Gender and Information and Communication Technologies interest: results from PISA 2018

Mariangela Zenga

1. Introduction

The information and communications technology (ICT) is a growing presence in the modern society, so knowledge and skills related to ICT should become an integral part of education. Moreover the development of digital literacy also takes place firstly at school but also in the informal learning at home, among peers and in other out-of-school contexts (Fraillon et al. (2014); Juhanak et al. (2019); Erstad (2012)). The literature on gender and ICT is a thriving topic in the last years. Previous research pointed out that the differences in gender are much more pronounced for ICT usage at home, instead of at school (BECTA (2008)): boys use more often ICT outside of school for leisure purposes (as for playing computer or console games) than girls. On the contrary, girls have a greater use of ICT for school work and online social networking. Considering attitudes, confidence and self-efficacy girls show lower level on ICT in comparison to boys.

In 2015, a new construct, *ICT Engagement*, was introduced by Zylka et al. (2015). ICT Engagement is theoretically based on self-determination theory (Deci and Ryan (2000)) and it is assumed to be "a crucial individual factor for developing and adapting ICT skills in a self-regulated way" that "facilitates learning and acquiring new knowledge and skills through the life span by using ICT in both formal and informal learning environments" (Goldhammer et al. (2017)). The ICT Engagement involves ICT interest, Perceived ICT competence, Perceived autonomy related to ICT use, and ICT as a topic in social interaction (Goldhammer et al. (2017)). In this work we are interested in the ICT interest (ICTI) that represents a "content-specific motivational disposition" and describes "individuals' long-term preference for dealing with topics, tasks, or activities related to ICT" (Goldhammer et al. (2017)). Six items are included in the construct using a four-point Likert response scale ranging from 1 to 4 (where: 1=Strongly disagree, 2= Disagree, 3=Agree, 4=Strongly Agree):

- I forget about time when I'm using digital devices;
- The Internet is a great resource for obtaining information I am interested in (e.g. news, sports, dictionary);
- It is very useful to have social networks on the internet;
- I am really excited discovering new digital devices or applications;
- I really feel bad if no internet connection is possible;
- I like using digital devices.

The overall index of ICTI based on the previous six items is scaled using a generalized partial credit model (Muraki (1992)) and values of the index correspond to Warm likelihood estimates (Warm (1989)) that are standardized in a second moment. In this way, the index shows the average equal to zero and the standard deviation equal to one across OECD countries (PISA (2018)).

Using 2018 PISA data, the relationship between gender and ICTI for 15-year-olds in OECD countries will be analyzed. Moreover a three-level multilevel model will show the effects on

Mariangela Zenga, University of Milano-Bicocca, Italy, mariangela.zenga@unimib.it, 0000-0002-8112-5627

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the ICTI of the characteristics of the respondent, of the school in which the student is and of the country in which the student's living.

2. Data

The OECD Programme for International Student Assessment (PISA) is a triennal international survey and it aims to assess the performance in mathematics, reading, science and financial literacies. It provides the most comprehensive and rigorous international assessment of 15-aged students learning outcomes to date. In several countries the questionnaire has questions on students' familiarity with ICTs and engagement in ICT. The assessments are also supplemented by background questionnaires. Pupils are asked about their motivations for study, attitudes to school, views on reading, and their socio-economic background. Another questionnaire asked headteachers about the challenges facing their schools, organisation and factors that they believe affect their students' performance.

In this paper we analyze 109,106 15-aged students (49.1% of female) of 8,115 schools who were sampled for PISA 2018 in the 23 OECD countries. Approximately 38% of students started to use a digital device when they were 6 years old or younger, 37% when they were 7-9 years old and 25% when they were 10 years old or older.

3. Statistical method

The multilevel models are used in literature when the aim of analysis is to investigate the relationships between outcomes and variables when data presents naturally a hierarchical structure (Goldstein (2011); Hox et al. (2017) and Rice and Leyland (1996)). In this work, a model with three levels is proposed: students within school belonging to a OECD country. In particular, the multilevel models will control for the presence of a possible effect of school, which may render students within the same school more alike in terms of experienced outcome than students coming from different schools, everything else held equal. Moreover, it is possible to consider also the influence of country. As aforementioned, the proposed model includes three levels: students i as level-1 unit ($i = 1, ..., n_j$), school j as level-2 unit ($j = 1, ..., J$) and country k as level-3 unit ($k = 1, ..., K$). The aim of the analysis is the identification of some relationships between ICTI and some characteristics related to the students, schools and countries. Let Y_{ijk} be the score of the ICTI, for student i within school j belonging to country k. Following Hox et al. (2017), let $X^{(1)} = \{X_{ijk}\}$ be the matrix for the explanatory variables at the level-1, $X^{(2)} = \{X_{jk}\}$ the matrix for the explanatory variables at the level-2 and $X^{(3)} = \{X_k\}$ the matrix for the explanatory variables at the level-3. The level-1 model states a linear relationship between the observed response and the level-1 covariates:

$$Y_{ijk} = \alpha_{0jk} + X^{(1)}\alpha_{1jk} + \epsilon_{ijk}. \tag{1}$$

At the level-2, the intercept of the level-1 model (eq. 1) can be written as:

$$\alpha_{0jk} = \beta_{00k} + X^{(2)}\beta_{1k} + u_{0jk}. \tag{2}$$

Finally, the level-2 intercept in equation 2 can be modeled as:

$$\beta_{00k} = \lambda_{00} + X^{(3)}\lambda_1 + \gamma_{0k}. \tag{3}$$

Combining equation 3 and equation 2 in equation 1, it yields the following:

$$Y_{ijk} = \lambda_{00} + X^{(1)}\alpha_{1jk} + X^{(2)}\beta_{1k} + X^{(3)}\lambda_1 + u_{0jk} + \gamma_{0k} + \epsilon_{ijk}. \tag{4}$$

In eq. 4, the fixed effects are given by the the overall intercept (λ_{00}), the student level, school level and country level covariates, the random effects are given by the school level and the country level ($u_{0jk} + \gamma_{0k}$), and the residuals are represented by ϵ_{ijk} . Respect to the meaning of the levels, u_{0jk} is the unobserved school random effect of the intercept amongst schools, with $u_{0jk} \sim N(0, \sigma_u^2)$; γ_{0k} is the random variation of the intercept amongst countries, with $\gamma_{0k} \sim N(0, \sigma_\gamma^2)$; moreover $\epsilon_{ijk} \sim N(0, \sigma_\epsilon^2)$. Random components at different levels are assumed uncorrelated, whilst non null correlations are assumed for students in the same school or in the same country. The random effect among schools can be interpreted as the mean score in ICTI of schools with respect to outcome adjusted for fixed coefficients related to student, school and country characteristics. The u_{0jk} estimates show the contribution of the j-th school to mean score in ITCI. Using the model in eq. 4, the intraclass correlation (ICC) is defined as:

$$\begin{cases} ICC_{Level-2} = \dfrac{\sigma_u^2}{\sigma_u^2 + \sigma_\gamma^2 + \sigma_\epsilon^2} \\ ICC_{Level-3} = \dfrac{\sigma_\gamma^2}{\sigma_u^2 + \sigma_\gamma^2 + \sigma_\epsilon^2} \\ \qquad\qquad\qquad\qquad\qquad . \end{cases} \tag{5}$$

In general, the ICC indicates the proportion of the variance explained by the grouping structure in the population. In particular, ICC in eq. 5 identifies the proportion of variance at the school level ($ICC_{Level-2}$) and at the country level ($ICC_{Level-3}$).

4. Results

First of all, we analyze the difference in gender for the ICTI. In 2018, the ICTI mean for the female is equal to -0.10, while it is equal to 0.10 for male group and the *F* test for Gender $F = 11.47, p = 0.0007$ suggests that there are differences in ICTI between male and female. Considering the interaction of gender and country on the ICTI, the *F* test ($F = 90.29, p < 0.0001$) suggests significant effects. The Fig.1 reports the countries difference in means for gender for the ICTI as

$$\Delta(ICTI) = ICTI_{Female} - ICTI_{Male} \tag{6}$$

If $ICTI < 0$ then Female group shows lower value in mean for ICTI respect to the male group, while if $ICTI > 0$ then female group shows greater value in mean for ICTI respect to the male group. If $ICTI = 0$ female group has the same level of interest in ICT than the male group. Czech Republic students show the lowest difference in means for ICTI (-0.27), followed by Luxembourg students (-0.23) and Belgian students (-0.25), while Greek students have the highest difference in means for ICTI (0.23), followed by Korean students (0.17) and Irish students (0.15).

As the second aim, we consider a three-level multilevel model considering the effect on several explanatory variables on ICTI. The explanatory variables are: GENDER, AGE (Age when the respondent first used a digital device), ESCS (index of family economic, social and cultural status), WEALTH (family wealth possession), ICTHOME (availability of ICT devices in student's home), ICTSH (availability of ICT devices in student's school) and USESH (ICT use at school). Table 1 reports the results for the models. The test on the random effects shows that a three levels model is required underlining that the ICTI depends both on the shool effect and on the country effect. As shown in Model 0, the ICC values for the three levels model indicate that approximately 19% of the variability in the ICTI is accounted by the school and 3% by the country.

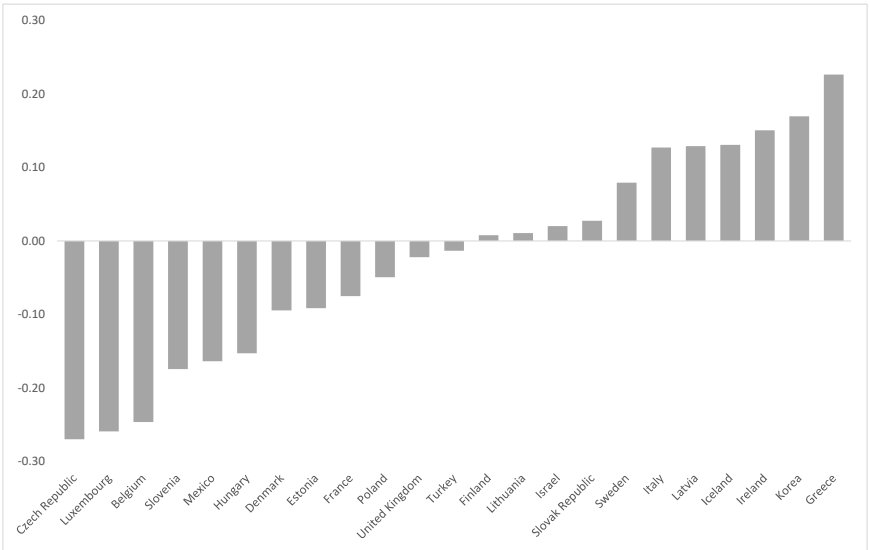

Figure 1: The difference in Gender in ICTI for OECD countries.

The results of the complete model (Model 1) show that the ICTI level of female respondents is higher than the level of male respondents. The age at which children start using a digital device has a significant relationship with the level of the ICTI. In particular, the sooner children approach a digital device, the higher their interest in ICT will be. The availability of ICT devices in student's home a significant positive relationship with ICTI, on the contary the availability of ICT devices in student's school have a negative impact. The family wealth possession results to have a positive impact on ICTI. Moreover as the use of ICT at school increases, the level of ICTI increases too.

5. Conclusion

The ICT interest is an individual preferring (long-term) participation in activities related to ICT and its use (Goldhammer et al. (2017)). For this reason it is important to investigate the relationship among the level of ICT interest of 15-years old students and variables in a family environment considering the influences of the school by a multilevel model. We verified that the gender difference exists, but it depends also by the country in which the students live. The results also seem to underline that the ICT interest depends in large scale on the school effect more than a country effect. Other factors were considered: gender, age at which children start using a digital device, availability of ICT devices in student's home, family wealth possession and use of ICT at school increases, the level of ICTI represent interesting explanatory variables for the model. No evidences seem to be related to the economic, social and cultural status of the student's family.

Table 1: Results of the three-level multilevel models. Source: calculations on 2018 PISA data. In table "rc" means "reference category"

	Model 0			**Model 1**		
Variable	**Est.**	**SE**	***p-value***	**Est.**	**SE**	***p-value***
Fixed Effects						
Constant	-0.041	0.040	0.298	0.0106	0.042	0.800
Gender (rc: Male)						
Female				0.014	0.006	0.023
Age (rc : 7-9 y. old)						
3 years old or younger				0.274	0.012	$< .0001$
4-6 years old				0.140	0.007	$< .0001$
10-12 years old				-0.079	0.008	$< .0001$
13 years old or older				-0.275	0.014	$< .0001$
ESCS				0.004	0.004	0.382
ICTHOME				0.006	0.005	0.001
ICTSCH				-0.018	0.001	$< .0001$
WEALTH				0.065	0.005	$< .0001$
USESCH				0.175	0.003	$< .0001$
Random Effects						
$\sigma^2_{Country}$	0.034	0.011	0.001	0.033	0.010	0.001
σ^2_{School}	0.233	0.006	$< .0001$	0.222	0.005	$< .0001$
$ICC_{Country}$	0.029			0.034		
ICC_{School}	0.192			0.193		
Log likelihood	-173,800.70			-171,061.30		
AIC	347,607.4			342,122.6		
N	109,106			109,106		
Country	23			23		

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