column titled “No class size outliers” omitted three observations in which class room size was more than 2 standard deviations from the global average.
Significance level: * p < 0.10; ** p < 0.05; *** p < 0.01.
Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

Appendix Table 2. Descriptive statistics: The multi-variate model

Variable	Single-year average	Multi-year average (without lags)	Multi-year average (with lags)
Number of observations	197	116	87
Normalized score	500	500	500
	(100)	(100)	(100)
Average class size	23.1	23.3	23.3
	(3.8)	(4.1)	(4.1)
Nominal annual instructional hours	949.3	948.1	947.2
	(116.3)	(108.1)	(106.2)
Actual annual instructional hours (estimate)	749.9	478.6	478.2
	(88.2)	(81.4)	(80.4)
Per student expenditure (% of GDP)	2.4%	2.4%	2.4%
	(0.5%)	(0.5%)	(0.5%)
Periodic change in exam score			1.4
			(25.8)
Periodic change in class size			-0.4
			(1.3)
Periodic change in nominal instructional hours			-23.0
			(123.8)
Periodic change in actual instructional hours (estimate)			-17.4
			(97.7)

Note: Each cell in the table displays the average value and below it in parenthesis, the standard error.
Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: OECD; IEA; TALIS

Appendix Table 3. Regression results: 1-year averaged model (discontinuous/with gaps)

	Dependent variable (single-year)								
	Composite scores					PISA score	TIMSS score	Composite math score	Composite science score
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Explanatory variables, natural log:	With per student expenditure	With per student expenditure, actual instruction hours	Without per student expenditure	Without per student expenditure, without fixed effects	With per student expenditure, without fixed effects	With per student expenditure, without fixed effects	With per student expenditure, without fixed effects	With per student expenditure, without fixed effects	With per student expenditure, without fixed effects
Average class size	0.008	0.011	0.025	-0.016	-0.113*	-0.0851*	-0.1323	-0.1494*	-0.115
	(0.069)	(0.0686)	(0.0658)	(0.0801)	(0.0624)	(0.0534)	(0.1269)	(0.0771)	(0.556)
Nominal annual instructional hours	0.025		0.026	-0.209***	-0.138**	-0.1325**	-0.1117	-0.1554**	-0.1365**
	(0.022)		(0.019)	(0.0776)	(0.0624)	(0.0521)	(0.1269)	(0.0635)	(0.0578)
Actual annual instructional hours (estimate)		0.025							
		(0.0221)							
Per student expenditure	-0.001	-0.001			0.004**	0.0051**	0.0032	0.0041**	0.0043**
	(0.0011)	(0.0011)			(0.0017)	(0.0018)	(0.0031)	(0.0019)	(0.0018)
Fixed effects at country level	Yes	Yes	Yes	No	No	No	No	No	No
R^2	0.03	0.03	0.02	0.18	0.39	0.44	0.23	0.41	0.40
F	1.3	1.3	1.8	4.19	6.8	34.3	3.2	36.7	35.1
(p-value)	(0.261)	(0.257)	(0.163)	(0.016)	(0.000)	(0.000)	(0.0344)	(0.000)	(0.000)
Number of observations	168	168	197	197	168	143	41	168	168
(Countries)	(32)	(32)	(33)	(33)	(32)	(31)	(15)	(32)	(32)

Note: By composite scores, we refer to composite scores comprised of the average of the sub-scores in relevant subjects on the various exams. Every regression included an intercept, and standard errors were clustered at the country level. In estimations with fixed effects, dummy variables for each country were not included; instead, demeaning was performed on the score itself according to the country (i.e., the model examines the impact of educational inputs on the residual score that is not explained by time-invariant aspects of each country's education system.) Therefore, the R^2 and F values, which help approximate the goodness-of-fit, consider only the variables presented in the table, excluding any predictive power of the fixed effects themselves.
Significance level: * p < 0.10; ** p < 0.05; *** p < 0.01.
Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: IEA; OECD; TALIS

Appendix Table 4. Regression results: Multi-year averaged model (discontinuous/with gaps)

	Dependent variable: Natural log of the composite four-year average exam score						
Explanatory variables, natural log:	(1) Without per student expenditure	(2) With per student expenditure, nominal instructional hours	(3) Without per student expenditure, actual instructional hours	(4) Without per student expenditure, excluding fixed effects	(5) With past exam scores, nominal instructional hours	(6) With past exam scores, actual instructional hours	(7) With past exam scores, excluding fixed effects
Average class size	0.066	0.065	0.066	-0.001	-0.027	-0.025	0.023
	(0.0830)	(0.095)	(0.0941)	(0.0846)	(0.0738)	(0.0739)	(0.0163)
Nominal annual instructional hours	0.015	0.013		-0.216**	0.023		-0.046***
	(0.012)	(0.0167)		(0.0829)	(0.0153)		(0.0171)
Actual annual instructional hours (estimate)			0.015			0.024	
			(0.0167)			(0.0152)	
Per student expenditure		-0.001	-0.001		-0.002	-0.002	0.0006
		(0.0017)	(0.0017)		(0.0019)	(0.0019)	(0.0007)
Previous exam score					0.308***	0.308***	0.844***
					(0.0664)	(0.0666)	(0.0416)
Fixed effects at country level	Yes	Yes	Yes	No	Yes	Yes	Yes
R^2	0.04	0.04	0.04	0.17	0.21	0.22	0.88
F	3.16	0.76	0.81	3.54	10.83	10.85	145.97
(p-value)	(0.047)	(0.521)	(0.492)	(0.032)	(0.000)	(0.000)	(0.000)
Number of observations	128	116	116	128	98	98	98
(Countries)	(33)	(32)	(32)	(33)	(31)	(31)	(31)

Note: Every regression included an intercept and standard errors were clustered at the country level. In estimations with fixed effects, dummy variables for each country were not included; instead, demeaning was performed on the score itself according to the country (i.e., the model examines the impact of educational inputs on the residual score that is not explained by time-invariant aspects of each country's education system.) Therefore, the R^2 and F values, which help approximate the goodness-of-fit, consider only the variables presented in the table, excluding any predictive power of the fixed effects themselves.
Significance level: * p < 0.10; ** p < 0.05; *** p < 0.01.
Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: IEA; OECD

Appendix Table 5. Results of the difference model: 1-year averaged model (discontinuous/with gaps)

	Dependent variable: Change in the natural log of the composite four-year average exam score						
Explanatory variables, natural log:	(1) Without per student expenditure	(2) With per student expenditure, nominal instructional hours	(3) With per student expenditure, actual instructional hours	(4) Without per student expenditure, excluding fixed effects	(5) With past exam scores, nominal instructional hours	(6) With past exam scores, actual instructional hours	(7) With past exam scores, excluding fixed effects
Change in average class size	-0.0145	-0.0104	-0.102	0.0071	0.0204	-0.0221	-0.0097
	(0.0678)	(0.0765)	(0.0786)	(0.0528)	(0.0685)	(0.0697)	(0.0524)
Change in nominal annual instructional hours	-0.0099	0.0007		0.0013	0.0157		0.0144
	(0.0218)	(0.0284)		(0.0117)	(0.0199)		(0.0140)
Change in actual annual instructional hours (estimate)			0.0014			0.0168	
			(0.0282)			(0.0196)	
Per student expenditure		-0.0008	0.0000		-0.0020	-0.0020	0.0008
		(0.0023)	(0.0007)		(0.0019)	(0.0019)	(0.0007)
Previous exam score					-0.7743***	-00.7749***	-0.1485**
					(0.0822)	(0.0821)	(0.0574)
Fixed effects at country level	Yes	Yes	Yes	No	Yes	Yes	No
R^2	0.0040	0.0052	0.0052	0.0003	0.5074	0.5081	0.1206
F	0.12	0.10	0.10	0.02	29.47	29.59	3.28
(p-value)	(0.885)	(0.962)	(0.962)	(0.977)	(0.000)	(0.000)	(0.015)
Number of observations	93	87	87	93	87	87	87
(Countries)	(27)	(26)	(26)	(27)	(26)	(26)	(26)

Note: In each regression, an intercept and country-level standard errors were included.
Significance level: * p < 0.10; ** p < 0.05; *** p < 0.01.
Source: Nachum Blass, Benjamin Bental, and Michael Debowy, Taub Center | Data: IEA; OECD

Controlled trial

During the COVID-19 crisis, many local authorities increased the number of days students were allowed to attend school in groups of up to 20 students, enabling them to have approximately 25 hours of instruction per week. Each authority implemented a solution that best suited its needs. To the best of our knowledge, no attempt was made to examine the academic and educational outcomes of these interventions.

We propose that the Ministry of Education conduct a trial, accompanied by longitudinal research, aimed at examining the impact of changes in class size and instructional hours on students' academic and educational achievements. Our recommendation is that the experiment focus on assessing the impact on mathematics and English for two main reasons: first, because the number of weekly instructional hours allocated to these subjects is greater, and second, because most research has shown that the impact of formal education is more significant in these subjects relative to others.

Research Design: The participating schools will have two or three parallel classes at each grade level. Students will be randomly assigned to different groups of varying sizes; the largest group will receive the highest number of instructional hours per week, while the smallest group will receive the fewest hours. The composition of the groups will change periodically to ensure that each student will study in groups of all class sizes and instructional hours. The curriculum will remain consistent across all groups and will be taught by the same teacher. At the beginning and end of each period, an achievement exam will be conducted. The goal is for each student to participate in all class size and instructional hour scenarios.

At the end of each period, data will be gathered on the progress of the learning group as a whole and of each student individually, regarding the material studied, as well as the satisfaction levels of students and parents. Additionally, during the experiment, observations will be made regarding the teaching methods and student behavior in each group.

The research can start as a pilot study in one or two schools, focusing on one subject, and then gradually expand to involve more schools, different grade levels, and additional subjects.