Does the Way in which Students Use Computers Matter for their Performance?

Ponzo, Michela

Department of Economics and Statistics, University of Calabria

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Michela Ponzo[♣]

Department of Economics and Statistics, University of Calabria, 87036 Arcavacata di Rende (CS), Italy. E-mail: michela.ponzo@unical.it.

In this paper we investigate possible differences in student performance depending on the frequency and the type of computer usage both at home and at school of 15-years-old Italian students. Using the *PISA 2006 dataset and controlling for a wide range of individual and school characteristics, our results suggest that students using the computer at home very often obtain higher test scores than those who never use it. More importantly, we find a significant positive correlation between student achievement and the use of computer at home as educational/learning device. Focusing on the frequency of computer usage at school, it emerges that student achievement increases with the intensity of computer use but the effect becomes smaller the more often they use the computer and even negative when students use the computer at school almost every day.*

JEL classifications: I2, I21.

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1. Introduction

The effects on student performance of resources devoted to education have been deeply investigated in the economic literature and represent a central concern in the debate about educational policies. Researches on educational production function analyze a number of educational factors affecting students performance. Among all the inputs entering in the process of student learning, computer use constitutes a relevant topic in investigating the effects of technology on student achievement and on the returns of education.

A stream of research has recently investigated the impact of the computer use on worker productivity and wages in the labor market. In a seminal paper, Krueger (1993) has showed that computer users earn substantially higher wages than non-users. He has found a substantial computer wage premium ranging between 10% and 15%, interpreted as a premium for computer skills. However, DiNardo and Pischke (1997) cast doubt that this finding reflects true returns to computer skills, since they have found a premium of similar size for workers' use of pens and pencils. On the basis of this result they have concluded that not computer skills but a more general set of unobserved skills should be responsible for the computer wage premium. More recently, Borghans and ter Weel (2004) have found that while writing documents and making calculations using advanced mathematical or statistical procedures have a significant positive impact on wages, basic computer skills do not seem to matter for earnings.

Apart from this evidence focusing on the impact of computer use on worker wages, an increasing literature investigates the impact of using computers (both at home and at school) on student achievement. Evidence on this topic shows mixed results. Reviews of observational studies on the effect of classroom computers on student achievement reveal either no impact or negative effects of using computers for instructional purposes on students outcomes (Oppenheimer, 1997; Kirkpatrick and Cuban, 1998; Wenglinsky, 1998). In more recent years, a stream of research exploits natural experiments to evaluate the effects on student performance of computer availability and use at school (Angrist and Lavy, 2002; Borman and Rachuba 2001; Rouse and Krueger, 2004). In a quasi-experimental study in Israeli schools, Angrist and Lavy (2002) find that the introduction of computer-aided instruction (CAI) exerts a negative effect on fourth grade math scores while it has no impact on student performance at the eight grade level for math and other subjects.

Similarly, Borman and Rachuba (2001) and Rouse and Krueger (2004) independently analyze randomized experiments of an instruction computer program designed to improve student language and reading skills of some American public schools. In both studies, large impacts of the computerized instruction can clearly be ruled out.

In addition to this stream of research focusing on computer use at school, other studies evaluate the impact of the use of computer at home. Attewell and Battle (1999) find that students who access to the computer at home for educational purposes obtain higher test scores in mathematics and reading. Papanastasiou, Zembylas, and Vrasidas (2003) show that students who frequently use computers at home tend to have higher achievement in science test scores. However, results also show that student achievement in scientific literacy is negatively related to the use of certain types of educational software commonly used in scientific research. In a similar vein, Fuchs and Woessmann (2004) investigate the effects of ICT use at home and at school on student achievement. The authors find that student performance shows an inverted U-shaped relationship with the extent of computer and internet use at school whereas a negative correlation emerges between student achievement in math and reading and the availability of computer at home. By contrast, student achievement appears to be positively related to the use of computers at home for accessing emails and Web pages.

More recently, Wittwer and Senkbeil (2008) find that student access to the computer is not related to their performance in mathematics. However, a positive effect on mathematical achievement is observed for a small group of students who use the computer in problem-solving activities.

The Italian educational literature, analyzing the determinants of student performance using the PISA dataset, has mainly focused on the role of family background, on school level peer effects (Checchi 2004) and on the causes of the existence of regional disparities in student outcomes (Checchi, 2004; Tramonte, 2004; Bratti, Checchi, Filippin, 2007; Montanaro, 2007).

The current paper focuses on the effectiveness of computer usage both at home and at school on Italian student achievement. Using the third cycle of the Survey Programme for International Student Assessment (hereafter indicated as *PISA*) – and in particular a short questionnaire on student familiarity with ICT – at first we analyze whether the frequency in the use of the computer at home and at school, without regards to the type of usage, is related to student test scores; subsequently, we evaluate whether the specific way in which the computer is used at home (learning or leisure activities) affects student performance as measured by their secondary educational test scores. As far as we know, there are no other studies on the relevance of the frequency and the way of computer usage on student achievement in Italy.

In estimating the educational production function using cross-sectional data, there could be a risk of omitting relevant variables, since many factors – such as ability, motivation, support from the family – determining student performance are very difficult to observe and measure. In order to reduce biases deriving from omitted variables, in our estimations we control for a very wide range of individual characteristics, family background and school variables provided by the rich *PISA* dataset. It is worthwhile to stress that the estimated effects should be considered with care since they describe a correlation rather than cause-and-effect. With data at hand we cannot exclude the influence of omitted factors or that causality runs in the opposite direction. However, the consistency of our results with other findings in the international literature is quite reassuring.

Our main findings suggest that students using the computer at home almost every day achieve higher test scores than those who never use it. On the contrary, it emerges a negative correlation between student performance and the use of the computer at school on a daily basis. Moreover, we find a negative relationship between the number of computers per student available at school and student performance. Focusing on the way in which computer is used, we find evidence of a significant positive correlation between student achievement and computer usage as learning device at home.

The paper is organized as follows. Section 2 describes the *PISA* dataset we use and gives some descriptive statistics. Section 3 reports and discusses several specifications of a regression model relating the computer usage both at home and at school to student outcomes. Section 4 concludes.

2. The Data

The data source we use for our empirical analysis is the survey on the *Programme International Student Assessment* (*PISA*) developed every 3 years by the Organization for Economic Cooperation and Development (OECD). *PISA* is a system of international assessments focusing on 15-year-olds' capabilities in reading, mathematics and science literacy. In this paper we use the third wave of *PISA* which refers to data collected in 2006 mainly focused on measuring performance on science literacy. The *PISA* contains a rich set of information on students', parents' and schools characteristics[1]. The latter are collected through a questionnaire completed by school principals. *PISA* 2006 also collected data from some countries that choose to administer a short questionnaire on students familiarity with Information and Communication Technology (ICT). In the ICT questionnaire, students were asked about their familiarity with ICT, the availability and frequency of ICT use, and their confidence in performing activities related to ICT. The comprehensiveness of PISA dataset allows researchers to include a number of variables that reduces the potential bias due to the omission of relevant variables typical of this type of studies.

The Italian sample includes 21,773 students at the age of 15 tested in 806 schools. It is stratified for macro-geographical areas (North West, North East, Centre, South and Island) and for

[1] PISA data are freely available at *www.pisa.oecd.org.*

type of secondary schools attended (Lyceums, Technical schools and Vocational institutes). In a number of cases, information on parents' and schools' backgrounds are missing values. Our final sample includes 17, 167 observations.

We define the dependent variable, *Test Scores*, as the mean of student performance in the fields of Reading, Mathematics and Science. The questions we use to define our variables of interest are taken from the student ICT questionnaire and are the followings: 1) "How often do you use a computer at home?" Five answer categories are given: "almost every day", "once or twice a week", "a few times a month", "once a month or less", "never". Using this question, we define four dummy variables capturing the frequency of computer usage at home by students (the omitted category is constituted by students who never use the computer at home). Similarly, students also report how often they use computers at their school. Again, we use four dummy variables defined as above.

In addition, in order to investigate whether the various ways in which students use a computer at home have differential effects on their academic performance, we use the following question: 2) "How often do you use computers for the following reasons?" As above five answer categories (ranging from "almost every day" to "never",) are given for each of the following eleven possible alternatives: "Browse Internet", "Play games", "Write documents", "Collaborate on Internet", "Use spreadsheets", "Download software", "Graphics programs", "Educational software", "Download music", "Write programs", "Email or chat rooms".

On the basis of the specific activities that students carry out using the computer, we group together all the student's *Learning Activities* (including write documents; use spreadsheets; collaborate internet; use educational software and write programs) and the student *Leisure Activities* (browse internet; play games; download software; graphics programs; download music and "email or chat rooms") that we include in the analysis. In order to take into account student choices ("almost every day", "once or twice a week", "a few times a month", "once a month or less", "never") in all the different activities, for each group we undertook a principal component analysis summarizing the two different ways in which students use the computer at home. Principal component analysis creates linear combinations of the original variables which capture the greatest variance. We only use the first principal component (PCA).

Unfortunately, the lack of information on the *PISA* dataset on the way in which students use the computer at school, does not allow us to investigate whether the different ways in which students use the computer at school have differential effects on their performance.

Table 1 presents descriptive statistics for the main variables used in the analysis. The mean value of Test Scores is 479.26 with a standard deviation of 89.53. About 90% of Italian students have at least one computer available to them at home. Based on a five-point scale measuring overall frequency of use, the great majority of students (63%) reports daily computer usage at home while about 31% of them use it between a few times each week and less than once a month. A little minority of students (6%) never use the computer at home.

[Table 1 around here]

Females make up 50% of the sample. Students mainly came from three different types of high schools: Lyceums (about 40%), Technical (32%) and Vocational/Other schools (about 28%)[2].

Students living in the North-West constitute 23% of the population, those residing in the North-East are 39% while 4% lives in the Centre, 14% in the South and 20% on the Islands[3]. Schools are located in five different types of community: village or rural area (below 3,000 inhabitants) that make up 2.4% of the sample, small town with 3,000 to about 15,000 inhabitants (24%), town with 15,000 to about 100,000 inhabitants (49%), city with 100,000 to about 1,000,000 inhabitants (21%) and large city with over 1,000,000 inhabitants (4.2%).

Father education and Mother education represent the number of years of schooling of parents. It is set at 0 for no educational qualification; 5 for elementary school; 8 for middle school; 11 for some high school; 13 for high school; 18 for university. The average number of years of parents

[2] The Italian secondary school system can be described as tripartite, with an academic "generalist track" (Lyceum), a technically oriented education (Technical school) or a more labour market orientated track (vocational track).

[3] North-West includes the following regions: Piedmont, Lombardy, Liguria; North-East includes Veneto, Trento and Bolzano, Friuli Venezia Giulia, Emilia Romagna; Centre includes Tuscany, Lazio, Marche, Umbria; South includes Campania, Apulia, Molise, Basilicata, Calabria; Islands includes Sicily and Sardinia.

schooling in the sample is 11. The ESCS index is derived from five variables related to the students' family background: highest level of parental education, highest parental occupation, family wealth, cultural possessions, and home educational resources. The mean value of the ESCS is -0.078.

As regards computer access of students at school, 7.5% reports daily usage, about 48% of them use the computer a few times each week and 11% less than once a month. The average number of computers per student available at school is 0.19 (roughly one computer every 5 students).

The average school size (given by the total number of boys and girls enrolled) is 662.83.

3. An Empirical Analysis of the Relationship between Computer Usage and Student Achievement

In this Section we analyze whether the frequency with which students use the computer at home and at school as well as the way in which students use the computer at home are related to their academic achievement.

Our estimates are based on the following multivariate educational production function:

$$(1)\quad Y_{ij} = \beta_0 + \beta_1 X_{ij} + \sum_{h=1}^{4} \beta_h H_{ij} + \sum_{s=1}^{4} \beta_s S_{ij} + \beta_3 Leisure\_Activities_{ij} + \beta_4 Learning\_Activities_{ij} + \\ + \beta_5 F_{ij} + \beta_6 S_j + \varepsilon_{ij}$$

where Y_{ij} is the *Test Scores* achieved by student *i* at school *j*, X_{ij} is a vector of individual characteristics, H_{ij} and S_{ij} are two vectors of dummy variables describing the frequency of using the computer at home and at school respectively, $Leisure\_Activities_{ij}$ and $Learning\_Activities$ represent a measure of the way in which students use the computer at home, F_{ij} is a vector of variables capturing family background characteristics, S_j is a vector of school characteristics and ε_{ij} is an error term.

Results of our estimations concerning the effects of the frequency and the way of computers use at home on student achievement are reported in Table 2. In all equations sample weights provided in the PISA dataset are used. The reported standard errors are robust to the heteroskedasticity and corrected for the potential clustering of the residual at the school level.

[Table 2 around here]

We investigate if students who report more frequent use of computers at home obtain higher test scores than those who never use it. Column (1) shows the estimated coefficients in a model in which we only use individual characteristics, macro-geographical variables and city size dummies. From the estimates, it emerges that students achieve higher test scores the more often they use the computer. Specifically, results show that students using the computer at home almost every day perform much better (14.4) than those who never use it (reference group). The coefficient is significant at the 1% level. Students using the computer a few times each week obtain higher test scores than those who never use it (10.83) even if the impact on test scores is not as strong as those of students using the computer every day. At the contrary, it seems that students who use the computer at home less than once a month do not significantly differ from the reference category.

However, the fact that students achieve higher test scores the more often they use the computer at home may simply reflect that more able students tend to use more frequently the computer. In order to reduce the bias deriving from omitted variables, in our estimations we control for detailed information on student abilities as well as for a wide range of individual characteristics and family background.

As regards individual controls, it emerges that female students have lower educational achievements. The difference with respect to male students amounts to 8.2 points. This difference changes only slightly in the specifications including further controls. Students attending a Lyceum (Scientific and Humanities High schools) perform much better (+104.49) than those coming from Vocational and Other schools (reference group). Furthermore, students attending Technical schools perform better than those in Vocational schools even if the impact on test scores is not as strong as those of students in Scientific/Humanities schools (+59.96). The advantage of students attending Lyceum may capture both an effect of student ability or family socio economic conditions (typically, Italian students with better family background enrol in Lyceum). Moreover, students with a higher High School level obtain a much better academic performance.

In column (1) we also control for macro-regional dummies and for the size of the cities. In particular, geographical dummy variables may capture broader socio-economic conditions of different regional labour markets. Individuals living in areas with a badly functioning labour market (South and Islands in Italy) experience higher unemployment rate. The presence of this factor and the distortions affecting labour markets (see De Paola and Scoppa, 2007) may discourage students to invest in human capital. As expected, it emerges that students in Southern Italy perform significantly worse than those in the North. Moreover, we control for City Size dummies to take into account the fact that larger cities tend to be associated with a greater endowment of human capital and, as a consequence, more prone to generate externalities favouring the accumulation of skills. From our analysis it appears that the performance of students living in cities and metropolitan areas is significantly better than those attending schools located in small towns.

In column (2), several controls accounting for family background are added. It is common that students with better socio economic background tend to have better educational resources and obtain higher academic outcomes. In fact, in our analysis the educational level (in years) achieved by the parents of student is strongly positively related to the their educational performance. Besides, the dummy variables accounting for parental occupational conditions (White collar/Blue collar classification) have a strong and highly significant effect on student performance (the base category is father/mother not employed).

In sum, our results show that, controlling for a wide range of individual characteristics and socio-economic background, the more often students use a computer at home the higher the test scores they achieve.

In columns (3) and (4) we investigate the effects of the specific uses to which computers are taken at home. Specifically, we analyze (column 3) whether students differing in the way they use a computer at home, that is, as learning or leisure device, achieve different academic outcomes.

It emerges that students engaging in educational activities with the help of the computer at home achieve better learning results. This finding is probably due to the fact that using the computer a home as educational device facilitate learning and therefore knowledge. Conversely, using a computer for leisure purpose leads to worse results at school. Particularly, for these students the computer probably plays an important role in entertainment meaning that an excessive use of it can reduce time devoted to study outside of school. These results are in line with previous studies that point out that excessive game playing, for example, is negatively related to school performance (e.g., Gentile, Lynch, Ruh Linder, and Walsh, 2004), whereas educational activities are related to better learning outcomes (e.g., Wenglinsky, 1998; Fuchs and Woessmann, 2004). This pattern of results holds once family characteristics are controlled for in column (4). It emerges a statistically significant and sizable positive effect on student performance of using the computer at home as learning device (+6.19) whereas, students using the computer at home for leisure activities achieve worse learning outcomes (-1.30). Moreover, as robustness check, we compute the average values of the variables measuring both the *Learning Activities* and *the Leisure Activities* in order to analyze how students differ in their ways of using a computer at home. However, these different measures (mean values and PCA) lead to very similar results therefore, in our estimations we merely include the two indices based on the principal component analysis.

In Table 3 we estimate several specifications of the relationship between frequency of computer usage at school and student performance. Specifically, we investigate if students who report more frequent use of computers at school achieve higher test scores than those who never use it. In addition we evaluate whether the availability of computers per student at school is related to his/her performance.

[Table 3 around here]

By controlling for individual characteristics and geographical variables, column (1) shows that the frequency of computer usage at school is related to students performance in a non-linear way. In fact, we find that students using computers at school less than once a month perform much better (12.14) than those who never use it (the reference category). However, students using the computer few times each week perform worse than those using it less than once a month. More importantly, it seems that students achieve even lower scores when they use computers at school almost every day (-12.01 with respect to the reference category).

The negative effect of an excessive computer use at school on student test scores may reflect the fact that, even if computerized instructions constitute a valuable input in the student learning process, a high intensity of computer use at school may substitute alternative forms of teaching instruction, thus producing negative effects on student performance (Fuchs and Woessmann, 2004). The effects of the frequency of computer usage at school on student performance remain almost the same once we control for school characteristics and family background (columns 3 and 4).

Column (2) adds to the first specification the variable on the number of computers per student available at school. This variable is negatively related to student performance and the effect remains throughout the other specifications that add school and family background control variables. In the other specifications, we add as control variables a number of school characteristics such as school size, class size and a variable capturing the quality of educational resources, since as shown in other studies (Fuchs and Wossmann, 2004, among others), students enrolled at schools with a greater endowment of resources tend to perform substantially better in terms of educational achievement. However, our results of interest remain almost the same in all models: students who use the computer at school every day perform worse than those who use it less frequently, and hence a higher intensity of computer use at school leads to a negative effect on student achievement. Furthermore, the mere availability of computers per student at school is negatively related to his/her performance.

Finally, results reported in Table (4) are based on the most complete specification, which controls for a wide range of individual characteristics, family background and school variables, to investigate possible differences in student performance depending on how often a computer is used both at home and at school.

[Table 4 around here]

In accordance with the previous findings, it emerges that student performance is higher as the frequency of computer use at home increases. From our estimations it emerges that using the computer almost every day leads to an increase on student outcomes of about 16 points. However, this does not mean that computer use causes higher performance, but simply that there is a relationship between the two variables. It could be that higher performance and the frequency of computer use are the consequence of an omitted variable that is, for example, the higher ability of student or his/her greater motivation. It is worthwhile to note that with data at hand, in our analysis we partly capture prior ability of students by controlling for the type of High School attended, the High School level, father and mother education, parental occupational, resources available at home, and so on.

In contrast to the effects of computer use at home, the frequency with which students use the computer at school seems to produce a negative effect on student performance. This effect becomes negative and statistically significant when student use the computer at school almost every day. Since it appears to be counterproductive using computers at school almost every day, results suggest that the computer can be beneficial to student achievement if it is not conceived as a substitute for conventional forms of teaching instruction.

In addition, students perform sizably and statistically significant better when they use the computer at home for learning purpose. Conversely, it emerges that using the computer at home as leisure device leads to worse educational achievement.

4. Concluding Remarks

In this study we have attempted to explore the effects of the frequency of computer use at home and at school on the test scores of 15 years old students in Italy as reported in the PISA 2006 survey. Specifically, we have investigated if secondary school students which frequently use the computer at home perform better than those making a more limited use of it. In addition, in order to examine the effectiveness of students computer use, we have also focused on the way in which students use the computer at home and how this may affect their school performance. Finally, we have analysed if the frequency of computer use at school has an impact on student performance.

Controlling for a wide range of individual variables, family background and school characteristics, our results suggest that students using the computer at home almost every day obtain higher test scores than those who never use it. Moreover, we find a significant positive correlation between student academic achievement and an intense computer usage at home as educational device. Notwithstanding the fact that, in the most complete specifications, we are controlling for a host of factors which are correlated with student educational attainment, we find evidence that student computer-related behavior at home plays an important role in predicting their academic achievement. In particular, students using a computer at home almost every day increase their test scores of about 16 points, significantly at the 1 % level. In addition, results suggest that students differ in their academic performance depending on how they use the computer at home. Whereas leisure activities do not benefit student achievement, the use of the computer for learning purpose improves their school performance of about 6.5 points.

As regards other relevant findings of our investigation, it emerges that the frequency of computer usage at school has a negative effect on student performance. Moreover it emerges that the mere availability of computers per student at schools leads to lower academic achievement.

From a policy perspective, this analysis indicates that efforts should shift from providing access to increasing the use of Information and Communication Technologies in ways that are productive for learning and its application in the economy and society both at school and at home.

A limitation of this study is the cross sectional nature of PISA dataset that does not allow us to be sure of the existence of a causal effect. In other words, the relationship between frequency of computer use or specific types of software usage with academic achievement can not be taken as complete evidence of the impact of computers on learning. For example, it is possible that omitted factors related to the use of computers may indirectly influence educational performance. In order to limit these problems in our empirical analysis we have controlled for a host of individual characteristics, socio-economic background and school characteristics.

Despite these shortcomings, the analysis performed shows that it is not the use of computers itself that influence the student performance, but the frequency of computer usage, the way in which it is used and the context in which this takes place.

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APPENDIX

Table 1. Descriptive statistics

Variables	Mean	Std. Dev.	Min	Max	Obs
Test Scores	479.263	89.527	76.333	732.618	21773
Mathematics Scores	473.628	92.290	7.563	895.225	21773
Reading Scores	477.008	102.626	1.020	1078.888	21773
Science Scores	487.153	93.266	95.989	800.566	21773
Student Characteristics					
Frequency of computer usage at home:					
Almost every day	0.635	0.482	0	1	20982
A few times each week	0.212	0.409	0	1	20982
Between once a week and once a month	0.069	0.176	0	1	20982
Less than once a month	0.026	0.112	0	1	20982
Never	0.058	0.162	0	1	20982
Leisure activities (PCA)	0.000	1.508	-2.694	3.167	20889
Learning activities (PCA)	0.000	1.625	-4.452	2.750	20723
Leisure activities (Mean value)	2.879	0.981	1	5	20889
Learning activities (Mean value)	3.450	0.907	1	5	20723
Female	0.498	0.500	0	1	21773
Lyceum	0.397	0.489	0	1	21773
Technical school	0.321	0.467	0	1	21773
Vocational and Other schools	0.282	0.450	0	1	21773
Grade (school year level)	9.847	0.408	9	11	21597
North West	0.226	0.418	0	1	21773
North East	0.389	0.488	0	1	21773
Centre	0.038	0.190	0	1	21773
South	0.144	0.351	0	1	21773
Islands	0.204	0.403	0	1	21773
Village (< 3,000 inhabitants)	0.024	0.152	0	1	21300
Small town (3,000-15,000)	0.236	0.425	0	1	21300
Town (15,000-100,000)	0.487	0.500	0	1	21300
City (100,000-1,000,000)	0.211	0.408	0	1	21300
Large city (over 1,000,000)	0.042	0.201	0	1	21300
Family Background Characteristics					
Mother education (in years)	10.891	3.601	0	18	21239
Father education (in years)	10.936	3.741	0	18	20947
Index of economic, social, and cultural status (ESCS)	-0.078	0.957	-3.389	3.022	21683
Father white collar	0.529	0.499	0	1	21095
Father blue collar	0.426	0.495	0	1	21095
Father unemployed	0.044	0.206	0	1	21095
Mother white collar	0.534	0.499	0	1	21773
Mother blue collar	0.156	0.362	0	1	21773
Mother unemployed	0.310	0.463	0	1	21773
School Characteristics					
Frequency of computer usage at Schools:					
Almost every day	0.075	0.263	0	1	20922
A few times each week	0.478	0.499	0	1	20922
Between once a week and once a month	0.164	0.369	0	1	20922
Less than once a month	0.107	0.309	0	1	20922

Never	0.177	0.381	0	1	20922
Computers available at school per student	0.195	0.181	0	1.769	20619
School size	662.831	419.982	9	2536	20810
Class size	24.931	9.731	13	52	21773
Quality of educational resources (index)	0.214	0.980	-2.639	2.135	21220

Data Source: PISA 2006.

Table 2. Determinants of Students Test Scores. Columns (1-2) Frequency of Computer Usage at Home. Columns (3-4) Way of Computer Usage at Home.

Variables	(1)	(2)	(3)	(4)
PC use: less than once a month	3.018	2.559		
	(5.950)	(6.152)		
PC use: between once a week and once a month	8.461*	10.338*		
	(5.067)	(5.275)		
PC use: a few times each week	10.833**	11.301**		
	(4.737)	(4.961)		
PC use: almost every day	14.436***	14.692***		
	(4.696)	(4.938)		
Learning activities			6.581***	6.188***
			(0.547)	(0.554)
Leisure activities			-2.206***	-1.303**
			(0.604)	(0.623)
Female	-8.243***	-8.540***	-11.377***	-11.661***
	(1.438)	(1.465)	(1.411)	(1.436)
Lyceum	104.491***	98.770***	101.231***	95.047***
	(1.897)	(2.116)	(1.909)	(2.130)
Technical school	59.958***	58.089***	59.303***	57.506***
	(1.906)	(1.973)	(1.901)	(1.964)
Grade (school year level)	41.886***	40.097***	40.574***	38.281***
	(1.822)	(1.861)	(1.814)	(1.843)
North East	16.107***	15.779***	15.295***	14.721***
	(1.647)	(1.667)	(1.642)	(1.657)
Centre	-22.718***	-22.583***	-21.797***	-21.846***
	(2.563)	(2.611)	(2.556)	(2.595)
South	-60.556***	-56.997***	-57.440***	-54.200***
	(1.832)	(1.926)	(1.831)	(1.913)
Islands	-73.535***	-69.146***	-69.135***	-64.884***
	(2.057)	(2.132)	(2.035)	(2.108)
Small town (3,000-15,000)	21.959***	23.773***	20.180***	21.184***
	(5.615)	(5.846)	(5.389)	(5.572)
Town (15,000-100,000)	25.956***	27.961***	23.993***	25.335***
	(5.509)	(5.748)	(5.277)	(5.471)
City (100,000-1,000,000)	27.330***	28.705***	25.361***	26.262***
	(5.600)	(5.851)	(5.377)	(5.587)
Large city (over 1,000,000)	31.524***	32.166***	29.953***	29.511***
	(6.059)	(6.285)	(5.828)	(6.011)
Mother education (in years)		0.591**		0.281
		(0.284)		(0.284)
Father education (in years)		0.928***		0.800***
		(0.283)		(0.280)
Index of economic, social, and		-2.298		0.718

cultural status (ESCS)				
		(1.490)		(1.486)
Father white collar		15.356***		15.500***
		(3.916)		(3.967)
Father blue collar		14.377***		14.786***
		(3.917)		(3.959)
Mother white collar		12.347***		10.982***
		(1.933)		(1.905)
Mother blue collar		11.114***		10.944***
		(2.228)		(2.214)
Constant	-19.227	-37.673*	-0.964	-6.779
	(18.713)	(20.000)	(18.318)	(19.463)
Observations	20391	19176	19934	18776
R-squared	0.451	0.459	0.461	0.470
Pseudo R-squared	-113641	-106560	-110801	-104040

Notes: Ordinary Least Squares Regressions. The dependent variable is *Test Scores*. Standard errors (robust to heteroskedasticity) are reported in parentheses. The standard errors are corrected for the potential clustering at the school level. The symbols ***, **, * indicate that coefficients are statistically significant, respectively, at the 1, 5, and 10 percent level. Sample weights are used. Data source: *PISA* 2006.

Table 3. Determinants of Students Test Scores. Frequency of Computer Usage at School.

Variables	(1)	(2)	(3)	(4)
PC use (school): less than once a month	12.140***	12.040***	12.055***	12.187***
	(3.123)	(3.151)	(3.008)	(2.997)
PC use (school): between once a week and once a month	7.348**	8.611***	7.985***	6.932**
	(3.109)	(3.020)	(2.942)	(2.890)
PC use (school): a few times each week	5.766*	7.855**	6.601**	6.737**
	(3.205)	(3.250)	(3.267)	(3.128)
PC use (school): almost every day	-12.093**	-8.858*	-9.605**	-9.295**
	(4.689)	(4.716)	(4.603)	(4.628)
Computers available at school per student		-35.201***	-24.527*	-22.415*
		(12.396)	(12.804)	(11.930)
Female	-9.734***	-8.906***	-8.530***	-8.512***
	(2.411)	(2.355)	(2.324)	(2.246)
Lyceum	105.197***	102.599***	101.882***	95.371***
	(4.897)	(4.812)	(4.785)	(4.875)
Technical school	61.025***	60.789***	60.598***	58.248***
	(4.946)	(4.866)	(4.835)	(4.632)
Grade (school year level)	42.750***	41.397***	41.173***	39.092***
	(2.488)	(2.467)	(2.439)	(2.391)
North East	-22.365***	-22.908***	-21.866***	-22.004***
	(6.465)	(6.418)	(6.478)	(6.264)
Centre	-59.965***	-62.113***	-62.009***	-58.236***
	(5.123)	(5.069)	(5.158)	(5.046)
South	-74.205***	-74.441***	-72.486***	-67.803***
	(5.633)	(5.656)	(5.682)	(5.579)
Small town (3,000-15,000)	23.520*	25.740*	22.164	23.254
	(14.087)	(15.385)	(16.861)	(16.057)

Town (15,000-100,000)	26.825*	26.615*	20.383	21.970
	(13.815)	(15.039)	(16.695)	(15.914)
City (100,000-1,000,000)	28.805**	28.739*	20.057	21.048
	(13.885)	(15.166)	(16.911)	(16.149)
Large city (over 1,000,000)	33.591**	32.737**	24.119	24.230
	(15.385)	(16.565)	(18.063)	(17.196)
School size			0.014***	0.014***
			(0.005)	(0.005)
Class size			-0.424*	-0.400*
			(0.243)	(0.233)
Quality of educational resources (index)			1.091	0.637
			(2.106)	(2.019)
Mother education (in years)				0.333
				(0.307)
Father education (in years)				0.808**
				(0.335)
Index of economic, social, and cultural status (ESCS)				0.393
				(1.602)
Father white collar				14.155***
				(5.072)
Father blue collar				13.571***
				(4.884)
Mother white collar				11.472***
				(1.883)
Mother blue collar				11.020***
				(2.429)
Constant	-11.514	7.030	13.771	2.161
	(28.057)	(28.666)	(30.210)	(30.801)
Observations	20329	19592	19480	18316
R-squared	0.453	0.456	0.460	0.467
Pseudo R-squared	-113247	-109092	-108392	-101607

Notes: Ordinary Least Squares Regressions. The dependent variable is *Test Scores*. Standard errors (robust to heteroskedasticity) are reported in parentheses. The standard errors are corrected for the potential clustering at the school level. The symbols ***, **, * indicate that coefficients are statistically significant, respectively, at the 1, 5, and 10 percent level. Sample weights are used. Data source: *PISA* 2006.

Table 4. Determinants of Students Test Scores.

Variables	(1)	(2)
Less than once a month	2.278	
	(6.826)	
Between once a week and once a month	10.925**	
	(5.318)	
A few times each week	11.939**	
	(5.525)	
Almost every day	15.727***	
	(5.101)	
Learning activities		6.203***
		(0.530)
Leisure activities		-1.373**
		(0.593)
Female	-7.160***	-10.377***

	(2.228)	(2.103)
Lyceum	94.192***	92.865***
	(4.902)	(4.621)
Technical school	56.975***	55.950***
	(4.703)	(4.394)
Grade (school year level)	38.187***	36.499***
	(2.429)	(2.399)
North East	17.211***	15.963***
	(4.462)	(4.305)
Centre	-22.252***	-21.216***
	(6.286)	(5.960)
South	-57.736***	-54.036***
	(5.052)	(4.904)
Islands	-66.886***	-61.619***
	(5.577)	(5.179)
Small town (3,000-15,000)	23.139	20.774
	(16.474)	(14.809)
Town (15,000-100,000)	22.238	20.346
	(16.324)	(14.655)
City (100,000-1,000,000)	21.392	19.532
	(16.554)	(14.908)
Large city (over 1,000,000)	24.444	22.846
	(17.575)	(15.927)
Mother education (in years)	0.415	0.111
	(0.303)	(0.299)
Father education (in years)	0.889***	0.832**
	(0.335)	(0.335)
Index of economic, social, and cultural status (ESCS)	-1.616	1.087
	(1.653)	(1.655)
Father white collar	14.568***	13.827***
	(5.092)	(5.111)
Father blue collar	13.607***	13.590***
	(4.921)	(4.888)
Mother white collar	11.494***	10.160***
	(1.860)	(1.857)
Mother blue collar	10.390***	9.658***
	(2.479)	(2.440)
Less than once a month at school	12.730***	13.443***
	(3.015)	(2.911)
Between once a week and once a month at school	7.419**	8.900***
	(2.881)	(2.860)
A few times each week at school	6.648**	7.058**
	(3.086)	(3.051)
Almost every day at school	-8.008*	-8.791*
	(4.728)	(4.893)
Computers available at school per student	-23.183*	-20.580*
	(11.916)	(10.962)
School size	0.014***	0.012***
	(0.005)	(0.004)
Class size	-0.430*	-0.393*
	(0.235)	(0.229)
Quality of educational resources (index)	0.624	1.049
	(2.038)	(1.903)
Constant	-10.364	14.012
	(31.562)	(29.553)
Observations	18157	17716

R-squared	0.467	0.476
Pseudo R-squared	-100679	-97956

Notes: Ordinary Least Squares Regressions. The dependent variable is *Test Scores*. Standard errors (robust to heteroskedasticity) are reported in parentheses. The standard errors are corrected for the potential clustering at the school level. The symbols ***, **, * indicate that coefficients are statistically significant, respectively, at the 1, 5, and 10 percent level. Sample weights are used. Data source: *PISA* 2006.