ABSTRACT

Title: On the relationship between learning time and students' academic performance in

58 countries

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Abstract: *(minimum 300 words)*

The time that students have for learning is very relevant and, because of that, it is at the core of the education debate. In this study we analyse whether this time is contributing to students' competences or not and, in particular, we study the influence of weekly instruction and homework time on students' competences. For this purpose, we employ TIMSS 2019 data for 4th grade students in 58 countries. We go beyond correlation by using student fixed-effects within-students between-subjects. Our results indicate that weekly instruction and homework time do not have an influence on students' competences in most of the countries under analysis, whereas they have a low positive one in some of them.

Keywords: *(maximum 6 words)* weekly instruction time; weekly homework time; student fixed-effects; TIMSS; fourth grade.
JEL codes: I20, I21, I28.

1. Introduction

The use that students make of their learning time has been at the core of education debate for many years. This, joined to the increasing relevance that international large-scale tests (such as e.g. PISA[1] or TIMSS[2]) have gained to measure students' competences and skills, has led to questioning whether students and schools are making the most of the time students spend in their education. However, research on this subject is far from conclusive. In particular, there are two main types of learning time that students have to develop their competences: weekly instruction time, i.e. learning time at school, and homework time, i.e. out-of-school learning time; both of them will be the focus of the present research study.

Regarding school learning time, this is, *weekly instruction time*, there is a strand of the literature which indicates that it does not have an influence on students' academic performance. This result was found by authors such as Woesmman (2010), who studied 16 states in Germany for three subjects and three years, or Lopez-Agudo and Marcenaro-Gutiérrez (2018), who analysed PISA 2015 data for Spain. Nevertheless, other strand of the literature (with higher amount of research works) indicates that there is a positive relationship between weekly instruction time and students' academic performance. Some of these research studies are those of Lavy (2015) for 50 countries in PISA 2006, Rivkin and Schiman (2015) for 72 countries in PISA 2009, Cattaneo, Oggenfuss, and Wolter (2017) for Switzerland in PISA 2009, Andersen, Humlum, and Nandrup (2016) for students in Denmark, and Meroni and Abbiati (2016) for sixth grade Italian students. Furthermore, some meta-analyses have also indicated this positive relationship; for instance, Patall, Cooper, and Allen (2010), who analysed the influence of weekly instruction time in 15 studies since 1985, and Walberg, Niemiec, and Frederick (1994), who studied 100 works on this topic.

Other studies such as OECD (2011) or Mullis, Martin, Foy, and Drucker (2012) indicated this positive relationship, but also remarked that not all types of weekly instruction time improve students' academic performance; only instruction time in high quality lessons would improve it. For instance, Baker, Fabrega, Galindo, and Mishook

[1] Programme for International Student Assessment.
[2] Trends in International Mathematics and Science Study.

(2004) indicated, for 52 countries that participated in PISA 2000 and TIMSS 1999 tests, that a higher amount of weekly instruction time does not seem to positively influence students' academic achievement, indicating that this positive influence may be due to other factors such as instruction time quality. Gromada and Shewbridge (2016) and OECD (2013), for PISA 2012, also remarked that a higher amount of weekly instruction time should be accompanied by an improvement on its quality – e.g. by teaching quality or classroom climate – to improve students' academic performance. Others such as Aronson, Zimmerman, and Carlos (1999) indicated that weekly instruction time can only be converted into higher academic performance if students are kept engaged with the lessons, so this instruction time can be effectively used.

Regarding the out-of-school use of students' learning time, i.e. *weekly homework time*, it has been usually perceived by educators as the main way in which students learn when they are not at school. This homework has been defined by authors like Corno and Xu (2004) as the "job of childhood", to the extent that it develops students' responsibility and attitude, preparing them for their future work. Nevertheless, schools and parents usually disagree in the homework issue, due to the high amount that parents perceive their children are receiving, in contrast with the normal amount perceived by teachers (Cooper, 2001). This has reached to the point in which parents think that their children could be "wasting their childhood" due to this amount of homework[3], a situation which has even provoked "homework strikes" in some countries[4].

As with weekly instruction time, previous research studies on this issue have shown somewhat mixed results. One strand of the literature points towards a positive influence of weekly homework time on students' academic performance. For instance, Cooper, Robinson, and Patall (2006) performed a meta-analysis on studies conducted between 1987 and 2003 in the United States, finding a positive correlation of 0.60 standard deviations (SDs) of weekly homework time on students' achievement. Scheerens, Luyten, Steen, and Luyten-de Thouars (2007) also performed a meta-analysis of 21 studies, but obtained a much lower effect size of 0.073 SDs. They also

[3] As indicated in "The guardian" newspaper: https://www.theguardian.com/world/2016/nov/02/spanish-parents-urged-to-put-children-on-weekend-homework-strike

[4] As indicated in "Dailymail Online" newspaper: http://www.dailymail.co.uk/wires/ap/article-3807263/Goodbye-homework-elementary-schools-classes.html

indicated that the strength of the association depends on the country, with the largest effect sizes found in the Netherlands and the United States. Higher results were found by Hattie (2009), who performed a meta-analysis on a total of 5 meta-analysis composed by 161 studies, finding an effect size of 0.29 SDs, which ranged from 0.15 in primary education to 0.64 in high school. Likewise, Hendriks, Luyten, Scheerens, and Sleegers (2014) performed a meta-analysis of 17 studies at individual level and 10 studies at school/class level, finding a very small positive effect size of around 0.05 SDs. Other authors such as Scheerens and Hendriks (2014) performed a comprehensive review of the literature to analyse this influence of weekly homework on students' academic achievement, finding an effect size of 0.29 SDs, whereas Baş, Şentürk, and Ciğerci (2017) carried out a meta-analysis on 11 studies and found a smaller average effect of approximately 0.20 SDs.

These positive-association results of the meta-analyses are consistent with the few cross-national analyses conducted to date. In this sense, OECD (2011) indicated that students who did more homework in developed countries performed higher in science. Similarly, Falch and Rønning (2012) performed a cross-national analysis on 16 countries and also found a positive association of around 0.20 SDs, while Murillo and Martinez-Garrido (2014) used data from Latin American students and found that weekly homework time presented a positive influence on students' academic achievement, but only when teachers gave feedback to students and built upon their work in subsequent classes.

On the other hand, Dettmers, Trautwein, and Lüdtke (2009) found mixed results for 40 countries participating in PISA 2003, indicating a positive relationship between weekly homework time and academic achievement in some countries, but a negative one in other countries. Baker and LeTendre (2005) also analysed the correlation between weekly homework time and academic performance in mathematics for many countries that participated in TIMSS 1999, finding a negative association.

Therefore, it seems that there are no conclusive results about the influence of weekly homework time on students' academic performance, so it requires further research. Indeed, Trautwein and Köller (2003) performed a review of 20th century homework research and found that the empirical evidence regarding the benefits of

homework is rather weak. These conclusions have been also supported by a recent analysis by the Education Endowment Foundation in the UK on the international literature which indicated, about the influence of weekly homework time on students' academic performance, that "A number of reviews and meta-analyses have explored this issue. There is stronger evidence that it is helpful at secondary level, but there is much less evidence of benefit at primary level" (Education Endowment Foundation, 2017, p. 1). This was also supported by Kohn (2006), who highlighted many limitations of the existing empirical studies on the influence of primary school homework on students' academic performance, ranging these limitations from most existing evidence being purely correlational to low reliance on available homework measures, as they are solely based on students' self-reports.

In this context, the present study employs data from the Trends in International Mathematics and Science Study (TIMSS) 2019 for 4th grade students in 58 countries to delve into the relationship between weekly instruction and homework time and students' competences. This research study is novel in at least two ways: (a) first, we intend to go beyond correlation on the analysis of the influence of weekly instruction and homework time on students' competences, by the use of student fixed-effects within-students between-subjects; (b) second, we explore this issue for 58 countries, which enhances the external validity of our results.

The rest of the paper is structured as follows: we describe the data and methodology employed, followed by the results, their discussion and conclusions.

2. Data

The present study employs recent TIMSS data for 2019. This international large-scale assessment test was conducted by the International Association for the Evaluation of Educational Achievement (IEA) and intends to provide a measure of 4th and 8th grade student competences in mathematics and science for the 58 participating countries. For this purpose, students take mathematics and science cognitive tests, together with a student questionnaire, a household questionnaire completed by the parents, and teachers take another one about their teaching. A two-stage cluster sample design is employed in TIMSS (Martin, von Davier, & Mullis, 2020): in the first stage, schools are sampled

with probabilities proportional to their size, whereas all students in one or more classes within the school are chosen to participate in the second stage.

In the present study we focus on 4th grade students (i.e. primary education students), and we take advantage of the information provided by teachers about the weekly minutes of instruction time received by students and also weekly minutes of assigned homework time; both variables were converted into hours to facilitate the interpretation of our results. These variables are separately reported for mathematics and science, which will let us apply our identification strategy, as we will see in the following section.

In order to reduce the burden and time of taking the whole set of questions, the IEA created a booklet structure so that students who participated in TIMSS only had to answer a set of mathematics and science questions that were included in 22 booklets. Therefore, students did not answer all questions, so their scores were imputed for those questions that they did not answer using an Item Response Theory (IRT) model – more information can be found in Martin, von Davier, and Mullis (2020). However, according to Jerrim, Lopez-Agudo, Marcenaro-Gutierrez, and Shure (2017), student fixed-effects would not be correctly applied if imputed values are used, so we created alternative cognitive scores using students' responses. In order to do this, a value of 1 has been assigned to "Correct response", 0.5 to "Partially correct response" and 0 to "Incorrect response". Then, the scores of all the questions answered by the student have been added to create cognitive scores, which have been standardised by country.

3. Methodology

The methodology employed in this research study is student fixed-effects within-students between-subjects (mathematics and science). In particular, the model that has been specified is:

$$Y_{sijc} = \alpha + \beta IT_{sijc} + \gamma HT_{sijc} + \delta X_{sijc} + \vartheta SCH_{sjc} + \varepsilon_{sijc} \quad (1)$$

where s represents the subject ($s = 1$ for mathematics and $s = 2$ for science), i for student, j for school and c for country (for $c = 1, \ldots, 58$ countries). Y_{sijc} are students'

standardised cognitive scores[5]; α is a constant term; IT_{sijc} is weekly instruction time; HT_{sijc} is weekly homework time; X_{sijc} are student characteristics (e.g. sex, socio-economic status, etc.); SCH_{sjc} are school characteristics (e.g. school funding, school area, etc.); ε_{sijc} is the idiosyncratic error term.

In the following, we take differences between-subjects to apply student fixed-effects, reaching to the base model:

$$\Delta Y_{sijc} = Y_{1ijc} - \Delta Y_{2ijc} = \beta \Delta IT + \gamma \Delta HT + \delta \Delta X + \vartheta \Delta SCH + \Delta \varepsilon \qquad (2)$$

To the extent that student and school characteristics are similar between-subjects, $\Delta X = 0$ and $\Delta SCH = 0$. Therefore, the unique source of variation between subjects would be weekly instruction (ΔIT) and homework (ΔHT) time, so β would indicate the influence of weekly instruction time on students' competences and γ would be the influence of weekly homework time on students' competences. However, the differential ability (AB_{sijc}) that students could have in mathematics and science could bias these coefficients. Therefore, a control for students' ability has been included in model (2) using as a proxy of it, alternatively, the student confident in the subject index (presenting a correlation with students' standardised cognitive scores between 0.17 and 0.44 for mathematics and 0.09 and 0.33 for science) and the student likes learning the subject index (presenting a correlation with students' standardised cognitive scores between 0.06 and 0.35 for mathematics and between 0.01 and 0.34 for science), which were created for each subject by the IEA, using information on the student questionnaire[6]. Hence, the final difference model is:

$$\Delta Y_{sijc} = \beta \Delta IT + \gamma \Delta HT + \delta \Delta X + \vartheta \Delta SCH + \Delta AB + \Delta \varepsilon \qquad (3)$$

In these estimations, TIMSS recommended practices have been used (student sampling weights and Jackknife replication weights) in order to account for TIMSS sample design and to correct standard errors[7].

[5] These scores have been standardised using each country's mean and standard deviation in each subject. This is aimed at reporting results as effect sizes, for international comparison purposes.
[6] More information about the creation of these indexes can be found in TIMSS technical report (Martin, von Davier, & Mullis, 2020).
[7] These methodologies cluster at school level better than multilevel estimations (Martin, von Davier, & Mullis, 2020).

4. Results

In the following we present the main results from the model estimated in equation (2). Regarding weekly instruction time, we can see that most of the countries present a null influence; only Armenia and Hong Kong present a negative influence, while Bosnia Herzegovina, Canada, Czech Republic, Germany, New Zealand, Norway, Oman, Poland, Spain, Turkey, United Arab Emirates and the United States present a low positive influence (a maximum of 0.07 standard deviations or SDs per additional hour of weekly instruction). Regarding weekly homework time, it seems that most countries also present a null influence, while countries such as Australia, Belgium Flemish, Denmark, England, France, Germany, Hong Kong, Japan, Lithuania, New Zealand, Philippines, Poland, Portugal, Saudi Arabia, Singapore, Sweden and the United States present a low positive influence (with a maximum of 0.166 SDs per additional hour of weekly homework); however, for Qatar, weekly homework time presents a low negative influence.

-Insert Table 1-

Then, the student confident in the subject index and the student likes learning the subject index have been added, respectively, in Tables 2 and 3. As previously indicated, these variables might serve as a proxy of students' ability in each subject, hence controlling by the potential bias of our results due to unobservables. Both tables show that the coefficients for weekly instruction and homework times do not change; hence, it seems that these unobservables might not be conditioning the influence of the time variables under analysis.

-Insert Table 2-

-Insert Table 3-

5. Discussion and conclusions

In the present study the relationship of weekly instruction and homework time with students' competences has been analysed for 4th grade students in 58 countries. In particular, (a) we went beyond correlation by the use of student fixed-effects within-students between-subjects to analyse this influence; (b) second, we explored this issue

for 58 countries, which enhances the external validity of our results. We have found that, in most of the countries, weekly instruction and homework time do not have an influence on students' competences, although there are some countries in which they present a low but positive influence. These mixed results may explain why previous research works could present differences on this influence, as their results might be conditioned on the education system of the country under analysis.

Regarding *weekly instruction time*, it seems that students may be receiving an excessive amount of unproductive instruction time. As authors such as Gromada and Shewbridge (2016) indicated, this may imply higher monetary costs of education – through, for instance, teachers' salaries, teaching materials, etc. – and higher time costs – e.g. opportunity cost of this time due to time limitations in the activities that students can do in a day, etc. –, which may translate into a waste of resources. However, some parents may feel that this high amount of weekly instruction time is positive, to the extent that they assume that their children are always learning at school, joined to the common parental perception of schools as a kindergarten service (Belle, 1999); this may reduce parents' concern about the effective use of this time for their children's learning. Therefore, divulgation campaigns on these results should provide parents with this information, so they can decide how to use their children's learning time in a better way.

The most likely explanation for these null results may be that TIMSS measures students' skills or competences (as other international large-scale assessment tests such as PISA), which are related to the abilities that students use in their daily life, and not to content-based knowledge, which is more related to memorisation or to mechanical tasks (as indicated by authors such as Ananiadou and Claro, 2009; INEM, 2009; Kohn, 2006; Pamies, Blanco, Granados, & Villanueva, 2015). Therefore, although the TIMSS data do not allow us to determine the causes of the null influence, it seems that the weekly instruction time received by students may not improve their competences, which could be due to a more content-based focus of school lessons. Thus, this may suggest the need of re-orienting school instruction into a competence-oriented approach, so students can improve their skills. This may suppose a change on students' curriculum and also on teachers' formation, so teachers could learn how to design their lessons to improve

students' skills. In fact, this improvement may not only help children in their daily lives, but also in their job seeking, to the extent that these skills are demanded in the labour market (Pamies, Blanco, Granados, & Villanueva, 2015).

Other useful education policy could be reducing the amount of weekly instruction time received by students. This may let students use their free time in other extra-curricular activities or in leisure time, so they could have the opportunity of developing other necessary competences for their social and working lives. In this sense, some literature has indicated that activities such as, e.g., learning to play an instrument (Hille & Schupp, 2015), participating in clubs or playing sports (Lipscomb, 2007) or social activities that help to improve personal and social skills (Durlak, Weissberg, & Pachan, 2010) could help students develop these competences.

Regarding *weekly homework time*, a null influence has been mostly found, which may support the vision of parental organisations that students are receiving a high amount of "unproductive" homework. In a similar way to weekly instruction time, this null influence might be also indicating that students are receiving content-based homework instead of a competence-oriented one (Kohn, 2006). Therefore, higher-quality homework, i.e. competence-oriented homework, may help students improve their skills. In addition, a lower load of homework may provide more out-of-school time to students, so they can develop other competences in extra-activities. Thus, these policies would be oriented at providing students with fewer but high-quality homework, so they can enjoy their youth because, as indicated by Cosden, Morrison, Gutierrez, and Brown (2004, p. 220), it is necessary to "*balance homework with other aspects of the child's home life to promote positive developmental outcomes*".

The present research study has some limitations: first, weekly instruction and homework times are reported by the teacher, so they might be subject to report error. Second, there may be some unobservables which cannot be controlled by the student fixed-effects methodology, so we are cautious when interpreting our results. Third, these results are applicable to 4th grade students, so students from other grades should be analysed.

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Appendix

-Insert Table A1-

Table 1. The influence of instruction and homework time, base model

Countries	Instruction time (weekly hours)		Homework time (weekly hours)		Mathematics (Ref.: Science)		Constant		Observations	R-squared
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.		
Albania	0.015	0.046	-0.008	0.020	-0.029	0.072	-0.043	0.081	3,917	0.777
Armenia	-0.088***	0.028	0.014	0.019	0.143**	0.065	0.171***	0.058	4,345	0.775
Australia	0.005	0.009	0.090***	0.030	-0.034	0.038	-0.024	0.029	4,923	0.799
Austria	0.014	0.015	0.015	0.019	-0.089***	0.033	-0.170***	0.038	5,024	0.760
Azerbaijan	-0.067	0.043	-0.014	0.020	0.151	0.099	0.060	0.069	4,493	0.784
Bahrain	0.002	0.015	-0.049	0.037	-0.011	0.028	0.011	0.063	4,856	0.744
Belgium Flemish	-0.005	0.015	0.064*	0.033	-0.031	0.029	0.032	0.071	4,241	0.767
Bosnia Herzegovina	0.033**	0.016	0.014	0.023	-0.063*	0.036	-0.081*	0.042	4,921	0.762
Bulgaria	-0.013	0.033	0.007	0.012	0.034	0.071	-0.166***	0.055	4,008	0.844
Canada	0.064***	0.013	0.049	0.041	-0.226***	0.048	-0.358***	0.037	12,036	0.753
Chile	0.004	0.007	0.012	0.063	-0.018	0.025	-0.218***	0.042	4,598	0.756
Chinese Taipei	0.000	0.007	-0.009	0.023	-0.053	0.043	-0.140***	0.025	4,762	0.765
Croatia	0.010	0.020	0.000	0.024	-0.046	0.037	-0.189***	0.052	5,102	0.766
Cyprus	-0.008	0.016	0.021	0.024	0.013	0.055	0.042	0.042	3,744	0.797
Czech Republic	0.060***	0.020	-0.011	0.031	-0.179***	0.057	-0.218***	0.038	6,565	0.790
Denmark	0.000	0.012	0.094***	0.022	-0.049*	0.029	-0.129***	0.033	3,358	0.763
England	-0.008	0.019	0.166***	0.046	-0.098*	0.054	-0.194***	0.053	1,504	0.772
Finland	-0.005	0.013	-0.019	0.033	-0.027	0.022	-0.148***	0.030	6,515	0.767
France	0.018	0.011	0.099**	0.039	-0.114**	0.045	-0.177***	0.028	5,171	0.785
Georgia	-0.024	0.015	0.001	0.017	0.035	0.049	-0.003	0.046	4,456	0.773
Germany	0.028**	0.014	0.039**	0.019	-0.167***	0.043	-0.160***	0.037	3,749	0.776
Hong Kong	-0.050***	0.013	0.058*	0.034	-0.162**	0.074	0.023	0.060	1,209	0.769
Hungary	0.010	0.009	-0.003	0.030	-0.064**	0.029	-0.192***	0.029	5,405	0.788
Iran Islamic Rep.	0.029	0.035	0.006	0.019	-0.023	0.041	-0.098	0.082	5,832	0.812
Ireland	-0.005	0.016	0.029	0.030	-0.006	0.063	-0.013	0.039	4,058	0.805
Italy	-0.002	0.007	0.019	0.016	-0.027	0.034	-0.129***	0.031	5,495	0.769
Japan	0.041	0.043	0.027*	0.015	-0.099*	0.060	-0.104	0.101	4,003	0.775
Kazakhstan	-0.006	0.012	0.011	0.014	0.005	0.036	0.025	0.043	3,686	0.809
Korea Rep.	0.028	0.023	0.037	0.050	-0.106***	0.024	-0.215***	0.047	5,326	0.769
Kosovo	-0.018	0.021	0.026	0.016	0.010	0.053	-0.041	0.047	3,525	0.778
Kuwait	-0.028	0.028	0.010	0.038	0.065	0.060	0.089	0.068	3,573	0.793
Latvia	-0.019	0.020	-0.005	0.027	0.018	0.044	-0.012	0.048	4,073	0.779
Lithuania	-0.013	0.019	0.030*	0.017	-0.038	0.042	-0.094**	0.040	5,061	0.770
Malta	0.009	0.010	0.012	0.023	-0.042	0.048	-0.011	0.020	3,472	0.694
Montenegro	0.013	0.010	-0.007	0.014	-0.022	0.020	-0.006	0.029	4,315	0.791
Morocco	-0.006	0.017	-0.036	0.024	0.070	0.059	0.116***	0.041	6,351	0.819
Netherlands	0.001	0.017	0.057	0.060	-0.038	0.074	-0.163***	0.041	3,021	0.734
New Zealand	0.025**	0.011	0.100**	0.048	-0.106**	0.044	-0.014	0.027	4,355	0.803

North Macedonia	-0.003	0.022	-0.017	0.023	0.044	0.050	0.014	0.064	3,007	0.816
Northern Ireland	0.006	0.012	0.012	0.025	-0.053	0.058	-0.031	0.029	2,723	0.794
Norway	0.074***	0.025	-0.011	0.030	-0.122**	0.048	-0.267***	0.056	3,268	0.755
Oman	0.048***	0.017	-0.016	0.050	-0.025	0.027	-0.114*	0.061	5,597	0.831
Pakistan	-0.010	0.025	0.037	0.044	0.054	0.054	-0.071	0.148	2,158	0.760
Philippines	-0.005	0.009	0.048**	0.020	0.001	0.024	-0.049	0.059	4,543	0.777
Poland	0.126*	0.066	0.080***	0.015	-0.278***	0.103	-0.200**	0.102	4,108	0.799
Portugal	0.007	0.009	0.058*	0.034	-0.082**	0.039	-0.187***	0.035	5,560	0.756
Qatar	0.007	0.006	-0.037***	0.014	-0.011	0.022	-0.159***	0.027	5,580	0.803
Russian Federation	-0.023	0.023	-0.006	0.014	-0.006	0.040	-0.100**	0.042	5,943	0.777
Saudi Arabia	-0.017	0.013	0.085**	0.043	-0.027	0.035	-0.014	0.044	2,886	0.762
Serbia	0.003	0.008	0.003	0.016	-0.039	0.034	-0.060*	0.035	4,196	0.823
Singapore	-0.001	0.011	0.039**	0.018	-0.135***	0.041	-0.198***	0.036	7,746	0.785
Slovak Republic	0.011	0.012	-0.007	0.023	-0.030	0.027	-0.203***	0.032	5,558	0.799
South Africa	0.007	0.008	0.007	0.010	-0.033	0.026	0.067	0.046	7,688	0.846
Spain	0.017**	0.008	-0.011	0.015	-0.123***	0.020	-0.322***	0.047	9,570	0.777
Sweden	0.002	0.012	0.095*	0.050	-0.027	0.024	-0.202***	0.041	4,132	0.765
Turkey	0.022*	0.012	0.019	0.023	-0.014	0.020	-0.049	0.050	3,748	0.756
United Arab Emirates	0.019***	0.006	0.003	0.017	-0.069***	0.022	-0.171***	0.056	14,919	0.812
United States	0.015***	0.004	0.037*	0.020	-0.116***	0.021	-0.260***	0.025	9,661	0.795

Notes: TIMSS recommended practices have been used (Jackknife and student weights). “Coeff.” stands for “Coefficient” and “S.E.” stands for “Standard error”.
Estimation method: Student fixed-effects.
Dependent variable: Standardised cognitive scores. Standardisation has been performed using each country’s mean and standard deviation for each subject.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors’ own calculations.

Table 2. The influence of instruction and homework time, controlling by confidence in the subject index

Countries	Instruction time (weekly hours)		Homework time (weekly hours)		Mathematics (Ref.: Science)		Student confident in the subject index		Constant		Observations	R-squared
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.		
Albania	0.018	0.048	-0.005	0.020	-0.041	0.075	0.037***	0.010	-0.441***	0.139	3,848	0.775
Armenia	-0.100***	0.035	0.025	0.019	0.144*	0.081	0.043***	0.008	-0.195*	0.113	3,845	0.774
Australia	-0.004	0.010	0.085***	0.031	-0.021	0.041	0.089***	0.009	-0.864***	0.090	4,780	0.810
Austria	0.011	0.016	0.005	0.020	-0.075**	0.036	0.049***	0.007	-0.672***	0.079	4,923	0.765
Azerbaijan	-0.065	0.042	-0.012	0.019	0.129	0.097	0.039***	0.008	-0.328***	0.103	4,376	0.781
Bahrain	-0.008	0.015	-0.041	0.041	0.001	0.027	0.054***	0.007	-0.518***	0.103	4,708	0.747
Belgium Flemish	-0.006	0.015	0.065*	0.034	-0.040	0.029	0.084***	0.007	-0.782***	0.110	4,208	0.778
Bosnia Herzegovina	0.033**	0.016	0.017	0.023	-0.076**	0.036	0.026***	0.007	-0.332***	0.087	4,771	0.760
Bulgaria	-0.013	0.033	0.011	0.012	0.038	0.069	0.059***	0.008	-0.776***	0.084	3,932	0.844
Canada	0.063***	0.013	0.061	0.041	-0.251***	0.046	0.074***	0.005	-1.056***	0.066	10,955	0.758
Chile	0.004	0.007	0.002	0.060	-0.029	0.024	0.059***	0.007	-0.735***	0.076	4,308	0.759
Chinese Taipei	0.001	0.007	-0.006	0.022	-0.014	0.043	0.068***	0.006	-0.794***	0.067	4,738	0.769
Croatia	0.009	0.019	0.008	0.024	-0.054	0.035	0.064***	0.007	-0.823***	0.080	5,047	0.771
Cyprus	-0.015	0.019	0.021	0.023	-0.052	0.068	0.089***	0.005	-0.820***	0.070	3,692	0.811
Czech Republic	0.047**	0.021	-0.017	0.037	-0.158***	0.058	0.059***	0.007	-0.753***	0.060	6,288	0.796
Denmark	0.005	0.013	0.082***	0.022	-0.081**	0.033	0.085***	0.007	-0.949***	0.072	3,296	0.771
England	-0.009	0.020	0.160**	0.068	-0.140**	0.057	0.055***	0.010	-0.712***	0.104	1,365	0.784
Finland	-0.004	0.013	-0.010	0.032	-0.077***	0.022	0.086***	0.007	-0.969***	0.071	6,423	0.774
France	0.018	0.012	0.100**	0.039	-0.154***	0.046	0.054***	0.005	-0.674***	0.054	4,966	0.794
Georgia	-0.016	0.017	0.002	0.018	0.001	0.055	0.047***	0.006	-0.494***	0.083	4,094	0.772
Germany	0.035**	0.015	0.037*	0.020	-0.176***	0.048	0.061***	0.007	-0.733***	0.072	3,118	0.778
Hong Kong	-0.048***	0.014	0.051	0.034	-0.162**	0.075	0.045***	0.015	-0.387**	0.164	1,174	0.773
Hungary	0.008	0.010	0.002	0.026	-0.063**	0.029	0.055***	0.004	-0.745***	0.051	5,285	0.791
Iran Islamic Rep.	0.030	0.035	0.010	0.019	-0.016	0.041	0.029***	0.009	-0.400***	0.127	5,702	0.813
Ireland	-0.004	0.014	0.027	0.029	-0.034	0.057	0.078***	0.008	-0.760***	0.081	3,966	0.812
Italy	-0.002	0.007	0.016	0.016	-0.036	0.035	0.056***	0.006	-0.680***	0.065	5,404	0.772
Japan	0.025	0.044	0.025*	0.015	-0.044	0.061	0.123***	0.009	-1.227***	0.130	3,981	0.785
Kazakhstan	-0.005	0.012	0.011	0.014	-0.021	0.039	0.063***	0.009	-0.600***	0.103	3,580	0.808
Korea Rep.	0.029	0.026	0.043	0.051	-0.116***	0.025	0.108***	0.007	-1.198***	0.084	5,266	0.777
Kosovo	-0.018	0.022	0.028	0.017	-0.002	0.056	0.025***	0.007	-0.274***	0.092	3,360	0.774
Kuwait	-0.028	0.026	0.015	0.040	0.075	0.056	0.034***	0.008	-0.216**	0.105	3,265	0.795
Latvia	-0.007	0.020	0.005	0.026	-0.005	0.045	0.093***	0.008	-0.920***	0.096	4,003	0.789
Lithuania	-0.022	0.021	0.028	0.018	-0.049	0.042	0.076***	0.006	-0.798***	0.075	4,852	0.777
Malta	0.011	0.010	0.010	0.022	-0.042	0.048	0.057***	0.007	-0.579***	0.080	3,444	0.700
Montenegro	0.014	0.010	-0.010	0.013	-0.028	0.021	0.022***	0.006	-0.211***	0.077	4,088	0.787
Morocco	-0.006	0.016	-0.035	0.024	0.062	0.055	0.027**	0.012	-0.161	0.141	6,136	0.819
Netherlands	0.000	0.017	0.033	0.070	-0.086	0.076	0.073***	0.008	-0.847***	0.065	2,862	0.742
New Zealand	0.024**	0.012	0.107**	0.050	-0.128***	0.046	0.091***	0.008	-0.836***	0.079	4,180	0.809
North Macedonia	0.007	0.027	-0.011	0.021	0.009	0.057	0.022**	0.009	-0.189	0.120	2,807	0.815
Northern Ireland	0.004	0.011	0.019	0.025	-0.081	0.056	0.091***	0.009	-0.885***	0.091	2,697	0.805
Norway	0.066***	0.024	-0.002	0.027	-0.120***	0.044	0.079***	0.009	-1.044***	0.102	3,073	0.762

Oman	0.044**	0.018	-0.017	0.048	-0.023	0.026	0.038***	0.008	-0.472***	0.100	5,411	0.832
Pakistan	-0.010	0.025	0.031	0.045	0.042	0.059	0.037	0.027	-0.383	0.292	1,976	0.759
Philippines	-0.012	0.009	0.051**	0.023	-0.015	0.025	0.063***	0.016	-0.556***	0.145	4,253	0.778
Poland	0.103	0.064	0.085***	0.016	-0.238**	0.100	0.068***	0.009	-0.799***	0.132	3,964	0.802
Portugal	0.005	0.009	0.049	0.035	-0.029	0.037	0.065***	0.005	-0.835***	0.062	5,479	0.761
Qatar	0.005	0.006	-0.047***	0.014	0.003	0.022	0.053***	0.007	-0.669***	0.075	5,363	0.805
Russian Federation	-0.021	0.022	-0.005	0.014	-0.015	0.038	0.050***	0.005	-0.570***	0.062	5,881	0.779
Saudi Arabia	-0.018	0.014	0.106**	0.045	-0.046	0.034	0.045***	0.009	-0.448***	0.102	2,680	0.757
Serbia	0.004	0.008	0.006	0.015	-0.060*	0.034	0.078***	0.008	-0.828***	0.087	4,125	0.828
Singapore	-0.005	0.011	0.033*	0.018	-0.125***	0.041	0.053***	0.005	-0.673***	0.062	7,719	0.789
Slovak Republic	0.017	0.012	-0.010	0.024	-0.053*	0.029	0.052***	0.008	-0.708***	0.090	5,494	0.802
South Africa	0.007	0.008	0.006	0.010	-0.037	0.028	0.050***	0.009	-0.369***	0.092	7,092	0.847
Spain	0.012	0.007	-0.012	0.016	-0.113***	0.020	0.057***	0.006	-0.853***	0.075	9,258	0.784
Sweden	0.001	0.013	0.078*	0.047	-0.055**	0.027	0.074***	0.008	-0.922***	0.097	4,034	0.770
Turkey	0.024*	0.013	0.008	0.026	-0.004	0.022	0.059***	0.008	-0.642***	0.095	3,643	0.759
United Arab Emirates	0.017***	0.006	-0.001	0.015	-0.064***	0.022	0.029***	0.007	-0.447***	0.088	14,459	0.813
United States	0.011***	0.004	0.043**	0.021	-0.116***	0.023	0.062***	0.004	-0.843***	0.049	8,875	0.800

Notes: TIMSS recommended practices have been used (Jackknife and student weights). “Coeff.” stands for “Coefficient” and “S.E.” stands for “Standard error”.
Estimation method: Student fixed-effects.
Dependent variable: Standardised cognitive scores. Standardisation has been performed using each country’s mean and standard deviation for each subject.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors’ own calculations.

Table 3. The influence of instruction and homework time, controlling by student likes learning index

Countries	Instruction time (weekly hours)		Homework time (weekly hours)		Mathematics (Ref.: Science)		Student likes learning the subject index		Constant		Observations	R-squared
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.		
Albania	0.017	0.050	-0.005	0.021	-0.044	0.077	0.042***	0.010	-0.524***	0.135	3,861	0.776
Armenia	-0.096***	0.030	0.023	0.019	0.138**	0.068	0.033***	0.009	-0.121	0.107	3,882	0.772
Australia	-0.007	0.010	0.085**	0.033	0.021	0.043	0.067***	0.006	-0.664***	0.060	4,786	0.807
Austria	0.016	0.015	0.011	0.021	-0.086**	0.036	0.043***	0.006	-0.597***	0.077	4,954	0.763
Azerbaijan	-0.061	0.043	-0.014	0.019	0.117	0.099	0.043***	0.009	-0.369***	0.121	4,405	0.779
Bahrain	-0.007	0.014	-0.038	0.041	0.011	0.027	0.057***	0.008	-0.570***	0.096	4,739	0.748
Belgium Flemish	-0.008	0.015	0.058*	0.034	-0.021	0.028	0.054***	0.007	-0.460***	0.096	4,159	0.773
Bosnia Herzegovina	0.031**	0.016	0.008	0.022	-0.068*	0.035	0.035***	0.007	-0.399***	0.075	4,801	0.760
Bulgaria	-0.018	0.033	0.008	0.011	0.059	0.070	0.046***	0.006	-0.635***	0.086	3,953	0.845
Canada	0.062***	0.013	0.059	0.042	-0.220***	0.047	0.057***	0.005	-0.902***	0.060	10,999	0.757
Chile	0.006	0.007	-0.001	0.063	-0.031	0.023	0.047***	0.005	-0.658***	0.066	4,379	0.761
Chinese Taipei	-0.001	0.007	-0.009	0.024	0.011	0.045	0.051***	0.004	-0.647***	0.053	4,745	0.768
Croatia	0.009	0.018	0.007	0.024	-0.037	0.035	0.055***	0.007	-0.699***	0.070	5,062	0.770
Cyprus	-0.018	0.019	0.006	0.024	0.012	0.069	0.063***	0.006	-0.547***	0.074	3,717	0.804
Czech Republic	0.046**	0.022	-0.019	0.035	-0.156***	0.060	0.048***	0.006	-0.644***	0.047	6,303	0.796
Denmark	0.001	0.013	0.088***	0.023	-0.049	0.034	0.059***	0.007	-0.675***	0.073	3,311	0.767
England	-0.009	0.020	0.171**	0.071	-0.118**	0.058	0.045***	0.008	-0.636***	0.100	1,366	0.783
Finland	-0.004	0.015	-0.012	0.032	-0.067***	0.023	0.068***	0.006	-0.734***	0.062	6,425	0.773
France	0.023*	0.012	0.093**	0.041	-0.169***	0.045	0.050***	0.005	-0.660***	0.050	4,996	0.793
Georgia	-0.019	0.017	0.002	0.018	0.000	0.051	0.029***	0.008	-0.320***	0.086	4,123	0.771
Germany	0.035**	0.015	0.043**	0.020	-0.162***	0.048	0.046***	0.006	-0.588***	0.064	3,177	0.776
Hong Kong	-0.057***	0.014	0.044	0.036	-0.095	0.073	0.040***	0.012	-0.350***	0.126	1,176	0.773
Hungary	0.005	0.009	0.002	0.022	-0.053*	0.027	0.048***	0.005	-0.653***	0.053	5,296	0.792
Iran Islamic Rep.	0.029	0.035	0.007	0.019	-0.017	0.042	0.031***	0.007	-0.437***	0.112	5,725	0.813
Ireland	-0.007	0.015	0.037	0.030	0.032	0.057	0.045***	0.007	-0.466***	0.076	3,943	0.808
Italy	-0.002	0.007	0.015	0.017	-0.017	0.035	0.041***	0.005	-0.537***	0.061	5,399	0.770
Japan	0.024	0.047	0.036**	0.016	-0.035	0.067	0.072***	0.007	-0.798***	0.130	3,986	0.781
Kazakhstan	-0.006	0.011	0.010	0.014	-0.035	0.036	0.058***	0.009	-0.564***	0.096	3,608	0.809
Korea Rep.	0.022	0.026	0.043	0.054	-0.073***	0.026	0.067***	0.005	-0.833***	0.068	5,286	0.776
Kosovo	-0.020	0.022	0.027	0.017	0.003	0.055	0.024***	0.009	-0.270***	0.096	3,394	0.774
Kuwait	-0.026	0.026	0.014	0.040	0.075	0.057	0.034***	0.007	-0.223**	0.092	3,289	0.794
Latvia	-0.017	0.022	0.008	0.028	0.003	0.051	0.082***	0.008	-0.778***	0.095	4,017	0.787
Lithuania	-0.017	0.019	0.026	0.018	-0.036	0.040	0.055***	0.006	-0.628***	0.067	4,856	0.774
Malta	0.012	0.010	0.008	0.022	-0.040	0.047	0.042***	0.007	-0.447***	0.083	3,442	0.697
Montenegro	0.012	0.010	0.000	0.012	-0.040**	0.019	0.039***	0.007	-0.395***	0.084	4,100	0.788
Morocco	-0.006	0.018	-0.035	0.024	0.062	0.060	0.024***	0.007	-0.142	0.101	6,203	0.820
Netherlands	0.001	0.017	0.052	0.064	-0.034	0.077	0.047***	0.008	-0.605***	0.080	2,914	0.739
New Zealand	0.024**	0.012	0.105**	0.050	-0.092*	0.047	0.047***	0.005	-0.475***	0.055	4,216	0.805
North Macedonia	0.006	0.027	-0.008	0.022	0.009	0.058	0.039***	0.010	-0.378***	0.130	2,856	0.814
Northern Ireland	0.003	0.012	0.014	0.025	0.016	0.062	0.063***	0.009	-0.669***	0.098	2,692	0.801
Norway	0.080***	0.022	-0.004	0.029	-0.103**	0.047	0.048***	0.007	-0.756***	0.090	3,098	0.758

Oman	0.047***	0.018	-0.015	0.049	-0.025	0.026	0.019*	0.011	-0.296**	0.115	5,447	0.830
Pakistan	-0.007	0.026	0.032	0.046	0.053	0.058	0.021	0.017	-0.253	0.244	1,974	0.759
Philippines	-0.008	0.009	0.045**	0.022	-0.015	0.024	0.035***	0.012	-0.335***	0.110	4,330	0.777
Poland	0.100	0.065	0.083***	0.016	-0.238**	0.103	0.048***	0.008	-0.579***	0.122	3,994	0.799
Portugal	0.007	0.009	0.052	0.034	-0.035	0.038	0.047***	0.005	-0.718***	0.061	5,499	0.759
Qatar	0.003	0.006	-0.047***	0.014	0.012	0.022	0.043***	0.005	-0.560***	0.062	5,384	0.805
Russian Federation	-0.020	0.023	-0.003	0.014	-0.034	0.040	0.047***	0.007	-0.553***	0.082	5,892	0.779
Saudi Arabia	-0.020	0.014	0.094**	0.042	-0.042	0.036	0.020**	0.008	-0.187**	0.081	2,730	0.755
Serbia	0.002	0.008	0.004	0.017	-0.046	0.035	0.064***	0.007	-0.655***	0.083	4,133	0.827
Singapore	-0.006	0.011	0.035*	0.018	-0.102**	0.043	0.039***	0.004	-0.576***	0.055	7,727	0.787
Slovak Republic	0.013	0.012	0.000	0.025	-0.053*	0.028	0.049***	0.005	-0.661***	0.060	5,501	0.803
South Africa	0.007	0.008	0.005	0.010	-0.058**	0.028	0.047***	0.008	-0.371***	0.074	7,259	0.848
Spain	0.011	0.007	-0.008	0.015	-0.111***	0.021	0.047***	0.006	-0.763***	0.070	9,332	0.782
Sweden	-0.003	0.013	0.075	0.047	-0.027	0.026	0.048***	0.006	-0.635***	0.079	4,041	0.768
Turkey	0.021	0.014	0.012	0.025	-0.015	0.021	0.041***	0.008	-0.476***	0.093	3,704	0.755
United Arab Emirates	0.018***	0.006	0.001	0.015	-0.058***	0.022	0.027***	0.005	-0.458***	0.077	14,557	0.813
United States	0.011**	0.005	0.043**	0.022	-0.085***	0.024	0.045***	0.004	-0.692***	0.045	8,699	0.798

Notes: TIMSS recommended practices have been used (Jackknife and student weights). “Coeff.” stands for “Coefficient” and “S.E.” stands for “Standard error”.
Estimation method: Student fixed-effects.
Dependent variable: Standardised cognitive scores. Standardisation has been performed using each country’s mean and standard deviation for each subject.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Authors’ own calculations.