IZA Institute of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 10433

Computer Gaming and Test Scores: Cross-Country Gender Differences among Teenagers

Yann Algan
Nicole M. Fortin

DECEMBER 2016

I Z A Institute of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 10433

Computer Gaming and Test Scores: Cross-Country Gender Differences among Teenagers

Yann Algan
Sciences Po and IZA

Nicole M. Fortin
University of British Columbia, Canadian Institute for Advanced Research and IZA

DECEMBER 2016

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Computer Gaming and Test Scores: Cross-Country Gender Differences among Teenagers*

Using the PISA surveys (2000-2012), this paper explores the relationship between math test scores and everyday computer gaming by gender and for high income and middle income countries. We use two identification strategies in the spirit of an ideal experiment that would reduce computer gaming through limited internet access or through schools alternative demands. We find that everyday computer gaming has positive effects for boys, but negative effects for girls arising mostly in collaborative games suggesting a role for social effects. Computer gaming is becoming the new "swimming upstream" factor in the quest to close the gender gap in math.

JEL Classification: J16, I2

Keywords: math test scores, computer gaming, internet access, gender differences

Corresponding author:
Nicole M. Fortin
Vancouver School of Economics
University of British Columbia
6000 Iona Drive
Vancouver, BC
Canada
Email: nicole.fortin@ubc.ca

* We would like to acknowledge Mingyi Hua for her outstanding reseach assistance on this project. We would like to thank George Akerlof, Martha Bailey, Paul Beaudry, Vincent Boucher, Steve Durlauf, Susan Dynarski, David Green, Brian Jacob, Philip Oreopoulos, Thomas Lemieux, and seminar participants at CIFAR Workshop on SIIWB, the 2015 CEA Meetings, the 2015 EALE/SOLE Meetings, thte Workshop on Social Identity and Social Interactions in Economics, the University of Michigan, the University of Calgary, the University of Waterloo, and UBC-Okanagan for helpful comments and discussions. Financial support was provided by CIFAR and SSHRC Grants #410-2011-0567.

NON-TECHNICAL SUMMARY

In this study, we ask whether the fact that teenage boys spend much more time than teenage girls playing computer games every day help them maintain their advantage in math test scores. We use data from the PISA surveys (2000-2012) to make use of different intensity of gaming across countries, emerging from differences in Internet access, to assess the effect of gaming on math tests scores. We perform some within-school analyses to enhance our understanding of the mechanisms at play. For males, we argue that the positive enhancement of visual-spatial, problem solving, and social networking skills likely compensate the distraction effect of intense gaming. For females, playing MMOs (rather than SPGs) is associated with lower test scores, which suggests a role for social effects possibly linked to the gaming culture which demands further investigation. Parents should nevertheless be wary if their teenagers play into the night.

I. Introduction

Increasing the use of information and communication technologies (ICT) has long been part of public policies aimed at increasing economic growth, especially in middle-income (MI) countries.[1] In higher income (HI) countries, breaking the digital divide is seen as essential to increasing human capital acquisition among low income groups (Goolsbee and Guryan, 2006; Machin, McNally, and Silva, 2007). But it also increases other computer uses, such as computer gaming with possible unintended consequences. The latter might explain the mixed results found in the substantial economic literature on the impact of general computer use on human capital enhancement (Angrist and Lavy, 2002; Malamud and Pop-Eleches, 2011; Vigdor, and Ladd, 2010; Fairlie and London, 2012; Fairlie and Robinson, 2013; Beuermann et al., 2013). Fuchs and Wößmann (2004) who study the use of computers at home and at school on student learning using PISA 2000, find that the conditional relationship between student achievement and computer and internet use at school has an inverted U-shape. They conjecture that the availability of computers at home seems to distract students from effective learning.[2]

The most important computer/internet-enabled potentially distracting entertainment activities are computer gaming and music downloading (or streaming). Computer gaming has indeed become a ubiquitous activity among teenage boys, but less so among teenage girls. In the PISA 2012, 42% of boys vs. 12% of girls play any computer game everyday; 31% of boys vs. 6% of girls play collaborative games, also known as Massively Multi-player On-line (MMO), everyday.[3] By contrast, there are smaller gender differences in other internet uses: 46% of boys vs. 40% of girls download music at home everyday and 47% of boys vs. 46% of girls chat on-line at home everyday. Figure 1 traces the evolution of the frequency of

[1] See Colecchia and Schreyer (2002), Czernich, Falch, Krestschmer, and Wößmann (2011), Kretschmer (2012).

[2] On the other hand, Biagi and Loi (2013) find using PISA 2009 that students test scores increase with the intensity of computer use for gaming activities while they decrease with the intensity of computer use for activities that are more related with school curricula.

[3] In PISA 2012, students were asked in the ICT supplement how frequently they use a computer outside of school to play one-player games and collaborative on-line games: 1) never or hardly ever, 2) once or twice a month, 3) once or twice a month, 4) almost every day, and 5) every day. We focus on the most intense use 4) and 5) which we call "everyday".

computer gaming and music downloading by gender over the five PISA waves. It shows substantial growth over time among boys in everyday gaming, while among girls there is a decrease in intense gaming along with an increase in non-gaming. The evolution of music downloading on the other hand is more similar across genders.[4]

In addition to the substantial gender divide in intense computer gaming, there is a persistent gender gap in math test score that ranges from 4 to 17 points on the normalized (in each wave) average of 500 (2-3% range). Figure 2 display the gender differences in math test scores averaged across all countries participating in the ICT supplement in Panel A, and an even larger HI/MI countries divide, in Panel B.[5] There is also a substantial divide between HI and MI countries in the determinants of intense gaming.[6] These differences lead us to perform our analyses separately by gender and separating HI and MI countries.

Because of potential positive effects of gaming on visual-spatial and attention skills (Green and Bavelier, 2003, 2012), problem solving and strategic thinking (Adachi and Willoughby, 2013), we focus mainly on the relationship between everyday computer gaming and math test scores.[7] We explore three potential mechanisms by which intense gaming (by comparison with lower intensities) could affect test scores: 1) a negative distracting effect linked to time spent gaming and rewards earned; 2) a positive effect on cognitive skills; and 3) social effects, likely positive for boys and negative for girls, discussed below.[8]

Many of the papers above on the impact of ICT use on academic performance exploit quasi-natural experiments or randomized control trials (RCT). For example, Angrist and Lavy (2002) analyze the effects of a large-scale computerization

[4]The question initially asked in 2003 and 2006 on how often do you use computers at home to "download music from the Internet" has evolved to include "downloading music, films, games or software from the Internet" in 2009 and 2012. Whether this should include music or film "streaming" is left to the respondent. We use this variable to denote an internet-abled non-gaming activity.

[5]Given the ICT participating countries varied by wave, not much should be infered from the time paths of scores. Also the normalization to the average of 500 is done over a set of 30 OECD countries, not necessary those participating in the ICT supplements.

[6]For example, family background variables are relatively more important in MI countries, whereas in HI countries school variables are relatively more important predictors of everyday gaming.

[7]We present some complementary evidence on reading test scores and problem solving.

[8]Recent papers (Fairlie, 2015; Pabilonia, 2015) on the interaction between computer/media use and schooling outcomes have focused on the distraction effects studying whether computer/media use displaces homework time. We introduce frequency of homework in some specifications below but argue that it is not a clear predictor of academic outcomes (e.g. weaker students may have to study more).

policy in elementary and middle schools in Israel, based on a comparison between schools that received funding and those that did not. Beuermann et al. (2013) present the results of a RCT conducted in the context of the One Laptop per Child (OLPC) initiative, where laptops for home use were randomly provided to children attending primary schools in Lima, Peru. It is easy to conceive of a RCT where computers are distributed to a treated group but not to a control group in ways to minimize spillover effects.[9] In the case of computer gaming, our "ideal" experiment would have a treated group play computer games everyday for a sufficiently long time period to impact test scores but prevent a control group from doing so.[10] With this ideal experiment in mind, we appeal to strategies which would restrict computer gaming through limited internet access or through schools alternative demands.[11] We note that social effects, especially important in adolescence, may not manifest themselves in the context of RCTs and therefore our set-up is informative.

Unlike several earlier papers which used a single PISA wave, this paper exploits up to five waves of the PISA surveys (2000, 2003, 2006, 2009, and 2012) in order to appeal to an instrumental variable strategy similar to that of Czernich et al. (2011).[12] Our within-country instrumental variable strategy uses data from the International Telecommunication Union (ITU) on pre-existing fixed-telephone line subscriptions in a non-linear logistic diffusion model of individual internet users and computers in the home by country: predicted values of both diffusion rates are used as instruments allowing overidentification tests to be performed.[13] Figure 3 traces the parallel evolution from 1995 to 2013 of the number of internet users (in all PISA participating countries) computed from ITU data and of the

[9] Beuermann et al. (2013) do find some small spillover effects among close friends of laptop recipients.

[10] This strategy has been used to study the impact of video games consoles on boys (Weis and Cerankosky, 2010). Video games are not the focus of the current paper because facilitating access to video games is not part of public policies, nor it is related to related to internet access. Also questions about video gaming were not asked in the earlier waves of PISA. We nevertheless draw on the literature that has studied video games. Note this experimental set-up does not completely address to issue of who selects into intense gaming, an issue which we discuss in more detail below.

[11] MMOs require high speed internet access, while single player games do not. We exploit the distinction between the two types of games below.

[12] The following papers who study computer use and test scores focus on a particular PISA wave: Fuchs and Wößmann (2004) use PISA 2000, Spiezia (2011) use PISA 2006, and Biagi and Loi (2013) use PISA 2009.

[13] Note that Notten et al. (2009) using the PISA 2003 find that country's level of modernization only affects whether digital applications are available at the family home, but not how they are used.

MMO subscriptions available from MMOData.net.[14] The first decade of the 21st century is an ideal study period where the substantial growth in internet access and speed can be seen an exogenous cause of internet-enabled gaming among teenagers. On the other hand, the use of non-linear Bartik-type instruments means that the identification is set at the country level emerging from non-linear departures from country-specific trends. It is not always as strong as desired given that relatively few countries are observed for all available waves. Also the validity of our exclusion restriction relies on conditioning of an extensive set of individual and country-level variables.

We therefore provide within school-year fixed effects estimates as a complementary approach. Our within school-year fixed effects models also take advantage of multiple waves of the PISA; they allow us to additionally control for school climate factors, such as teachers and students hindrance to learning and sense of belonging. We are thus able to include a much richer set of contextual school variables that studies based on administrative data (e.g. Vigdor, and Ladd, 2010). These models are thought to capture the type of school demands that could prevent students from gaming everyday. In all specifications, we control for family computer and internet access, as well as a host of individual, family, school and country characteristics.

We find that everyday computer gaming has generally positive effects on math test scores for boys and negative or neutral effects for girls. We explain these differential effects in terms of gender-specific interactions of the three mechanisms of interest, on which we provide evidence below. For example, consistent with a cognitive enhancement channel, we find positive effects of gaming on math scores for boys that contrast with the larger negative effects of music downloading on these scores and with negative effects of gaming on reading test scores.[15] Our case for gender-specific social effects rests on the comparison between single-player games (SPGs) and MMOs in PISA 2009 and PISA 2012. There we find for

[14] We note that MMO subscription curve does appear to follow a logistic curve more than the internet user curve. The decline in monthly subscriptions towards the end of the period is associated with a change in business model towards free basic access and more component sales (e.g. additional avatar lives).

[15] We chose music downloading as an alternative internet-enabled activity because it appears orthogonal to mathematical ability.

girls positive effects of SPGs but negative effects of MMOs suggesting a role for social effects, while the opposite is true for boys in HI countries. We view these suggestive findings on the social effects of gaming as a novel contribution of the paper. Our counterfactual calculations indicate that computer gaming increases gender differences in math scores by 2-3 points (from 14% to 40% of the gap) and therefore can be seen as a "swimming upstream" factor in the quest to close that gap. Nevertheless, closing that gaming gap by enticing girls to play more may be advisable only if gaming content is re-examined in view of the negative effects identified.

The paper is organized as follows. Section II discusses the source of gender differences in computer gaming as well as its anticipated effects on test scores. Section III presents the data and some descriptive evidence. Section IV describes the empirical strategies and reports the main results. Finally, Section V concludes.

II. Gender Differences and Anticipated Impact of Computing Gaming

Beyond use by adolescents, the advent of the internet-enabled gaming and music downloading has transformed the entertainment industry. The entertainment software industry (computer and video games) is poised to surpass the movies industry in economic might. The U.S. Entertainment Software Association (ESA, 2013) boasted that total consuming spending in the gaming industry was to close $21 billion in 2012. The Association is preoccupied by female representation among gamers and reported that in 2012, women represented 45% of gamers of all ages. In PISA 2012, we also find that girls represent 48% of computer gamers. However, these relative incidences numbers do not reflect the fact that girls play computer games much less frequently than boys, as shown in Figure 1.

The literature investigating the sources of gender differences in computer/video gaming has identified four sets of explanations for these differences: They pertain to game content, the gaming community, gender differences in the social and competitive appeal of gaming, and gender differences in physiological responses. First, most game content presents a highly stereotypical view of women. Female game characters are under-represented, significantly more helpless and sexually provocative than male characters who are likely to be strong, more aggressive and powerful (Ogletree and Drake, 2007). Males are more likely to be main characters and heroes, while females were more often supplemental characters, more sexy and innocent, and also wear more revealing clothing which likely attract male players (Beasley and Collins Standley, 2002; Miller and Summers, 2007). A quick look at the free on-line portion of the most popular computer games of 2012—*Diablo III, Guild Wars 2,* and *World of Warcraft: Mists of Pandaria* (according to ESA, 2013)—does indeed show well-endowed scantly clothed female characters.[16]

A consequence of this portrayal of female characters has been that girl gamers often experience the gaming culture as secondary gamers (Schott and Horrell, 2000). Girl gamers do not extend their playing habits to engage in game play outside the home or participate to the same extent in the wider gaming culture. Some of the parents' positive views about games as opportunities for their teens to "connect with friends" (ESA, 2013) may not apply to girls to the same extent. In addition to sexual gender stereotyping of game characters, female gamers disliked the lack of meaningful social interaction and the violent content of games, and are less engaged by the competitive elements of games (Hartmann and Klimmt, 2006). Women who have expressed discontent at the sexism in games and demanded a more balanced portrayal of males and females in games have been harassed by the on-line community, including anonymous threats of violence against these women (Kendall-Morwick, 2015).[17]

Harassment leads female gamers to limit their social interaction online (chat on-line) which puts them a disadvantage in competition, particularly in strategic games that require teamwork and may result in negative reactions from fellow teammates (Richard, 2013). Both the social and competitive aspect of computer gaming deter female gamers. In addition, differential physiological responses to reward intensity help explain the gender differences in engagement with gaming.

Hoeft et al. (2008) find that compared to females, males showed greater activa-

[16] In 2012, *The SIMS 3*, a role-playing game more popular with girls ranked 4th. When understood in the context of potentially steering young male gamers away from watching porn, this portrayal can be seen as part of the business model.

[17] Clearly games such as the *Candy Crush Saga*, a match-three puzzle video that game out on April 12, 2012, stays clear of these controversial issues. Research also shows that girls are more attracted to puzzle games than to fighting games.

tion and functional connectivity in their mesocorticolimbic system when playing computer/video games. Important gender differences emerge in reward prediction, learning reward values and cognitive state during computer/video gaming. It is interesting to note that the prospect of monetary rewards in males also engages a wider network of mesolimbic brain regions compared to only limited activation for social rewards, while for females both types of rewards lead to similar activations (Spreckelmeyer et al. 2009). Hamlen (2010) finds that for boys, the increased play time leads to increased feelings of success and achievement, which then prompts more time playing; girls actually feel just as competent in their gaming ability, but lack the initial motivation for the rewards offered.

The literature on gaming is also useful to help understand the potential link to math test scores. Although parents in the United States (ESA, 2013) impose time usage limits on computer/video games more than any other form of entertainment: 83% of parents place time limits on video game playing vs. 76% of parents on television viewing. A large majority of parents (71%) believe that game play provides mental stimulation and education to their children. In psychology, the vast majority of research on the effects of gaming has focused on potential negative impacts: the potential harm related to violence, addiction, and depression. Papers (Skoric et al. 2009; Rehbein et al. 2010) attempting to link these potential effects to academic achievement found that addiction (or clinical dependency) is indeed associated with lower academic achievement. In Rehbein et al. (2010), the percentage of German teenagers showing a dependency to gaming is relatively low (3% among boys and 0.3% among girls).[18]

There are also many psychological studies focusing on the positive cognitive aspects of gaming, such improvements in visual-spatial and attention skills and in problem solving skills (e.g. Green and Bavelier, 2003, 2012). Adachi and Willoughby (2013) in a longitudinal analysis contrasting the use of more or less strategic video game play among teenagers, find that greater frequency of strategic video game play is predictive of greater self-reported problem solving skills. Jackson et al. (2010) reports more nuanced correlational findings: for youth with

[18]However, the establishment of specialized treatment centers for problematic gaming in South-East Asia, Europe, and the United States reflects a growing need for professional help.

low initial levels of visual-spatial skills, playing videogames facilitates the development of visual-spatial skills. Increases in visual-spatial skills are found to be correlated with mathematical skills, but not with average grades in school.

In summary, the existing literature on the effects of gaming confirms that our emphasis on intense gaming and on gender differences in gaming is well-placed. Gender differences arise along three of the five dimensions outlined by Gentile (2011) to evaluate the impacts of games on youth: amount of play, game content, and context of play. Previous research also provides clues on the mechanisms to explore. The negative effects of intense gaming would arise from distraction/displacement effects associated with a lot of time spent playing and with reward systems that may be more immediate than incremental improvements in grades. Some positive effects of gaming would likely arise through the enhancement of visual-spatial and problem solving skills which, in turn, could improve math scores, and through increased social interactions, more so for boys than for girls. For girls, additional negative effects may arise from the sexualized portrayal of female characters which would undermine their confidence in mathematics in ways similar to those found in the stereotype treat literature (e.g. Spencer, Steele, and Quinn, 1999).

III. Data and Basic Facts

In this section, we first present the student, country, and ICT data used and show why we need to perform the analysis separately by HI/MI countries. Next we turn to individual and school variables to compare how everyday gamers and other students might differ across observables between HI/MI countries.

There are few datasets that contain information on both standardized tests scores and gaming habits. These include surveys from the PISAs targeting 15-year-olds and conducted by the Organization for Economic Cooperation and Development (OECD), as well as the Trends in International Mathematics and Science Study (TIMMS) and Progress in International Reading Literacy Study (PIRLS) administered to 4th and 8th grade students by the International Association for the Evaluation of Educational Achievement (IEA). Here, we focus on the PISA surveys because of a larger coverage of countries over more years, noting that only a subset of countries (listed in Table A1) actually participates in the ICT supplement. Table A1 also indicates whether a country is high income or middle income according to the UN (2012) country classification.[19]

We also prefer to focus on adolescents because they are more likely attracted to popular MMOs and more in control of their time use than children. On the other hand, the PISA does have not good time use data to illustrate the intensity of daily gaming. To discuss the issue of time substitution, we turn to the TIMMS. Eight graders in TIMMS 2008 were asked "How many hours a day" they devote to several activities using five categories. For "playing computer games" comparing the percentages of boys and girls in these categories, we find 25% of boys vs. 41% of girls spend no time at all, 25% vs. 18% less than 1 hour, 24% vs. 8% 1 to 2 hours, 13% vs. 8% more than 2 but less than 4 hours, and 13% of boys vs. 6% of girls play 4 or more hours. To summarize these numbers more concisely, we assign hours corresponding to the mid-point of the first four categories, and a conservative 6 hours to the "4 or more hours" category; we find that on average boys play computer games 2.6 hours a day vs. 1.5 hours for girls.

We use the same averaging scheme to compare the average number of hours dedicated to several activities in Table 1. They show that everyday gamers, those spending at least one hour a day playing computer gamers, generally enjoy more screen and internet time, and more time with friends (possibly in the course of these activities) than non-gamers. They also play more sports. Computer gaming only seems to take time away from household chores and homework, but relatively little. One important expandable activity, not included in the survey, is sleep time. Rehbein et al. (2010) does indeed mention that an important indicator of problem gaming is "loosing sleep over it", which could lead teenagers to subsequently miss their morning classes, a question we explore below.

Our study combines the data from the PISA 2000, 2003, 2006, 2009 and 2012 surveys, resulting in 1,902,724 possible observations from 45,915 schools/year in 76 countries. The panel of countries is unbalanced with many developed countries

[19]The average GDP per capita is HI countries is around $35,000, while it is only around $8,000 in MI countries.

not participating in the ICT supplements, notably France, but we have data from Germany, Canada, and Japan (the United States for 2000 and 2003). This leaves us with only 57 countries. In our within-country analysis, we have to exclude two countries observed only once (Shanghai, China in 2012 and Panama in 2009).

Our country-level control variables include the logarithm of GDP, the female labor force participation, youth male and youth female unemployment rates, all from the World Bank Indicators. Female labor participation has been used in previous studies to capture the impact of social norms on the math gender differentials. Youth unemployment rates are meant to capture alternative uses of time, such as the relative un/availability of part-time work. As noted above, our ICT variables are retrieved from the ITU, they include the fixed-telephone line subscriptions, the percentage of individual internet users, and the percentage of homes with a computer.

Most PISA countries employ a two-stage stratified sampling technique to get a representative sample of the target population in each country. The first stage draws a random sample of schools in which 15-year-old students are enrolled and the second stage randomly targets 34 students (on average) in that age range in each school.[20] We do not know whether the same schools are sampled across the different waves, thus we conduct within school-year analyzes; for these, we exclude students whose school peers were not interviewed. We are left with 1,158,920 possible observations from 30,522 schools/year in 57 countries.

In the PISA scholastic assessment, tests on reading, mathematics, and science are divided into several item clusters, with each item cluster requiring 30 minutes of test time. Each student completes a subset of the clusters randomizes across several booklets, and thus undergoes two hours of total testing divided by a 5-minute break. For each test and each student, PISA reports five plausible random values drawn from the posterior distributions of the students scores (OECD, 2012). Estimations have to be carried out separately for each one of the five plausible values using a set of eighty replicate weights that account for the

[20]We construct our school/year identifier by concatenation of a 3-letter country code and the SCHOOLID provided by PISA. There is a wide dispersion in the number of students per school: there are 117 schools with more than 100 students and 231 schools with only one student.

two-stage design.[21] We use the "pv" procedure programmed by Kevin Macdonald in STATA to perform this multi-stage estimation and for the computation of the standard errors in our individual based regressions. We note the point estimates are identical to those obtained using the average of the five plausible values, but the standard errors are about 2 to 3 times as large. The non-availability of actual test scores thus represents an important drawback of using the PISA surveys. The PISA mathematics reporting scale is normalized to mean 500 and individual standard deviation of 100 across 30 OECD countries; it is directly comparable across PISA waves from 2003 onwards.[22] The average PISA math scores for boys and girls in HI and MI countries are reported in the tables of results below.[23]

The questions on electronic gaming have become more sophisticated over time in the PISAs, separating video games, single-player games (SPG) from collaborative games (MMO) in 2009 and 2012. This is potentially quite important given that Smith (2007) finds after comparing other types of games to MMOs that the latter represent a "different gaming experience with different consequences". He finds that the number of weekly hours played by participants (three-quarter males) randomly assigned to MMOs is twice (14.4 hours) as large as those assigned to SPGs (6.6 hours), and leads to greater interference with real-life socializing and academic work, but to greater acquisition of new "friendships". Because we include earlier waves, we recode the answers to lowest common denominator: any games. But, we also perform separate analyses only for 2009 and 2012 using the finer distinctions. As indicated above, these activities are listed under "How often do you use a computer for the following activities outside of school?", and vary by waves; they include "playing games" and "downloading music" among others.[24] The answers record the intensity of the activities: Everyday/almost everyday, a few times a week, between once a week and once a month, less than once a month/hardly ever/never. Following the literature on anticipated effects of

[21] To obtain the replicate weights, PISA uses the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates.

[22] The PISA 2000 reading scale is directly comparable to the other waves, the mathematics scale less so. We thus provide results that exclude the 2000 PISA wave.

[23] They are computed on the samples of the OLS specifications, as these averages vary very little across samples. Similarly, when everyday gaming is used as a dependent variable (Tables 2 and A3) the averages are reported at the top of the tables.

[24] Music downloading is asked starting with PISA 2003.

gaming, we focus on the high intensity gamers (also sometimes called "hardcore" players) compared to the more casual users (omitted group); essentially we think that playing once a month or once a week is unlikely to confer the presumed cognitive enhancement or to represent a substantial distraction.[25]

A. Cross-Country Evidence

We first present cross-country scatter plots that illustrate the non-linearities of the relationship between the percentage of everyday computer gamers (and music downloaders) and average math scores (on the horizontal axis for ease of comparison). These scatter-plots represent a tell-tale figure of the basic stylized fact uncovered in this paper. For boys, Figure 4A shows a positive relationship in the mid-range of math scores (typically MI countries) and a negative relationship in the high-range of math scores (typically HI countries). This relationship is consistent with the view that, at the country level, higher ranges of math scores are reached only when a smaller percentage of students engage in these distracting activities. Interestingly, Japan (before 2012), Singapore, and Korea figure among the high math score countries with lower than average percentage of everyday gamers. A similar relationship is observed for music downloading in Figure 4C for boys and Figure 4D for girls. Strikingly on the other hand, Figure 4B shows a uniformly negative relationship for girls between the percentage of everyday computing gamers and average math scores.

In Table 2, we present estimates of the relationships illustrated in Figure 4A and 4B, additionally controlling for the logarithm of GDP per capita, the percentage of individuals using the Internet and of households with a computer in each country at each time period to better isolate the effects of computer gaming. The estimates are reported for all countries [columns (1), (2), (5), and (8)], for HI countries [columns (3), (6), and (9)] and for MI countries [columns (4), (7), and (10). The table reports the estimates from three specifications: the OLS uses the sample of all countries in each category, the between-country uses a random-effects specification and the within-country a fixed-effects specification, these two

[25] The non-user category is too collinear with internet access and home computer to be entered successfully.

last specification exclude countries observed only once.

They show that, among boys, the OLS specification yield significant positive estimates of everyday gaming for MI countries and negative estimates for HI countries. A similar sign pattern is found in the between-country specification, but significance is reduced and disappears completely in the within-country specification. Among girls, on the other hand the significant point estimates are all negative. We even find a negative and significant coefficient in the within-country specification for all countries. These descriptive results point to clear differences between boys and girls.[26] They also emphasize the need to distinguish HI and MI countries in subsequent analyzes.

B. Student and Family Variables

Our individual within-country analyses include a host of student characteristics and family variables: presence of an internet link in the home, presence of a computer in the home, the student's age, first or second generation immigrant status, father and mother education (primary (omitted category), secondary or tertiary education) and occupation (white-collar high-skilled, white-collar low-skilled, blue-collar high-skilled, blue-collar low-skilled (omitted category), mother homemaker), and the number of books in the home (5 categories - lowest omitted). In Appendix Table B1, we report the means of these variables by everyday gamers and other users, by gender and by HI/MI country category to see whether boys and girls intense gamers are different from each other and from other users on the basis of observables.

The more salient differences between everyday gamers and others are unsurprisingly the higher percentage of internet link and computer in the home among the gamers. In HI countries, everyday gamers come from families with parents of somewhat lower education level, but the differences are not large. In MI countries, the difference between everyday gamers and others are more striking. Gamers come from families with more educated parents employed in occupations with higher status, more books in the home, and they are more likely to be immigrants.

[26] The estimates for music downloading (available upon request) are generally less signifcant, but more negative for boys and less negative for girls.

On the basis of individual characteristics, there are little statistically significant differences between male and female everyday gamers. In HI countries, everyday female gamers come from families with fewer fathers with tertiary education and high-skilled white collar jobs. In MI countries, none of the differences in means are statistically significant at the 5% level.

To further check whether girl everyday gamers are a glaringly negatively selected group, we computed kernel densities of the PISA math test scores comparing everyday gamers and non-users to the entire group. These are displayed for 2012 in Appendix Figure A1 by HI and MI countries.[27] In Checchi and Flabbi (2013), test score densities of German and Italian students from different high school tracks show clear stochastic dominance patterns of the academic track over the vocational track for example. No such evidence appears here in HI countries. By comparison with the entire sample of boys, everyday boy gamers are over-represented on the middle of the distribution. Among everyday girl gamers, there is more mass in lower middle and less mass in the upper middle of the test score distribution than among all girls. In MI countries, by contrast the distribution of test scores of everyday gamers appears to stochastically dominate that of non-users. Again, this underscores the need to study HI and MI countries separately.

C. School Variables

In our within-school-year models, we add the following school-level measures: international grade level, proportions of girls at school, percentage of certified teachers and of qualified teachers, student-teacher ratio, dummies for instructional material not lacking and strongly lacking. Several variables capture the relatively abundance of computer resources: percentage of computers connected to the internet, ratio of computers to school size, dummies for computer resource not lacking and strongly lacking.[28] In addition we include some school climate factors, namely learning hindrance factors and sense of belonging in some specifications. These school climate factors, described below, are deemed very impor-

[27] Densities for other years are available upon request.

[28] These school variables are by and large the same of the ones used in Fuchs and Wößmann (2008).

tant by educators and speak to the interaction between identity and social effects (Turner et al., 2014).

Seemingly important variables such as time spent on homework is not recorded consistently over the waves. This may be due the changing nature of homework over the period, part of which increasingly takes place in the school and the increased use of tutors. Another confounding factor for time spent on homework is the increasing role of "multitasking while doing homework" (Pabilonia, 2015). This implies that longer time spent on homework does necessarily mean a greater quantity (or higher quality) of homework done given that many students may be simultaneously texting or Facebooking. For 2009 and 2012, we use a simple measure of homework available in categories similar to gaming and other activities: "Doing homework everyday". Some gender differences in social norms about doing homework everyday (Bishop, 2006) also make it difficult to anticipate the effect of homework on test scores: In some boys' culture, it may be best to score high without spending much time on homework.

School climate factors have been found to be among the most important determinants of student engagement (Algan, Cahuc, and Shleifer, 2013). We use two important sets of factors: These include factors hindering learning, available at the school level, and factors capturing students' sense of belonging to the school, available at the student level. The detailed questions asked are reported in Appendix Table A2. We divide the factors hindering learning into teachers factors, such as teachers low expectations of students, and students factors, such as student absenteeism and student skipping classes. Following the tradition in the psychology literature, summary measures of the teachers behavior and of students behavior, and of students' sense of belonging are constructed using the Cronbach's alpha coefficient of internal consistency.[29] In other specifications, we also include the single variables that show the highest correlation with our dependent variables, that is "Student skipping classes" and the "Feel like I belong" and "Feel awkward" variables.

We report the means of these variables by everyday gamers and other users,

[29] All factors have a scale reliability coefficient over 0.80.

by gender and by HI/MI countries in Appendix Table B2. We find that between 55% and 64% of everyday gamers are also everyday music downloaders, whereas that percentage among others is between 25% and 29%. Among boys, there are more everyday gamers in small communities in HI Countries, while the reverse is true in MI countries. Among boys, they are more everyday gamers in school that have a higher computer-student ratio and lower teacher-student ratio, but this does not hold among girls.

IV. Empirical Strategies and Results

In this section, we explain our empirical strategies starting with the estimation of our non-linear instrumental variables and first-stage results, which show the determinants of intense gaming. Our IV strategy uses predicted internet and home computer diffusion at the country level. In the context of country and time fixed effects models, our identification comes from the non-linearities in the diffusion process.[30] This diffusion process is thought to an exogenous determinant of intense gaming given that high speed internet access is required to make the MMO experience enjoyable, but the demand from teenage gamers is not seen as the driving force behind country-level internet infrastructure. Clearly broadband internet penetration would have been a preferred instrument; but this variable is not available for a broad array of countries over the time horizon considered, it appears somewhat too late. Similarly, a finer geographical level would have been preferable, but it would likely not be finer than the school level.[31] Thus our school-year fixed models which include school fixed-effects and school level variables, such as the type of location of the school and the percentage of computers connected to the web, can be seen as controlling for the level of internet access at a level higher than the individual level.[32]

[30]Indeed, models with country-specific time trends (not presented) yield estimates similar to the country and time fixed effects model.

[31]An important exception is Vigdor and Ladd (2010) who use the availability of broadband internet at the ZIP code level and follow students over time using a North-Carolina administrative database. They do not have information on students' gaming habits, but in student fixed-effect specifications, they find that that increased availability of high speed internet is actually associated with less frequent self-reported computer use for homework.

[32]However, this does compare schools with lower and higher exogenous web access.

A. Instrumental Variables and First-Stage

Because, as shown in Figure 4, intense computer gaming is correlated with internet access (important for MMO) and the presence of a computer in the home (sufficient for SPG especially for girls), we use the percentage of individuals using the Internet, I_{ct}, and the percentage of households with a computer, H_{ct}, to construct our instruments. These measures are available from 1995 on, although the initial year varies by country. These country-level measures are thought to capture some exogenous "peer effects" in computer gaming linked to the ICT infrastructure.

To remove further endogeneity biases with current economic conditions that may influence current specific educational internet use, we follow a Bartik type approach similar to that of Czernich et al. (2011). The idea is to use country-level data on the number of fixed-telephone line subscriptions, F_{ct_0}, at the beginning of the period (1999 or later in some cases) to predict the current year level of internet users, $\widehat{I}_{ct}$, from an estimated logistic curve which is thought to describe well the diffusion process of these technologies. The approach estimates the following model:

[1] $$I_{ct} = \frac{a_0 + a_1 F_{ct_0}}{1 + \exp[-\beta(t - \tau)]} + \varepsilon_{ct}$$

where $a_0 + a_1 F_{ct_0}$ corresponds to the maximum level of penetration, and the parameters β and τ determine the diffusion speed and the inflexion point of the diffusion process, respectively.

We computed different prediction models for all countries, and for HI and MI countries separately, which differ substantially in the estimated inflexion point τ.[33] We use the same strategy for $\widehat{H}_{ct}$. Figure 5 shows that there is sufficient variation in telephone-lines at the beginning of the period to yield substantial differences in the non-linear diffusion model of internet penetration across countries. But the fit with percentage of everyday gamers varies by countries.[34] For each country, the

[33] The estimates of τ for I_{ct} are as follows: 6.986 (0.184) for all countries, 6.457 (0.170) for HI countries, and 11.378 (0.590) for MI countries. Detailed results are available upon request.

[34] A similar figure that includes all countries is presented in Appendix Figure A2.

actual and predicted levels of internet penetration are drawn using the left axis scale, while the percentages of everyday male gamers are plotted using the right axis scale. The predicted levels of internet penetration provide a good fit for some countries, for example Austria and Japan, but less so for other countries, such as Greece. On the other hand, the time patterns of predicted internet penetration and gaming activity match well for Greece, but not so much for Japan.[35]

We next assess the strength and potential exogeneity of various instruments by presenting the results of the first stage estimation:

$$[2] \quad G_{ict} = \alpha_1 \widehat{I}_{ct} + \alpha_2 \widehat{H}_{ct} + \alpha_3 I_{ict} + \alpha_4 H_{ict} + \Gamma \mathbf{X}_{ict} + \Lambda \mathbf{X}_{ct} + \theta_t + \pi_c + \upsilon_{ict}$$

where G^g_{ict} is an indicator variable that individual i is an everyday gamer, $\mathbf{X}_{ict}$ represent the individual variables and $\mathbf{X}_{ct}$ the country-level variables listed above, respectively, and θ_t and π_c are the year and country dummies, and υ_{ict} the error term. While Bartik type instruments are often used in the literature without additional testing of the exclusion restriction, we present some overidentification tests below that show issues with this restriction in MI countries in particular.

The results of the first-stage estimation are presented in Table 3 for HI and MI countries, separately. Columns (1),(4), (7), and (10) of the Table exclude the instruments and show the most important correlates of intense gaming to be the presence of a home computer, followed by the presence of internet access in the home. However, there are significant differences between boys and girls in the importance of the effects.[36] This is consistent with Winn and Heeter (2009) who find that even if there is a computer in the home, girls may have less access or may have more chores to perform. Log GPD per capita is an important positive correlate of intense gaming for boys, less so for girls. Interestingly across HI and MI countries, immigrant status reverse signs, being negative in HI countries and positive in MI countries. In HI countries, everyday gaming is associated with lower parental socio-economic status, measured by education and occupation. This is

[35]In Japan, video gaming consoles have been more popular than computer games. But as can be seen from the figure, there a very significant uptake from 2009 to 2012, possibly linked to MMOs.

[36]It would have interesting to include the presence of siblings by gender but this information was not available.

much less the case in MI countries. Columns (2) , (5), (8), and (11) introduce the predicted levels of internet penetration and home computer based on HI and MI countries, respectively.[37] Columns (3), (6), (9) and (12) use similar measures predicted with a diffusion model estimated for all countries. Among HI countries, either measure are strong predictors of everyday gaming, but the measures computed with the "All Countries" model lead to change in the other point estimates, suggesting that the exclusion restriction will less likely to be satisfied in this case. Among MI countries, the opposite is true suggesting that in these countries the predicted internet and home computer diffusion likely capture a gaming "peer effect" that operates worldwide. We choose the predicted instruments that have the better chances of passing our overidentification test.

B. Within-Country Individual and Instrumental Variables Results

We estimate the following country and year fixed effects model,

$$T_{ict} = \beta_1 G_{ict} + \beta_2 I_{ict} + \beta_3 H_{ict} + \Gamma \mathbf{X}_{ict} + \Lambda \mathbf{X}_{ct} + \theta_t + \pi_c + \epsilon_{ict} \tag{3}$$

The results of within-country OLS and instrumental variables strategy are presented separately by gender and by HI/MI countries in Table 3. Columns (1) and (4) report the OLS estimates, columns (2) and (4) report IV-HI and IV-All estimates for the HI and MI countries respectively, where IV-HI and IV-MI refers to the first instruments presented in Table 3 based on country-group predictions, and IV-All refers to the second instruments predicted for the entire set of countries. Columns (3) and (6) exclude PISA 2000 for reasons explained above.

Given that our identification arises from non-linearities in internet and home computer diffusion at the country level, it is not surprising to find estimates of intense gaming of a magnitude similar to the country-level estimates reported in Appendix Table B1. Among HI countries in the upper panel of Table 3, our IV strategy is moderately successful in columns (2) and (5) in terms instruments strength and excludability, but the plausible values routines yield large errors.

[37] The opposite sign on the two variables reflects a high level of collinearity; when entered separately both point estimates turn positive when significant.

With the exclusion of PISA 2000 in columns (3) and (6), some of the identifying non-linearities are loss and the instruments are less successful.[38] Excluding Japan in columns (4) and (8) restores the validity of the exclusion restriction, but yields a somewhat weak instrument for girls. As shown in Figure 4, Japan is a clear outlier in the scatter of average math test scores vs. percentage of boy gamers; this leads to a weak relationship between internet penetration and the percentage of computer gamers as shown in Figure 5.[39] In the bottom panel of Table 3, the results among MI countries show similar results and issues. Nevertheless despite the large standard errors that come with the use of plausible test scores values, the significant point estimates show consistent negative effects for girls, but not so much for boys. At a minimum, the male minus female differences in the estimates are always positive, everyday gaming emerges as a factor that can account for the relative advantage for boys in math.

C. School-Year Fixed Effects Models

In order to explore the potential mechanisms at play to account for gender differences in the effect of gaming, we turn to school-year fixed effects models,

$$[4]\ T_{ist} = \beta_1 G_{ist} + \beta_2 I_{ist} + \beta_3 H_{ist} + \beta_4 \ln GDP_{ct} + \Gamma \mathbf{X}_{ist} + \Lambda \mathbf{X}_{st} + \theta_t + \delta_{st} + \epsilon_{ist},$$

where $\mathbf{X}_{st}$ are the school-level measures described in section III.C and δ_{st} are the school-year fixed effects (absorbed). When we use observations for at least three waves, we have sufficient variations to estimate school specific variables in addition to the school fixed effects and find important differences across HI and MI countries in the estimated coefficients of many school variables. Our first goal is to appraise the three mechanisms of interest by which intense gaming is thought to affect math test scores. Our second goal is to further assess issues of selection into gaming, at the individual-family level and at the school level. As argued earlier, the schooling environment introduces many students to computers

[38] As shown in Figure 3, the inflexion point in MMOs subscription over time occurs between 2000 and 2005.

[39] As explained above, this is due to Japanese teenagers' stronger preferences for video games rather than computer games before 2012.

which can become the gateway to gaming.

We begin with country-level estimates for Canada and Italy, the two countries with a largest number of observations and a large number of schools. By abstracting from differences across countries in the "Women and Math" culture, these single country results illustrate more clearly the potential for intense gaming to hamper the closing of the gender gap in math scores.[40] As shown in Table 5, the average gender differences in math scores are approximately 14 points in Canada and 18 points in Italy. The within-school-year fixed effects estimates of everyday gaming range from 3.076 (1.408) to 3.857 (1.097) for boys and from -6.385 (3.099) to -2.503 (1.302) for girls, across the two countries. If everyday gaming was somehow restricted to less intense forms of gaming, the gender gap in math scores would decrease by 9 points (about 70% of the gap) in Canada and by 6 points (about 35% of the gap) in Italy.

We next use the entire set of ICT participating countries to investigate the distraction channel and the social effect channel. To further probe the distraction channel, we control for music downloading, another potential distracting internet-enabled activity and therefore have to exclude PISA2000. To consider the hindrance to learning factors, we have to exclude PISA2006 which did not ask these questions. To also consider the sense of belonging factors, we can only include PISA2003 and PISA2012. With the latter, we can check whether the potential social effect of gaming arise from the school social environment.

Tables 6a and 6b report for boys and girls, respectively, the results of the OLS and within-school-year models, controlling for hindrance to learning factors in some specifications. In these within-school-year models, the estimates of computer gaming are generally in the 4 to 6 points range of PISA scores, positive for boys and generally negative for girls.[41] In our within-school-year models, the estimates for girls in HI countries loose significance and become almost positive when student hindrance to learning factors, including student skipping classes,

[40]De San Román and de la Rica Goiricelaya (2012) consider the impact of gender role attitudes on gender differences in PISA2009 math scores. For that reason, we have included female labor participation in our country controls, but it likely does not capture all aspects of this issue.

[41]Given the standardization of PISA scores at mean 500 and standard deviation 100, these numbers can be interpreted as percentage of the standard deviation.

are introduced in columns (3) and (4).[42] The estimates for girls in MI countries are more negative, but also become insignificant in the within-school-year models. For boys, the positive estimates of gaming are of the same order of magnitude in HI and MI countries. The estimates of music downloading are negative and generally larger than the estimates of everyday gaming and importantly, of the same order of magnitude for boys and girls; this underscores the importance of distraction channel and the distinctiveness of gender differences in gaming. The estimate of student hindrance to learning factors, in particular student skipping classes, are negative and generally significant.

Beyond the effect of computer gaming on test scores, there are other interesting HI and MI countries differences that may speak to the mixed results of experimental literature (e.g. Beuermann et al., 2013)). School computers with web access have larger positive coefficients in HI countries, but are generally not significant in MI countries. The coefficients of the student-teacher ratio display the counterintuitive negative sign in HI countries, where at-risk students are enrolled in smaller classes, but the coefficients are negative and highly significant in MI countries. Using specification (4), we compute that reducing the percentage of school computers with web access from an average of 90% in HI countries to the average of about 60% in MI countries would reduce the test scores of both boys and girls by about 10 points, closing from 15 to 17% of the HI/MI gap.

We explore further the impact of the school climate factors by including our sense of belonging variables which are available only in PISA2003 and PISA2012. A "first-stage" specification, much like equation [2], that includes the school variables, in addition to the individual and family variables is presented in Appendix Table A3. It shows a negative correlation between intense gaming and the sense of belonging, measured either by our index or the "Feel I belong" variable. The "Feel awkward" variable is not significant for boys, but show a positive correlation with intense gaming for girls in both HI and MI countries.[43] The association between everyday gaming and the percentage of school computers with web access,

[42] When entered together the teachers and students hindrance to learning factors are of opposite signs reflecting a high degree of collinearity between these variables, but the student factors dominate.

[43] We cannot infer a direction of causality: are girl gamers feeling awkward because they play computer games or are awkward girls attracted to computer gaming?

generally negative, is significantly only for boys.

In Table 7 using PISA2003 and PISA2012, we report the estimates of our corresponding OLS, that include our hindrance to learning factors, and of our within-school-year specifications, that exclude these school level factors. Comparing the odd columns to the even columns shows that our "sense of belonging" variables alter only slightly our estimates of everyday gaming on math test scores: they remain positive for boys, but negative or non-significant for girls. Where we include the two components "Feel I belong" and "Feel awkward", we find some negativity associated with the latter effect. But interestingly and speaking to an hypothesized self-selection of awkward girls into gaming, the inclusion of this variable does not affect the coefficients of intense gaming on math test scores more for girls than for boys.

Finally, we present analyses focusing on PISA2009 and PISA2012 to differentiate single-player games (SPGs) from collaborative games (MMOs) and to control for the frequency of homework. The differentiation between the games that are played individually and over the internet is our strongest test of the social effect of the "gaming culture", which exists mainly in the context of MMOs. Additional tests of the cognitive channel are performed by comparison with other dependent variables, namely a problem solving exercise (available in PISA2012) and reading scores.

In Tables 7a and 7b, with only two waves, we can include the school-specific variables in an OLS specification, but not in the within-school-year models. For boys, in HI countries, the positive coefficients of everyday gaming are only significant for MMOs; in MI countries, the reverse is true in the within-school-year models. These results are consistent with the problem solving and social networking enhancing aspects of MMOs, which are less likely to flourish in MI countries given the lower levels of high speed connections.[44] For girls, in the within-school-year models, the magnitude of the negative and statistically significant coefficients of everyday MMOs (about 5 points) is equal to the positive and statistically

[44] In Appendix Tables A5a and A5b, we report similar results for reading test scores. There we find negative effects of MMOs for boys in HI countries of a similar magnitude as those found for girls. The estimates for the other groups are similar to those of math test scores.

significant coefficients of everyday SPGs. These results are consistent with the anticipated negative effects discussed in the literature about the secondary role of girl gamers in MMOs. The opposite signs coefficients could also explain the difficulty in finding significant effects for girls in previous specifications. Using specification (4), we construct the counterfactual that sets everyday MMOs to zero, and find that in HI countries this reduces the gender gap in math test score by 2 points or 14% of the gap. In MI countries, the corresponding reduction is of 3 points of 40% of the gap. These effects are not large, but represent a new obstacle in the much sought after closing of the gender gap in mathematics.

The estimates of other school variables are interesting. They show that everyday homework is more likely positively associated with math test scores among girls than among boys in HI countries. Actually in MI countries, there is a negative association between everyday homework and math test scores, consistent with a "too smart to do homework" boys' culture (Bishop, 2006).

As an additional test of the cognitive enhancement channel, in Table 8 we focus on the computer based assessment (CBA) of problem solving skills (CP) performed in PISA2012 for a subsample of students. There are 16 units available measured with the use of 2 to 4 questions for a total of 42 items (OECD, 2014).[45] We focus on a unit (CP007 - TRAFFIC) which asks three shortest route problems between different points indicated on a map, linked by segments of different distances. We estimate OLS and within-school specifications similar to ones above. Table 8 shows that the estimates of everyday SPGs on this problem-solving test are positive for boys and girls in HI countries (but not significant in MI countries where the sample sizes are rather small). In line with the previous results on math test scores, the estimates of everyday MMOs are negative for girls, although not significantly so in MI countries. These results warrant further investigations as the assessment of problem solving skills in the PISA is continually improving.

[45] We aggregate the items for each unit using the Cronach's alpha procedure and we normalize the resulting index to have mean zero and variance of one over the entire sample.

D. Summary and Discussion of the Empirical Results

We now summarize our empirical results. Our country-level IV estimation strategy (Table 3) clearly shows a gender differential in favor of boys in the coefficients of everyday gaming on math test scores. But these coefficients are imprecisely estimated preventing us to claim a precise causal effect, although the sign of the differential is likely correct. Our single country school-year fixed effects models (Tables 4a and 4b), for Canada and Italy, show more precisely estimated coefficients: positive for boys and negative for girls of the same order of magnitude. These estimates imply that gender differences in everyday gaming could account for 35% to 70% of the gender gap in math scores in these countries, and constitute a new "swimming upstream" factor in the quest to close that gap.

Our within country school-year fixed effects models seek to advance our understanding of the mechanisms behind these gender differences, in particular, the distraction and social effects channels which have received less attention in the literature. Considering the distraction channel, Tables 6a and 6b report larger negative effects for music downloading than for gaming but no gender differential in these effects; this highlights the gender-specificity of computer gaming. Consistent with a distraction/displacement mechanism, the positive effects of gaming for boys is enhanced and the negative effects of gaming for girls are mitigated when student behavioral issues are controlled for, in particular student skipping classes. The sense of belonging factors introduced in Table 7 speak to the role that gaming plays in the social identity of teenagers. Everyday gaming itself is associated with a lower sense of belonging to the school for both boys and girls, but a significant feeling of awkwardness only for girls (Table A3). These results point to a possible mechanism where everyday gaming by reducing the sense of belonging to the school and increasing absenteeism would lower test scores, a combination of distraction and social effects.

The comparison of the effects of SPGs vs. MMOs is likely the most revealing in terms of social effects. We find different positive and negative effects by game type and gender. In HI countries, for boys, MMOs show positive effects while SPGs show no significant effects (Table 8a). For girls, just the opposite, SPGs show positive effects, but MMOs show negative effects on both on math test scores (Table 8b) and problem-solving (Table 9). In MI countries where there is less high-speed internet, SPGs show positive effects, and MMOs no significant effects for boys. For girls, both SPGs and MMOs show negative effects, but the latter are larger. These results are consistent with stronger positive effects of gaming for boys when they connect with the gaming community. For girls, the opposite effects may reflect some negative social interactions described in the gaming literature.

Given that boys outnumber girls 3:1 in everyday gaming, even if we were to dismiss the negative effects found among girls on the basis of lower robustness or unclear self-selection of girls into this activity, we would be left with a substantial male-female advantage in the skills enhanced by playing MMOs. Because the array of skills in building network of team members in the context of MMOs are transferable in the world of global internet businesses (Martin, 2010; Werbach and Hunter, 2012), this male advantage will likely become non-trivial in the future.

V. Conclusion

In this paper, we use a host of empirical strategies to estimate the effect of everyday computer gaming (by comparison with more casual gaming) on math test scores within the limitations of the PISA 2000-2012 surveys. This complements recent studies which found mixed effects of various initiatives, implemented in many countries, to bridge the so-called digital divide in computer access among youths, either at home or in schools. Our instrumental variables strategy exploits differences in the speed of the internet diffusion process across countries as a source of randomness in youths' access to on-line gaming. Our within-school-year fixed models help investigate three mechanisms or channels, —a negative distracting effect, an enhancement effect on cognitive skills, and gender-specific social effects—, by which intense gaming in the field could affect math test scores.

Computer gaming is a new daily reality where another chasm between genders has appeared. This paper provides convincing international evidence of gender differences in the effect of everyday computer gaming, as experienced in the field, on math test scores. Overall, everyday gaming has the positive impact, predicted by some (Green and Bavelier, 2003, 2012; Adachi and Willoughby, 2013), on math test scores for boys. But the opposite is true for girls, the effect is generally negative and at best non significant. For boys, the positive enhancement of visual-spatial, problem solving, and social networking skills likely compensate the distraction/displacement effect. For girls, the fact that the negative effect is largely associated with MMOs (rather than SPGs) suggests a role for social effects possibly linked to the gaming culture on which further investigation is needed.

Given that the choices of games and the intensity of play are an integral part of the "treatment" provided by the gaming experience, our analysis may be more revealing than controlled experiments would be. Although none of our estimation strategies by itself provides as firm evidence as an experimental and quasi-experimental set-up would, the extensive specifications we offer go a fair distance in understanding the sources of potential selection biases. Our findings are informative to further address the sources of heterogeneity in treatment that might cloud existing quasi-experimental set-ups. There are substantial conceptual difficulties and ethnical concerns in getting young students, especially young women, to spend time everyday, playing games where the portrayal of female characters might be detrimental to their self-image.

Given the large differences in internet access between HI and MI countries, we also find substantial differences in who plays games across the different income group countries. Parental influences loom larger in MI countries where those with higher socio-economic status play more. In HI countries, school characteristics are more important determinants of who plays. Interestingly, we find that school access to the internet is negatively associated with intense gaming and strongly positively associated with math test scores for boys in HI countries. These findings help set new paths to investigate the mixed results of the literature on the impact of ICT use on academic achievement.

Concerned parents should check that their children are not loosing sleep or skipping classes to play electronic games. To the extent that computing gaming increases some types of specialized human capital, from visual-spatial skills to on-line networking, large gender differences in intense gaming will contribute to exacerbate these gender differences in the labor market. Beyond the narrow math test scores studied here, the skills acquired while gaming may be important in some professions such robotic laporoscopic surgery and drones guidance among others. However, closing that gaming gap by enticing girls to play more may not be advisable. Issues with gaming content and the gaming community should also be addressed first.

REFERENCES

Adachi, P. J., and Willoughby, T. (2013). "More than just fun and games: The longitudinal relationships between strategic video games, self-reported problem solving skills, and academic grades," *Journal of Youth and Adolescence,* 42(7): 1041-1052.

Algan, Yann, Cahuc, Pierre, and Shleifer, Andrei (2013). "Teaching Practices and Social Capital," *American Economic Journal: Applied Economics,* 5(3): 189210.

Angrist, J., and Lavy, V. (2002). "New Evidence on Classroom Computers and Pupil Learning," *Economic Journal,* 112(482): 735-765.

Beuermann, D. W., Cristia, J. P., Cruz-Aguayo, Y., Cueto, S., and Malamud, O. (2013). "Home Computers and Child Outcomes: Short-Term Impacts from a Randomized Experiment in Peru" (No. 18818). National Bureau of Economic Research.

Beasley, B., and Collins Standley, T. (2002). "Shirts vs. Skins: Clothing as an Indicator of Gender Role Stereotyping in Video Games," *Mass Communication & Society,* 5(3): 279-293.

Biagi, F., and Loi, M. (2013). "Measuring ICT Use and Learning Outcomes: Evidence from Recent Econometric Studies," *European Journal of Education,* 48(1): 28-42.

Bishop, John H. (2006). "Drinking from the Fountain of Knowledge: Student Incentive to Study and Learn Externalities, Information Problems and Peer Pressure." In *Handbook of the Economics of Education,* ed. Erik Hanushek and Finnis Welch. Vol. 2: 909-944. Amsterdam: Elsevier - North Holland.

Checchi, D., and Flabbi, L. (2013). "Intergenerational Mobility and Schooling Decisions in Germany and Italy: The Impact of Secondary School Tracks. *Rivista di politica economica,* (3): 7-57.

Colecchia, A., and Schreyer, P. (2002). "ICT Investment and Economic Growth in the 1990s: Is the United States a Unique Case?: A Comparative Study of Nine OECD Countries." *Review of Economic Dynamics,* 5(2): 408-442.

Czernich, N., Falck, O., Kretschmer, T., and Wößmann, L. (2011). "Broadband Infrastructure and Economic Growth". *Economic Journal,* 121(552): 505-532.

De San Román, A.G. and de la Rica Goiricelaya, S. (2012). "Gender Gaps in PISA Test Scores: The Impact of Social Norms and the Mothers Transmission of Role Attitudes," IZA DP No. 6338.

Entertainment Software Association (ESA) (2013). *Essential facts about the Computer and Video Game Industry: 2012 Sales, Demographic and Usage Data.*

Fairlie, R.W., and London, R.A. (2012). "The Effects of Home Computers on Educational Outcomes: Evidence from a Field Experiment with Community College Students," *Economic Journal,* 122(561): 727-753.

Fairlie, R.W., and Robinson, J. (2013). "Experimental Evidence on the Effects of Home Computers on Academic Achievement among Schoolchildren," *American Economic Journal: Applied Economics,* 5(3): 211-240.

Fairlie, R.W. (2015). "Do Boys and Girls Use Computers Differently, and Does It Contribute to Why Boys Do Worse in School than Girls?" IZA Discussion Paper no. 9302.

Fuchs, T., and Wößmann, L. (2004). "Computers and Student Learning: Bivariate and Multivariate Evidence on the Availability and Use of Computers at Home and at School," *Brussels Economic Review,* 47(3-4), 359-386.

Fuchs, T., and Wößmann, L. (2008). "What Accounts for International Differences in Student Performance? A Re-examination Using PISA Data" (pp. 209–240). *Physica-Verlag HD.*

Gentile, D. A. (2011). "The Multiple Dimensions of Video Game Effects," *Child Development Perspectives,* 5(2): 75–81.

Goolsbee, A. and Guryan, J. (2006). "The Impact of Internet Subsidies in Public Schools," *Review of Economics and Statistics,* 88: 336-347.

Green, C. S., and Bavelier, D. (2003). "Action Video Games Modify Visual Attention," *Nature,* 423: 534-537.

Green, C. S., and Bavelier, D. (2012). "Learning, Attentional Control, and Action Video Games," *Current Biology,* 22(6): R197–R206.

Hamlen, K. R. (2010). "Re-examining Gender Differences in Video Game Play: Time Spent and Feelings of Success," *Journal of Educational Computing Research,* 43(3): 293-308.

Hartmann, T., and Klimmt, C. (2006). "Gender and Computer Games: Exploring Females Dislikes," *Journal of Computer-Mediated Communication,* 11(4): 910-931.

Hoeft, F., Watson, C. L., Kesler, S. R., Bettinger, K. E., and Reiss, A. L. (2008). "Gender Differences in the Mesocorticolimbic System during Computer Game-Play," *Journal of Psychiatric Research,* 42(4): 253–258.

Jackson, L. A., Von Eye, A., Witt, E. A., Zhao, Y., and Fitzgerald, H. E. (2011). "A Longitudinal Study of the Effects of Internet Use and Videogame Playing on Academic Performance and the Roles of Gender, Race and Income in these Relationships," *Computers in Human Behavior,* 27(1): 228–239.

Junco, R. (2012). "Too Much Face and Not Enough Books: The Relationship between Multiple Indices of Facebook Use and Academic Performance," *Computers in Human Behavior,* 28(1): 187-198.

Kendall-Morwick, J. (2015. "The Need for Voices in CS to Address the# GamerGate Controversy," In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education,* February: 514-514. ACM.

Kretschmer, T. (2012). "Information and Communication Technologies and Productivity Growth," *OECD Digital Economy Papers,* No. 195, OECD Publishing.

Machin, S., McNally, S., and Silva, O. (2007). "New Technology in Schools: Is There a Payoff?," *Economic Journal,* 117(522): 1145–1167.

Malamud, O., and Pop-Eleches, C. (2011). "Home Computer Use and the Development of Human Capital," *Quarterly Journal of Economics,* 126(2): 987–1027.

Martin, Owens Jr. (2010). "There's an App for That (or soon will be): Smart Phones, Social Networking, and Internet Gaming." *Gaming Law Review and Economics* 14: 171–174.

Miller, M. K., and Summers, A. (2007). "Gender Differences in Video Game Characters Roles, Appearances, and Attire as Portrayed in Video Game Magazines," *Sex Roles,* 57(9-10), 733–742.

Notten, N., Peter, J., Kraaykamp, G., and Valkenburg, P. M. (2009). "Research Note: Digital Divide across Borders - a Cross-National Study of Adolescents Use of Digital Technologies," *European Sociological Review,* 25(5): 551–560.

OECD (2012). PISA 2012 Technical Report.

OECD (2014), *PISA 2012 Results: Creative Problem Solving: Students Skills in Tackling Real-Life Problems* (Volume V), PI SA, OECD Publishing.

Ogletree, S. M., and Drake, R. (2007). "College students video game participation and perceptions: Gender differences and implications." *Sex Roles,* 56(7-8), 537–542.

Pabilonia, S. W. (2015) "Childrens Media Use and Homework Time" forthcoming in *The Economics of Multitasking* Eds. C. Kalenkoski and G. Foster, Palgrave Macmillan.

Rehbein, F., Psych, G., Kleimann, M., Mediasci, G., and Möße, T. (2010). "Prevalence and Risk Factors of Video Game Dependency in Adolescence: Results of a German Nationwide Survey," *Cyberpsychology, Behavior, and Social Networking,* 13(3): 269–277.

Richard, G. T. (2013, April). "Designing Games That Foster Equity and Inclusion," In *Proceedings of the CHI2013 Workshop: Designing and Evaluating Sociability in Online Video Games,* Paris, France (pp. 83–88).

Schott, G. R., and Horrell, K. R. (2000). Girl Gamers and their Relationship with the Gaming Culture. *Convergence: The International Journal of Research into New Media Technologies,* 6(4): 36–53.

Skoric, M. M., Teo, L. L. C., and Neo, R. L. (2009). Children and Video Games: Addiction, Engagement, and Scholastic Achievement. *Cyberpsychology & Behavior,* 12(5): 567–572.

Smyth, J. M. (2007). "Beyond Self-Selection in Video Game Play: An Experimental Examination of the Consequences of Massively Multiplayer Online Role-Playing Game Play," *CyberPsychology & Behavior.* 10(5): 717–721.

Spiezia, V. (2011). Does Computer Use Increase Educational Achievements? Student-level Evidence from PISA. *OECD Journal: Economic Studies*, 2010(1): 1–22.

Spencer, S. J., Steele, C. M., and Quinn, D. M. (1999). "Stereotype Threat and Women's Math Performance," *Journal of Experimental Social Psychology,* 35(1): 4–28.

Spreckelmeyer, K.N., S. Krach, G. Kohls, L. Rademacher, A. Irmak, K. Konrad, T. Kircher, and G. Gründer. (2009) "Anticipation of Monetary and Social Reward Differently Activates Mesolimbic Brain Structures in Men and Women." *Social Cognitive and Affective Neuroscience,* 4(2): 158–165.

Turner, Isobel, Katherine J. Reynolds, Eunro Lee, Emina Subasic, and David Bromhead. (2014) "Well-Being, School Climate, and the Social Identity Process: A Latent Growth Model Study of Bullying Perpetration and Peer Victimization." *School Psychology Quarterly,* 29(3): 320.

United Nations (UN) (2012). *World Economic Situation and Prospects 2012,* New York: United Nations Publication

Vigdor, J. L., and Ladd, H. F. (2010). "Scaling the Digital Divide: Home Computer Technology and Student Achievement" (No.16078). National Bureau of Economic Research.

Weis, R., and Cerankosky, B. C. (2010). "Effects of Video-Game Ownership on Young Boys Academic and Behavioral Functioning A Randomized, Controlled Study," *Psychological Science,* 21(4) 463-470.

Winn, J., and Heeter, C. (2009). "Gaming, Gender, and Time: Who Makes Time to Play?." *Sex Roles,* 61 (1-2): 1–13.

Werbach, K., and Hunter, D. (2012). "For The Win: How Game Thinking Can Revolutionize your Business," Wharton Digital Press, 2012.

Table 1 - Average Number of Daily Hours Spent on Several Activities by Gender and Gaming Style

TIMMS 2008 - 8th graders	Boys		Girls	
Activities	Everyday Gamers (> 1 hour)	Others	Everyday Gamers (> 1 hour)	Others
Play or talk with friends	2.7	1.8	2.7	1.9
Watch TV and videos	2.6	1.5	2.7	1.7
Use the internet	2.4	0.8	2.5	1.0
Play sports	2.3	1.9	1.4	1.1
Do homework	1.5	1.6	1.9	2.0
Do jobs or chores at home	1.2	1.3	1.3	1.5
Read a book for enjoyment	0.9	0.8	1.0	0.9
Work at a paid job	0.7	0.7	0.4	0.3

Note: The averages are computed as the percentage of boys and girls in each of five categories multiplied by the mid-point of the hours boundaries of each category: 0 for the no time, 0.5 for the less than 1 hour, 1.5 for the 1 to 2 hours, 3 hours for 2 but less than 4 hours, and 6 hours for the 4 or more hours.

Table 2. Cross-Country Aggregate Estimates on Math Scores

Dependent Variable: Average Math Score	All Countries	All Countries	High Income	Middle Income	All Countries	High Income	Middle Income	All Countries	High Income	Middle Income
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	OLS	OLS	Between	Between	Between	Within	Within	Within
A: Boys										
Everyday Gamers (%)		16.68	-76.24***	136.1***	46.21	-85.20*	172.7	-6.202	2.067	-15.97
		(21.36)	(19.28)	(47.67)	(49.84)	(42.61)	(74.39)	(19.74)	(19.01)	(69.86)
Individuals using	0.585*	0.539*	0.472	1.321**	1.201	-0.321	0.779	0.220	0.554**	0.552
with Internet (%)	(0.316)	(0.322)	(0.290)	(0.637)	(0.788)	(0.668)	(1.324)	(0.245)	(0.264)	(0.598)
Household with	0.967***	0.955**	0.684**	-0.598	0.440	1.742**	-0.403	-0.218	-0.390*	-0.384
a computer (%)	(0.369)	(0.369)	(0.340)	(0.726)	(0.996)	(0.839)	(2.607)	(0.219)	(0.227)	(0.523)
Log GDP per capita	6.815	7.677	-9.554*	2.383	3.950	-15.02	32.02	2.902	2.238	-28.28*
	(5.255)	(5.376)	(4.841)	(13.82)	(13.08)	(10.88)	(29.58)	(6.015)	(7.361)	(13.86)
R-squared	0.594	0.591	0.355	0.483	0.657	0.676	0.818	0.069	0.101	0.628
B: Girls										
Everyday Gamers (%)		-145.0***	-139.3***	-227.2**	-155.7	-211.8**	307.2	-60.21**	-35.90	-87.23
		(43.82)	(47.05)	(89.15)	(108.5)	(93.91)	(617.3)	(29.71)	(31.93)	(61.12)
Individuals using	0.655**	0.435	0.158	1.310*	0.790	-0.828	1.405	0.275	0.496*	0.621
with Internet (%)	(0.307)	(0.303)	(0.278)	(0.656)	(0.821)	(0.614)	(2.945)	(0.221)	(0.253)	(0.463)
Household with	1.062***	0.968***	0.757**	1.285	1.191	2.071**	1.129	-0.273	-0.392*	-0.384
a computer (%)	(0.358)	(0.347)	(0.334)	(0.837)	(1.026)	(0.774)	(5.843)	(0.203)	(0.227)	(0.352)
Log GDP per capita	1.592	0.746	-4.731	-44.17***	-10.24	-11.81	27.02	7.383	7.153	-19.94*
	(5.107)	(4.968)	(4.792)	(13.56)	(13.04)	(10.06)	(97.63)	(5.386)	(7.039)	(10.40)
R-squared	0.593	0.594	0.345	0.448	0.658	0.626	0.929	0.012	0.108	0.530
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	167	167	123	44	160	122	38	160	122	38
Number of countries	55	55	35	20	45	33	12	45	33	12

Note: The between-country estimates are from a random-effects specification and the within-country a fixed-effects specification, these two last specification exclude countries observed only once. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3. Determinants of Everyday Computer Gaming PISA 2000-2012 : First-stage Results

Dependent Variable	Boys : HI Countries			Girls: HI Countries			Boys: MI Countries			Girls: MI Countries		
Everyday Gaming		0.389			0.124			0.359			0.145	
Countries used	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
in prediction model:		HI	All		HI	All		MI	All		MI	All
Predicted Percent		-0.984***	-1.213***		-0.429***	-0.577***		-0.139	-1.621**		-0.231	2.756***
Internet Users		(0.205)	(0.208)		(0.140)	(0.142)		(0.673)	(0.770)		(0.508)	(0.560)
Predicted Percent		1.310***	2.119***		1.049***	1.479***		0.196	2.531*		0.044	-5.047***
Home Computers		(0.247)	(0.342)		(0.168)	(0.233)		(1.038)	(1.320)		(0.781)	(0.964)
Home Link to	0.077***	0.078***	0.078***	0.008***	0.011	0.011***	0.057***	0.057***	0.057***	0.009***	0.010***	0.009***
Internet	(0.002)	(0.011)	(0.002)	(0.002)	(0.010)	(0.002)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Home Computer	0.131***	0.131***	0.131***	0.066***	0.067***	0.067***	0.271***	0.271***	0.270***	0.171***	0.172***	0.172***
	(0.003)	(0.036)	(0.003)	(0.002)	(0.024)	(0.002)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
First-generation	-0.056***	-0.056**	-0.029***	-0.028***	-0.029*	-0.024***	0.020***	-0.008**	0.020***	0.005	-0.012***	0.004
Immigrant	(0.004)	(0.025)	(0.002)	(0.003)	(0.017)	(0.001)	(0.007)	(0.004)	(0.007)	(0.007)	(0.003)	(0.007)
Father Higher	-0.025***	-0.025**	-0.001	-0.024***	-0.024***	-0.011***	-0.007	0.016***	-0.007	-0.033***	0.030***	-0.033***
Education	(0.003)	(0.012)	(0.002)	(0.002)	(0.005)	(0.002)	(0.005)	(0.004)	(0.005)	(0.004)	(0.003)	(0.004)
Mother Higher	-0.014***	-0.014*	-0.001	-0.011***	-0.010	-0.019***	0.012**	-0.015***	0.012**	0.026***	-0.031***	0.025***
Education	(0.003)	(0.008)	(0.004)	(0.002)	(0.011)	(0.002)	(0.005)	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)
Mother	-0.015***	-0.015**	-0.006**	-0.005***	-0.005**	-0.016***	-0.001	0.006	-0.000	-0.003	-0.022***	-0.004
Homemaker	(0.002)	(0.007)	(0.003)	(0.001)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Observations	423,439	423,439	423,439	424,162	424,162	424,162	111,669	111,669	111,669	120,849	120,849	120,849
R-squared	0.076	0.076	0.076	0.037	0.037	0.037	0.171	0.171	0.171	0.075	0.075	0.075

Note: All regressions include country and time fixed effects, as well as country controls. Other included variables are: Age, 2nd generation immigrant status, father and mother secondary education, father and mother occupation (4 categories), books in the home (5 categories). Standard errors clustered at the country level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4. Within-Country and Instrumental Variables Estimates of the Computer Gaming on Math Scores
PISA 2000-2012

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Math Scores	HI Countries							
	Boys: 520.79				Girls: 506.67			
	OLS	IV-HI	IV-HI	IV-HI	OLS	IV-HI	IV-HI	IV-HI
Everyday Gaming	-3.073**	38.68	43.21	81.65*	-17.54*	-61.32	-100.7**	-443.1***
	(1.301)	(32.51)	(63.55)	(43.78)	(9.213)	(51.87)	(49.51)	(163.0)
Home Link	18.94***	15.77***	13.23**	7.004*	14.86***	15.18***	16.55***	15.05***
to Internet	(3.358)	(2.511)	(5.699)	(4.130)	(2.361)	(2.399)	(1.676)	(3.077)
Home Computer	21.54***	16.11***	15.97*	15.74	17.83***	20.70***	22.48***	66.33***
	(2.103)	(4.253)	(8.918)	(10.78)	(1.971)	(4.573)	(3.907)	(17.38)
Observations	423,439	423,439	385,953	375,424	424,162	424,162	385,375	375,228
R-squared	0.274	0.231	0.221	0.099	0.291	0.265	0.193	0.310
First Stage Statistics								
DWH (p-value)		0.2050	0.0310	0.0000		0.0117	0.0000	0.0000
Gaming endogenous		No	Weakly	Yes		Yes	Yes	Yes
F-stat		17.17	32.19	53.27		87.25	117.68	7.541
Inst. weak		No	No	No		No	No	Somewhat
Overid (p-value)		0.0650	0.0000	0.7386		0.8863	0.000	0.134
Inst. excludable		Yes	No	Yes		Yes	No	Yes

Dependent Variable:	MI Countries							
Math Scores	Boys: 452.96				Girls: 444.75			
	OLS	IV-All	IV-All		OLS	IV-All	IV-All	
Everyday Gaming	-3.152	-79.37	396.4		-18.64***	-183.0	-355.7**	
	(2.843)	(2392)	(1801)		(6.404)	(275.0)	(150.4)	
Home Link	3.877	8.216	-21.38		7.789**	9.239*	9.125***	
to Internet	(4.560)	(95.66)	(120.9)		(3.162)	(4.853)	(2.523)	
Home Computer	24.53***	45.08	-79.47		23.89***	52.32	80.58***	
	(3.164)	(684.1)	(468.2)		(3.863)	(46.93)	(26.46)	
Observations	111,669	111,669	101,778		120,849	120,849	110,158	
R-squared	0.268	0.130			0.296			
First Stage Statistics								
DWH (p-value)		0.2050	0.0000			0.0117	0.0000	
Gaming endogenous		No	Yes			Yes	Yes	
F-stat		17.17	0.33			87.25	8.99	
Inst. weak		No	Yes			No	Somewhat	
Overid (p-value)		0.0650	0.8711			0.8863	0.0045	
Inst. excludable		Yes	Yes			Yes	No	

Note: All regressions include country and time fixed effects, as well as country controls. Other included variables are: Age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories). Standard errors in parentheses computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. Columns (3) and (7) omit PISA2000. For HI countries, columns (4) and (8) also exclude Japan.

*** p<0.01, ** p<0.05, * p<0.1

Table 5. School-Year Fixed Effects Estimates of Everyday Computer Gaming on Math Scores
Canada− PISA 2000-09 and Italy− PISA 2003-12

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Math Score	Canada				Italy			
	Boys: 537.90		Girls: 524.29		Boys: 492.80		Girls: 474.37	
Explanatory Variables	OLS	Within School	OLS	Within School	OLS	Within School	OLS	Within School
Everyday Gaming	1.809	3.076**	-8.819**	-6.385**	3.542**	3.857***	-12.08***	-2.503*
	(1.530)	(1.408)	(4.090)	(3.099)	(1.380)	(1.097)	(2.140)	(1.302)
Home Link to Internet	-1.147	-0.679	1.398	1.670	4.664*	-0.470	12.34***	6.998***
	(4.003)	(3.997)	(3.744)	(3.657)	(2.394)	(2.264)	(2.514)	(1.904)
Home Computer	34.05***	29.79***	17.40***	14.31***	18.71***	14.22***	15.20***	9.472***
	(5.988)	(5.123)	(5.440)	(5.419)	(3.672)	(3.064)	(3.540)	(2.373)
School Computers with Web Access	0.735	-5.325	-1.916	-10.90	27.43***	29.93	29.33***	21.91
	(12.62)	(21.88)	(11.06)	(10.03)	(7.979)	(24.01)	(7.153)	(23.01)
Student-Teacher Ratio	1.913***	2.888***	1.510***	1.507***	6.172***	6.151***	5.745***	7.559***
	(0.484)	(0.499)	(0.437)	(0.382)	(1.421)	(1.670)	(0.864)	(1.366)
School Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
No. of Schools		1,008		1,005		1,840		1,742
Observations	22,546	22,546	23,720	23,720	31,026	31,026	29,906	29,906
R-squared	0.236	0.374	0.230	0.367	0.331	0.597	0.298	0.577

Notes: Data for the four different waves of PISA to which Canada and Italy participated are used; all regressions include time fixed effects. Other included variables are: age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade, ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

Table 6a. School-Year Fixed Effects Estimates of Everyday Computer Gaming on Boys' Math Scores
PISA 2003-12

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Boys' Math Score	HI Countries: 526.67				MI Countries: 455.12			
Explanatory Variables	OLS	Within School	Within School	Within School	OLS	Within School	Within School	Within School
Everyday Gaming	3.786***	5.734***	5.997***	5.936***	4.076**	6.437***	6.434***	6.489***
	(1.366)	(1.086)	(1.044)	(1.052)	(1.851)	(2.075)	(2.077)	(2.086)
Everyday Music	-21.44***	-12.12***	-11.92***	-11.99***	-12.07***	-6.794***	-6.695***	-6.762***
Downloading	(0.813)	(1.479)	(1.458)	(1.445)	(2.592)	(2.469)	(2.470)	(2.467)
Home Link	20.30***	10.70***	10.14***	10.14***	6.013***	1.811	1.752	1.798
to Internet	(1.407)	(1.572)	(1.559)	(1.540)	(1.529)	(2.465)	(2.480)	(2.462)
Home Computer	16.59***	11.50***	11.35***	11.39***	13.67***	8.649***	8.576***	8.564***
	(1.496)	(1.469)	(1.460)	(1.460)	(1.945)	(2.827)	(2.854)	(2.831)
School Computers	23.63***	34.38***	28.71***	29.42***	1.830	-4.099	-5.420	-5.107
with Web Access	(4.759)	(8.891)	(8.027)	(8.296)	(4.725)	(8.125)	(8.051)	(8.058)
Student-Teacher	1.872***	2.311***	2.330***	2.294***	-1.194***	-1.458***	-1.485***	-1.440***
Ratio	(0.195)	(0.697)	(0.665)	(0.640)	(0.143)	(0.427)	(0.425)	(0.429)
Hindrance to Learning:[a]								
Teacher Factors			18.21***				-3.078	
			(5.688)				(9.311)	
Student Factors			-47.66***				-7.541	
			(6.109)				(9.301)	
Student Skipping				-22.41***				-5.029*
Class				(1.743)				(2.937)
School Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
No. of Schools		13,265	13,265	13,265		3,431	3,431	3,431
Observations	284,705	211,185	211,185	211,185	68,546	50,339	50,339	50,339
R-squared	0.284	0.549	0.552	0.552	0.330	0.553	0.554	0.554

Notes: All regressions include time fixed effects. Other included variables are: age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade, ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

[a] Not available in 2006

Table 6b. School-Year Fixed Effects Estimates of Everyday Computer Gaming on Girls' Math Scores
PISA 2003-12

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Girls' Math Score	HI Countries: 511.82				MI Countries: 446.90			
Explanatory Variables	OLS	Within School	Within School	Within School	OLS	Within School	Within School	Within School
Everyday Gaming	-6.619**	0.750	1.109	1.072	-11.35***	-5.583	-5.491	-5.541
	(2.877)	(2.298)	(2.241)	(2.266)	(2.614)	(3.604)	(3.612)	(3.603)
Everyday Music	-23.15***	-12.51***	-12.24***	-12.24***	-11.29***	-5.598***	-5.564***	-5.571***
Downloading	(0.725)	(0.752)	(0.713)	(0.716)	(2.094)	(1.550)	(1.549)	(1.552)
Home Link	21.30***	10.03***	9.588***	9.752***	10.74***	3.785**	3.809**	3.765**
to Internet	(1.287)	(1.586)	(1.521)	(1.539)	(1.608)	(1.858)	(1.854)	(1.866)
Home Computer	12.16***	8.003***	7.560***	7.636***	18.85***	12.36***	12.23***	12.32***
	(1.313)	(1.473)	(1.951)	(1.922)	(1.713)	(1.733)	(1.731)	(1.726)
School Computers	10.09	34.90***	28.93***	30.28***	7.912*	9.862	9.419	9.303
with Web Access	(6.591)	(10.72)	(9.684)	(10.03)	(4.498)	(7.366)	(7.142)	(7.274)
Student-Teacher	2.014***	2.173***	2.065***	1.884***	-1.120***	-1.732***	-1.731***	-1.692***
Ratio	(0.196)	(0.568)	(0.541)	(0.522)	(0.126)	(0.402)	(0.394)	(0.400)
Hindrance to Learning:[a]								
Teacher Factors			18.31***				0.859	
			(6.587)				(9.219)	
Student Factors			-50.22***				-10.57	
			(6.603)				(9.359)	
Student Skipping				-23.29***				-4.092
Class				(2.291)				(2.860)
School Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
No. of Schools		12,972	12,972	12,972		3,443	3,443	3,443
Observations	281,170	208,869	208,869	208,869	76,379	56,261	56,261	56,261
R-squared	0.294	0.548	0.553	0.553	0.321	0.558	0.559	0.558

Notes: All regressions include time fixed effects. Other included variables are: age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

[a] Not available in 2006

Table 7. School- Year Fixed Effects Estimates of Everyday Computer Gaming on Math Scores
PISA 2003 and 2012

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Boys' Math Score	HI Countries: 533.23				MI Countries: 463.07			
Explanatory Variables	OLS	OLS	Within School	Within School	OLS	OLS	Within School	Within School
Everyday Gaming	5.686*	6.257*	7.747***	8.111***	8.729*	8.924*	7.409*	7.381
	(3.234)	(3.393)	(2.197)	(2.269)	(4.912)	(4.968)	(4.496)	(4.567)
Everyday Music	-20.16***	-20.21***	-14.53***	-14.54***	-11.72**	-12.73***	-8.176*	-8.869*
Downloading	(1.142)	(1.141)	(1.376)	(1.373)	(4.627)	(4.713)	(4.479)	(4.582)
Home Link	19.39***	18.93***	6.798***	6.554***	3.423	3.665	2.697	2.962
to Internet	(2.793)	(2.690)	(2.310)	(2.399)	(3.736)	(3.897)	(4.891)	(5.031)
Home	17.18***	15.93***	9.718***	9.404***	9.737**	9.346**	1.779	1.615
Computer	(2.171)	(1.741)	(1.741)	(1.761)	(3.838)	(3.917)	(3.677)	(3.713)
Student Skipping	-19.37***	-19.11***			-5.100	-4.889		
Class	(1.678)	(1.655)			(3.248)	(3.280)		
Feel I belong		9.211***		4.728***		4.892		4.091
		(2.324)		(1.534)		(3.504)		(2.570)
Feeling awkward		-22.40***		-15.04***		-21.87***		-14.49***
		(1.926)		(1.303)		(3.542)		(3.032)
No. of Schools			8,426	8,426			2,163	2,163
Observations	90,471	90,471	90,471	90,471	20453	20,453	20453	20,453
R-squared	0.285	0.294	0.572	0.575	0.313	0.323	0.573	0.576
Girls' Math Score	HI Countries: 515.57				MI Countries: 452.41			
Everyday Gaming	-4.922	-4.277	0.505	0.920	-8.771	-7.911	-6.610	-6.054
	(5.372)	(5.518)	(3.752)	(3.852)	(6.102)	(6.227)	(5.169)	(5.285)
Everyday Music	-21.28***	-21.13***	-12.05***	-11.93***	-8.263***	-8.181***	-4.653*	-4.510*
Downloading	(1.470)	(1.441)	(0.942)	(0.953)	(3.198)	(3.097)	(2.751)	(2.686)
Home Link	20.90***	20.87***	6.861***	6.778***	6.129*	5.937	2.251	2.039
to Internet	(3.172)	(3.009)	(1.877)	(1.797)	(3.515)	(3.731)	(3.271)	(3.414)
Home	12.65***	11.72***	8.189***	7.708***	14.24***	13.78***	8.341***	8.033***
Computer	(1.882)	(1.871)	(2.321)	(2.389)	(3.717)	(3.749)	(2.433)	(2.390)
Student Skipping	-18.48***	-18.27***			-6.204**	-6.170**		
Class	(1.675)	(1.693)			(2.688)	(2.698)		
Feel I belong		9.578***		6.737***		4.673		5.951
		(2.390)		(1.760)		(4.934)		(4.309)
Feeling awkward		-8.568***		-5.898***		-20.33***		-15.34***
		(2.624)		(1.959)		(3.067)		(2.874)
No. of Schools			8,426	8,426			2,163	2,163
Observations	89,500	89,500	89,500	89,500	22,355	22,355	22,355	22,355
R-squared	0.292	0.295	0.566	0.567	0.292	0.300	0.572	0.576

Note: Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1. Includes the same variables as Tables 5a and 5b.

Table 8a. School-Fixed Effects Estimates of Everyday Computer Gaming on Boys' Math Scores
PISA 2009 and 2012

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Boys' Math Score	HI Countries: 527.19				MI Countries: 454.78			
Explanatory Variables	OLS	OLS	OLS	Within School	OLS	OLS	OLS	Within School
Everyday SPG	-0.210	-0.053	-0.009	0.796	1.529	1.681	1.739	2.419**
	(1.223)	(1.136)	(1.197)	(0.705)	(1.232)	(1.238)	(1.246)	(0.989)
Everyday MMO	1.944*	2.674***	2.430**	4.903***	1.360	1.606	1.535	1.314
	(1.031)	(0.987)	(1.028)	(0.644)	(1.937)	(1.990)	(1.972)	(1.269)
Everyday Music	-19.02***	-17.57***	-17.46***	-9.920***	-3.923***	-4.238***	-4.110***	-1.694*
Downloading	(0.809)	(0.809)	(0.833)	(0.591)	(1.222)	(1.166)	(1.154)	(1.004)
Everyday	2.620	4.351***	3.569**	0.816	-6.906***	-7.073***	-7.201***	-4.166***
Homework	(1.614)	(1.547)	(1.617)	(1.016)	(1.813)	(1.821)	(1.809)	(1.304)
Home Link	20.97***	19.99***	19.73***	6.026***	4.902**	5.094***	4.936**	-1.689
to Internet	(2.120)	(2.100)	(2.091)	(1.269)	(1.932)	(1.907)	(1.936)	(1.427)
Home	14.04***	15.32***	15.23***	9.774***	13.31***	13.14***	13.29***	9.489***
Computer	(2.444)	(2.426)	(2.416)	(1.522)	(1.860)	(1.868)	(1.890)	(1.290)
School Computers	24.22**	24.78**	20.04*		-3.501	-3.162	-3.447	
with Web Access	(10.57)	(10.36)	(10.52)		(4.343)	(4.350)	(4.373)	
Student-Teacher	1.543***	1.345***	1.131***		-1.044***	-1.063***	-1.066***	
Ratio	(0.266)	(0.234)	(0.252)		(0.142)	(0.142)	(0.142)	
Hindrance to Learning:								
Teacher Factors		11.34***				5.174		
		(2.975)				(4.294)		
Student Factors		-41.17***				-9.183**		
		(3.028)				(3.750)		
Student Skipping			-18.20***				-4.153***	
Class			(1.269)				(1.483)	
School Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	No
No. of Schools				15,606				4,995
Observations	168,388	166,994	166,994	205,531	43,411	43,113	43,113	63,005
R-squared	0.286	0.311	0.305	0.601	0.320	0.321	0.321	0.614

Note: All regressions include age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade. Where included the school controls are the ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

Table 8b. School-Fixed Effects Estimates of Everyday Computer Gaming on Girls' Math Scores
PISA 2009 and 2012

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Girls' Math Score	HI Countries: 512.35				MI Countries: 454.78			
Explanatory Variables	OLS	OLS	OLS	Within School	OLS	OLS	OLS	Within School
Everyday SPG	1.773	1.880	1.838	5.134***	-4.032**	-4.003**	-3.964**	1.539
	(1.391)	(1.329)	(1.362)	(0.935)	(1.600)	(1.598)	(1.606)	(1.258)
Everyday MMO	-11.33***	-10.85***	-10.83***	-4.825***	-12.10***	-12.37***	-12.55***	-8.559***
	(1.760)	(1.681)	(1.699)	(1.247)	(2.545)	(2.273)	(2.258)	(1.689)
Everyday Music	-24.10***	-22.52***	-22.40***	-12.07***	-4.888***	-4.670***	-4.645***	-3.421***
Downloading	(0.778)	(0.787)	(0.792)	(0.601)	(1.377)	(1.368)	(1.373)	(0.933)
Everyday	7.242***	10.02***	8.620***	3.840***	0.889	0.542	0.489	1.307
Homework	(1.419)	(1.482)	(1.462)	(1.008)	(1.790)	(1.780)	(1.804)	(1.367)
Home Link	21.02***	19.72***	19.82***	7.755***	11.55***	11.69***	11.53***	2.898**
to Internet	(1.928)	(1.766)	(1.801)	(1.196)	(1.991)	(1.977)	(1.990)	(1.416)
Home	8.253***	8.663***	9.043***	4.726***	13.88***	13.73***	13.88***	8.899***
Computer	(1.884)	(1.841)	(1.868)	(1.472)	(1.918)	(1.915)	(1.918)	(1.404)
School Computers	0.547	3.412	2.461		3.015	2.862	2.828	
with Web Access	(16.00)	(15.41)	(15.05)		(3.987)	(4.008)	(3.953)	
Student-Teacher	1.754***	1.619***	1.370***		-0.916***	-0.929***	-0.923***	
Ratio	(0.248)	(0.228)	(0.225)		(0.132)	(0.133)	(0.132)	
Hindrance to Learning:								
Teacher Factors		11.05***				8.337*		
		(2.396)				(4.380)		
Student Factors		-36.38***				-10.39**		
		(2.655)				(4.277)		
Student Skipping			-15.89***				-2.516	
Class			(1.150)				(1.655)	
School Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	No
No. of Schools				15,307				4,978
Observations	167,805	166,565	166,565	206,954	48,747	48,593	48,593	69,139
R-squared	0.297	0.318	0.314	0.600	0.320	0.322	0.321	0.623

Note: All regressions include age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade. Where included the school controls are the ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

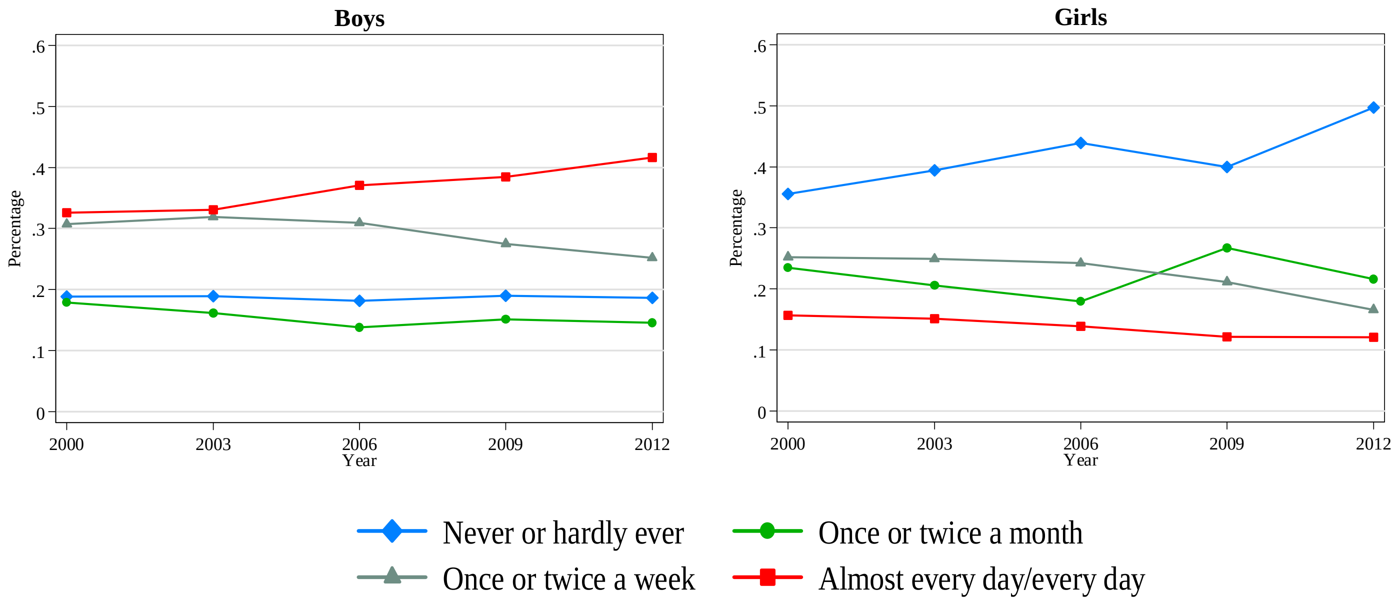
Table 9. Estimates of Everyday Computer Gaming on Problem Solving Skills (Item Traffic) - PISA 2012

Dependent Variable: Traffic (CP007)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	HI Countries				MI Countries			
	Boys: 0.189		Girls: 0.109		Boys: -0.219		Girls: -0.339	
Explanatory Variables	OLS	Within School	OLS	Within School	OLS	Within School	OLS	Within School
Everyday SPG	0.0927*	0.140**	0.240***	0.313**	0.015	-0.185	-0.093	0.109
	(0.0523)	(0.0568)	(0.062)	(0.117)	(0.114)	(0.126)	(0.063)	(0.156)
Everyday MMO	0.0113	-0.0317	-0.197***	-0.202*	0.078	0.267**	-0.039	-0.155
	(0.0615)	(0.0784)	(0.047)	(0.102)	(0.089)	(0.077)	(0.083)	(0.610)
Everyday Music	-0.111***	-0.132	-0.099**	0.093	0.028	0.036	-0.128***	-0.174
Downloading	(0.0318)	(0.0963)	(0.040)	(0.138)	(0.041)	(0.224)	(0.017)	(0.119)
Home Link	-0.175	-0.505***	0.293**	0.085	0.010	-0.094	0.127***	-0.042
to Internet	(0.123)	(0.161)	(0.125)	(0.299)	(0.033)	(0.056)	(0.018)	(0.067)
Home	0.118**	0.150**	-0.124***	-0.045	0.080	0.241*	0.247**	0.172
Computer	(0.0511)	(0.0614)	(0.019)	(0.096)	(0.068)	(0.088)	(0.069)	(0.105)
Feel I belong	0.171***	0.178	0.078	0.062	0.336***	0.396	0.004	0.068
	(0.0491)	(0.145)	(0.048)	(0.107)	(0.038)	(0.189)	(0.039)	(0.124)
School Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
No. of Schools		3,335		3,300		616		616
Countries		25		25		5		5
Observations	5,337	5,337	5,400	5,400	1,108	1,108	1,214	1,214
R-squared	0.069	0.690	0.069	0.678	0.101	0.686	0.096	0.684

Notes: Other included variables are: Age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade, ratio of computers to school size, percentage of girls in the school, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1

Figure 1. Percentage of PISA Students by Gender Who Use a Computer outside of School for

A. Computer Games



B. Music Downloading

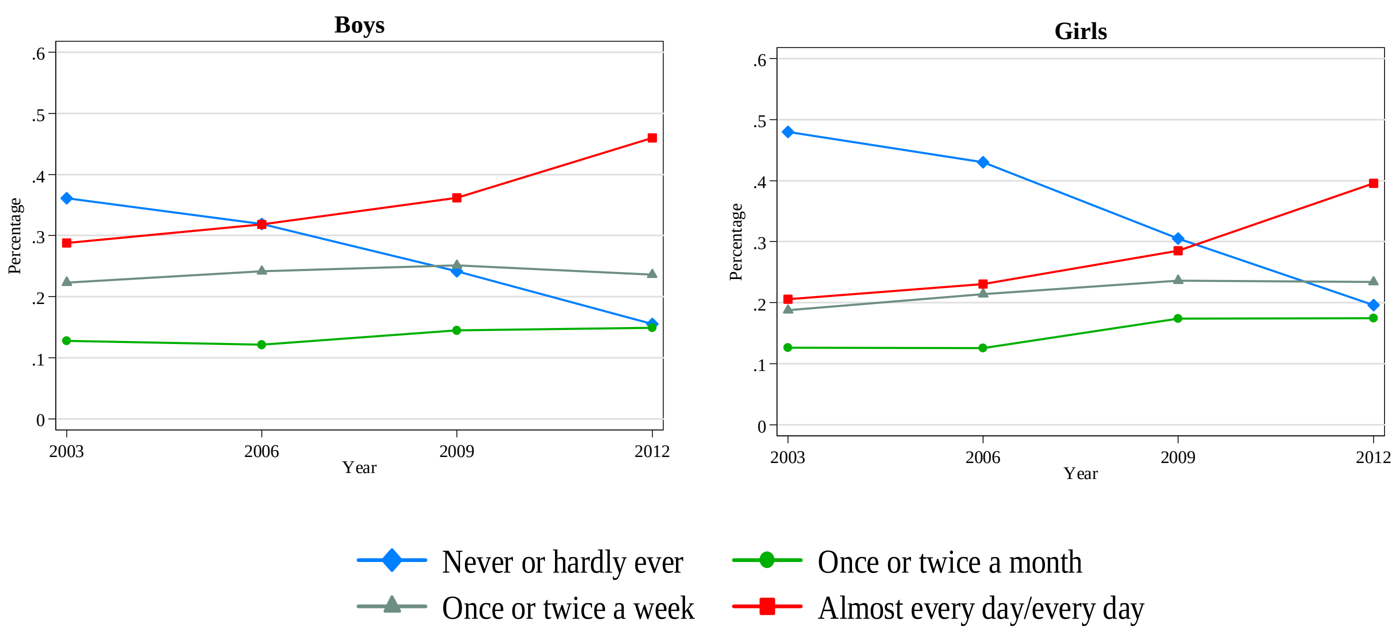
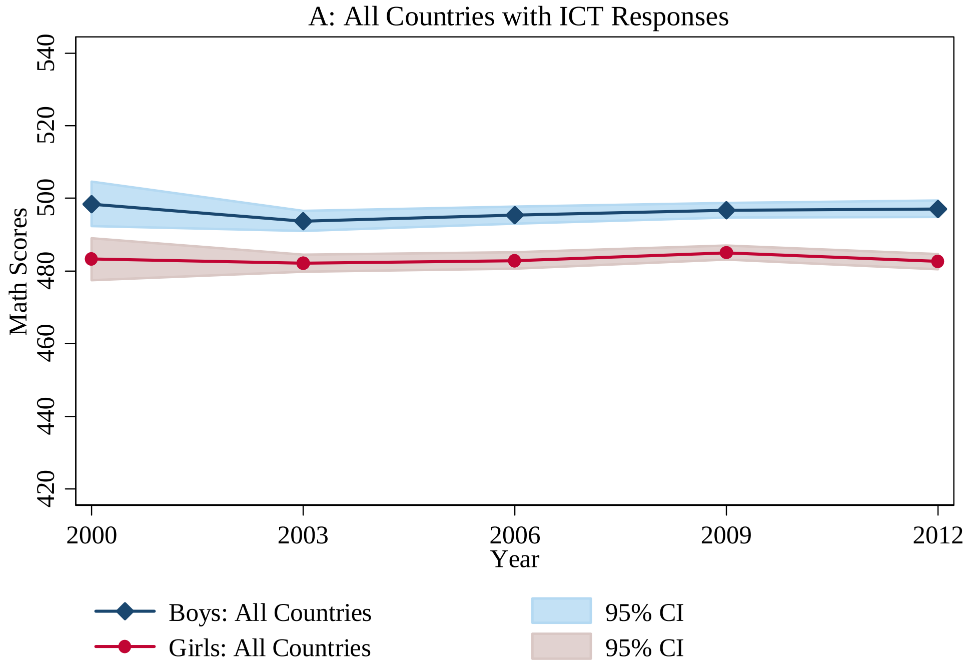
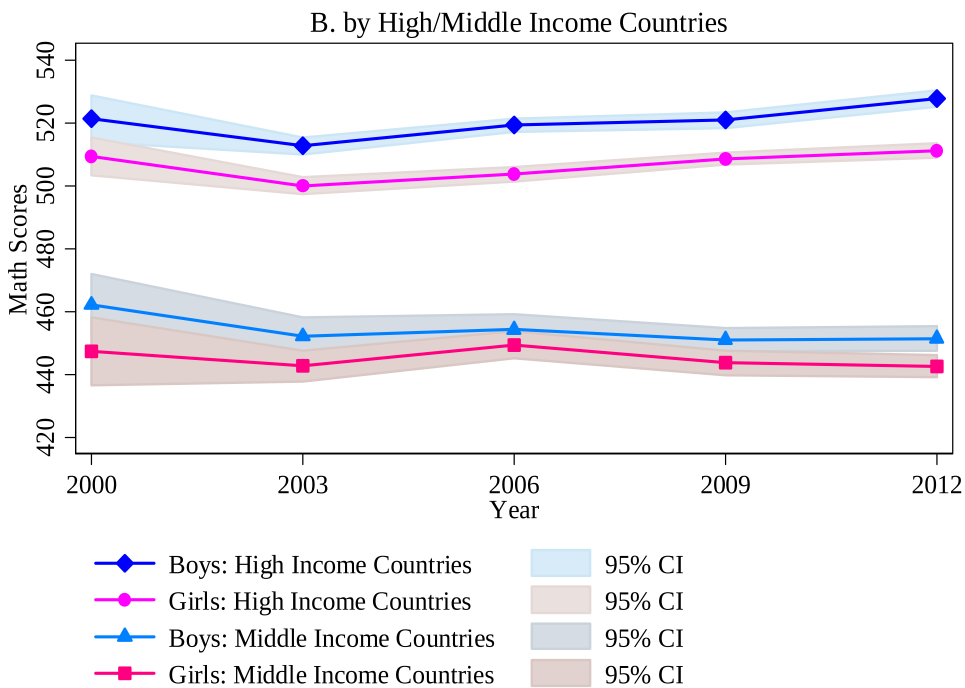


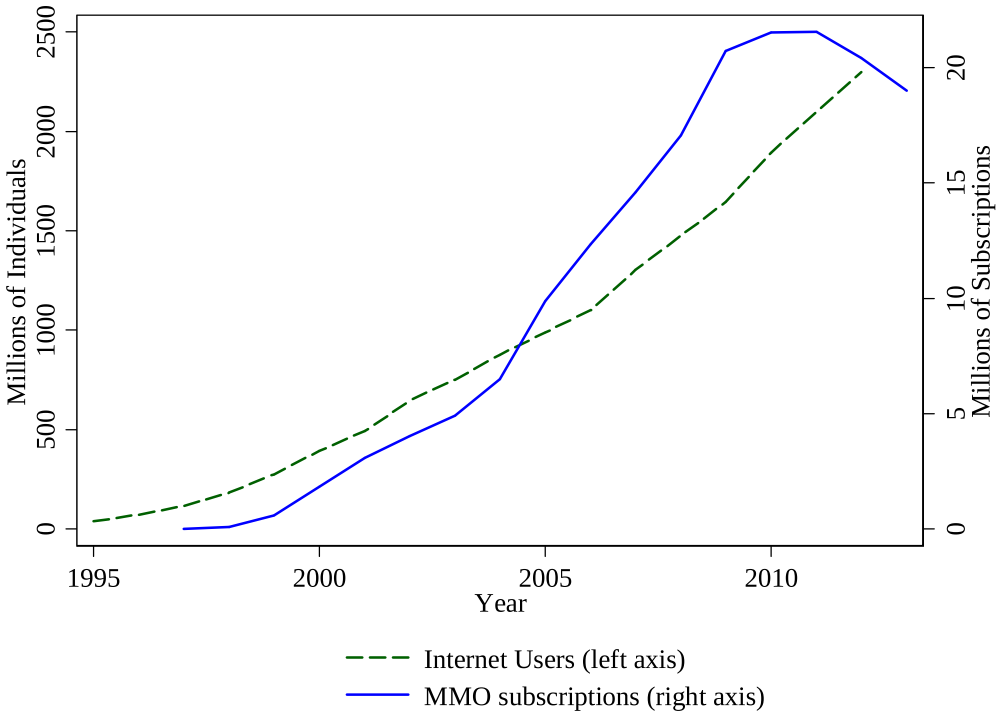
Figure 2. Gender Differences in PISA Mathematics Test Scores





Note: Standard errors computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented with the STATA "pv" command.

Figure 3. Growth of Internet and On-Line (MMO) Gaming



Source: Internet Users is computed from ITU data; MMO subscriptions are from MMOData.net
*MMO: Massively Multi-player On-line

Figure 4. Percentage of Everyday Gamers and Music Downloaders and Math Test Scores by Country, Year, and Gender

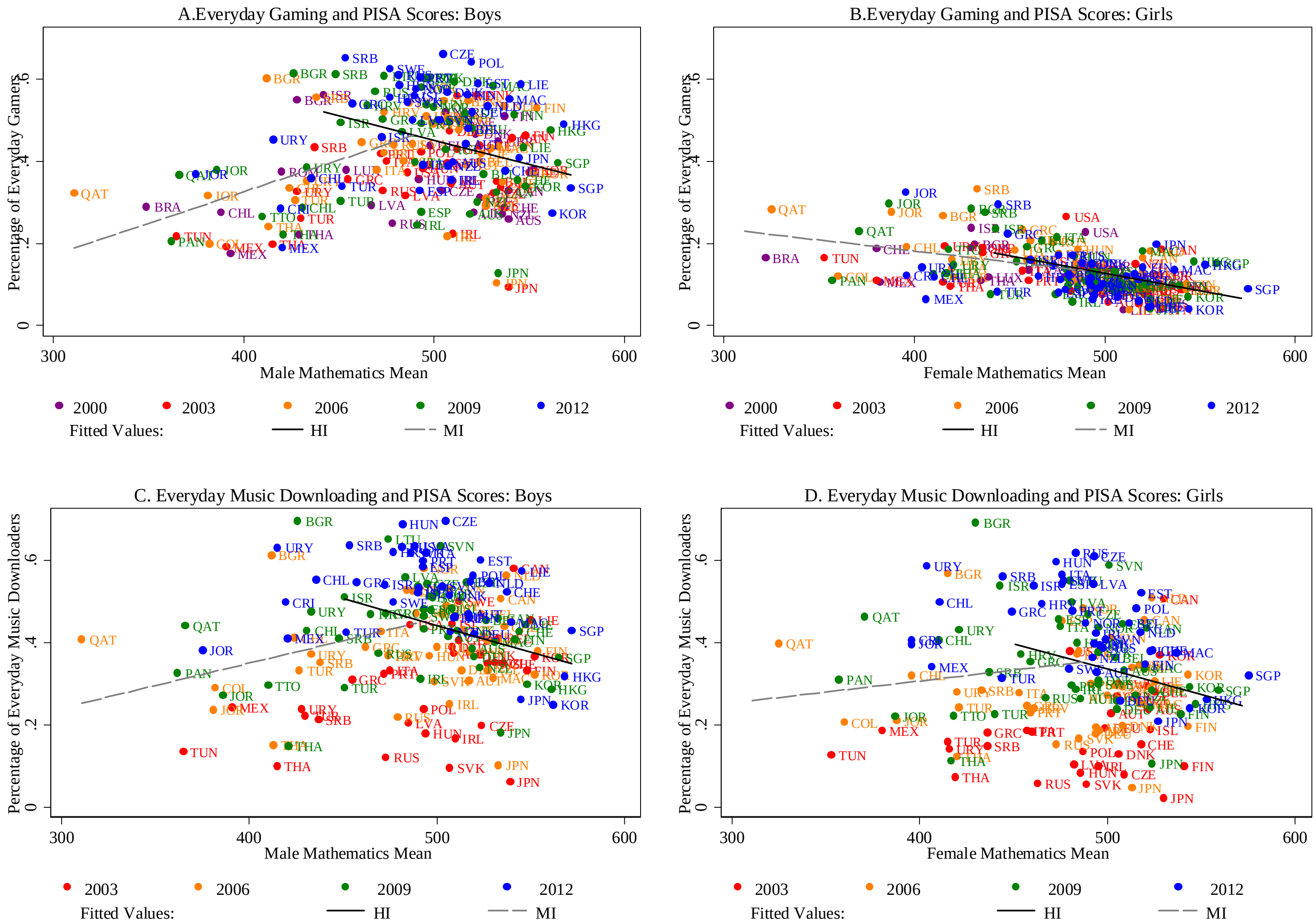
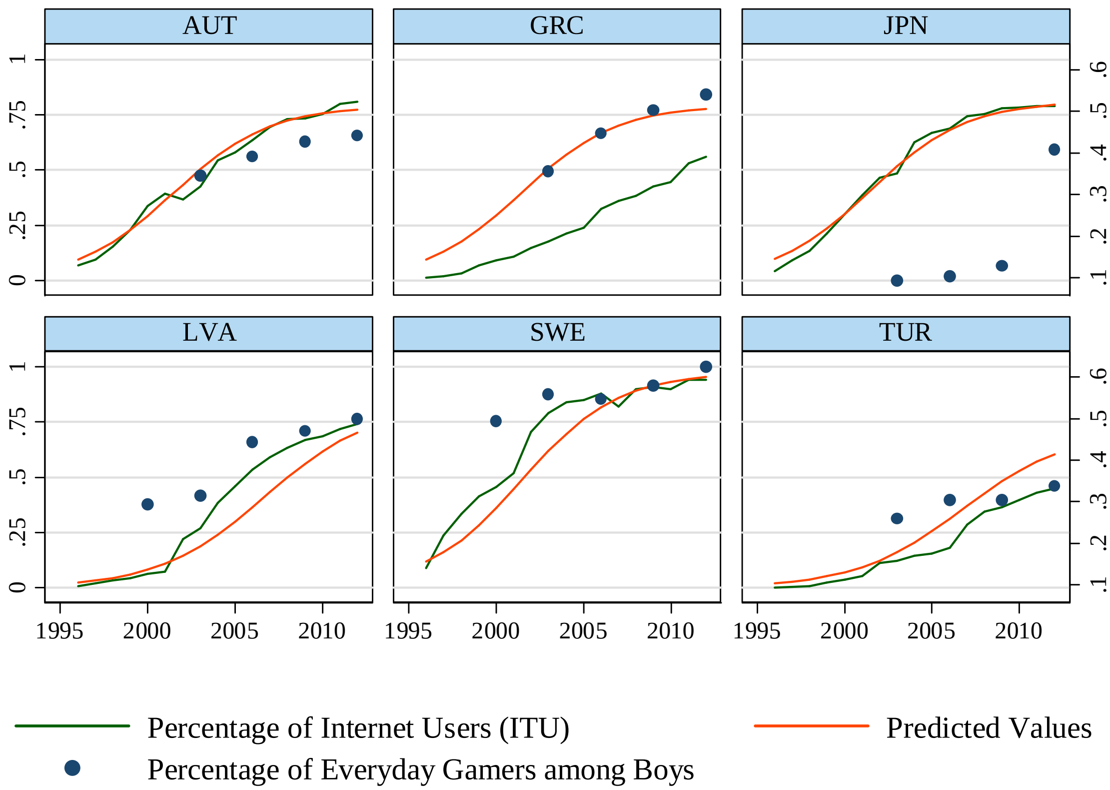


Figure 5. Percentage of Internet Users (Actual and Predicted) and Percentage of Everyday Gamers among Boys – Selected Countries



Appendix A - Variables Definitions and Complementary Results

Table A1. Countries Participating in the ICT Survey

Country	Code	High Income	PISA ICT Participation				
			2000	2003	2006	2009	2012
Australia	AUS	Yes	Yes	Yes	Yes	Yes	Yes
Austria	AUT	Yes	No	Yes	Yes	Yes	Yes
Belgium	BEL	Yes	Yes	Yes	Yes	Yes	Yes
Brazil	BRA	No	Yes	No	No	No	No
Bulgaria	BGR	No	Yes	No	Yes	Yes	No
Canada	CAN	Yes	Yes	Yes	Yes	Yes	No
Chile	CHL	No	Yes	No	Yes	Yes	Yes
China	CHN	No	No	No	No	No	Yes
Colombia	COL	No	No	No	Yes	No	No
Costa Rica	CRI	No	No	No	No	No	Yes
Croatia	HRV	Yes	No	No	Yes	Yes	Yes
Czech Republic	CZE	Yes	Yes	Yes	Yes	Yes	Yes
Denmark	DNK	Yes	Yes	Yes	Yes	Yes	Yes
Estonia	EST	Yes	No	No	No	Yes	Yes
Finland	FIN	Yes	Yes	Yes	Yes	Yes	Yes
Germany	DEU	Yes	Yes	Yes	Yes	Yes	Yes
Greece	GRC	Yes	No	Yes	Yes	Yes	Yes
Hong Kong	HKG	Yes	No	No	No	Yes	Yes
Hungary	HUN	Yes	Yes	Yes	Yes	Yes	Yes
Iceland	ISL	Yes	No	Yes	Yes	Yes	Yes
Ireland	IRL	Yes	Yes	Yes	Yes	Yes	Yes
Israel	ISR	Yes	Yes	No	No	Yes	Yes
Italy	ITA	Yes	No	Yes	Yes	Yes	Yes
Japan	JPN	Yes	No	Yes	Yes	Yes	Yes
Jordan	JOR	No	No	No	Yes	Yes	Yes
Latvia	LVA	No	Yes	Yes	Yes	Yes	Yes
Liechtenstein	LIE	Yes	Yes	Yes	Yes	Yes	Yes
Lithuania	LTU	No	No	No	Yes	Yes	No
Luxembourg	LUX	Yes	Yes	No	No	No	No
Macao, China	MAC	Yes	No	No	Yes	Yes	Yes
Mexico	MEX	No	Yes	Yes	No	No	Yes
Montenegro	MNE	Yes	No	Yes	No	No	No
Netherlands	NLD	Yes	No	No	Yes	No	Yes

Note: The High Income/Middle Income Classification is from the United Nations (2012). The Gulf States are not classified as High Income countries because higher incomes may not extend to entire population surveyed.

Appendix Table A1. Countries Participating in the ICT Survey (ctd.)

Country	Code	High Income	PISA ICT Participation				
			2000	2003	2006	2009	2012
New Zealand	NZL	Yes	Yes	Yes	Yes	Yes	Yes
Norway	NOR	Yes	Yes	No	Yes	Yes	Yes
Panama	PAN	No	No	No	No	Yes	No
Poland	POL	Yes	No	Yes	Yes	Yes	Yes
Portugal	PRT	Yes	No	Yes	Yes	Yes	Yes
Qatar	QAT	No	No	No	Yes	Yes	No
Romania	ROM	No	Yes	No	No	No	No
Russia	RUS	No	Yes	Yes	Yes	Yes	Yes
Serbia	SRB	No	No	Yes	Yes	Yes	Yes
Singapore	SGP	Yes	No	No	No	Yes	Yes
Slovakia	SVK	Yes	No	Yes	Yes	Yes	Yes
Slovenia	SVN	Yes	No	No	Yes	Yes	Yes
South Korea	KOR	Yes	No	Yes	Yes	Yes	Yes
Spain	ESP	Yes	No	No	Yes	Yes	Yes
Sweden	SWE	Yes	Yes	Yes	Yes	Yes	Yes
Switzerland	CHE	Yes	Yes	Yes	Yes	Yes	Yes
Taiwan	TWN	Yes	No	No	No	No	Yes
Thailand	THA	No	Yes	Yes	Yes	Yes	No
Trinidad and Tobago	TTO	No	No	No	No	Yes	No
Tunisia	TUN	No	No	Yes	No	No	No
Turkey	TUR	No	No	Yes	Yes	Yes	Yes
United Kingdom	GBR	Yes	Yes	Yes	No	No	No
United States	USA	Yes	Yes	Yes	No	No	No
Uruguay	URY	No	No	Yes	Yes	Yes	Yes

Note: The High Income/Middle Income Classification is from the United Nations (2012).The Gulf States are not classified as High Income countries because higher incomes may not extend to entire population surveyed.

Table A2. School Climate Factors

A. Factors Hindering Learning : In your school, to what extent is the learning of students hindered by the following phenomenon? Answers coded 1 to 4 : Not at all, Very little, To some extent, A lot	
Teachers Behavior	*Students' Behavior*
a) Teachers' low expectations of students	b) Student absenteeism
c) Poor student-teacher relations	d) Disruption of classes by students
e) Teachers not meeting individual students' needs	g) Students skipping classes
f) Teacher absenteeism	h) Students lacking respect for teachers
i) Staff resisting change	j) Student use of alcohol or illegal drugs
k) Teachers being too strict with students	l) Students intimidating or bullying other students
m) Students not being encouraged to achieve their full potential	
B. Sense of Belonging: My school is a place where? Answers originally coded 1 to 4: Strongly agree, Agree, Disagree, Strongly disagree are recoded: 0 (Disagree, Strongly Disagree) and 1 (Strongly agree, Agree)	
a) I feel like an outsider	b) I make friends easily
c) I feel like I belong	d) I feel awkward and out of place
e) Other students seem to like me	f) I feel lonely
g) I feel happy at school	h) Things are ideal at school
i) I am satisfied at school	

Note: Summary measures of the teachers' behavior and of students' behavior, and of students' sense of belonging are constructed using the Cronbach's alpha coefficient of internal consistency (popular in psychology). All factors have a scale reliability coefficient over 0.80. In B. Sense of Belonging, all questions were asked in 2012, a subset in 2000 and 2003. Therefore, our index omits g), h, and i).

Table A3. Effects of School Variables on Everyday Computer Gaming
PISA 2003 and 2012

Dependent Variable: Everyday Gaming	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	HI Countries				MI Countries			
Explanatory Variables	Boys: 0.375		Girls: 0.112		Boys: 0.368		Girls: 0.127	
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Everyday Music	0.273***	0.270***	0.106***	0.105***	0.307***	0.307***	0.134***	0.131***
Downloading	(0.015)	(0.016)	(0.010)	(0.010)	(0.031)	(0.031)	(0.017)	(0.016)
Home Link	0.042***	0.041***	-0.015	-0.014	0.006	0.006	-0.048**	-0.046**
to Internet	(0.008)	(0.008)	(0.017)	(0.017)	(0.036)	(0.036)	(0.018)	(0.018)
Home	0.108**	0.107**	0.038	0.036	0.219**	0.213**	0.170**	0.166**
Computer	(0.043)	(0.043)	(0.027)	(0.028)	(0.085)	(0.082)	(0.068)	(0.067)
Sense of Belonging[a]	-0.086***	-0.048***	-0.067***	-0.019**	-0.016	-0.033***	-0.026**	-0.015
	(0.020)	(0.013)	(0.014)	(0.008)	(0.023)	(0.009)	(0.008)	(0.014)
Feeling awkward		0.005		0.024***		0.001		0.031***
		(0.008)		(0.006)		(0.009)		(0.002)
School Computers	-0.046***	-0.046***	-0.012	-0.012	-0.043***	-0.045***	-0.009	-0.011
with Web Access	(0.012)	(0.012)	(0.011)	(0.011)	(0.012)	(0.012)	(0.007)	(0.007)
Student-Teacher	-0.002	-0.002	-0.003***	-0.003***	-0.001	-0.001**	-0.000*	-0.000
Ratio	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Hindrance to Learning:								
Teacher Factors	-0.037***	-0.033***	0.018	0.020	-0.028**	-0.026**	-0.005	-0.001
	(0.011)	(0.011)	(0.016)	(0.017)	(0.009)	(0.009)	(0.011)	(0.011)
Student Factors	0.054***	0.050***	-0.005	-0.007	0.032***	0.031***	0.020**	0.017*
	(0.015)	(0.014)	(0.016)	(0.016)	(0.009)	(0.009)	(0.007)	(0.008)
Observations	94,786	92,764	93,287	91,698	20,948	20,482	22,811	22,414
R-squared	0.132	0.132	0.036	0.035	0.231	0.232	0.083	0.083

Note: All regressions include time fixed effects. Other included variables are: age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade, ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[a] In even columns, sense of belonging index is replaced by single " belong" variable. "Feel awkard" is reversed in the index.

Table A4a. School- Year Fixed Effects Estimates of Everyday Computer Gaming on Boys' Reading Scores
PISA 2009 and 2012

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Boys' Reading Score	HI Countries: 475.88				MI Countries: 438.59			
Explanatory Variables	OLS	OLS	OLS	Within School	OLS	OLS	OLS	Within School
Everyday SPG	-6.310***	-6.230***	-6.204***	1.090	1.880	1.926	1.997*	3.275***
	(1.960)	(1.955)	(1.946)	(1.353)	(1.180)	(1.184)	(1.193)	(1.088)
Everyday MMO	-14.34***	-14.35***	-14.49***	-9.944***	-0.900	-0.535	-0.581	-0.604
	(2.371)	(2.271)	(2.267)	(1.785)	(1.815)	(1.844)	(1.834)	(1.481)
Everyday Music	-1.364	-1.261	-1.221	-0.570	-2.735**	-3.012**	-2.877**	-0.399
Downloading	(1.179)	(1.189)	(1.191)	(0.863)	(1.303)	(1.261)	(1.252)	(1.084)
Home Link	10.19***	10.29***	10.17***	1.626	3.617*	3.794**	3.643*	-1.504
to Internet	(1.752)	(1.757)	(1.763)	(1.374)	(1.862)	(1.873)	(1.871)	(1.393)
Home	10.40***	10.37***	10.51***	7.773***	11.24***	11.17***	11.32***	8.463***
Computer	(1.729)	(1.736)	(1.731)	(1.322)	(1.989)	(2.034)	(2.030)	(1.337)
Everyday	6.185***	5.814***	5.709***	3.886***	-4.411**	-4.536**	-4.681***	-3.401**
Homework	(1.540)	(1.538)	(1.555)	(1.308)	(1.856)	(1.827)	(1.816)	(1.398)
School Computers	-2.667	-3.721	-3.499		71.43***	68.93***	68.56***	
with Web Access	(7.673)	(7.779)	(7.762)		(7.943)	(7.856)	(7.888)	
Student-Teacher	9.220	9.499*	8.700		10.72**	11.19**	10.14**	
Ratio	(5.742)	(5.763)	(5.766)		(4.529)	(4.398)	(4.403)	
Hindrance to Learning		8.292**						
Teacher Factors		(3.891)				6.586		
		-9.893**				(4.048)		
Student Factors		(3.909)				-9.903***		
			-2.903*			(3.635)		
Student Skipping			(1.529)				-4.590***	
Classes			(1.269)				(1.310)	
School Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	No
No. of Schools				15,606				4,995
Observations	168,388	166,994	166,994	205,531	43411	43113	43113	63005
R-squared	0.286	0.311	0.305	0.601	0.312	0.314	0.314	0.576

Note: All regressions include age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade. Where included the school controls are the ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

Table A4b. School-Fixed Effects Estimates of Everyday Computer Gaming on Girls' Reading Scores
PISA 2009 and 2012

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Girls' Reading Score	HI Countries: 532.75				MI Countries: 475.88			
Explanatory Variables	OLS	OLS	OLS	Within School	OLS	OLS	OLS	Within School
Everyday SPG	3.319**	3.377***	3.347***	4.738***	2.007*	2.200**	2.243**	1.763**
	(1.316)	(1.265)	(1.288)	(0.975)	(1.166)	(1.088)	(1.138)	(0.719)
Everyday MMO	-14.90***	-14.52***	-14.53***	-7.638***	0.217	0.801	0.577	3.653***
	(1.873)	(1.800)	(1.820)	(1.261)	(0.926)	(0.907)	(0.937)	(0.643)
Everyday Music	-20.07***	-18.77***	-18.75***	-10.69***	-16.98***	-15.73***	-15.64***	-9.340***
Downloading	(0.758)	(0.753)	(0.758)	(0.571)	(0.777)	(0.770)	(0.785)	(0.563)
Home Link	18.50***	17.43***	17.57***	6.721***	16.87***	16.00***	15.79***	3.673***
to Internet	(1.897)	(1.773)	(1.805)	(1.284)	(2.187)	(2.200)	(2.188)	(1.375)
Home	9.265***	9.624***	9.882***	5.500***	14.86***	15.99***	15.85***	12.03***
Computer	(1.784)	(1.753)	(1.791)	(1.523)	(2.350)	(2.363)	(2.340)	(1.633)
Everyday	6.810***	9.124***	7.863***	1.617	1.715	3.347*	2.564	-1.403
Homework	(1.428)	(1.505)	(1.492)	(1.058)	(1.841)	(1.745)	(1.836)	(1.081)
International	22.38***	21.96***	21.98***	36.11***	27.11***	26.40***	26.53***	39.09***
Grade	(0.808)	(0.824)	(0.806)	(0.596)	(0.717)	(0.749)	(0.732)	(0.584)
School Computers	7.214	-1.368	0.628		19.75***	16.92***	21.17***	
with Web Access	(5.459)	(5.478)	(5.373)		(6.010)	(5.829)	(5.821)	
Percentage of Girls	0.935***	0.824***	0.634***		1.152***	0.972***	0.785***	
in the School	(0.220)	(0.201)	(0.202)		(0.245)	(0.216)	(0.235)	
Student-Teacher	7.513***	6.115***	5.434***		6.842***	4.954**	3.788	
Ratio	(1.841)	(1.816)	(1.857)		(2.432)	(2.338)	(2.397)	
Hindrance to Learning:								
Teacher Factors		9.675***				11.12***		
		(2.440)				(3.131)		
		-30.26***				-37.06***		
Student Factors		(2.465)				(2.955)		
			-12.46***				-16.13***	
Student Skipping			(0.999)				(1.129)	
Classes			(1.269)		-60.33**	8.663	12.28	-0.232
School Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	No
No. of Schools				15,606				4,995
Observations	168,388	166,994	166,994	205,531	43,411	43,113	43,113	63,005
R-squared	0.286	0.311	0.305	0.601	0.320	0.321	0.321	0.614

Note: All regressions include age, immigrant status, 2nd generation immigrant status, father and mother education (3 dummies) and occupation (4 categories), mother homemaker, books in the home (5 categories), international grade. Where included the school controls are the ratio of computers to school size, percentage of girls in the school, of certified teachers and of qualified teachers, school's community location (6 categories), dummies of instructional material and computers not lacking and strongly lacking. Standard errors clustered at the country-level in parentheses. They are computed using the Fay variant of the Balanced Repeated Replication with a Fay coefficient equal to 0.5 and 80 replicates as implemented in the Stata "pv" command. *** p<0.01, ** p<0.05, * p<0.1

Appendix Figure A1. Density of PISA 2012 Mathematics Test Score by Gender and HI/MI Countries

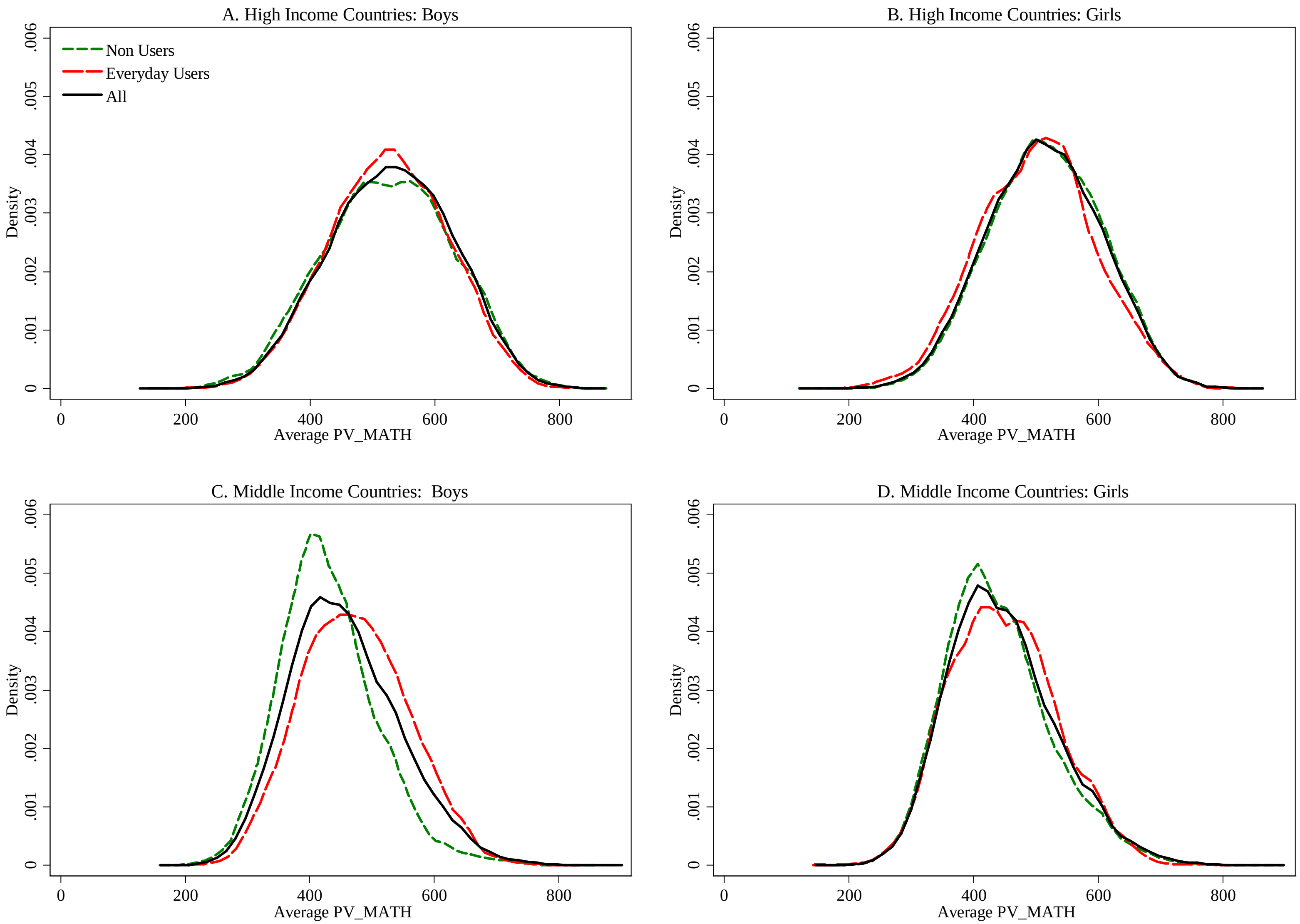
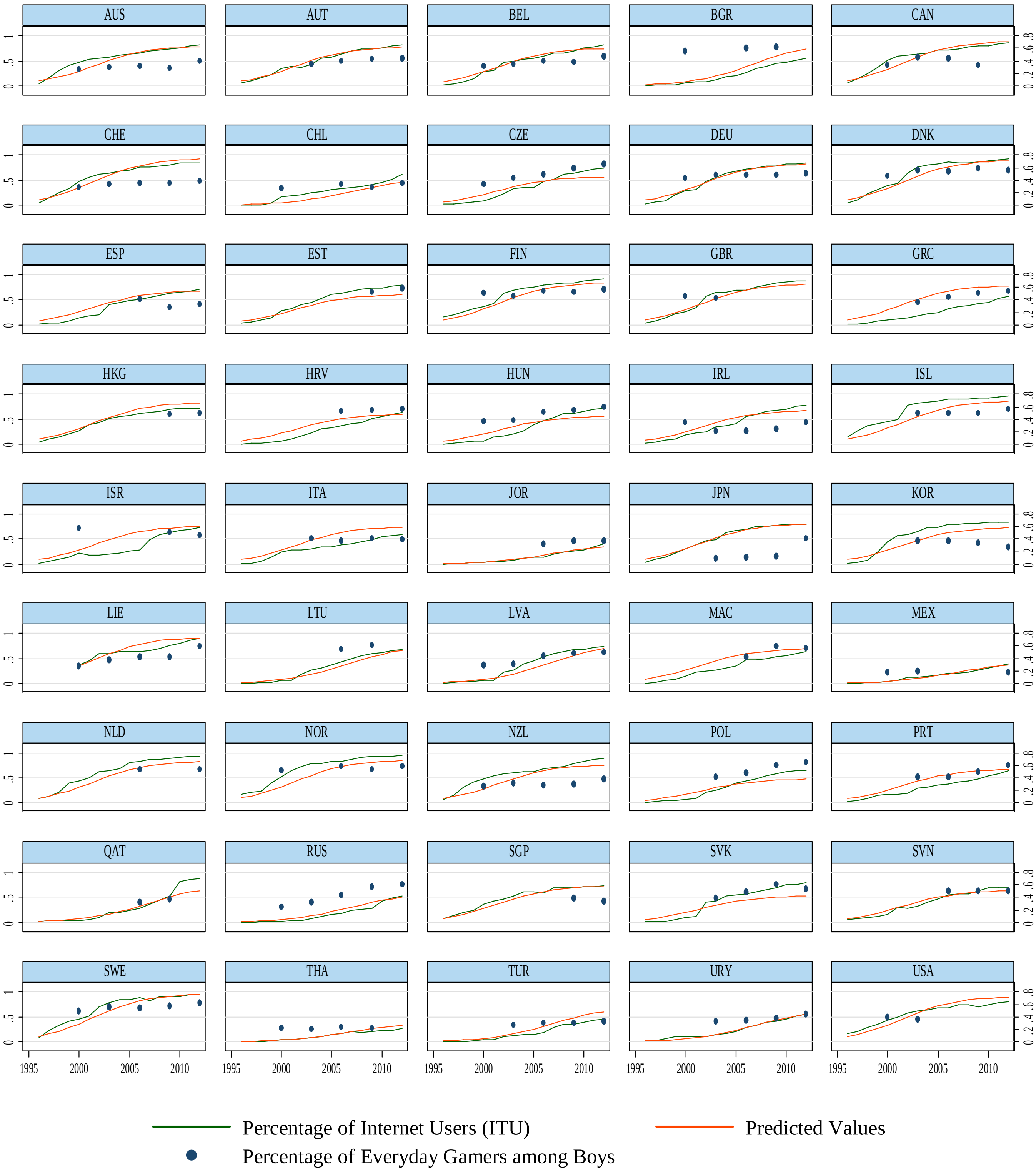


Figure A2. Percentage of Internet Users (Actual and Predicted) and Percentage of Everyday Gamers among Boys



Appendix B. Descriptive Statistics

Table B1. Means of Individual Variables by Country-Income Group, Gender and Gaming - PISA 2000-12

	High Income					Middle Income				
	Boys		Girls			Boys		Girls		
Individual Variables	Everyday Gamers 0.389	Others	Everyday Gamers 0.124	Others		Everyday Gamers 0.359	Others	Everyday Gamers 0.145	Others	
Home Link to Internet	0.877***	0.812	0.837	0.823	†††	0.625***	0.342	0.563**	0.388	
Home Computer	0.938*	0.834	0.927**	0.876	†††	0.834***	0.471	0.827***	0.525	
Age	15.76**	15.78	15.76*	15.77		15.79	15.78	15.77	15.78	
First Generation Immigrant	0.043	0.045	0.042	0.044		0.048***	0.028	0.028*	0.021	
Second Generation Immigrant	0.041	0.041	0.038	0.042		0.031**	0.021	0.033***	0.021	
Father Secondary Education	0.533**	0.496	0.534	0.523		0.483*	0.393	0.502*	0.414	
Father Tierciary Education	0.249**	0.298	0.212**	0.267	†††	0.269***	0.183	0.227*	0.189	†
Father White Collar High Skill	0.361	0.379	0.327**	0.376	†††	0.305***	0.234	0.292	0.245	
Father White Collar Low Skill	0.114	0.128	0.112	0.128		0.099	0.102	0.102	0.102	
Father Blue Collar High Skill	0.236*	0.220	0.243	0.229		0.209*	0.257	0.210	0.246	
Mothe Secondary Education	0.582	0.572	0.596	0.605		0.465*	0.370	0.514*	0.406	†
Mother Tierciary Education	0.225*	0.248	0.197	0.220	†	0.303***	0.193	0.259***	0.193	
Mother Homemaker	0.209*	0.231	0.216	0.214		0.298*	0.377	0.271	0.345	
Mother White Collar High Skill	0.340	0.334	0.326	0.352		0.364***	0.241	0.351**	0.273	
Mother White Collar Low Skill	0.300	0.305	0.320	0.319		0.199*	0.170	0.218	0.187	
Mother Blue Collar High Skill	0.053	0.049	0.046	0.052		0.060	0.094	0.072	0.098	
Home Books 11-15	0.153	0.142	0.159	0.140		0.204**	0.254	0.186**	0.245	
26-100	0.321	0.299	0.309*	0.313		0.307***	0.263	0.322*	0.284	
101-200	0.186	0.195	0.197	0.208	†	0.168**	0.118	0.174	0.140	
201+	0.232*	0.264	0.234	0.258		0.186***	0.125	0.193**	0.152	
Log GDP per capita	10.25	10.31	10.29	10.29		8.878	8.723	8.725	8.760	
Youth Male Unemployment	16.86	15.79	16.71	16.25		15.87	14.31	14.94	14.14	
Youth Female Unemployment	16.73	15.16	16.88	15.78		17.66	16.29	17.30	15.98	
Female Labor Force Participation	64.33	63.53	63.95	63.98		57.63	53.69	58.71	55.80	

Note: Statistical significance of differences in means across everyday gamers and others indicated as *** p<0.01, ** p<0.05, * p<0.1. Statistical significance of differences in means across boy everyday gamers and girl everyday gamers indicated as ††† p<0.01, †† p<0.05, † p<0.1.

Table B2. Means of School Variables by Country-Income Group, Gender and Gaming - PISA 2003-12

	High Income						Middle Income					
	Boys			Girls			Boys			Girls		
School Variables	Everyday Gamers		Others	Everyday Gamers		Others	Everyday Gamers		Others	Everyday Gamers		Others
Download Music Every Day[a]	0.585	***	0.271	0.551	***	0.279	0.635	***	0.245	0.586	***	0.286
International Grade	9.548	***	9.688	9.664	*	9.687	9.425	**	9.532	9.479	*	9.584
School's Community Location												
Small Town (3K – 15K)	0.184	***	0.155	0.188	*	0.163	0.120	**	0.169	0.153		0.159
Town (15K – 100K)	0.335	**	0.305	0.331		0.325	0.261		0.249	0.236		0.248
City (100K 1 million)	0.257	**	0.292	0.264		0.285	0.300	**	0.249	0.289		0.262
Large City (> 1 million)	0.149	***	0.178	0.135	**	0.158	0.225	***	0.187	0.222		0.201
Percentage of School Computers with Web Access	0.921	***	0.907	0.920		0.915	0.685	***	0.607	0.645		0.658
Computer Strongly Lacking	0.065		0.062	0.062		0.062	0.205	**	0.264	0.233		0.244
Computer Not at all Lacking	0.358		0.357	0.364		0.348	0.177		0.159	0.198		0.175
Instruction Material Strongly Lacking	0.027		0.031	0.026		0.028	0.097	**	0.150	0.120		0.125
Instruction Material Not at all Lacking	0.493		0.504	0.483		0.499	0.307	***	0.229	0.292		0.266
Computer-Student Ratio	0.474	***	0.426	0.424		0.421	0.331	***	0.229	0.267		0.261
Student-Teacher Ratio	13.28	***	13.72	13.14	**	13.59	18.24	***	18.44	20.23	**	19.61
Percentage of Girls in the School	0.427	***	0.407	0.540	**	0.564	0.447		0.537	0.532		0.544
Percentage of Certified Teachers	0.945	***	0.951	0.946		0.951	0.848	***	0.742	0.832	***	0.757
Percentage of Qualified Teachers	0.859	***	0.832	0.888	***	0.866	0.869		0.823	0.841		0.872
Hindrance to Learning:[b]												
Teacher Factors	1.925	**	1.948	1.955	**	1.922	2.105		2.127	2.111		2.086
Student Factors	2.031	*	2.012	2.065	***	1.981	2.225		2.204	2.203		2.148
Student Skipping Class	2.153	***	2.083	2.177	***	2.062	2.766	***	2.610	2.662		2.568
Sense of Belonging[c]	0.425	*	0.418	0.405	**	0.434	0.430		0.426	0.436		0.453
'Feel like I belong' dummy	0.794	**	0.820	0.795	**	0.833	0.837	**	0.877	0.874		0.902

Note: Statistical significance of differences in means across everyday gamers and others indicated as *** p<0.01, ** p<0.05, * p<0.1.

[a] Not available in 2000 [b] Not available in 2006 [c] Available only in 2003 and 2012