Adolescents' Homework Performance in Mathematics and Science: Personal Factors and Teaching Practices

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Classical educational research provides empirical evidence of the positive effect of doing homework on academic results. Nonetheless, when this effect is analyzed in detail there are inconsistent, and in some cases, contradictory results. The central aim of this study was to systematically investigate the effect of homework on performance of students in mathematics and science using multilevel models. The original sample consisted of 7,725 Spanish adolescents with a mean age of 13.78 (± 0.82) of which 7,451 were evaluated after purging the sample of the students who did little to no homework. A 2-level hierarchical-linear analysis was performed, student and class, with 4 individual adjustment variables: gender, socioeconomic and cultural level, year repetition, and school grades, which were used to reflect previous student achievement. The individual level examined time spent, effort made, and the way homework was done. The class level considered frequency of assignment and quantity of homework. Prior knowledge, estimated using school grades, is shown to be the most important predictor of achievement in the study. Its effect is greater than the combined effect of all the other variables studied. Once background factors are controlled, the homework variables with most impact on the test are student autonomy and frequency of homework assignment by teachers. Autonomy when doing homework was shown to be the most important individual-level variable in both mathematics and science, and not effort and or time spent doing homework. The optimum duration of homework was found to be 1 hr a day.

Keywords: homework, mathematics, science, academic performance, multilevel models

The characteristics and effects of homework have been widely studied, both from a general perspective (Blazer, 2009), and specific areas such as the relationship between homework and academic performance (Cooper, 1989a; Cooper, Robinson, & Patall, 2006; Cooper & Valentine, 2001; Cooper, Steenbergen-Hu, & Dent, 2012; Goldstein, 1960; Paschal, Weinstein, & Walberg, 1984; Trautwein & Köller, 2003), family involvement (Hoover-Dempsey, Battiato, Walker, Reed, DeJong, & Jones, 2001; Patall,

Cooper, & Robinson, 2008; Pomerantz, Moorman, & Litwack, 2007), the role of teachers (Epstein & van Voorhis, 2001), students' perceptions (Warton, 2001), and the way the students manage and do their homework (Xu, 2013). Research about the relationship between homework and academic performance has evolved from positivist and experimentalist positions (Goldstein, 1960) toward more integrated, comprehensive approaches (Cooper, 1989a; Cooper et al., 2006; Paschal et al., 1984). The general conclusion of this research is that there is a positive relationship between homework and academic performance but recent work has led to a profound change in this general conclusion. Trautwein and Köller (2003) severely criticized large parts of the previous research on this topic and laid the foundations for a new generation of studies, signaling the need to use more sophisticated statistical models to allow a more rigorous analysis of the variables involved. With this new focus, the most commonly used models have been two-level hierarchical-linear models, generally student and class, although other designs are possible. These multilevel models have been used to predict academic performance (De Jong, Westerhof, & Creemers, 2000; Dettmers, Trautwein, & Lüdtke, 2009; Núñez, Vallejo, Rosario, Tuero, & Valle, 2014; Trautwein, Köller, Schmitz, & Baumert, 2002; Tymms & Fitz-Gibbon, 1992), the time spent on homework (Trautwein, 2007), the effort made (Trautwein, Niggli, Schnyder, & Lüdtke, 2009; Trautwein, Schnyder, Niggli, Neumann, & Lüdtke, 2009), self-regulation (Xu, 2010a),

interest in the assignments (Xu, 2008, 2011), motivation (Dettmers, Trautwein, Lüdtke, Kunter, & Baumert, 2010; Trautwein, Lüdtke, Schnyder, & Niggli, 2006), reasons for completing homework (Xu, 2010b), emotions felt (Dettmers, Trautwein, Lüdtke, Goetz, Pekrun, & Frenzel, 2011), behavioral strategies used (Lubbers, Van Der Werf, Kuyper, & Hendriks, 2010), and the attitude toward subjects (Farrow, Tymms, & Henderson, 1999). Three-level hierarchical models have also been used, although less frequently, with fundamental designs such as student, school and system (OECD, 2013), student, class, and school (Murillo & Martínez-Garrido, 2013), and other three-level combinations (Pattal, Cooper, & Wynn, 2010; Trautwein & Lüdtke, 2007, 2009).

In the first multilevel study centered on the relationship between homework and academic performance Tymms and Fitz-Gibbon (1992) found differing results depending on the analysis level. In general the data indicate that, at an individual level, time spent has little effect on academic performance (De Jong et al., 2000), and in some cases there was even a negative correlation, so that the more time spent on homework, the worse the academic performance (Trautwein, 2007; Trautwein, Schnyder et al., 2009). Nevertheless, these three studies found a statistically significant, positive relationship at the class level, that is, the students in classes that are assigned more homework tend to have better academic results. De Jong et al. (2000) note the possibility that students with lower levels of previous knowledge need more time to complete their assignments, which leads to the negative correlation. Trautwein (2007) and Trautwein and Ludtke (2007) empirically confirmed this hypothesis, and found that the students that were more able, who knew more, and who had higher expectations of success tended to spend less time on their homework. On the other hand, it seems clear that the relationship between time spent doing homework and academic results is not linear (Blazer, 2009; Cooper & Valentine, 2001; Daw, 2012; Gobierno del Principado de Asturias, 2013; Gobierno Vasco, 2012; Ministerio de Educación, Cultura y Deporte, 2003).

Frequency of homework, in the same way as time spent on it, presents two hallmark characteristics of a multilevel situation. The meaning it has depends on the measurement level; at an individual level it indicates the student's work habits, and taken as a class average it is an estimator of the frequency that the teacher assigns homework (Trautwein & Köller, 2003). In addition, it demonstrates differential effects depending on the level of analysis. With data aggregated by class, Farrow et al. (1999) found that frequency had a small positive effect on performance in mathematics and science, but at the student level the effect was negligible. In any case, the data point to the fact that the teacher regularly assigning homework matters more than the quantity. Trautwein (2007) and Trautwein et al. (2002) not only reported a positive association between the frequency of homework assignments and performance in mathematics, they also indicated that when the frequency is considered, the amount of the homework is no longer significant. However, frequency and time are not the only variables that affect academic performance. Dettmers et al. (2010, 2011) and Trautwein and Lüdtke (2007) indicate that effort is a better predictor of results in mathematics than either frequency or time spent. In fact effort has a central role in the theoretical model proposed by the Max Planck Institute (Trautwein et al., 2006). The relationship between effort and academic results generated a series of work aimed at studying the factors that predict effort. Curiously time does not appear to be among them, and as Trautwein (2007) indicated, the correlation between time spent on homework and effort is low and negative. It seems that effort is more related to motivation and personality traits (Trautwein et al., 2006), the role of the teacher (Patall et al., 2010; Xu, 2011), and previous performance (Xu, 2008).

Another key variable related to homework is the ability to work autonomously, that is, without parental involvement. De Jong et al. (2000) demonstrate that, after controlling adjustment variables, the effect of family help on results in mathematics is no longer statistically significant. In addition, family help does not seem to be associated with either effort (Trautwein & Lüdtke, 2007) or expectations of success, (Trautwein & Lüdtke, 2009) nor with interest in or enthusiasm for doing homework (Xu, 2008). Xu (2010a) found that students who needed less help, that is, those who were more autonomous when doing homework, achieved better results, whereas Trautwein and Lüdtke (2007) observed that students who receive more help also spend more time and, as already noted, get worse results. Taken together, this data seems to indicate that students who need more help and therefore, are less autonomous when doing homework, tend to demonstrate more difficulties with learning, motivation and concentration, and fewer self-regulating strategies. Other studies, not using multilevel approaches, also confirm the relationship between autonomy in homework and academic achievement (Cooper, Lindsay, & Nye, 2000).

The field of the study of homework is a crossroads where psychological research and the study of school effectiveness and educational improvement meet. Thanks to this combination we know that maximizing the homework-result relationship requires a mix of certain individual (personal) characteristics and certain teaching practices. Psychology gives unified models that combine input from neurobiology with research on cognitive factors and personality involved in learning, highlighting the importance of prior knowledge as the principal predictive variable of future achievement (Shell, Brooks, Trainin, Wilson, Kauffman, & Herr, 2010). Failure to consider prior knowledge in research into homework could undermine any conclusions made (De Jong et al., 2000). At the same time, research into personality factors and student attitudes has underscored the influence of motivation and effort, autonomy and regulation of behavior, and expectations about homework and the role of conscientiousness when it comes to optimizing the homework-result relationship (Lubbers et al., 2010; Trautwein et al., 2006; Trautwein & Ludtke, 2009; Xu, 2008; Zimmerman, 2001; Zimmerman & Kitsantas, 2005). Research on school effectiveness has also been concerned with the effect of teaching practices related to assignment, frequency, and other characteristics of homework. Scheerens, Witziers, and Steen (2013) used a concept of curriculum quality that includes three variables: opportunity to learn, effective learning time, and homework. Although in their meta-analysis the estimated mean effect size of homework is moderate (0.073), the value placed on homework in teaching practices is notable. As Dettmers et al. (2010) noted, homework works only so far as the teacher assigns work of sufficient quality.

Within this context the general aim of our work was to systematically study the effect of doing homework on academic results in mathematics and science subjects in adolescents. Multilevel models were used with two levels: students and classes. The student level examined time spent on homework, effort made and how it was done while the class level evaluated the frequency and quantity of homework set. In addition the effects of four background variables were controlled: gender, socioeconomic and cultural level, and two measures of previous academic performance (school grades and repetition of school year). The use of the latest generation hierarchical-linear

models will allow a much more precise, rigorous analysis of the complex relationships between homework and academic performance (Vallejo Seco, Ato García, Fernández García, & Livacic Rojas, 2013). This is the first study on homework carried out on a large sample of Spanish adolescents that combines the application of multilevel models and the psychometric advantages of Item Response Theory models. Homework is a significant part of the day to day lives of millions of students, parents, and teachers all over the world. Providing new data on homework in a southern European population gives added confirmatory value, bearing in mind the current debate in psychology and education on the need for accumulative and replicable science (Koole & Lakens, 2012; Nosek & Lakens, 2014). We hope, therefore, that our work can contribute to a crosscultural consolidation of current research into homework.

Method

Participants

The sample was made up of 7,725 students in the second year of obligatory secondary education in the Principality of Asturias, a region in the north of Spain. The mean age was 13.78 with a *SD* of 0.82. Girls made up 47.2% of the sample; 90.6% were Spanish nationals; and 72.9% were in the standard school year for their age whereas 27.1% were 1 or 2 years behind in relation to their age. The students were from 353 classes belonging to 148 schools. Technically this is the population as the evaluation was carried out on all of the registered students at the level studied in this geographical region in the academic year 2010–2011.

Procedure

The tests were performed within the official annual Principality of Asturias educational system evaluation program. Test management within each school was provided by the school authorities. The questionnaires and tests were given by active teachers in accordance with the *Instructions for the development of diagnostic evaluation*, set by the Department of Education of the Principality of Asturias Government. Each student completed a mathematics and science test with 24 items for each subject, as well as a questionnaire for homework evaluation.

Instruments

Questionnaire for homework evaluation. The total daily time dedicated to homework was calculated from two multiple choice items on the questionnaire. The first asked about the frequency that homework was done, the options were (a) never, (b) 2 or 3 days per week, (c) almost every day, and (d) every day. The second item asked about the total time spent on homework considering all subjects, the options were (a) less than 30 min, (b) between 30 and 60 min, (c) between 60 and 120 min, and (d) more than 120 min. For the second level analysis, the means of these variables for each class were calculated as estimators of the frequency of homework assignment by teachers and the amount of homework, respectively.

Effort was measured using three items (*I make an effort to get good marks*, *I finish my homework even if they are difficult or they take me a long time*, and *I am careful to keep my notebooks and work neat and tidy*) where 1 = *means never or almost never* and 4 = *always or*

almost always. Analysis of the principal components showed that these items conform to an essentially unidimensional scale (the first factor accounts for almost 64% of the common variance). In addition, the Cronbach's α coefficient (α = .71) seems appropriate considering that the scale is only composed of three items.

The way homework was done was evaluated using the question "How do you do your school assignments?" The options were (a) without help, (b) I occasionally need help, (c) I often need help, and (d) I always need help. A binary variable was constructed from this item where 1 signifies doing homework without help or occasional help and 0 signifies those who need frequent or constant help.

Tests of academic performance: Mathematics and science. Academic performance was measured using a test that evaluated mathematics and science, the detailed description of the content may be found in Gobierno del Principado de Asturias (2012). An item bank was created that was purified through a pilot study and following the protocol established by Fernández-Alonso (2005). Finally, 192 items were selected (96 mathematic and 96 science). There were three item formats used: multiple choice, short open-ended answer, and essay. The item pool was distributed in eight test booklets in accordance with the matrix design given in Fernández-Alonso and Muñiz (2011). Each student was presented with a test booklet containing 48 items (24 mathematics and 24 sciences) that they completed in two sessions of 50 min each with a break in between.

Given that the group of items was constructed to measure two competences (mathematics and science), the item pool was adjusted to a two-dimensional item response model. It was assumed that each item saturated in one and only one of the dimensions, for which a two-dimensional model among items was chosen (multidimensional between-item tests). The fitting of the bank was conducted with the ConQuest 2.0 program (Wu, Adams, Wilson, & Haldane, 2007). For the initial calibration of items, 2,000 subjects were selected from the total sample. This ensured that each item was responded to by 500 subjects. Once the adjustment of the items to the model was checked, the parameters of these were estimated. These parameters were used as initial values to calculate the score of the subjects on each competence in function of the response to the items. Finally, the marks were transformed to a scale with a mean of 500 and a *SD* of 100. The difficulty indexes of the tests comprise the entire possible rank of scores, both easy items and difficult items, although most of them (around 40%) were concentrated on the middle range of the distribution of difficulty. The mean Cronbach's α coefficient of the eight booklets was 0.85 (with a minimum of 0.82 and a maximum of 0.88).

Adjustment variables. Four adjustment variables were included. Two variables were used to look at sociological background: *gender* and *Socioeconomic and Cultural Index (ISEC)* of the participants. To ensure the quality of the ISEC, teachers were asked to report on the educational attainment and professions of the students' families. This information was reduced, using an analysis of principal components, to an index *N(0,1)* following the procedure described in Peña-Suárez, Fernández-Alonso, and Muñiz (2009). The remaining variables were used as measures of prior knowledge. School history was estimated using the variable *Repetition of school year*, a binary variable where 0 meant being in the school year corresponding to age and 1 signified those who were repeating a year. Finally, the *prior knowledge* variable was measured using the school grades of the students in mathematics and science. The school grades are presented in the following measurement scale (based on the Spanish grade

system): fail (0 points), pass or good (1 point), very good (2 points), and outstanding (3 points).

Data Analyses

First, to study students' homework behavior, descriptive statistics and Pearson correlations were calculated. Second, a multilevel analysis was performed to study the effect of homework on academic performance. With the aim of improving the representation of students who actually do the assigned homework, the 2.4% of students who never do homework were removed from the analysis (see Figure 1). For this reason, the multilevel analyses looked at 7,451 students rather than the 7,725 originally evaluated. A sequence of five hierarchical-linear models was constructed by subject (mathematics and science). These are models of random two-level coefficients: student and class (Raudenbush & Bryk, 2002). Each new model increases in complexity given that new explanatory variables are added while keeping those in the previous model. The modeling strategy used HLM 6.03 software (Raudenbush, Bryk, Cheong, & Congdon, 2004). HLM does not give standardized regression coefficients, therefore the data presented in this study are presented in two ways: the original scale $N(500, 100)$ and the normalized scale $N(0, 1)$. The former is used in the graphics and shows the predictions of results

at the true scale. The normalized data are presented in the tables and is interpreted as a standardized coefficient of ordinary regression analysis. The range of missing values in the variables varied between 5% and 12%. To impute missing values, two methods were used depending on the type of missing data presented: when a case was incomplete the data point was replaced by the mean of the person, whereas for completely missing data we used a procedure of multiple imputation with auxiliary variables in the SPSS program (IBM Corp, 2011). Fernández-Alonso, Suárez-Álvarez, and Muñiz (2012) found that use of this combination is especially recommended when data loss is greater, and its loss mechanism is more conditioned.

Results

Completion of Homework by the Students

Figure 1 shows the frequency distribution of the items describing the completion of homework by the students. As can be seen, the students spend, on average, between 1 and 2 hr doing homework from all subjects.

The total amount of homework assigned by teachers is a little over 70 min a day (see Table 1). According to Murillo and
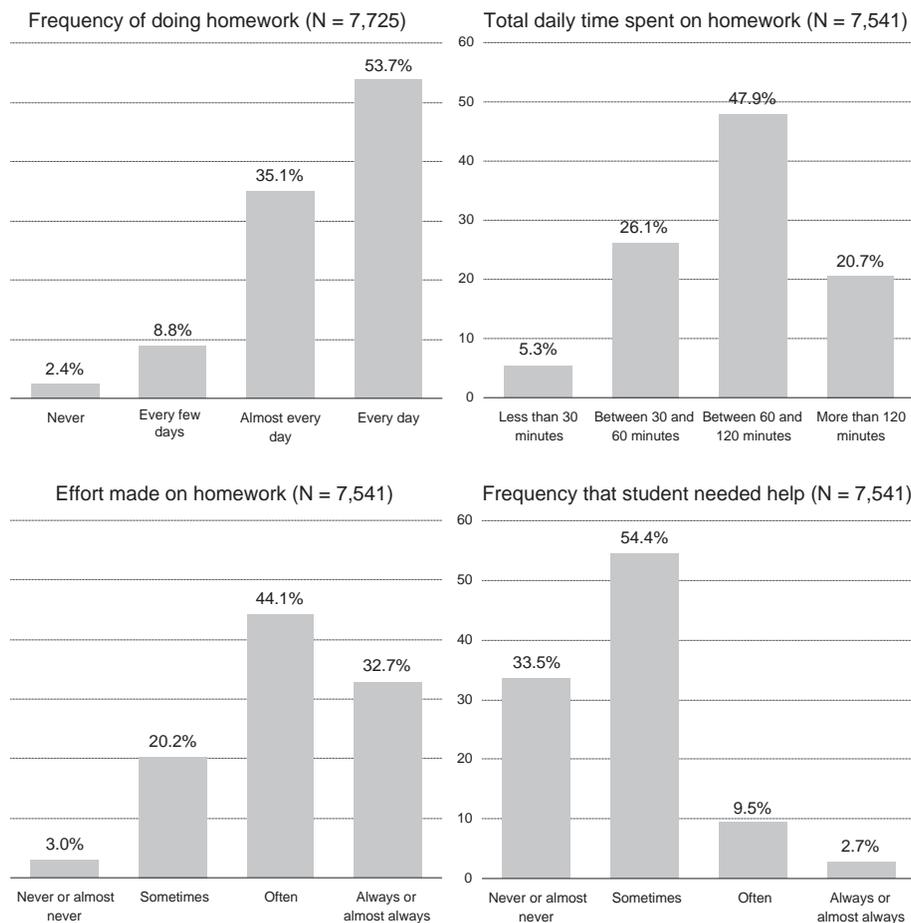

Figure 1. Completion of homework by students.

Table 1
Descriptive Statistics and Pearson Correlations of the Variables

	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Homework time (total daily minutes)	73.24	39.09	—										
2. Effort	2.08	0.71	.51	—									
3. How homework is done (1 = *without help*)	0.88	0.33	−.05	.08	—								
4. Sex (1 = *girl*)	0.48	0.50	.15	.19	.00	—							
5. Socioeconomic and cultural index (SEC)	12.41	3.51	.14	.19	.06	−.02	—						
6. Repeater (1 = *yes)*	0.26	0.44	−.28	−.36	−.11	−.07	−.34	—					
7. Prior knowledge in mathematics	1.36	0.88	.21	.38	.17	.03	.32	−.46	—				
8. Prior knowledge in science	1.59	0.92	.28	.46	.17	.06	.38	−.55	.70	—			
9. Score in mathematics	501.7	99.9	.13	.26	.18	−.03	.35	−.39	.57	.55	—		
10. Score in science	501.3	99.9	.07	.18	.16	−.11	.32	−.32	.47	.50	.66	—	
11. Frequency of homework assignment (*class*)	2.39	0.27	.23	.21	.02	.04	.17	−.19	.15	.20	.20	.17	—
12. Homework time (*class*)	72.48	13.46	.32	.21	−.02	.05	.18	−.18	.11	.17	.18	.14	.76

Martinez-Garrido (2013) in Spanish-speaking countries, including Spain, homework assignments are usually paper and pencil tasks such as complementary lectures (81.5% of teachers assign this kind of homework often or very often), problems to solve (66.3% of teachers assign often or very often), write an essay or research (53.1% often or very often), and small research or experiments (44%). According to this data, the teachers show a certain uniformity in the practice of assigning homework meaning that the difference in the time taken to do homework variable is more about the student's level (i.e., 94.6% of the variance is because of the difference in student commitment and only 6.4% is because of differing homework practices on the part of the teachers). This latter value is slightly lower than the international mean in PISA 2003 (7.6%) and slightly higher than the Spanish estimate (5.4%) in that same study (Dettmers et al., 2009).

Multilevel Models to Predict Academic Performance

Tables 2 and 3 show the results of the hierarchical-linear models. The null model, without independent variables, indicates that 82% of the variance of results in mathematics and 87.1% of results in science are found in Level 1 (students), while the variance between classes is 18% in mathematics and 12.9% in science. Model 1 includes the variables time spent, frequency of assignment, and amount of homework. In the first place, it confirms that both the time-result relationship and the amount-result relationship are curvilinear. In both cases the effect of the quadratic element is statistically significant (95% confidence interval [CI]) albeit negative. In other words, there is an optimal amount of, and time to spend on, homework and once that threshold is passed, the time spent and the amount of

Table 2
Hierarchical-Linear Models to Predict Mathematics Performance

	Null model: Without predictors B (*SE*)	Model 1: Time, quantity, and frequency B (*SE*)	Model 2: Effort and autonomy B (*SE*)	Model 3: Adjustment variables B (*SE*)	Model 4: Prior knowledge B (*SE*)
Level 1					
Total daily minutes	—	0.23 (0.04)	0.02 (0.04)	0.01 (0.04)	−0.07 (0.04)
Total daily minutes ^ 2	—	−0.15 (0.04)	−0.02 (0.04)	−0.01 (0.04)	0.03 (0.04)
How homework is done (1 = *without help*)	—	—	0.16 (0.01)	0.15 (0.01)	0.09 (0.01)
Effort	—	—	0.19 (0.01)	0.18 (0.01)	0.04 (0.01)
Sex (1 = *girls*)	—	—	—	−0.07 (0.01)	−0.06 (0.01)
Socioeconomic and cultural index (SEC)	—	—	—	0.23 (0.01)	0.11 (0.01)
Repeater	—	—	—	—	−0.09 (0.01)
Grades in mathematics	—	—	—	—	0.43 (0.01)
Level 2					
Frequency of homework assignment	—	0.13 (0.03)	0.11 (0.03)	0.10 (0.03)	0.07 (0.03)
Quantity: Average minutes per day per class	—	0.29 (0.14)	0.30 (0.13)	0.17 (0.12)	0.06 (0.11)
Quantity: Average minutes per day per class ^ 2	—	−0.25 (0.12)	−0.24 (0.12)	−0.15 (0.10)	−0.03 (0.10)
Variance					
Between classes	0.180	0.136	0.125	0.086	0.079
Within classes	0.820	0.813	0.759	0.723	0.561
Percentage of explained variance					
Between classes		24.4%	30.6%	55.2%	56.1%
Within classes		0.9%	7.4%	11.8%	31.6%
Total		5.1%	11.6%	19.1%	36.0%

Table 3

Hierarchical-Linear Models to Predict Science Performance

	Null model: Without predictors B (*SE*)	Model 1: Time, quantity, and frequency B (*SE*)	Model 2: Effort and autonomy B (*SE*)	Model 3: Adjustment variables B (*SE*)	Model 4: Prior knowledge B (*SE*)
Level 1					
Total daily minutes	—	0.17 (0.04)	0.02 (0.04)	0.01 (0.04)	−0.09 (0.04)
Total daily minutes ^ 2	—	−0.14 (0.04)	−0.04 (0.04)	−0.04 (0.04)	0.02 (0.04)
How homework is done (*1 = without help*)	—	—	0.15 (0.01)	0.13 (0.01)	0.08 (0.01)
Effort	—	—	0.14 (0.01)	0.13 (0.01)	−0.01 (0.01)
Sex (*1 = girls*)	—	—	—	−0.13 (0.01)	−0.12 (0.01)
Socioeconomic and cultural index (SEC)	—	—	—	0.24 (0.01)	0.12 (0.01)
Repeater	—	—	—	—	−0.04 (0.01)
Grades in science	—	—	—	—	0.42 (0.01)
Level 2					
Frequency of homework assignment	—	0.13 (0.03)	0.11 (0.03)	0.10 (0.03)	0.06 (0.02)
Quantity: Average minutes per day per class	—	0.21 (0.11)	0.21 (0.11)	0.07 (0.10)	0.03 (0.08)
Quantity: Average minutes per day per class ^ 2	—	−0.18 (0.10)	−0.17 (0.10)	−0.06 (0.08)	0.01 (0.07)
Variance					
Between classes	0.129	0.099	0.094	0.064	0.057
Within classes	0.871	0.869	0.832	0.777	0.650
Percentage of explained variance					
Between classes		23.3%	27.1%	50.4%	55.8%
Within classes		0.2%	4.5%	10.8%	25.4%
Total		3.2%	7.4%	15.9%	29.3%

homework stop being effective and end up being detrimental (see Figure 2).

The top of the curve is between 90 and 100 min per day of homework for all subjects combined and this may be considered the most effective amount of time, as from this point on results begin to decline. However, the most effective is not always the most efficient. For example, for students in classes where the amount of homework is 50 min, results in the middle of the scale (i.e., 504 points in science) are predicted. The gain expected in science for students in classes where the amount of homework is 70 min is around an eighth of a *SD* (517 points) but the gains between 70 and 90 min barely reach 3% of a *SD*. That small gain requires 2 hr more homework per week, which is a large time investment for such small gains. For that reason, assigning more than 70 min homework per day does not seem very efficient, as the expectation of improved results is very low. In the case of mathematics the curve is more pronounced but the interpretation is
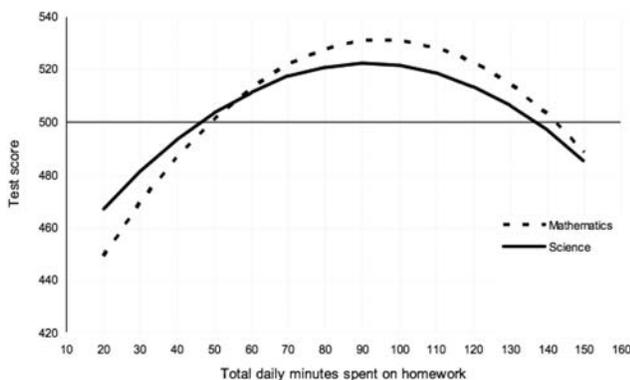

Figure 2. Prediction of performance as a function of total daily time spent on homework.

similar: around 1 hr a day of homework seems to be sufficient time to achieve satisfactory results.

As can be seen in Tables 2 and 3, the frequency of assignment gives results consistent with Model 1: more frequent homework assignment, better results. In contrast, the amount of homework gives more erratic results. Although in mathematics the effect of homework volume is significant, in the case of science, the value is at the limit of statistical significance ($p = .063$). In short, Model 1 indicates that, keeping the other variables constant, a difference of near 50 points is predicted between those students in classes where the teachers systematically assign homework and those students in classes where homework is assigned occasionally or sporadically. The predictions of Model 1 seem reasonable, although the percentage of variance it explains (especially the variance within the classes) is small. That suggests the existence of other factors related to homework that account for the differences between the classes and the students.

Model 2 explores the role of the two individual variables not related to time: effort and needing help to do homework. This model shows that both effort and autonomy in doing homework have more explanatory power than the variables considered in the previous model. In fact, time spent loses statistical significance whereas the variables related to teaching practice in terms of homework hardly change compared with the previous model. Finally, Model 2 explains twice the total variance that Model 1 does. This explanatory gain is produced in the variance within the centers, which confirms that the effort and the way the homework is done is more important than the time spent, the frequency or the amount of homework. Figure 3 shows the prediction for mathematics according to the need for help with homework, supposing constant effort by students and homework assigned daily by the teacher.

Figure 3 allows two interpretations to be made. First, student autonomy is more effective as it predicts 54 points more than for
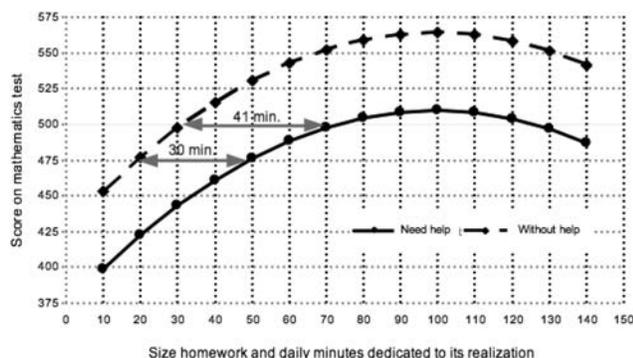
Figure 3. Prediction of mathematics performance as a function of quantity, time, and how the homework was done.

those students who need frequent or constant help. In addition, dependent students hardly score more than the average despite showing significant commitment. Second, autonomous students are more effective, especially at higher levels of ability. For example, to score 475 points, a dependent student would need, on average, 30 min per day more than an autonomous student. However, to score 500 points the dependent student would have to spend 41 min more than the autonomous student. In other words, a dependent student who spends 70 min a day on homework would expect results in the 50th percentile whereas an autonomous student who spends the same amount of time would expect to score in the 70th percentile. In science, the curve follows the same pattern as in mathematics, while noting that students who do homework without help are predicted to score 500 points with less than 25 min per day, the difference between student profiles is greater: to score 500 points, a student who needs help with homework spends 50 min more per day than a student who does homework without help.

Model 3 (see Tables 2 and 3) includes the two sociological adjustment variables. SEC is shown to be the variable with the most explanatory power, as the homework variables at an individual level see little variation. At the classroom level, the amount of homework loses its statistical significance definitively, and only the frequency of assignment retains its positive, significant effect (95% CI) in both subjects. It should also be noted that, with the inclusion of sociological adjustment variables, the total percentage of variance explained increases significantly in both mathematics and science, doubling in the latter case.

Finally, including the variables of previous academic achievement in Model 4, the results vary substantially. Prior knowledge, estimated using school grades, is shown to be the most important predictor of achievement in the test. Its effect is greater than the combined effect of all the other variables in the previous models. Furthermore, on the inclusion of variables of previous achievement, the effect of SEC is halved, which serves as a note of caution about the relationship between SEC and school grades. In terms of the homework variables, it should be noted that first, the relationship between results and homework time is, once again, negative, beyond statistical doubt in the case of science, and on the limit of statistical significance in the case of mathematics ($p = .07$). These results may be interpreted in the following way: once background factors are controlled, those students who spend more time are

possibly those who have bigger gaps in their learning or problems concentrating. Autonomy, that is, doing homework without parental involvement was shown to be the most important individual level variable, it is, after all, the only variable related to student behavior toward homework that is significant, both in mathematics and in science. The homework effort variable gave an unexpected result: in science it lacks statistical significance and in mathematics its effect is significantly reduced on the inclusion of the previous achievement variables. Finally, at a classroom level, the frequency of homework assignment, while having a reduced effect, retains its significance.

As a whole the results may be interpreted as follows: once the adjustment variables are controlled, the homework variables with most impact on the test are doing homework without help and frequency of homework assignment by teachers. Discounting the adjustment factors and all the homework related variables (including doing homework autonomously) the results of the students who attend classes in which homework is assigned daily are predicted to exceed the forecasted mean for students in classes with less frequently assigned homework by 15% of the *SD*. If the condition of doing homework autonomously is added to that, this difference is increased over a quarter (27%) of the *SD*.

The previous estimations do not take into account that compared with students who need frequent or constant help, students who do homework without parental involvement make more effort and spend less time on homework (a variable that is negatively associated with success). Figure 4 looks at all of these circumstances. It is clear that, once the adjustment variables are controlled, the difference in terms of frequency of homework assignment is close to 20 points, whereas the difference between students who need help with homework and those who do not is around 30 points. Therefore, the combined effect of variables related to student behavior toward homework and teaching practices on school grades may cause differences in the region of 50% of the *SD* in the scale of school results. The results in science are not presented in the chart but the combined effect of these variables is a little more moderate and is about 40% of the *SD*.

Discussion and Conclusions

The results of the study agree with those found in studies from Germany (Trautwein, 2007; Trautwein et al., 2002), Great Britain (Farrow et al., 1999), The Netherlands (De Jong et al., 2000), Switzerland (Trautwein, Schnyder et al., 2009), and others in Spain (Gobierno de Aragón, 2010; Gobierno Vasco, 2012). The results of the multilevel models have important practical implications. First, Model 1 confirms that the relationship between homework and academic results is not linear, something already raised by Cooper and Valentine (2001) and Daw (2012). The data suggest that spending 60 min per day doing homework is a reasonable and effective time. Furthermore, the results indicate that both the quantity of homework and the frequency of assignment are related to academic results. In any case, the predominance of frequency over quantity of homework is consistent with the data from Trautwein (2007) and Trautwein et al. (2002) and is closer to the standpoint of Farrow et al. (1999), showing that the effect of homework quantity is small. It is worth stressing that the explanatory power of this model is moderate (little more than 6% of the total variance), in line with that noted by De Jong et al. (2000).
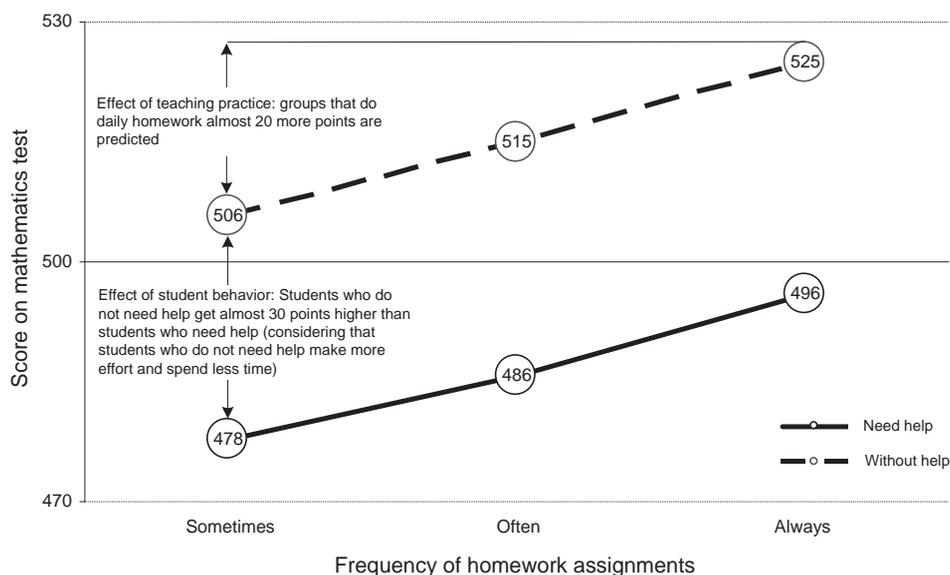
Figure 4. Prediction of mathematics performance as a function of frequency of assignment and how the homework was done.

Model 2 looks at the impact of effort and the amount of help needed to do homework. The conclusion is that when it comes to homework how is more important than how much. Once individual effort and autonomous working is considered, the time spent becomes irrelevant. This data is consistent with the central position of effort in predicting academic performance (Dettmers et al., 2010, 2011; Trautwein & Lüdtke, 2007). In addition, autonomy when doing homework may be linked to processes of self-regulation and these have been found to be positively associated with performance (Xu, 2010a). Our multilevel analysis confirms correlations that have been published by some Spanish educational authorities, which indicate that students who need frequent or constant help with homework have worse academic results (Gobierno de Aragón, 2010; Gobierno Vasco, 2012).

This reading, together with Models 3 and 4 confirms that to study the relationship between homework and academic performance, it is necessary to include adjustment variables as they give the models the added value of school effectiveness (Schereens, 1992). The inclusion of adjustment variables in studies of homework is essential for at least two reasons. First, because of their explanatory power, something that is clear when comparing the variance explained by the latter model compared with the previous ones. Second, because our data agree with that of De Jong et al. (2000) and Dettmers et al. (2009), which showed that not considering adjustment variables may undermine the results of the study. Regardless, separating the adjustment variables into two different models (on the one hand, sociological factors, and on the other, previous achievement) allows two interpretations of the data that would have been difficult to see if all of the background variables had been together in one model. First, it can be seen that the inclusion of sociological variables in Model 3 has hardly any impact on the homework variables (with the exception being the definite loss of significance of the amount of homework). However, when previous achievement is included in Model 4 the results

vary significantly, suggesting that behavior toward homework is more closely related to school experience than sociological variables. Second, it should be pointed out that the inclusion of previous achievement reduces the effect of SEC to half its previous value. The data seems to indicate that, within the adjustment variables, a student's school history has a larger effect on behavior toward homework than social origin, and this data is consistent with that found in Suárez-Álvarez, Fernández-Alonso, and Muñiz (2014).

Some conclusions may be drawn in relation to the results from Model 4. From the Level 2 factors, the principal conclusion is that the frequency of homework assignment (but not the amount of homework) has statistical significance both in mathematics and in science. This result is consistent with that described by Farrow et al. (1999) and with the findings of Trautwein (2007) and Trautwein et al. (2002), which showed that when frequency is considered, the effect of the amount of homework loses statistical significance. This data is also compatible with evidence on the potentially positive effects of teachers' homework policies (Buijs & Admiraal, 2013; Dettmers et al., 2010; Epstein & van Voorhis, 2001; Patall et al., 2010).

In terms of Level 1 variables, three conclusions stand out. First, when background factors are considered, the time spent on homework becomes negative, which is in line with the results from Trautwein (2007), Trautwein and Ludtke (2007), and Trautwein, Schnyder et al. (2009). In addition, autonomy, that is, doing homework without parental involvement, is the homework behavior-related variable with the best connection to results. This data compares with conclusions by Xu (2010a), and is consistent with theories that emphasize the role of self-control in the learning process (Zimmerman & Kitsantas, 2005). Finally, it should be noted that once prior knowledge is discounted, the homework effort variable presents a small effect in mathematics and no effect in science. This data contradicts the central position of effort in the

model of Trautwein et al. (2006), and the conclusions drawn by Dettmers et al. (2010, 2011). Looking at the correlation matrix (see Table 1) it is worth noting that our effort measure is high and positively correlated with homework time ($r = .51$), whereas Trautwein (2007) indicated that these variables are independent. In addition, effort shows a better correlation with the teachers' scores than with the results in the test. This is more pronounced in science. Although colinearity between homework effort and teachers' scores has been ruled out, there is covariation between these two variables. The teachers very probably consider the students' efforts in their scores that would explain why this effect loses significance when school grades are controlled for. This result indicates that school grades may produce some bias when used as estimators of previous knowledge. According to data from the Gobierno del Principado de Asturias (2010) only a small proportion of teachers assign school grades based exclusively or mainly on results of standardized achievement tests. The majority also consider other aspects, such as behavior, interest, participation, and effort. For 40% of teachers these aspects together are given as much or more weight than standardized achievement tests when assigning school grades. Furthermore, as indicated by Trautwein, Schnyder et al. (2009), school grades are not strictly comparable between classrooms, as teachers assign them with reference to the class group level and not the total student population. Although school grades have the advantage of being easy to obtain, objective measures of previous achievement based on ad hoc tests seem more appropriate (Murillo & Martínez-Garrido, 2013; Trautwein, 2007).

Finally, to appropriately interpret the results, some consideration must be made of the study's limitations. As Trautwein and Lüdtke (2009) noted, the word "effect" must be understood as "predictive effect." In other words, it is possible to say that effort doing homework is connected to performance; however, it is not possible to say in which direction the association runs. In fact the data presented are correlations and as such one can only speak of an association between variables and not of directionality in the analysis. In addition, the sample was restricted to students around 13-years old and as noted by Cooper (1989a, 1989b), the strength of the homework-results relationship depends in large part on the student's age.

One of the limitations of the study is that the items referring to homework are generic, they do not distinguish between the two subjects being evaluated, mathematics and science. There is evidence that indicates that behavior, motivation and emotions about homework can vary between subjects (Goetz, Nett, Martiny, Hall, Pekrun, Dettmers, & Trautwein, 2012; Trautwein & Lüdtke, 2007; Trautwein et al., 2006). Therefore, for example, motivation has a pattern associated with gender; boys demonstrate more expectancy and task value in physics-mathematics subjects, and girls demonstrate more effort in communicative-linguistic subjects (Trautwein & Lüdtke, 2009).

Nonetheless, when the dependent variables are school results the differences between subjects are not so clear. Lubbers et al. (2010) separated homework time in language and mathematics and found that the effects of both variables were equal for predicting achievement in the two subjects. Chang, Wall, Tare, Golonka, and Vatz (2014) have highlighted the same pattern in relation to homework time-achievement in a variety of foreign languages, and Goetz et al. (2012) reported similar correlations between academic results,

emotions, and self-concept in four different subjects. Bearing in mind that our target variables are achievement in subjects that are somewhat associated with each other, mathematics and science, it is not unreasonable to consider that the results would not have varied much even if the homework related variables had been separated by subject. Nevertheless, in future studies it will be worth distinguishing between subjects for homework related variables.

Furthermore, it should be mentioned that the analysis models presented were focused on the study of students' behavior when doing homework and in the teachers' homework assignment practices and it might be worth exploring a study based on a comprehensive theoretical framework as proposed by Cooper (1989a); Trautwein et al. (2006) and Xu (2008), which would allow the inclusion of all the relevant variables to academic performance, such as motivation and interest in the homework (Dettmers el al., 2010; Xu, 2008, 2011), self-sufficiency (Zimmerman & Kitsantas, 2005), and self-regulation (Rosário, Lourenço, Paiva, Rodrigues, Valle, & Tuero-Herrero, 2012; Xu, 2010a). The inclusion of these variables will certainly improve the explanatory power of the model.

Our data sends a clear message to teaching professionals: well used, homework remains a vital tool for comprehensive education of adolescents. The results indicate that regular assignment of homework and how it is carried out are two key aspects, which have a series of implications for educational practice. School homework has traditionally been considered as an opportunity to augment teaching and the time spent on a subject (Paschal et al., 1984), but this argument loses force once the limited predictive capacity of homework time is seen (Trautwein, 2007; Trautwein, Schnyder et al., 2009). Nevertheless, far from being devalued, school homework has demonstrated new, rich values and is currently seen as an opportunity to improve the student's engagement with their own learning (Xu, 2013; Zimmerman & Kitsantas, 2005). This is surely our work's main message to teachers, that doing homework is still valid nowadays in technically sophisticated learning contexts. Our data indicate that it is not necessary to assign huge quantities of homework, but it is important that assignment is systematic and regular, with the aim of instilling work habits and promoting autonomous, self-directed learning. Homework should not exclusively aim for repetition or revision of content, as this type of task is associated with less effort and lower results (Trautwein et al., 2002). On the contrary, homework should present a certain level of challenge or difficulty, without being so challenging that it discourages effort (Dettmers et al., 2010). In the last decade, school homework has been connected to principle variables such as effort, responsibility, study techniques, causal attributions before the task, and self-efficacy (Kitsantas & Zimmerman, 2009). Stoeger and Ziegler (2008) consider that self-regulation is something which can be trained when doing homework, whereas providing data that indicates that the students who took best advantage of the experimental program were precisely those who had the least self-efficacy at the beginning, which seems to be evidence that teachers' homework policies do not only have positive effects on students' motivation, but also compensatory effects. In summary, our data encourages teachers to use homework as an effective tool for students' education and training.

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