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Incidence of a Non-Sustainability Use of Technology on Students' Reading Performance in Pisa

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Abstract: This article describes an investigation that made a comparative analysis of the influence of the use of technology for non-academic activities on the reading performance of students in 21 countries within the Organisation for Economic Co-operation and Development (OECD), as measured by the Program for International Student Assessment (PISA). To do this, we coded the SumIC001-008-010 variables ("Devices available at home" and "How often do you use digital devices for the following activities outside school") in the PISA survey and quantified the effect by the proportion of variance explained of each variable in the model for each country. The results show that the reading score increases according to the variable for type and quantity of devices at home but falls drastically in all 21 countries when the "SumIC001" variable exceeds 15 points. Our research also found that the two activities that most negatively impacted reading performance if done on a regular basis were "playing online games via social networks" and "uploading your own created contents." These results would seem to confirm that the non-sustainability and prolonged use of technology outside school is objectively negative for the development of reading competence in young people.

Keywords: ICT; reading performance; reading competence; PISA; digital devices; outside of school; non-academic activities; frequency of use

1. Introduction

Results of studies show that the influence of the use of technology inside and outside school on students' academic performance worldwide is contradictory and hard to determine [1–3]. For example, in 2012, 96% of 15-year-old students in OECD (Organisation for Economic Co-operation and Development) countries stated that they had a computer at home, and 72% said they used a digital device at school. More and more studies show that the use of technology and digital devices in the classroom does not directly correlate to improvements in students' academic results and can have a negative effect on their educational performance [4]. It has been shown that students who use computers at school in moderation and strictly for educational purposes achieve better results than students who hardly ever use them, but if computer use is more pronounced, the results in reading, maths, and the sciences worsen across all OECD countries regardless of the students' socio-educational

context [3]. Educational policies and didactic and pedagogical trends increasingly advocate the use of technology inside and outside the classroom as a support mechanism for teaching and learning. However, caution is needed before doing so, and an analysis should be undertaken to examine and reflect on the supposed benefits of technology use inside and outside the classroom, and to identify those academic and non-academic activities, and corresponding didactic approaches, that can help improve students' academic performance and level of competence. The aim of this study is to examine if the use of technology for non-academic activities outside school can have an objectively negative impact on reading performance and, if so, to define the type of activity responsible for this deficit and determine the extent to which possession and use of a device is prejudicial for the development of students' reading skills.

2. Ict outside School and Their Influence on Students' Academic Results and Reading Performance

The use of technology has transformed the way we access texts and culture from parameters whose audiovisual elements have acquired a prominent role [5–9]. The Program for International Student Assessment (PISA) study has shown that students spend far more time online outside school than during the school day. According to data from this study, students in OECD countries spend more than two hours a day, seven days a week, connected, and this time is spent mainly on fun and leisure activities. The most common online activities that students indulge in are social networking (83%); downloading music, films, and games (70%); and chatting (69%). Half the students use the Net at least once a week to search for information of a more practical nature (66%), to read or send emails (64%), or read news (63%). In addition, 40% are gaming online on their own, and 36% in groups; 31% of students use the computer at least once a week to upload self-created content (music, videos, photos, etc.) [3].

Recent scientific literature has identified the negative impact of the time adolescents spend in front of the screen of their digital devices on areas that include sleep [10,11], physical activity [12], and social welfare [13]. This has led public authorities in several countries to raise the alarm about the potentially negative consequences of the continuous use of technology (e.g., [14]), recommending a reduction in the time children and teenagers spend on the Net during their free time to less than two hours a day [15,16]. In this day-to-day adolescent context mediated by digital devices and technology, reading competence appears to be conditioned by the student's own previous culture and the context and the purpose of the students' reading [17]. Students' reading performance is measured by considering the purpose of the reading, social relations, type of text, and subject area [17,18]. In recent PISA studies, assessment has focused on students' acquisition of skills [19] and reading competence [18,20].

Reading competence increases when the reader is challenged by new types of text, formats and contexts, and measures these new situations against previous ones [21,22]. The growing presence of digital devices at home raises many questions about their influence on adolescents' reading and writing competence [23]. The use of technology is undoubtedly a source of motivation for the majority of adolescents, and some studies have demonstrated a positive relation between technology use and academic results [24,25]. Nevertheless, the use of technology mainly arouses controversy, with its supporters and detractors in terms of the effect on students' academic performance [26,27]. Some researchers view technology as causing the destruction of traditional literacy [28], while others see in it new possibilities for boosting reading competence [5,9,29,30]. Some state that the digital revolution by no means signals the end of the habit of reading; rather, it provides new forms to promote it [31]. Indeed several studies have shown that the integration of technology in schoolwork is a two-way relationship; for example, a gamer can pick up a printed book because he/she is interested in a story on which the game is based or on an event related to it [32–34].

Young people use technological devices in non-academic situations or actions mainly for leisure activities, gaming, chatting or interacting on social networks [35]. Results on, and interpretations of, the influence of this non-academic digital activity on students' educational performance vary. Fuchs and Woessmann [36] used the PISA 2000 results to show that students who never read an email or

browsed a website for their own pleasure scored six points lower in reading, whereas students who did so several times a week scored six points higher in maths and nine in reading. The authors also demonstrated a positive correlation between using a home computer to access websites and email and students' academic performance. Gumus and Altamis [37] showed that the use of computers for non-academic activities helped students get better results, particularly in reading ($\beta 1 = 0.370$ for females and $\beta 1 = 0.379$ in males, $p < 0.001$). Moran et al. [38] stated that technology could have a positive effect on reading comprehension (an effect measure of 0.489). Likewise, Thompson and De Bortoli [39] noted that students with access to computers at home scored 61 score points higher on the PISA mathematics assessment than those without similar access (average score 514). Fuchs and Woessmann [36] also found that students who had the Internet at home scored five points higher on the PISA in math and about four points higher in reading.

The results of studies on the impact technology use on students' reading performance are contradictory, which had led investigators to call for a solid theoretical framework supported by practical evidence that addresses the issue of reading didactics from the digital society perspective, and which involves connected devices [40]. Research in this field is complex, given that reading competence is polyhedral and draws in other learning dimensions such as comprehension, metacognition, motivation, strategic and situated use, family and socio-cultural background, etc., all of which would have an important influence on any theoretical and interventional models for inside and outside the classroom. We also know that that traditional printed book reading is enriched by new audiovisual support like images, icons, and sounds, which share the reading space with print and interfere in a positive sense by facilitating interpretations and meanings in the texts [30,41]. International organizations have long been alerting to us to this new sociodigital context and its influence on reading. The National Reading Conference (NRC) drew up a white paper on "Effective Literacy Instruction for Adolescents" [32], which explicitly recognized the complexity of addressing reading in this 21st century media context. The International Reading Association [42] raised similar concerns and made the following recommendations: (a) ensuring access to a wide variety of reading materials, (b) building skills and desire to read complex materials, (c) modeling and giving explicit instruction, and (d) developing an understanding of the complexities of individual adolescent readers. What is clear is that students use technology for both academic and leisure activities [35]. Also evident is that, when students use digital devices in moderation, they get better academic results than those who hardly use them, and that those who use these devices in excess score badly in reading. What remains to be studied in depth is the type of activities with digital devices that can negatively impact on the development of reading competence and where that threshold begins.

3. Materials and Methods

The main objective of this research was to quantify how the variables associated to the "Use of ICT outside of school" can influence students' reading score in PISA. To do so, the following two macrovariables in the PISA study were used [3]: "Are any of these devices available for you to use at home?" (IC001) and "How often do you use digital devices for the following activities outside of school?" (IC008-IC010), which correspond to the "ICT (Information and communications technolog) Familiarity Questionnaire" (use of ICT "Information and communications technology" outside of school and attitudes towards computers), (see Appendix A for the description of the variables used in this study). The sample analyzed, consisting of 21 countries (Belgium, Bulgaria, Czech Republic, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, and Sweden) and 257,624 students.

To develop the methodology, it was calculated a univariate linear model on the variable "Read1," which is the compilation of the means of the plausible reading scores in the PISA database. Therefore, the "SumIC001" variable was coded, created to transform the various "IC001" variables into one, firstly by recoding the variables. "IC001" consisted of a series of questions that enabled us to establish the use and availability of digital devices outside school. We then used this information to create a variable

that could quantify the number of devices available and their use by the students. For example, the IC001QTA1 variable "availability of desk-top PC" when recoded would be "Does not have one = 0; Has one but does not use it = 1; Has one and uses it = 2." Following this logic, the results of all the questions were added to obtain the variable "SumIC001," which is the sum of the quantity of devices available and their use by the students; the higher the score, the greater the availability and use of these digital devices outside school. This approach enabled us to establish various correlation analyses.

On checking that the IC008 variable then divided into 13 nominal question variables, it was decided to evaluate the variables separately. As a result, the first model included the effect of the "IC001, IC002, IC003, IC004, IC006, and IC007" variables, and the second comprised the effect of all the "IC008" question "subvariables." Later, the size of the effect was quantified by the proportion of variance explained (the size from the "eta" to the partial square) of each of the variables in the model for each country. That value, multiplied by 100, gave the variation percentage in "Read1" that can be explained by the variables. To implement this, a sum of the total effect of the variables on "Read1" was made for both models. Later, the mean of these two effects was calculated to obtain an effect variable of the "IC" variables relating to the "Reading Score" for each country. A mean of the effect totals on each model was calculated by considering that it was mathematically incorrect to add the effects of different models, and by proposing a "final total effect" based on this assumption. Finally, a further analysis based on variable "SumIC001" was performed; taking into account that a series of categorical variables (the "IC001" variable questions) had been converted into a scale variable (SumIC001), it was interesting to make a correlation analysis between "Read1" and "SumIC001" to evaluate the presence of linear relations between such variables. Does the greater availability and use of digital devices mean better result values in the Reading Score?

4. Results

First, the results of the multi-factor ANOVA on the "Read1" (Reading Score) are presented. Effect Variables: IC001, IC002, IC003, IC004, IC006, IC007 (Table 1).

Table 1. Within-subject effects tests. Variable dependent: "Read1."

Country Code 3-Character		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Belgium	Corr. M.	10,874,406,872	44	247,145,611	39,940	0.000	0.189
	Intercept	16,926,317,516	1	16,926,317,516	2,735,412	0.000	0.266
	SumIC001	2,709,259,958	22	123,148,180	19,902	0.000	0.055
Bulgaria	Corr. M.	9,928,004,922	43	230,883,835	29,691	0.000	0.226
	Intercept	15,692,644,176	1	15,692,644,176	2,018,055	0.000	0.315
	SumIC001	2,893,903,317	21	137,804,920	17,722	0.000	0.078
Czech Republic	Corr. M.	8,213,412,954	43	191,009,604	27,088	0.000	0.167
	Intercept	19,522,620,377	1	19,522,620,377	2,768,647	0.000	0.323
	SumIC001	3,336,812,837	21	158,895,849	22,534	0.000	0.075
Republic Czech	Corr. M.	8,213,412,954	43	191,009,604	27,088	0.000	0.167
	Intercept	19,522,620,377	1	19,522,620,377	2,768,647	0.000	0.323
	SumIC001	3,336,812,837	21	158,895,849	22,534	0.000	0.075
Denmark	Corr. M.	4,370,257,290	42	104,053,745	19,311	0.000	0.132
	Intercept	7,861,263,708	1	7,861,263,708	1,458,915	0.000	0.214
	SumIC001	1,413,265,127	20	70,663,256	13,114	0.000	0.047
Spain	Corr. M.	5,090,867,677	44	115,701,538	22,606	0.000	0.144
	Intercept	10,937,391,685	1	10,937,391,685	2,136,954	0.000	0.265
	SumIC001	1,172,414,416	22	53,291,564	10,412	0.000	0.037

Table 1. *Cont.*

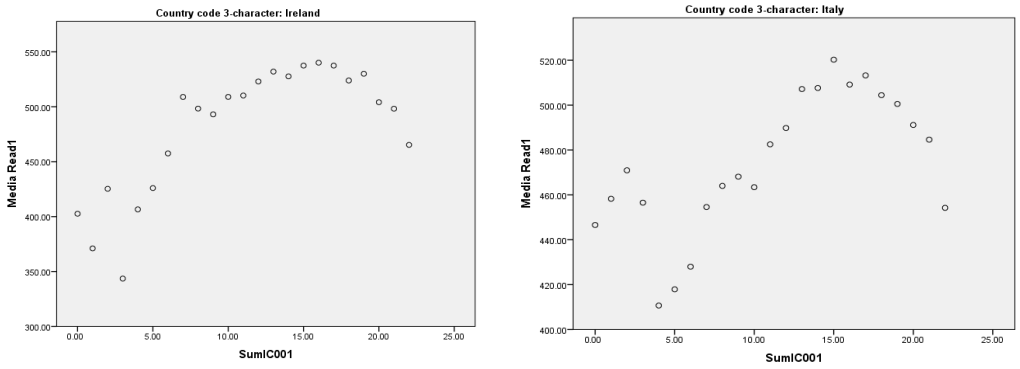
Country Code 3-Character		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Estonia	Corr. M.	4,902,539,954	42	116,727,142	21,396	0.000	0.157
	Intercept	14,350,477,582	1	14,350,477,582	2,630,390	0.000	0.353
	SumIC001	2,095,874,736	20	104,793,737	19,208	0.000	0.074
Finland	Corr. M.	4,844,872,7550	41	118,167,628	20,129	0.000	0.140
	Intercept	9,185,033,882	1	9,185,033,882	1,564,576	0.000	0.235
	SumIC001	1,972,222,927	19	103,801,207	17,681	0.000	0.062
France	Corr. M.	8,467,749,957	43	196,924,418	25,733	0.000	0.185
	Intercept	22,598,088,383	1	22,598,088,383	2,953,018	0.000	0.378
	SumIC001	2,432,939,749	21	115,854,274	15,139	0.000	0.061
Greece	Corr. M.	5,387,468,468	44	122,442,465	21,058	0.000	0.168
	Intercept	20,935,305,792	1	20935305,792	3,600,559	0.000	0.439
	SumIC001	1,871,295,146	22	85058,870	14,629	0.000	0.065
Hungary	Corr. M.	6,732,591,947	43	156571,906	25,242	0.000	0.185
	Intercept	3,981,461,486	1	3,981,461,486	641,877	0.000	0.118
	SumIC001	1,718,959,227	21	81,855,201	13,196	0.000	0.055
Ireland	Corr. M.	4,723,972,669	44	107,363,015	19,965	0.000	0.151
	Intercept	14,547,905,684	1	14,547,905,684	2705,249	0.000	0.353
	SumIC001	1,338,381,092	22	60,835,504	11,313	0.000	0.048
Iceland	Corr. M.	3,418,788,526	39	87,661,244	12,095	0.000	0.139
	Intercept	21,233,899,314	1	21,233,899,314	2,929,640	0.000	0.501
	SumIC001	1,032,715,644	18	57,373,091	7916	0.000	0.047
Italy	Corr. M.	7,302,292,299	44	165,961,189	28,051	0.000	0.113
	Intercept	30,917,514,999	1	30,917,514,999	5,225,763	0.000	0.351
	SumIC001	2,174,454,826	22	98,838,856	16,706	0.000	0.037
Lithuania	Corr. M.	7,976,834,529	44	181,291,694	32,156	0.000	0.208
	Intercept	20,195,893,415	1	20,195,893,415	3,582,162	0.000	0.399
	SumIC001	2,695,121,151	22	122,505,507	21,729	0.000	0.082
Luxembourg	Corr. M.	7,757,786,710	43	180,413,644	23,906	0.000	0.197
	Intercept	17,464,448,043	1	174,64,448,043	2,314,182	0.000	0.356
	SumIC001	1,849,485,058	21	88,070,717	11,670	0.000	0.055
Netherlands	Corr. M.	6,016,803,676	37	162,616,316	24,426	0.000	0.163
	Intercept	37,441,422,672	1	37,441,422,672	5,623,940	0.000	0.547
	SumIC001	2,071,548,288	16	129,471,768	19,447	0.000	0.063
Poland	Corr. M.	4,173,514,997	42	99,369,405	17,534	0.000	0.155
	Intercept	4,436,208,747	1	4,436,208,747	782,792	0.000	0.163
	SumIC001	1,860,518,513	20	93,025,926	16,415	0.000	0.076
Portugal	Corr. M.	9,466,451,259	43	220,150,029	37,546	0.000	0.207
	Intercept	51,815,548,221	1	51,815,548,221	8,837,022	0.000	0.588
	SumIC001	3,985,383,358	22	181,153,789	30,895	0.000	0.099
Slovak Republic	Corr. M.	8,049,547,805	44	182,944,268	29,021	0.000	0.199
	Intercept	9,293,062,456	1	929,3062,456	1,474,184	0.000	0.223
	SumIC001	2,850,245,044	22	129,556,593	20,552	0.000	0.081
Slovenia	Corr. M.	6,271,003,611	43	145,837,293	25,469	0.000	0.172
	Intercept	6,737,791,298	1	6,737,791,298	1,176,668	0.000	0.182
	SumIC001	2,734,954,438	21	130,235,926	22,744	0.000	0.083
Sweden	Corr. M.	4,863,460,233	42	115,796,672	17,907	0.000	0.148
	Intercept	6,265,377,227	1	6,265,377,227	968,879	0.000	0.182
	SumIC001	1,814,864,035	20	90,743,202	14,033	0.000	0.061

It can be observed that the influence of the "SumIC001" add variable on the result for reading is significant in the 21 countries analyzed (Sig.000). The countries where the percentage of the variance explained by the variable "SumIC001" in students' reading performance is higher is mainly in Eastern Europe: Bulgaria = 7.8%; Slovenia = 8.3%; Slovak Republic = 8.1%; Lithuania = 8.2%; Poland = 7.6% and, Portugal = 9.9%. Later, the point at which the "SumIC001" variable and the effects start to have a negative effect on "Reading Score" was calculated (Table 2).

Table 2. "SumIC001" variable and the effects on "Reading Score."

Country Code 3-Character		Mean	Std. Deviation	N
Belgium	Read1	501.7655	93.83249	9651
	SumIC001	16.4671	3.00231	7861
Bulgaria	Read1	434.6840	107.14943	5928
	SumIC001	15.0693	4.33790	4719
Czech Republic	Read1	498.4047	97.01967	6894
	SumIC001	15.0489	3.33931	5973
Denmark	Read1	487.2601	85.31990	7161
	SumIC001	15.2956	2.95768	5568
Spain	Read1	499.8391	80.13852	6736
	SumIC001	15.5671	3.42434	6131
Estonia	Read1	520.8162	81.80146	5587
	SumIC001	14.4388	3.46931	4959
Finland	Read1	527.6467	87.52816	5882
	SumIC001	15.0658	3.22040	5261
France	Read1	503.6678	105.21670	6108
	SumIC001	16.0263	3.24531	5092
Greece	Read1	476.8011	88.44407	5532
	SumIC001	14.9942	3.82079	4800
Hungary	Read1	477.2513	89.79812	5658
	SumIC001	14.9406	3.91130	4948
Ireland	Read1	520.7476	81.06800	5741
	SumIC001	15.9122	3.21401	5093
Iceland	Read1	482.4179	92.66222	3371
	SumIC001	15.3186	3.12144	3032
Italy	Read1	492.8792	83.92693	11,583
	SumIC001	16.0274	3.42233	10,005
Lithuania	Read1	465.5506	88.47107	6525
	SumIC001	14.5931	3.97098	5616
Luxembourg	Read1	482.2881	101.00571	5299
	SumIC001	16.7355	3.43491	4446
Netherlands	Read1	504.9517	95.81925	5385
	SumIC001	16.8562	2.66413	4744
Poland	Read1	506.5414	83.32806	4478
	SumIC001	15.7399	3.65607	4114
Portugal	Read1	486.5672	87.63613	7325
	SumIC001	15.7748	3.59541	6417
Slovak Republic	Read1	454.5665	98.02650	6350
	SumIC001	15.3105	3.74695	5366
Slovenia	Read1	485.9434	87.86514	6406
	SumIC001	15.1942	3.48792	5505
Sweden	Read1	500.1882	94.93591	5458
	SumIC001	15.2221	3.49772	4571

The results in Figure 1 (as an example of two countries) show, when the value exceeds 14.5 points, the reading result begins to fall.

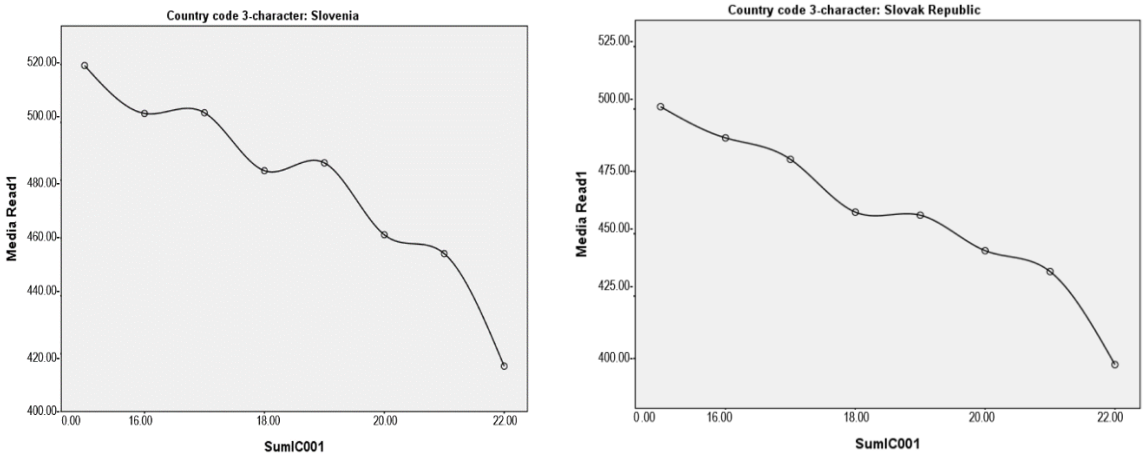


(**a**) (**b**)

Figure 1. Dispersion graphs of the mean in reading in accordance with the influence of the "SumIC001" variable.

Later, a correlation analysis between the "Read1" and "SumIC001" variables was carried out, but only for individuals with SumIC001 values greater than 14.5 (Table 3). All the correlations were significant and negative. The Pearson value showed the extent of the effect of SumIC001 on Read1 for extreme SumIC001 values.

As an example, Figure 2 shows the countries where the effect is more negative, namely in Slovenia (−0.359 **) and the Slovak Republic (−0.353 **).



(**a**) (**b**)

Figure 2. Correlation between "SumIC001" and "Read1" (Slovenia and the Slovak Republic).

Table 3. Correlation between "SumIC001" and "Read1."

Country Code 3-Character			SumIC001	Read1	Country Code 3-Character			SumIC001	Read1
Belgium	SumIC001	Pearson C.	1	−0.245 **	**Ireland**	SumIC001	Pearson C.	1	−0.209 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	6007	0.007			N	3510	3510
Bulgaria	SumIC001	Pearson C.	1	−0.320 **	**Iceland**	SumIC001	Pearson C.	1	−0.254 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	2463	2463			N	1836	1836
Czech Republic	SumIC001	Pearson C.	1	−0.330 **	**Slovenia**	SumIC001	Pearson C.	1	−0.359 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	3280	3280			N	3065	3065
Denmark	SumIC001	Pearson C.	1	−0.228 **	**Italy**	SumIC001	Pearson C.	1	−0.202 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	3414	3414			N	6828	6828
Spain	SumIC001	Pearson C.	1	−0.135 **	**Lithuania**	SumIC001	Pearson C.	1	−0.348 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	4031	4031			N	2677	2677
Estonia	SumIC001	Pearson C.	1	−0.334 **	**Luxembourg**	SumIC001	Pearson C.	1	−0.239 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	2332	2332			N	3406	3406
Slovak Republic	SumIC001	Pearson C.	1	−0.353 **	**Netherlands**	SumIC001	Pearson C.	1	−0.244 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	3093	3093			N	3893	3893
Finland	SumIC001	Pearson C.	1	−0.321 **	**Poland**	SumIC001	Pearson C.	1	−0.301 **
		Sig. (2-tailed)		−0.000			Sig. (2-tailed)		0.000
		N	2942	2942			N	2598	2598
France	SumIC001	Pearson C.	1	−0.282**	**Portugal**	SumIC001	Pearson C.	1	−0.345 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		,000
		N	3526	3526			N	4249	4249
Greece	SumIC001	Pearson C.	1	−0.304 **	**Slovenia**	SumIC001	Pearson C.	1	−0.305 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	2602	2602			N	2609	2609
Hungary	SumIC001	Pearson C.	1	−0.283 **	**Ireland**	SumIC001	Pearson C.	1	−0.209 **
		Sig. (2-tailed)		0.000			Sig. (2-tailed)		0.000
		N	2676	2676			N	3510	3510

** Correlation is significant at the 0.01 level (2-tailed).

In Figure 2, it can be observed that reading score falls dramatically when a value of 16–17 points is reached in the "SumIC001" variable. These results are systematic in all the countries analyzed. Thus, it could be stated that evidence shows that extensive contact with digital media has a negative effect on the development of young people's reading capacity. Table 4 shows the Pearson correlation coefficient for activities that impact negatively on the reading performance of the students from the 21-country sample analyzed.

The results in Table 4 show that the average of variables 7 and 12 is the highest in the countries analyzed. "Playing online games via social networks" (0.037) and "uploading your own created contents for sharing (e.g.,: music, poetry, videos, computer programs)" (0.031) are activities that have a negative effect on students' reading capacity when done on a daily basis.

Table 4. Non-academic activities and correlation with reading performance.

Countries IC008	Q03TA	Q07NA	Q10TA	Q12TA	Q13NA
Belgium	0.034	0.033	0.035	0.026	0.031
Bulgaria	0.008	0.043	0.027	0.032	0.017
Czech Republic	0.038	0.054	0.015	0.028	0.029
Denmark	0.022	0.009	0.026	0.041	0.034
Spain	0.032	0.023	0.028	0.017	0.031
Estonia	0.044	0.034	0.017	0.041	0.029
Finland	0.014	0.011	0.033	0.018	0.036
France	0.038	0.029	0.032	0.037	0.043
Greece	0.015	0.043	0.015	0.023	0.008
Hungary	0.023	0.047	0.013	0.034	0.029
Ireland	0.014	0.035	0.035	0.032	0.040
Iceland	0.007	0.012	0.019	0.043	0.041
Italy	0.044	0.035	0.016	0.022	0.025
Lithuania	0.015	0.046	0.003	0.034	0.023
Luxembourg	0.031	0.051	0.021	0.055	0.031
Netherlands	0.033	0.031	0.039	0.028	0.026
Poland	0.013	0.061	0.018	0.032	0.019
Portugal	0.021	0.070	0.007	0.037	0.010
Slovak Republic	0.032	0.036	0.022	0.025	0.018
Slovenia	0.032	0.045	0.025	0.045	0.018
Sweden	0.029	0.032	0.015	0.015	0.018
Total / Mean	0.025	0.037	0.021	0.031	0.026

$p < 0.01$ IC008Q03TA Using email. IC008Q07NA Playing online games via social networks (e.g., <Farmville®>, <The Sims Social>). IC008Q10TA Obtaining practical information from the Internet (e.g., locations, dates of events). IC008Q12TA Uploading your own created contents for sharing (e.g., music, poetry, videos, computer programs). IC008Q13NA Downloading new apps on a mobile device.

5. Discussion

The results of this investigation show that intensive use of technology, when exceeding 15 points in the "SumIC001" variable (possession and use of digital devices and technology at home) has a negative impact on the results for reading performance of all students in the 21 OECD countries analyzed in PISA. The PISA 2009 survey also indicated that excessive use of digital devices correlated negatively to results for reading performance [43]. This supports other results that show that the students who most use technologies score worse for reading, according to PISA [44–47]. This coincides with other studies that state that the use of technology in itself does not improve academic outcomes [48]. Other researchers have related intensive technology use among adolescents to poor academic results and personal and family problems, and even low physical performance [1,32,49]. Studies that have analyzed the influence of the use of technology on students' competence in subjects like maths show that intensive contact with digital devices undermines academic performance [36,50,51].

In contrast, this negative effect on reading competence is reversed if technology is used in moderation (those students whose scores do not exceed 15 points in the "SumIC001" variable); they also have better results than students who never use digital devices outside school. The positive effect of the judicious use of technology has also been documented in other studies, such as Leino [8], which showed that restrained use of technology can boost reading competence, especially among male students. A possible explanation for this could be that surfing Internet requires reading online texts, and those students who rarely pick up a printed book do their reading indirectly when Net surfing. Our findings, that moderate use of technology impacts positively on reading performance, better than those students who do not use digital devices at all, also fit with other studies that have shown that confidence in handling ICT reflects positively on students' reading capacity.

The results of our investigation show that intensive use of digital devices during the week to perform non-academic activities such as "playing online games via social networks" and "uploading your own created contents for sharing (e.g.,: music, poetry, videos and computer programs)" is

prejudicial for students' reading competence, as measured by PISA. This negative effect on the reading performance and social lives of students who are heavily involved in social networking has also been identified in other studies [34,36,52]. The negative effect of online social networking has been demonstrated in students' study habits and ability to develop tasks [53]. The OECD itself [3] has indicated that when students spend more than six hours a day online, they begin to show signs of isolation, tend to arrive late at school, or fail to turn up altogether. This could be due to that fact that the development of competences and learning requires a close teacher–student relationship that a student's intensive technology use inhibits. Results from the "Second International Adult Literacy Survey (SIALS)" in Finland also show that users of ICT who are active and versatile make for better and more active readers [17].

If the student is educated to use technologies in a suitable and productive way, this can increase their capacity to capture the main ideas and arguments put forward in a written text [54,55]. Several studies confirm that the positive effect of technology use on reading performance is conditioned by how digital devices are used [36,44,46,56,57] and where the type of activity carried out with a computer or digital device has the most impact [36,44,46,56,57]. It seems that the use of educational software has a negative influence on students' reading competence [44,47]. In contast, moderate technology use for activities such as searching for information, reading and writing emails, and reading news online has a curvilinear relation to the results for digital reading, proving that users who make sensible and specific use of technology score better than those who spend hours surfing the Net [43].

In the context of Latin American and reading in the Spanish language, evidence that technology use improved academic results in general was not demonstrated (for example, in Colombia [58]). Teachers in Peru stated that the influence of technology use on digital reading competence existed, according to the activities carried out online. Net surfing for leisure and the use of email correlated to greater digital reading competence, whereas group gaming impacted negatively [59]. It is also important to take into account that the results of the influence of technology on students' reading performance are conditioned, first by the fact that those students who read most away from Internet are the ones who score highest in reading (i.e., higher than those who use technology moderately) [3]. It seems clear that the intensive use of technology does not help students improve their reading competence, especially if the reading in question consists of the more traditional printed material. Empowering students to read better requires applying activities in which critical judgement, text interpretation, and analysis play a key role in enabling them to understand what they are reading and to analyze the arguments put forward, activities that should encompass discursive strategies of pragmatic interpretation such as irony, double meanings, etc. There is also a need for didactic strategies to encourage reading both inside and outside the classroom, with the understanding that the use of technology in itself does not substantially improve students' reading skills [33].

6. Conclusions

The most significant contribution of this investigation is a methodological procedure for determining the extent to which the use of technology can have a negative impact on students' performance in reading. We have coded two variables from the PISA 2015 [3] study (IC001, IC008) that ask students which type of digital device they used at home and what they used it for. The results for all the OECD countries analysed showed that a score of more than 14.5 for use of technology meant that all correlations were significant and negative, and the students' reading scores fell drastically. "Playing online games via social networks" and "uploading your own created contents for sharing (e.g., music, poetry, videos, computer programs)" were the activities that had an adverse effect on students' reading skills when done a daily basis.

This negative influence of the use of technology outside school has been documented in earlier studies [44–47], but no study had set out to establish the point at which the use of technology begins to have a damaging effect on the reading competence of students in the PISA area. The type of activities that students undertake with technology has a significant influence on reading performance;

for example, the use of technology for educational purposes, such as searching for information on the Net, and the reading and writing of emails, have been shown to have a positive effect on digital reading competence. Therefore, a way forward could be teachers and families guiding students in their use of technology outside the classroom, and the students themselves committing to using digital devices online less for play and more for learning [60]. The school should be a place where students are educated in the critical and responsible use of technology, thereby avoiding the dangers of exposure to material unsuitable for their age. The school should also instruct families on their children's responsible use of technology, by making parents aware that unsupervised use of digital devices can lead to psychological damage as a result of online harassment, addiction, poor educational performance, absenteeism and abandonment of studies, as well as sleep and avoidant personality disorders [61–66].

The results also suggest that the relation between students, digital devices, and learning is neither clear nor direct; it requires an intervention that is clearly didactic, that recognizes that technology in itself, far from implying an improvement in students' academic results, can hinder academic achievement and make it difficult for students to acquire and perfect competences as important as reading. The educational policies implemented in OECD countries that insist on investing considerable sums in computer equipment and digital resources should justify that expense beforehand by investigating whether it guarantees a clear improvement in academic performance and attitude in students in primary and secondary education. Rigorous research is, therefore, needed to determine how and why technology is to be used inside and outside the classroom in terms of efficacy and academic outcomes.

Furthermore, it would be advisable to reflect on and analyze, whether incorporating 21st-century technologies into pedagogical and didactic models framed in the previous century has a negative rather than a positive effect on students. It is essential to consider whether teacher training should be the key to integrating technology into the classroom before providing students with digital devices, without a clearly established educational plan and without knowing how technology links to and integrates with, the various subjects in the overall curriculum. These approaches will also have profound consequences on the digital reading and writing and digital competences of future University students [67,68]. It would be desirable to build on International Reading Association [42] proposals by boosting teacher training to integrate technology effectively in the development of reading, as well assessing and disseminating the most effective practices to promote reading and writing with digital media, in order to ensure that access to technology is equal and non-discriminatory for all students.

Finally, in line with Goal 4 (Sustainable Development Goals): Quality education. Affordable, reliable and context-sensitive digital education, can promote equal opportunities for girls and boys and reduce inequalities by ensuring every child has access to high quality content. Digital education technologies improves fundamental skills such as collaboration, problem solving and global awareness. It can easily connect boys and girls from different parts of the world with the possibility of sharing their content with peers living kilometres away. Equally important, learning technology can open future job opportunities [69]. So the didactics approaches inside and outside the classroom have to ensure a sustainable use of digital devices in order to foster inclusive and equitable quality education and promote lifelong learning opportunities for all.

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Appendix A

Table A. IC001 Are any of these devices available for you to use at home?

(Please select one response in each row.)

Yes, and I use it/Yes, but I don't use it/No

IC001Q01TA Desktop computer

IC001Q02TA Portable laptop, or notebook

IC001Q03TA <Tablet computer> (e.g., <iPad®>, <BlackBerry® PlayBookTM>)

IC001Q04TA Internet connection

IC001Q05TA <Video games console>, e.g., <Sony® PlayStation®>

IC001Q06TA <Cell phone> (without Internet access)

IC001Q07TA <Cell phone> (with Internet access)

IC001Q08TA Portable music player (Mp3/Mp4 player, iPod® or similar)

IC001Q09TA Printer

IC001Q10TA USB (memory) stick

IC001Q11TA <ebook reader>, e.g., <Amazon® KindleTM>

Table B. IC008. How often do you use digital devices for the following activities outside of school?

(Please select one response in each row.)

Never or hardly ever/Once or twice a month/Once or twice a week/Almost every day/Every day

IC008Q01TA Playing one-player games

IC008Q02TA Playing collaborative online games

IC008Q03TA Using email

IC008Q04TA <Chatting online> (e.g., <MSN®>)

IC008Q05TA Participating in social networks (e.g., <Facebook>, <MySpace>)

IC008Q07NA Playing online games via social networks (e.g., <Farmville®>, <The Sims Social>)

IC008Q08TA Browsing the Internet for fun (such as watching videos, e.g., <YouTube™>)

IC008Q09TA Reading news on the Internet (e.g., current affairs)

IC008Q10TA Obtaining practical information from the Internet (e.g., locations, dates of events)

IC008Q11TA Downloading music, films, games or software from the internet

IC008Q12TA Uploading your own created contents for sharing (e.g., music, poetry, videos, computer programs)

IC008Q13NA Downloading new apps on a mobile device

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