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Gender differences in mathematics outcomes at different levels of locality to inform policy and practice

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Abstract

This paper reports research into the relationship between personal and contextual variables and gendered differences in students' attainment in mathematics that take account of 'place' at different levels of intra-national locality (i.e. regional and macro-geographical levels, within the same country). A multilevel analysis performed on secondary data collected in Italy, where on average boys outperform girls in mathematics, showed that gender differences at local levels are complex and nuanced and not always consistent with the national picture. Moreover, gender differences in mathematics are associated with socio-cultural and economic factors that vary by region. We argue that educational research focusing on national and international level findings (such as for example PISA) should explore the association between gender differences in mathematics and sub-national socio-cultural and economic contexts in order to adequately inform policy and practice. Finally, we suggest that European researchers of inequality may need to attend to regionality and localities of place, and that the principle of subsidiarity could imply that policy and practice be devolved to the levels that research proves to be relevant.

Keywords

Gender, differences, mathematics, place, locality, region, multilevel modelling

Introduction

The investigation of gender differences in students' attainment has received increasing attention but has historically failed to explain important patterns across cultures and geographies. Recent studies based on national and international surveys have shown that, in many countries, male students achieve a significantly higher mean score than females in mathematics (EACEA, 2010; Guiso, Monte, and Sapienza, 2008; OECD, 2016, 2019) with only a few exceptions to this pattern, such as for example in Iceland (Halldórsson and Ólafsson, 2009) where girls significantly outperform boys in mathematics.

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Previous studies have already shown that gender differences in mathematics are sharper in gender unequal environments, as for example in countries characterized by larger gender gaps in economics, politics and education or by more traditional gender attitudes (OECD-PISA, 2015, 2018; Gonzalez de San Roman and De la Rica, 2016; Nollenberger et al., 2016). Gender differences in mathematics were also found to predict gaps in Higher Education in Science, Technology, Engineering and Mathematics (e.g. Bataille, Le Feuvre, and Kradolfer Morales, 2017; Loison et al., 2017).

The idea underlying these studies is that boys and girls tend to conform to the roles attributed to them by society depending on their gender, a concept used to describe how society defines and actually practices masculinity and femininity. As such, society transmits and expects certain normative behaviours and roles from boys and girls (Igbo et al., 2015; Kauffman, 1977), thus constituting a 'stereotype threat', a phenomenon in which the activation of a self-relevant stereotype leads people to show stereotype-consistent, compliant behaviour (Steele, 1997).

In this frame, schools and classrooms can be considered small-scale social locales of both society and its norms, because they are significant places where social practices associated with gender stereotypes are transmitted, reinforced by peers during the first two decades of life, just when knowledge about one's self shapes an individual's personality, self-concept and identity (Kessels, 2005). In this sense, peer groups schools and classrooms serve as important contexts for socialization of young adolescents (Legewie and DiPrete, 2012) and thus provide the main context for understanding students' identity in adolescence. A German study, for example, revealed that, at grades 8 and 9 (mean age 14.7 years), the distance between self-image and description of stereotype varied according to gender and any misalignment between the stereotypical prototype and real behaviour (i.e. gender role nonconformity) was condemned by peers: in particular, boys dislike girls who prefer physics (perceived as a male subject) to music (perceived as female subject) even when boys themselves preferred music to physics in practice; girls excelling in physics reported feeling unpopular with boys, whereas boys excelling in music did not similarly feel unpopular (Kessels, 2005). Such social threats may strike girls more significantly than boys because girls' nonconformity to the roles attributed to them by society has immediate negative effects on their social life; this suggests that gender stereotypes may have a normative component and that, especially within school, peers are powerful transmitters or reinforcers of social norms and gendered roles. In this perspective, relative female under-attainment is determined first by social perceptions of masculinity and femininity, but *relationally* by the individual in social interactions with relations mediated by stereotypical cultural models and associated identifications.

Within the classroom and school boundaries this process activates a multiplicative effect because favourite-subject preferences are affected by friends' preferences (*friend influence*) and classroom peers' preferences (*peer exposure*) (Raabe et al., 2019). Girls' and boys' gendered behaviours at school are widely documented in ethnographic studies of the key role of peers (in and outside school) in shaping attitudes toward school subjects (e.g. Bishop et al., 2003; Coleman, 1966), thus defining each classroom/school as a micro-environment within which social mechanisms are reinforced and perpetuated. It was recently shown, for example, that going to a school that supports girls' STEM [Science, Technology, Engineering, mathematics] orientations can significantly reduce the gender gap in studying scientific topics in Higher Education (Legewie and DiPrete, 2014). Nevertheless, according to the same study, despite this sizable reduction, even for students who attend schools that are supportive of girls' STEM orientations, 'gender gap, which net of individual as well as school characteristics, is presumably a consequence of broad gender beliefs about, and preferences for, majoring in science that emerge from the widely shared cultural environment' (Legewie and DiPrete, 2014: 275).

Exploring gender differences at sub-national levels

In this paper, we focus on the concept of place, a notion described recently as 'underconceptualised' in educational research despite efforts that consider spatial contexts (Butler and Sinclair, 2020: 64). We particularly look at students' place of residence, under a Bourdieusian view that the place students inhabit provides the sociocultural *local* milieu in which social relations may define the educational (classroom, school) and family/community/peer group *fields*, where students participate in and are positioned by others in sociocultural practices. Because of the structure of these fields, participants come to embody differences in their *habitus*. In other words, men and women experience different, gendered forms of participation in these practices, experiences that take material forms not reducible to a genotype (Bourdieu, 1977; 2001). Therefore, we argue that students' place in the community, i.e. the locale students live in, and where students participate in culturally mediated and gendered practices – can thus be conceptualised as explaining local differences in sociocultural norms and practices, as far as historically and geo-socially mediated differences are concerned. Our definition of place is consistent with others in the field, as recently reviewed and synthesised in Buttler and Sinclair (2020): 'Places provide the context in which we learn about ourselves and make sense of and connect to our natural and cultural surroundings; they shape our identities, our relationships with others, and our worldviews' (64). We refer to the concept of place conceptualised by Agnew (1987), as a bundle of sociocultural (but even emotional and sentimental) meanings attached to the area where people live in rather than to the concept of location or locale, that refer to the material place where people live (Cresswell, 2004).

Place is, thus, a complex, multidimensional socio-cultural concept. In the current study, we focus on just a few facets of this concept. In particular, we focused on people's perceptions of and attitudes about and towards gender and gendered roles in the hypothesis that these perceptions and attitudes are nuanced across sub-national levels and not always consistent with the national picture. Such a claim is supported by previous studies showing that the variability of gender attitudes by regions, within the same country, is large (Campa et al., 2011; Cascella and Pampaka, 2020; Crompton and Harris, 1997; Rice and Coates, 1995; Tuncer et al., 2005), and sometimes even bigger than that between countries (Authors, under review). Sociocultural norms and practices shape local communities' lives, for example, by affecting the female-over-male attainment in the key sectors of the social life (i.e. economics, politics, education, and health): previous studies have clearly shown in particular that the more traditional gender attitudes are, the larger the gender gaps in economics, politics, health and education are (e.g. Bericat and Sanchez Bermejo, 2008; Blancas Peral, et al., 2008a; Frias, 2008; Guiso et al., 2008; Harvey et al., 1990a; Kjeldstad and Kristiansen, 2001; Martínez Peinado and Cairó Céspedes, 2004; Noia, 2002; Rico Gonzalez and Gomez-Limon, 2011; Rioboo and Rioboo, 2009; Sugarman and Straus, 1988; Swarna, 2007; Thermaenius, 2000; Walby and Armstrong, 2010). As gender gaps in the key sectors of social life are affected by people's attitudes towards and about gender, in this paper, our operationalization of 'place' is further informed by the measurement of both gender gaps and gender attitudes, in the hypothesis that – when measured at sub-national levels – they are good proxies for the sociocultural local milieu students live in.

Exploring the relationship between contextual factors at different levels of locality and gender inequalities in education is not new in educational literature. For example, there are a number of studies on gender differences in mathematics across US regions (Legewie and DiPrete, 2014), states (Pope and Sydnor, 2010), school districts (Reardon et al., 2019), neighborhoods (Entwisle et al., 1994), or between rural and urban areas (Igbo et al., 2015), or regions within a country (Caner et al., 2016; Gonzalez de San Roman and De la Rica, 2016).

Recently, Gonzalez de San Roman and De la Rica (2016) investigated gender differences in OECD-PISA 2015 test scores across regions in Spain. Spanish regions, similarly to states or regions in other countries such as the US or the UK, are characterized by sharp differences in terms of mathematics curriculum, educational policies/systems and even language and/or cultural identity that can significantly affect students' performance (Ayalon and Livneh, 2013) thus making it difficult to understand the net effect of sociocultural factors on gender differences in mathematics.

However, what is not known and needs further investigation is how patterns of inequality vary at different levels of regionality, and the extent to which these variations can be accounted for by local socio-cultural factors. To this end, we have available secondary data at several levels (schools nested within local regions nested within macro-regions) about students' and their achievement in mathematics, along with secondary data used to measure both communities' gendered attitudes and gender gaps in the key sectors of social life, at national, regional and macro-geographical level. Even though gender attitudes and/or gender gaps have already been studied in relation to gender differences in mathematics (e.g. Guiso et al. 2008), they have been very rarely measured at sub-national levels within the same country (Gonzalez et al. 2016). Moreover, we also note that Italy is a particularly interesting case to focus on, as there is a relatively homogeneous education system compared to many European countries. Such homogeneity is a contrast with some European countries like Spain where some studies of regional variation have previously been reported but where regions are characterized by sharp differences in terms of the educational system (sometimes, even with a different mathematics curriculum) and dramatic cultural differences (even language differences).

In light of such preliminary considerations, the current paper thus intends to answer the following research questions (RQ):

RQ1: Whether and to what extent students' place is associated with students' mathematics attainment?

RQ2. How do potential variations of attitudes towards and about gender at regional level relate with gender differences in mathematics attainment?

Materials and method

Data, sampling and overview of analytical approach

To assess students' competence in mathematics, the Italian National Institute for the Evaluation of Educational System *Istituto Nazionale per la Valutazione del Sistema di Istruzione e Formazione* (hereafter INVALSI) administers mathematics tests every year. In this study, we analysed data collected by INVALSI from grade 10 (15–16 years-old students) in 2017. INVALSI employs a complex multistage sampling strategy (Falorsi, 2008), which makes the sample (n = 38,120) statistically representative at a national, macro-geographical and regional level.

In order to understand whether and to what extent the context (i.e. school, region, and macro-geographical areas) might explain students' attainment, a multilevel analysis was employed with dependent variable the (Rasch modelled *logit*) mathematics test score. Multilevel modelling is consistent with the hierarchical structure of the Italian data we analyse: individuals (n = 38,120) are nested within schools (n = 1,056), schools are nested within regions and regions (n = 21) within macro-geographical areas (n = 5).

Explanatory variables

Mathematics attainment was explored taking into account a set of predictors at individual, school, and geographical levels (Table 1).

Table 1. Variables used to estimate the multilevel model.

Continuous/Interval variables	Description	Source	Range	Mean (SD)
Mathematics attainment (Outcome)	Continuous	INVALSI	[180, 350]	200 (40)
Students' family socio-economic status	Continuous	INVALSI	[−3.42, 2.01]	0.002 (0.977)
School socioeconomic status	Continuous	INVALSI	[−3.07, 1.41]	−0.0626 (0.482)
Gender attitudes	Continuous logit score as measured with Rasch Model	European Values Survey	[−3.86, 5.88]	0.261 (0.892)
Regional Global Gender Gap index	Continuous index: 0 = gender inequality; 1 = gender equality	Italian national institute of Statistics	[0, 1]	
Categorical variables	**Categories**	**Source**	**Frequency**	**%**
Sex	Boys (Reference category)	INVALSI	19,797	51.9%
	Girls		18,294	48.0%
	missing		29	0.1%
Citizenship	Italian	INVALSI	32,250	43.1%
	First-generation		1,790	2.4%
	Second- generation (Reference category)		1,763	23.6%
	Missing		2,317	31.0%
Regularity	Regular	INVALSI	30,761	80.7%
	Anticipated enrolment (Reference category)		387	1.0%
	Retained		6,942	18.2%
	Missing		30	0.1%
School type	- Licei	INVALSI	164,889	88.4%
	- Tecnici (Reference category)		8,945	4.8%
	- Professionali		12,686	6.8%
Macro-geographical area	North West	INVALSI	7,992	21%
	North East		8,121	21.3%
	Centre (Reference category)		7,515	19.7%
	South		8,201	21.5%
	South and Islands		6,291	16.5%
Region	Valle D'Aosta	INVALSI	391	1.1%
	Piemonte		2,254	6.5%
	Liguria		1,644	4.8%
	Lombardia		3,700	0.1%
	Veneto		2,714	7.9%
	Friuli-Venezia Giulia		1,624	4.7%
	Emilia-Romagna		2,338	6.8%
	Toscana		1,944	5.6%
	Umbria		1,481	4.3%

(Continued)

Table 1. (Continued)

Categorical variables	Categories	Source	Frequency	%
	Marche		1,819	5.3%
	Lazio (Reference category)		2,259	6.6%
	Abruzzo		1,579	4.6%
	Molise		986	2.9%
	Campania		3,296	9.6%
	Puglia		2,337	6.8%
	Basilicata		1,306	3.8%
	Calabria		1,597	4.6%
	Sicilia		2,303	6.7%
	Sardegna		1,081	3.1%
	Prov. Aut. Bolzano		393	1.1%
	Prov. Aut. Trento		1,045	3.0%

Source: our elaboration on INVALSI data.

At the individual level, we used the variable 'sex' as a proxy for gender. As control variables, we included students' pathways through the education system (i.e. students enrolling in school before they turn 6-years-old, hereafter 'anticipated enrolment', 'retained', and 'regular' students), students' citizenship (i.e. Italian or First-/Second- generation foreigners), and the Economic, Social, Cultural Status (ESCS) index, constructed by INVALSI to measure students' family socio-cultural background (Campodifiori et al., 2010). Finally, we chose central Italy and Lazio as reference categories for the macro-geographical area and region, respectively, as in these areas students' attainment is in line with the national mean.

At school level, we included ESCS (as the average of individuals within each school) and school type. There are three school types in Italy (Licei, Tecnici, and Professionali) that share the same mandated mathematics curriculum up to grade 10 (that is the grade analysed in this paper), but with different distribution of students' characteristics, in terms of socioeconomic status, gender, citizenship and regularity of academic pathway (Table 2).

Although all school types allow access to university, Tecnici and Professionali offer a specific education/training and a direct access to the job market in a variety of sectors that do not require an academic degree (but that are more focused, for example, on technological competences or on the development of manual abilities), whereas Licei offer a broader education preparatory for university.

In order to explore gender inequality, previous studies employed the Global Gender Gap Index (GGGI) (Hausmann et al., 2006), intended to measure the gaps between men and women, in economics, health, educationand politics (e.g. Fryer and Levitt, 2010; Gonzalez de San Roman and De La Rica, 2016; Guiso et al., 2008; Ireson, 2018; Nollenberger et al., 2016; Stoet and Geary, 2018).

Gonzales and De La Rica (2016) showed that general social status and labour market differences are associated with gender differences in mathematics. We, therefore, calculated an outcome index aimed at quantifying gender gaps in key sectors of social life, whose structure is similar to that proposed by Haussman et al. (2006) (Appendix 1) but based on data collected at the regional rather than national level.

Figure 1 reports on GGGI's sub-indices. We did not include as predictors in the model either RGGI_2 (education) or RGGI_3 (Health and surveillance) because they show minimal variation across regions. As regard to female-over-male participation in the economy, this ranges from zero in southern Italy to 0.5 in northern Italy. Nonetheless, this sub-index reports on gaps in participating in

Table 2. Students' characteristics by school type.

Students' features	Licei (N = 16,489)	Tecnici (N = 12,686)	Professionali (N = 8,945)
Gender			
- Boy	38.0%	69.0%	53.4%
- Girl	62.0%	30.9%	46.4%
Regularity			
- Regular	90.6%	79.2%	64.6%
- Anticipated enrolment	1.5%	0.7%	0.5%
- Retained	7.9%	19.9%	34.8%
Citizenship			
- Italian	89.4%	82.8%	78.3%
- First-generation foreign	2.7%	5.2%	7.8%
- Second-generation foreign	3.4%	5.3%	5.9%
ESCS (mean (SD))	0.36 (0.93)	−0.12 (0.90)	−0.49 (0.91)

Source: our elaboration on INVALSI data.

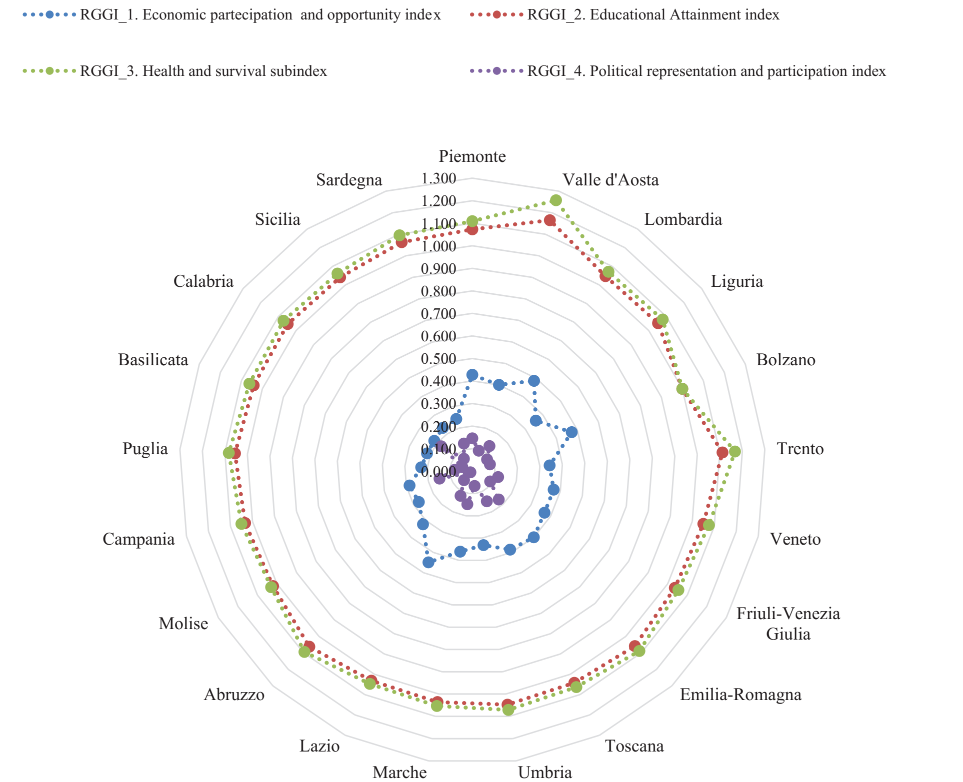
the job market without considering the type of job done by women and men (Ricardo et al., 2006), and thus without accounting for example for the number of women employed in scientific sectors over men. Moreover, a greater number of working women also implies better socioeconomic status: disentangling the effect of RGGI_1 and the effect of students' family ESCS is very hard. For this reason, we did not include RGGI_1 in our multilevel analysis but we just described its variation in Figure 1 along with the female-over-male ratio in politics that is very close to zero in all regions.

We further used the European Values Survey (EVS) data from 2008 with an aim to measure gender attitude, at local level. We used a measure already validated for Italy (Cascella and Pampaka, 2020) based on the answers provided by a sample of 1,519 individuals aged 21–65 to items aimed at measuring people's attitudes towards gender and gendered roles (Table A2, in Appendix 2). According to the model specification, the higher the score on this measure, the more traditional gender attitudes are, ranging from -3.86 to 5.88 logits. The lowest average values (indicating more traditional gender attitudes) are in South (0.24) and South and Islands (0.35). These values increase moving from the south to the north, thus showing that people's attitudes towards gender and gendered roles are more modern in northern Italy than in southern Italy. Of course, even macro-geographical areas hide some variability of gender attitudes, such as for example in Sardinia (in South and Islands) where the average value for gender attitudes is 0.42, which is in line with the North West, which is the most modern area in the country. Similarly, at Valle d'Aosta, a region located in the North West, the average of gender attitudes is -0.15, which is lower than many southern regions.

For each Italian region, the averaged Rasch measures are reported in Table 3 along with case numerosity, standard deviation, minimum and maximum value, the interquartile range (i.e. the difference between the upper, Q3, and lower, Q1, quartiles) in order to provide a range of variation that is not affected by outliers, skewness and kurtosis, to provide a more detailed picture of the distribution of person measures in each Italian region.

Model specification

A multilevel linear regression analysis was considered to be the most suitable for the purposes of our study to account for the hierarchical data structure mentioned earlier. Assuming there are effects of



Macro-geographical area	Regions
North West	Liguria; Lombardia; Piemonte; Valle d'Aosta
North East	Emilia-Romagna; Friuli Venezia Giulia; Veneto; Trentino Alto-Adige (Trento and Bolzano)
Centre	Lazio; Marche; Toscana; Umbria
South	Abruzzo; Campania; Molise; Puglia
South and Islands	Basilicata; Calabria; Sardegna; Sicilia

Figure 1. Gender gaps in economy, health, education, and politics by region.
Source: our elaboration on data provided by ISTAT, INVALSI, MoE, and MoH.

the social context on individuals, these effects must be mediated by intervening processes that depend on characteristics of the context (Hox et al., 2010). Multilevel modelling uses the shared variation of observations within structural levels to estimate outcomes, thus accounting for thenested structure of the data. It does so by modeling the interdependency within levels under the theoretical assumption that students from the same context (i.e. within the same level) share something more as compared to students from other contexts (Hox, et al., 2010). Schools are relatively socially homogeneous, especially in terms of socio-economic status and/or school facilities and leadership. Regions are politically but also educationally unified as they organize education at the local level: Italian regions define the school calendar, the magnitude of public financial contribution to private schools, the subdivision of regional territory into smaller functional territorial units, as well as school networks within the limits of available human and economic resources. Nevertheless, the mathematics curriculum, the learning goals and general guidelines are defined at central level, by the Ministry of Education.

Table 3. Gender attitudes by region.

Macro-regions	Regions	N	Mean	Median	Variance	Std. Dev	Min	Max	IQR	Skewness	Kurtosis
North West	Liguria	37	0.36	0.19	0.54	0.73	−0.79	2.19	0.82	−0.22	1.04
	Lombardia	215	0.48	0.50	0.48	0.69	−0.96	2.92	0.98	−0.07	1.05
	Piemonte	71	0.62	0.50	0.77	0.87	−0.96	3.31	1.32	0.09	1.23
	Valle d'Aosta	8	0.10	−0.05	0.33	0.58	−0.62	1.01	0.46	−0.31	0.77
North East	Emilia Romagna	98	0.59	0.50	0.60	0.77	−0.98	2.92	1.15	0.06	1.09
	Friuli Venezia Giulia	32	0.41	0.29	0.69	0.83	−0.96	2.92	0.97	−0.22	1.19
	Veneto	135	0.38	0.27	0.49	0.70	−0.96	3.31	0.82	−0.13	0.95
	Trentino Alto Adige	24	0.22	0.11	0.69	0.83	−0.87	2.62	0.54	−0.46	1.00
Centre	Marche	50	0.34	0.34	0.40	0.63	−0.96	2.33	0.72	−0.03	0.76
	Lazio	103	0.68	0.50	1.12	1.06	−0.96	5.86	1.32	−0.05	1.37
	Toscana	77	0.64	0.51	0.97	0.99	−0.79	5.88	1.06	0.03	1.03
	Umbria	30	0.47	0.34	0.48	0.69	−0.53	2.03	0.80	0.03	0.77
South	Abruzzo	25	0.24	0.09	0.90	0.95	−0.95	3.47	0.82	−0.43	1.25
	Campania	153	0.32	0.19	0.68	0.82	−0.98	3.86	0.79	−0.29	1.08
	Molise	16	0.26	0.17	0.41	0.64	−0.83	1.20	0.70	−0.13	0.84
	Puglia	93	0.13	0.03	0.38	0.62	−0.96	1.68	0.50	−0.29	0.79
South and islands	Basilicata	21	0.32	0.34	0.44	0.67	−0.96	2.10	0.66	0.19	0.47
	Calabria	79	0.33	0.10	0.77	0.88	−0.90	3.81	1.05	−0.29	1.34
	Sardegna	51	0.47	0.34	0.79	0.89	−0.96	2.92	0.98	−0.17	1.15
	Sicilia	128	0.34	0.22	0.91	0.95	−0.96	4.60	0.66	−0.29	0.95

Note. Gender attitude means significantly vary by macro-regions: North West = 0.48; North East = 0.44; Centre = 0.54; South = 0.25; and, South and Islands = 0.36 (F-test = 5.985; $p < 0.001$).
Source: our elaboration on EVS data.

After having explored the proportion of variance associated with each hierarchical level from the empty/null models (Hox et al., 2010), we estimated 2-level models (students in schools) with the aforementioned explanatory variables. In addition to the combined models including both boys and girls, we run two additional multilevel models (one for boys and one for girls) to explore the (potentially) different sensitivity of boys and girls to contextual factors. Each of these models (i.e. for girls and for boys) was specified in exactly the same way but without gender as explanatory variable. These models further account for the interaction between regions and school type in order to capture any differential effects of school type in combination with characteristics of region on male and female scores. In all models, in addition to personal characteristics, place and school type, we also accounted for the effect of gender inequality in the surrounding environment as described earlier.

Results

Looking at descriptive analysis of attainment scores, gender differences appear bigger where attainment is higher, i.e. in northern Italy compared to the south, and in Licei compared to Tecnici and Professionali (Figure 2).

At national level, regardless of school type, the difference between boys and girls is 7.72 points on the mathematics test scale with mean 200 and standard deviation of 40. However, when we account for school type, gender differences are statistically significant, and equal to 20.55, 8.85, 5.52 in Licei, Tecnici, and Professionali, respectively (Table 4).

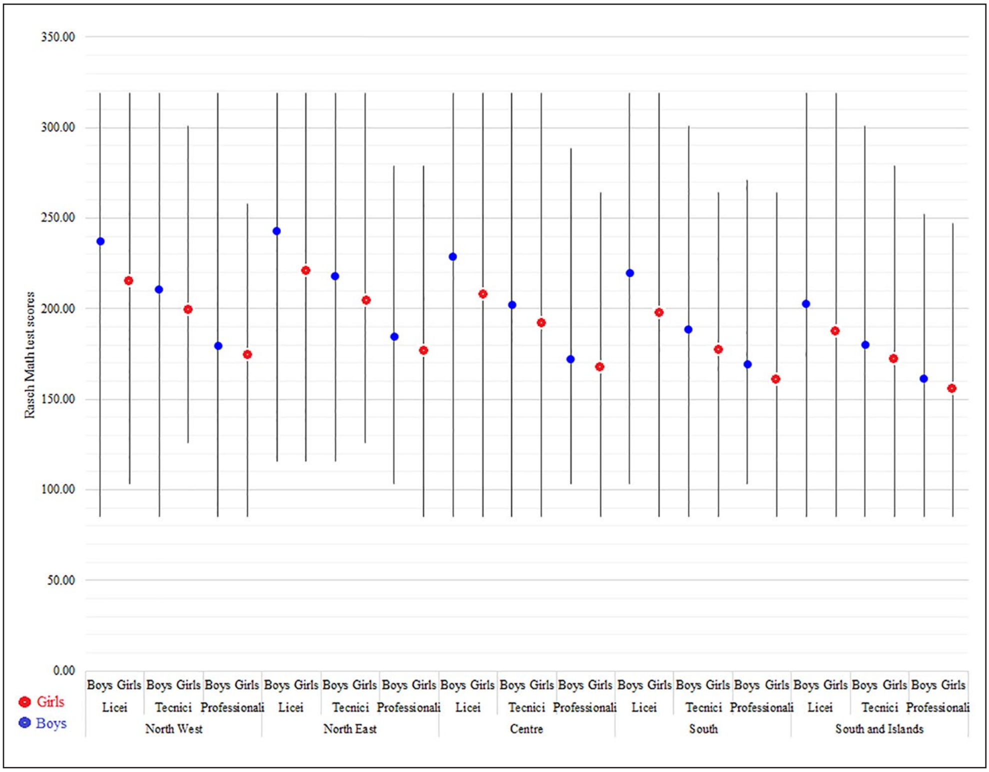


Figure 2. Students' mathematics ability by school type, gender and region.
Source: our elaboration on INVALSI data.

Nevertheless, this difference sharply varies when we consider regions and different school types. On average, test scores in Licei are above the national mean, with exceptions being some regions of Southern Italy, especially for females. Mathematics scores are lower for Tecnici, where attainment is lower than the national mean in all southern regions (especially for boys) and also in some central regions (especially for girls).

Given the hierarchical structure of the data (i.e. student, school, region and macro-geographical area), various multi-level regression models were initially estimated. The first step in the process involves the estimation of the null-model (i.e. without predictors) and the calculation of the variance partition coefficient (VPC et al., 1995) to estimate how much variation of the response variable each level can account for (Table 5).

The individual (student) and school levels capture together most of the variance (around 88%) whereas regions and macro-geographical areas account for the remaining 11% split in 2% of variance at regional level and 9% at macro-geographical level. Even though such a percentage is not negligible, the number of macro-regions (5) and regions (21) is small. Moreover, regions are clustered into macro-regions not only because they are geographically close to each other but also because they are usually considered socially, culturally and economically homogeneous (ISTAT, 2013). Therefore, we ignored the macro-geographical level and used regions as descriptors at the school level in our 2-levels model (i.e. students nested into schools).

Table 6 reports on five 2-level models where explanatory variables (i.e. fixed effects) were introduced sequentially in order to quantify the contribution of each key explanatory variable to the

Table 4. T-test for comparing the means of boys and girls mathematics test scores, in each school type.

School type	Levene Test for Equality of variances		T- test for equality of means						
	F	Sig.	t	df	Sig. (2-tails)	Mean difference	Difference (Std. Error)	95% Confidence Interval	
								Lower bound	Upper bound
Overall	129.66	<0.001	19.26	38089	<0.001	7.72	0.40	6.94	8.51
Liceo	65.454	<0.001	33.088	16484	<0.001	20.55	0.621	19.336	21.771
Tecnico	33.747	<0.001	13.640	12671	<0.001	8.85	0.649	7.580	10.123
Professionale	7.050	0.008	9.451	8930	<0.001	5.52	0.584	4.372	6.661

Source: our elaboration on INVALSI data.

variation of students' score in mathematics. Results show significant main effects of all student and school characteristics. For example, model 1 indicates that being a girl (as compared to a boy) is associated with about 8 points lower mathematics test score; attending Licei is associated with 7 points increase whereas attending Professionali is associated with 14 points decrease compared to attending the reference Tecnici school type.

In regard to gender attitudes, Model 2 suggests that a logit unit increase in gender attitudes (i.e. towards more modern attitudes) is associated with almost 19 points increase on the mathematics score. Model 3, in a similar manner indicates the local variation in mathematics attainment, when comparing the listed regions with the reference (i.e. Lazio). With the available data, analysis revealed that gender attitudes and regional dummies cannot be interpreted when both in the model are due to high collinearity (therefore we do not interpret Model 4 in this regards).[1] Looking comparatively at the model results however, provides evidence to support the hypothesis that the socio-cultural dimensions captured by our measure of gender attitudes are relevant contextual (local) factors significantly associated with variation in gender attitudes. We therefore argue that our measure of gender attitudes is a good proxy for 'region'.

Gender differences appear stable across models (from 1 to 4) and then increase (to 10) in model 5. This is likely due to the introduction of an interaction term (gender*region), which might further suggest mediation of region in the association of gender with mathematics attainment. To better explore and interpret the possible relationship between gender and region, we estimated two separate models, one for girls and one for boys (Table 7).

Table 7 confirms that students' place is significantly associated with the test scores in mathematics and that such a relationship varies by gender. For example (Model 3), female attainment is around -18 scores in Bolzano (North East) compared to that of girls living in Lazio (i.e. the reference category). In contrast, female attainment in Friuli Venezia Giulia (North East) is around 16 scores more than Lazio. Gender attitudes are very different in these two regions and equal 0.22 in Bolzano and 0.41 in Friuli Venezia Giulia (with the mean at macro-regional level being 0.44). This confirms our hypothesis that female attainment in mathematics is negatively associated with gender attitudes. Similarly, female attainment is around -72 points in Puglia (South) compared to that in Lazio; whereas, in Sardinia (South and Islands), female attainment is around +4 point compared to girls living in Lazio. Both Puglia and Sardinia are interesting case studies. In fact, gender attitudes average 0.13 in Puglia (i.e. below the mean in the south) and 0.47 in Sardinia (i.e. above the macro-regional mean, and in tune with the very modern

Table 5. Null-models and variance partition coefficient (VPC).

Variance at:	1-level	2-level	3-level	4-level	1-level	2-level	3-level	4-level	1-level	2-level	3-level	4-level
	Overall (Girls + Boys)				Girl				Boy			
Level 1 (student)	1544.9	707.9	707.9	707.9	749.2	749.4	749.2	749.2	1641.5	827.7	827.6	827.7
Level 2 (school)		640.3	486.4	487.1		710.6	564.9	565.9		824.7	665.9	667.0
Level 3 (region)			162.6	31.5			152.9	37.1			165.8	25.6
Level 4 (macro-region)				121.9				111.109				129.2
VPC at												
Level 1 (student)	100%	53%	52%	52%	100%	51%	51%	51%	100%	50%	50%	50%
Level 2 (school)		47%	36%	36%		49%	39%	39%		50%	40%	40%
Level 3 (region)			12%	2%			10%	3%			10%	2%
Level 4 (macro-region)				9%				7%				8%

Source: our elaboration on INVALSI data.

Table 6. Fixed effects of mathematics attainment in 2-level models against gender and other personal and contextual variables as predictors.

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Fixed Part										
cons	202.57	1.86	202.62	1.85	195.56	2.65	213.06	2.85	196.51	2.70
Gender (Ref: Boy)										
Girl	−8.45*	0.35	−8.50*	0.35	−8.71*	0.35	−8.71*	0.35	−11.08*	1.44
Regularity (Ref: In advance)										
Regular	−2.41	1.55	−2.60	1.55	−3.04	1.55	−3.04	1.55	−3.01	1.55
Retained	−11.72*	1.60	−12.00*	1.60	−12.56*	1.60	−12.56*	1.60	−12.53*	1.60
Citizenship (Ref: Second generation foreigners)										
Italian	3.52*	0.71	3.61*	0.71	3.81*	0.71	3.81*	0.71	3.80*	0.71
First generation foreigner	−2.44*	0.99	−2.44*	0.99	−2.41*	0.99	−2.41*	0.99	−2.38*	0.99
School type (Ref: Tecnici)										
Licei	7.27*	1.07	7.86*	1.07	8.72*	1.00	8.72*	1.00	8.64*	1.01
Professionali	−14.25*	0.99	−14.70*	0.99	−14.97*	0.93	−14.97*	0.93	−14.92*	0.94
(ESCS_studente-gm)	1.03*	0.19	1.02*	0.19	1.00*	0.19	1.00*	0.19	1.01*	0.19
(ESCS_classe-gm)	14.27*	0.81	14.07*	0.81	14.02*	0.80	14.02*	0.80	14.10*	0.80
(ESCS_scuola-gm)	12.24*	1.65	9.99*	1.66	6.12*	1.56	6.12*	1.56	6.12*	1.56
(RegionalGenderAttitude-gm)			19.93*	2.89			−190.79*	28.18		
Regione (Ref: Lazio)										
Valle D'Aosta					15.64*	5.57	−80.18*	14.16	15.52*	5.77
Piemonte					12.45*	2.84	48.38*	6.90	10.32*	2.98
Liguria					6.71*	3.06	7.74*	3.12	6.56*	3.21
Lombardia					19.94*	2.56	34.32*	3.96	19.62*	2.69
Veneto					24.78*	2.73	−3.75	4.01	24.83*	2.85
Friuli-Venezia Giulia					17.23*	3.10	15.33*	3.01	16.39*	3.25
Emilia-Romagna					13.87*	2.80	32.48*	4.62	13.16*	2.94
Toscana					8.84*	2.88	64.48*	9.67	7.62*	3.03
Umbria					5.53*	3.25	−40.39*	6.47	4.87*	3.37
Marche					14.15*	3.05	13.10*	3.00	11.72*	3.20
Abruzzo					3.73	3.57	−33.92*	5.65	0.73	3.75
Molise					1.93	3.99	−72.06*	10.57	0.24	4.16
Campania					2.12	2.64	−61.44*	8.67	1.68	2.75
Puglia					1.44	2.79	−72.05*	10.12	0.32	2.93
Basilicata					1.73	3.41	−3.67	3.24	0.39	3.55
Calabria					−12.39*	2.97	−86.95*	10.32	−14.34*	3.12
Sicilia					−8.77*	2.76	−54.41*	6.22	−10.50*	2.90

(Continued)

Table 6. (Continued)

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Sardegna					−12.79*	3.30	0.03	4.30	−14.61*	3.49
Bolzano					9.82*	4.65	−14.77*	5.18	12.37*	4.98
Trento					24.59*	3.63	0.00	0.00	24.23*	3.79
Interaction term 'gender*region' (Ref. Boys in Lazio)										
Girl*Valle D'Aosta									0.21	3.92
Girl*Piemonte									4.78*	2.02
Girl*Liguria									0.65	2.21
Girl*Lombardia									1.19	1.81
Girl*Veneto									0.29	1.92
Girl*Friuli-Venezia Giulia									2.11	2.21
Girl*Emilia-Romagna									1.88	1.99
Girl*Toscana									2.93	2.09
Girl*Umbria									1.60	2.35
Girl*Marche									5.29*	2.14
Girl*Abruzzo									6.73*	2.55
Girl*Molise									3.90	2.56
Girl*Campania									1.30	1.86
Girl*Puglia									2.76	2.04
Girl*Basilicata									3.26	2.32
Girl*Calabria									4.61*	2.22
Girl*Sicilia									4.08*	2.02
Girl*Sardegna									4.18	2.50
Girl*Bolzano									−4.93	3.84
Girl*Trento									1.18	2.42
Random Part										
Level: School										
Var(cons)	325.91	15.53	311.67	14.91	217.58	10.77	217.60	10.79	216.97	10.73
Level: Student										
Var(cons)	768.01	6.13	767.91	6.13	767.92	6.13	767.92	6.13	767.27	6.13
Units: School	1041		1041		1041		1041		1041	
Units: Student	32412		32412		32412		32412		32412	
Estimation:	IGLS		IGLS		IGLS		IGLS		IGLS	
-2*loglikelihood:	310011.5		309965		309629		309629		309600	

Note. *Statistically significant coefficient ($p < 0.05$).

Table 7. Fixed effects of 2-level models of mathematics attainment against other personal and contextual variables as predictors, estimated for boys and girls separately.

	GIRLS								BOYS							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Fixed part																
Constant	196.13	2.41	196.06	2.41	186.30	3.00	203.25	3.25	201.71	2.76	201.85	2.75	196.85	3.45	213.40	3.73
ESCS (Student)	1.27*	0.26	1.25*	0.26	1.22*	0.26	1.22*	0.26	0.84*	0.26	0.83*	0.26	0.82*	3.45	0.82*	0.26
ESCS (Classroom)	18.35*	1.10	18.09*	1.10	18.00*	1.00	17.82*	1.08	11.86*	1.19	11.53*	1.19	12.00*	1.00	11.53*	1.17
ESCS (School)	11.0*	1.95	8.85*	1.96	5.48*	2.00	5.48*	1.88	14.18*	2.00	11.89*	2.02	7.00*	2.00	6.93*	1.91
Gender attitudes			18.23*	3.06			–197.10*	30.52			19.53*	3.24			–170.45*	31.18
Regularity (Ref: In advance)																
Regular	–0.69	1.98	–0.99	1.98	–1.68	1.98	–1.67	1.98	–3.17	2.45	–3.51	2.45	–4.00	2.00	–4.32	2.45
Retained	–10.39*	2.08	–10.75*	2.08	–11.52*	2.08	–11.52*	2.08	–12.22*	2.50	–12.68*	2.50	–14.00*	3.00	–13.76*	2.50
Citizenship (Ref: Second generation)																
Italian	2.94	1.01	3.12*	1.01	3.51*	1.00	3.51*	1.01	3.87*	0.99	3.99*	0.99	4.00*	0.99	4.25*	0.99
First Generation	–3.05*	1.38	–3.03*	1.38	–2.99	1.38	–2.99*	1.38	–1.88	1.42	–1.92	1.42	–2.00*	1.00	–1.89	1.42
School type (Ref: Tecnici)																
Licei	2.16	1.38	3.01*	1.37	–4.73*	1.00	4.72*	1.29	10.54*	1.39	11.30*	1.39	13.00	1.00	12.75*	1.29
Professionali	–13.29*	1.35	–13.81*	1.35	–13.39*	1.00	–13.38*	1.26	–15.28*	1.29	–15.96*	1.28	–17.00	1.00	–16.59*	1.19
Region (Ref: Lazio)																
Valle D'Aosta					15.00*	6.00	–83.61*	15.32					14.97*	6.08	–70.62*	15.64
Piemonte					15.22*	3.15	52.33*	7.58					9.81*	3.16	41.91*	7.63
Liguria					5.81	3.39	6.87*	3.46					6.47	3.40	7.39*	3.46
Lombardia					20.89*	2.81	35.75*	4.36					18.59*	2.85	31.44*	4.39
Veneto					24.67*	3.00	–4.79	4.28					25.38*	3.00	–0.09	4.46
Friuli-Venezia Giulia					17.53*	3.42	15.56*	3.32					15.99*	3.43	14.29*	3.33
Bolzano					7.07	5.20	–18.33*	5.69					11.63*	5.40	–10.33	5.96
Trento					25.407*	3.935	0.000	0.000					21.97*	4.020	0.000	0.000
Emilia-Romagna					15.30*	3.09	34.52*	5.09					12.88*	3.11	29.50*	5.11
Toscana					10.42*	3.16	67.89*	10.57					7.27	3.21	56.98*	10.70
Umbria					8.34*	3.72	–39.09*	7.01					4.37	3.57	–36.65*	7.16
Marche					16.06*	3.36	14.98*	3.30					12.29*	3.42	11.35*	3.37

(Continued)

Table 7. (Continued)

	GIRLS								BOYS							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Abruzzo					6.89	3.91	–31.99*	6.03					–2.11	4.00	–35.74*	6.29
Molise					4.88	4.27	–71.55*	11.32					–1.02*	4.45	–67.12*	11.72
Campania					4.50	2.95	–61.14*	9.31					1.07*	2.94	–55.70*	9.61
Puglia					3.44	3.08	–72.48*	10.87					0.99*	3.16	–64.66*	11.23
Basilicata					4.49	3.76	–1.08	3.56					–0.59*	3.78	–5.41	3.60
Calabria					–8.35*	3.33	–85.38*	11.10					–15.53*	3.32	–82.14*	11.44
Sicilia					–6.22*	3.09	–53.37*	6.67					–11.60*	3.08	–52.37*	6.90
Sardegna					–9.49*	3.66	3.75	4.77					–15.37*	3.71	–3.92	4.80
Random Part																
Level: School																
Var(cons)	303.59	16.59	291.90	16.05	211.21	12.28	211.21	12.28	362.78	18.85	349.16	18.25	241.02	13.43	241.02	13.43
Level: Student																
Var(cons)	719.06	8.398	718.88	8.39	718.58	8.38	718.58	8.38	791.37	8.90	791.22	8.90	791.60	8.90	791.60	8.90
Units: School	975		975		975		975		1024		1024		1024		1024	
Units: Student	15614		15614		15614		15614		16798		16798		16798		16798	
Estimation:	IGLS		IGLS		IGLS		IGLS		IGLS		IGLS		IGLS		IGLS	
-2*loglikelihood:	148867.87		148832.92				148577.72		161824.63		161788.96		161489.82		161489.82	

Source: our elaboration on INVALSI data.

North West). Such a result is particularly interesting because, in the south, students' attainment is lower than in the north and, as shown by previous literature, female attainment in mathematics is usually very low in areas where students' attainment is low (Maccoby, 1974; OECD-PISA, 2015, 2019; Nollenberg et al., 2018). Therefore, results showing that female attainment can be higher than the national mean and that such a result is associated with more modern gender attitudes confirm the importance of accounting for gender attitudes in exploring gender differences in mathematics. Moreover, results from Table 7 confirm the importance of accounting for more local levels (i.e. regional rather than just national or macro-regional level): if we looked just at macro-regional level (see Table A3, in Appendix 3), we did not disclose either the variability of gender attitudes or the association between such variability and students' attainment in mathematics by gender (HP2).

Results also showed that the attainment difference between boys and girls living in the same place is sometimes smaller than the difference between girls living in different areas (i.e. girls living in the south compared with those living in the north) as well as girls living in the north and boys living in the south. This confirms once more that the characteristics of students' place affect both boys and girls but also that differences in test scores should be primarily attributed to contextual factors.

Gender attitudes do not interplay with the relationship between personal students' characteristics and mathematics test scores, regardless of gender (the coefficients for citizenship, regularity and socioeconomic status in model 1 are similar both in magnitude and direction to those in model 2, where gender attitudes have been added as predictor) (Table 7).

Discussion

Most of the previous large-scale statistical research about gender differences in mathematics is based on national or international data. In this paper we moved the focus of the analysis from the national to the regional level, under the hypothesis that sociocultural factors related to gender differences in mathematics may vary by region, within the same country. In addition, this paper goes a step further to report local and cross-regional differences where we considered further descriptors of gender role perceptions at regional levels. Moreover, we based our analysis on data from Italy, a country characterized by the same mathematics curriculum and assessment in all regions, thus allowing us to focus on how curriculum and assessment practices do engage with sociocultural factors and students' attainment.

To this end, we used (i) a refinement of the global gender gap index (Hausmann et al., 2006), the most frequently used index to measure gender gaps in the key sectors of social life (i.e. economics, politics, health and education) calculated at regional rather than at national level in contrast to previous studies; and, (ii) a new, updated scale (Authors, 2020) to measure people's attitudes towards gender and gendered roles in and outside family.

The gender attitude scale and, to some extent, the regional gender equality index revealed that southern Italian regions are characterized by higher gender inequality and traditional gender attitudes thus confirming the well-known historical-cultural differences in the north and in the south. The use of these measures, in contrast with the national picture and stereotyped perceptions of northern and southern Italy, further revealed a more nuanced sociocultural reality, with traditional regions in the north, and modern regions in the south.

Gender attitudes are associated with students' attainment in mathematics and, consistently with our research hypothesis, i.e. the more traditional the gender attitudes and the larger the gender gaps in the key sectors of the social life, the bigger the differences between girls and boys in mathematics (Table 6). The relationship between local sociocultural characteristics and students' attainment varies by region thus suggesting that it is contingent upon sociocultural characteristics of students' place, measured via our adaptation of the global gender gap index and the gender attitudes scale used in the current paper.

Results from our analysis confirmed the hypothesis that female attainment is more negatively associated with traditional gender attitudes whereas girls outperform boys in more progressive areas (Table 7). In addition to previous studies, our analysis also revealed that, to a different extent, traditional gender attitudes are negatively associated with both male and female attainment, thus suggesting that gender attitudes could be confounders with other variables explaining students' attainment. Such a result is consistent with some recent studies. For example, Cascella (2019) has shown that 'boys in low-SES environment tend to worsen their anti-school behaviour' (Cascella, 2019, 15) as also argued by Legewie and DiPrete (2012), and it is also known that gender attitudes are more traditional in areas relatively poorer than others (Authors, 2020). Nonetheless, in interpreting our results, we are aware that disentangling the role of students' place/area of residence – that includes gender attitudes as well as many other variables – is challenging without additional information. The secondary data used in this paper does not provide, for example, any information about school autonomy in selecting textbooks, classroom practices, assessment or teaching methods, facilities available at school and how they are used in teaching activities, the amount of money received by the region and how it is spent, and so on.

It should be further noted that gender attitudes in this paper have been measured by analysing data collected for the purposes of the European Values Survey, which cannot be directly linked to the students in the sample or their family. Therefore, we had no information about students' and families' perception about and toward gender. Nonetheless, in line with a recent meta-analysis based on 82 studies spanning 29 countries (Kågesten et al., 2016), we argue that students' perceptions about and towards gender is highly shaped by the sociocultural context they live in. Moreover, our research is intended to understand if and to what extent gender differences in mathematics are associated with the contextual sociocultural environment. Measuring gender attitudes in the surrounding environment is thus appropriate. EVS data is statistically representative at different levels of regionality thus allowing us to match students' attainment in mathematics and gender attitudes measured at the same geographical level.

The investigation at regional level also contributes to a very recent debate about the possible relationships between female under-attainment in mathematics and gender unequal society. Most of the previous literature has explained gender differences in mathematics as a function of gender gaps in the key sectors of the social life. In contrast, recent few studies (e.g. Ireson, 2017; Stoet and Geary, 2015, 2018), claimed that there is no significant correlation between mathematics attainment and a gender biased environment drawing on national measures (i.e. PISA and the Global Gender Gap Index respectively). Our results seem to suggest that such weak correlations and low effect size could be due to (at least) two factors. First, as with other studies, the authors (ibid) used the global gender gap index that, as shown in the current paper, employs not very useful indicators to capture gender inequality in industrially developed countries where the sense of deprivation is actually different from that in poorer countries. Second, their analysis is completely based on nationally aggregated data. In this paper, we showed that such data cannot capture the variability of sociocultural milieu at sub-national levels and thus cannot mirror the variability of the relationship between sociocultural factors and gender differences in mathematics.

Conclusion

There are several results from our analysis, with clear implications for educational policy, practice and research.

Our results showed variability in students' attainment from region to region, that mostly manifests as statistically significant gender differences at regional level, different in magnitude and sometimes even different in direction. Such a result calls for more caution in using results based on nationally aggregated data to inform national and regional educational policy. We found statistically significant differences between boys and girls but even between girls living in the north and girls living in the south as well as between girls living in the north and boys living in the south. In both cases, girls outperform boys in more progressive regions (in regard to gender attitudes measures) and outperform both boys and girls living in more traditional regions. We thus conclude that students' place plays a key role in explaining both male and female attainment. Moreover, girls in more traditional regions located in the south (where on average students' attainment is lower than in the north) are scaled at the very bottom of the attainment distribution, often without reaching the minimum level of mathematical knowledge required by the Ministry of Education, and as such the difference between boys and girls might be considered a more important problem in the south than in northern Italy, even though the measurement of female under-attainment is quantitatively less there.

These results suggest that educational policy should be more sensitive to the regional levels and, possibly, redistributive if inequalities are involved, and strengthens the case for more local decision-making as well as analysis.

The importance of *place* recommends the development of national policies that explicitly account for relevant sociocultural dimensions and for the variability of such factors place to place, within the same country. Therefore, we suggest that European researchers of inequality may need to attend to regionality and localities of place. The European policies, always intended to boost the harmonization of different national systems and, at the same time, to protect differences and countries' uniqueness, might include the principle of subsidiarity and thus support educational policy and practice devolved to the levels that research proves to be relevant.

Italy in this case has to be considered as a case study, of interest for an international audience as it contributes to current debates about gender differences in mathematics and it opens up new research questions and research strands within the European educational research space. In fact, previous studies (e.g. Caner et al., 2016; Gonzalez de San Roman and De la Rica, 2016) exploring people's attitudes towards gender and gendered roles disclosed their variability across European countries but also within each of them, at the sub-national level.

As recently shown, (e.g. Authors, under review), the variability of gender attitudes across regions within each European country is huge and, in some European countries (such as for example Germany or Sweden), the distribution of gender attitudes spreads across regions more than across countries. We therefore expect that results similar to those presented in this paper may be observed in other European countries and thus that accounting for more local variables is necessary in order to properly inform both policy and practice.

In conclusion, our exploration shed light into more local phenomena and interactions that would be hidden when looking at nationally aggregated data (within international comparisons), which could render such analyses misleading. In light of this, our results suggest that policy that typically focuses on national level research (e.g. national curriculum), looking at other nations who 'do better', should pause: it may be more informative and productive to deal with differences in the environment within a nation, likely due to quite different political-economic factors that shape more local differences e.g. between regions.

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Note

1. As we used secondary data, we could not link the data at a more local level which could then show variation within regions; in the presence of more refined data, results with models such as Model 4 may be useful in disentangling further the variation of mathematics attainment between regions and regional characteristics.

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Appendix 1

In the following table, our WEF's GGGI's adaptation at regional level is presented.

GGGI's and RGGGI's structure.

WEF GGGI's structure	GGGI adaptation at regional level (RGGGI)	Source
1. Economic participation and opportunity sub-index	**1. Economic participation and opportunity sub-index**	
1.1. Female labour force participation over male value	1.1. Female labour force participation over male value	ISTAT
1.2. Wage equality between women and men for similar work	1.2. Wage equality between women and men for similar work	ISTAT
1.3. Female estimated earned income over male value	1.3. Female estimated earned income over male value	ISTAT
1.4. Female legislators, senior officials and managers over male value	1.4. Female senior officials or in leadership position in private firms	ISTAT
1.5. Female professional and technical workers over male value	1.5. Female professional and technical workers over male value	not available at regional level
2. Educational Attainment sub-index	**2. Educational Attainment sub-index**	
2.1. Female literacy rate over male value	2.1. Female literacy rate over male value	ISTAT/MIUR
2.2. Female net primary enrolment rate over male value (nationally)	2.2. Female net primary enrolment rate over male value (regionally)	ISTAT/INVALSI
2.3. Female net secondary enrolment rate over male value	2.3. Female net secondary enrolment rate over male value	ISTAT/INVALSI
2.4. Female gross tertiary enrolment ration over male value	2.4. Female gross tertiary enrolment ratio over male value	ISTAT/INVALSI

(Continued)

Appendix 1. (Continued)

WEF GGGI's structure	GGGI adaptation at regional level (RGGGI)	Source
3. Health and survival sub-index	**3. Health and survival sub-index**	
3.1. Sex ratio at birth (converted to female-over-male ratio)	3.1. Sex ratio at birth (converted to female-over-male ratio)	ISTAT
3.2. Female healthy life expectancy over male value	3.2. Female healthy life expectancy over male value	ISTAT/MoH
4. Political empowerment	**4. Political empowerment**	
4.1. Females with seats in parliament over male value	4.1. Female major or president of region over males	Regions' web-sites
4.2. Females at ministerial level over male value	4.2. Women in leadership position at public local administration	ISTAT
4.3. Number of years with a female head of State (last 50 years) over male value	4.3. Number of years with a female head of Municipality or Region (last 50 years) over male value	Wikipedia

Source: Our adaptation from The Global Gender Gap Report 2017 (Full document on GGGI available at http://reports.weforum.org/global-gender-gap-report-2017.

Appendix 2

Table A2 reports on the items administered by the European Values Survey in 2008 and used in this paper to measure people's attitudes towards gender equality across the five Italian macro-geographical areas. Scale validation has been detailed by Cascella and Pampaka (2020) and here we overview the measurement properties of the items. In particular, Table A2 presents the items used to construct the scale, the parameter estimation that express the item difficulty (the higher the parameter, the lower the percentage of agreement) and its standard error, and the infit and outfit statistics in the mean square (MNSQ) express which are indicators of unidimensionality of the scale. Infit refers to the information-weighted fit and is more sensitive to the pattern of responses to items targeted on the person compared to the outfit, i.e. the outlier-sensitive fit, which is more sensitive to responses to items with difficulty far from a person's ability. For both infit and outfit, the ideal MNSQ value is 1.00 with standard deviations around 0.20.

Table A2. Item measures and fit statistics for 12 items used to measure gender attitudes.

Item	Measure	Model S.E.	Infit MNSQ	Outfit MNSQ
A man has to have children in order to be fulfilled (v152)	0.73	0.03	1.13	1.12
Both husband and wife should contribute to household income (v164)	1.29	0.05	1.08	1.11
In general, fathers are as well suited to looking after their children as mothers (v165)	0 .73	0.04	1.08	1.09
Being a housewife is just as fulfilling as working for pay (v162)	0.27	0.04	1.07	1.07
When jobs are scarce, men have more right to a job than women (v103)	0 .56	0.04	0.99	1.05
If a woman wants to have a child as a single parent, but she does not want to have a stable relationship with a man, do you approve or disapprove? (v151)	0 .59	0.03	1.03	1.05

(Continued)

Table A2. (Continued)

Item	Measure	Model S.E.	Infit MNSQ	Outfit MNSQ
Men should take as much responsibility as women for the home and children (v166)	1.54	0.05	1.00	0 .98
A pre-school child is likely to suffer if his or her mother works (v160)	1.05	0.05	0 .97	0.96
Homosexual couples should be able to adopt children (v154)	1.44	0.03	0.93	0.94
A working mother can establish just as warm and secure a relationship with her children as a mother who does not work (v159)	0 .48	0.04	0 .93	0.93
It is alright for two people to live together without getting married (v155)	0.23	0.03	0.86	0.88
A job is alright but what most women really want is a home and children (v161)	0 .76	0.04	0.87	0.86

Note. Person separation: 1.53 - Person reliability: 0.70 - Item separation: 22.71 - Item reliability: 1.00.
Source: our elaboration on EVS.

Appendix 3

A 3-level model (students nested into school and schools into region) has been estimated. Compared to girls living in central Italy, living in the north is positively associated with female attainment (around +7 points on the test scale), whereas living in the south is associated with test scores more negatively (-15.8 points on the test scale). Gender attitudes are associated with both male and female scores. At an individual level (model 1), the more modern the people's attitudes are towards and about gender, the higher the students' scores are (for both genders). The association between scores and gender attitudes decreases (but is still statistically significant for boys and not for girls) when we add regions (models 2, 3, and 4), thus indicating that gender attitudes are moderated by local sociocultural factors and that gender attitudes could be considered as a proxy for local sociocultural variables when students' place is not explicitly accounted for. Students' place clearly plays a critical role. Compared to living in central Italy (model 3), living in the north accounts more positively for male than female attainment (i.e. +8.33 points on the test scale for boys compared to +7.15 points for girls) but living in the south, where attainment is very low, accounts more negatively for boys than girls (with -12.417 points in South and -20.689 scores in South and islands for boys compared to -3.074 scores and -12.541 scores for girls in the same areas). Moreover, girls' scores are less associated (positively in Licei and negatively in Professionali, compared to the reference category) with school type than boys. In particular, attending Licei is slightly positively associated with females' scores but this association is much stronger (between a quarter and half SD) for boys' scores. When we introduce gender attitudes and macro-geographical areas as descriptors at regional level, and the interaction between students' place of residence and school type, attending Licei has a negative association with females' scores (-5) and a positive one for males' scores (+12). Looking at the interaction term between regions and school type, the results show a high variability of attainment among regions but with different magnitude and directions depending on students' gender. Finally, gender attitudes are critical in accounting for differences in individual scores (more than a quarter of SD for both males and females) (Model 1) but the strength of this association drops when macro-geographical areas and/or regions are added to the model (Model 4), thus suggesting that (i) territorial levels capture most of the variance explained by gender attitudes; and, (ii) gender attitudes may be a good proxy for social class.

Table A3. Fixed effects of 3-level (i.e. student, school, region) models of mathematics attainment, separately for girls and boys.

		GIRL				BOY			
		model 1	model 2	model 3	model 4	model 1	model 2	model 3	model 4
	Coeff. (S.E.)	193.292 (1.236)	188.010 (1.325)	188.205 (1.298)	189.923 (1.723)	199.884 (1.152)	196.765 (1.218)	196.359 (1.200)	198.446 (1.347)
	Citizenship (Ref: II Generation Foreign Student)								
	Italian	3.344 (1.177)*	5.511 (1.149)*	5.505 (1.149)*	5.730 (1.136)*	3.396 (1.153)*	6.011 (1.111)*	6.012 (1.112)*	5.899 (1.100)*
	I generation foreign	–4.374 (1.612)*	–5.148 (1.569)*	–5.141 (1.569)*	–4.367 (1.548)*	–4.858 (1.654)*	–5.272 (1.589)*	–5.319 (1.589)*	–4.742 (1.574)*
	Individual ESCS	3.442 (0.300)*	3.133 (0.292)*	3.137 (0.292)*	3.107 (0.288)*	2.418 (0.299)*	2.103 (0.288)*	2.107 (0.288)*	2.132 (0.285)*
	School Type (Ref: Tecnici)								
	Licei	2.526 (0.760)*	5.547 (0.753)*	5.549 (0.753)*	–5.885 (2.030)*	12.604 (0.757)*	16.625 (0.741)*	16.628 (0.741)*	12.053 (1.914)*
	Professionali	–15.413 (0.816)*	–15.870 (0.796)*	–15.871 (0.796)*	–24.605 (2.506)*	–19.502 (0.722)*	–21.287 (0.698)*	–21.335 (0.698)*	–30.862 (2.303)*
	ESCS averaged at school level	25.703 (0.895)*	20.540 (0.913)*	20.519 (0.912)*	22.575 (0.928)*	24.836 (0.964)*	16.297 (0.973)*	16.265 (0.973)*	17.089 (0.995)*
	Gender attitudes (at regional level)	17.718 (1.340)*	1.423 (1.941)	–	2.311 (4.153)	18.222 (1.369)*	3.552 (1.840)	–	–4.485 (2.729)*
	Macro-geographical area (Ref: Centre)								
	North West		8.825 (0.797)*	8.867 (0.795)*	7.154 (1.732)*		8.838 (0.795)*	8.696 (0.792)*	8.335 (1.187)*
	North East		12.120 (0.815)*	11.989 (0.795)*	12.222 (1.666)*		13.689 (0.789)*	13.942 (0.779)*	14.266 (1.178)*
	South		–3.074 (1.144)*	–3.628 (0.859)*	–8.749 (2.332)*		–7.267 (1.061)*	–6.001 (0.834)*	–12.417 (1.506)*
	South and Islands		–12.541 (0.986)*	–12.865 (0.881)*	–15.760 (2.098)*		–17.923 (0.933)*	–17.205 (0.856)*	–20.689 (1.366)*
	Cross level interaction (Ref: Girl attending Tecnici living in Lazio)								
North West	Licei*Valle D'Aosta				0.826 (5.049)				–15.529 (5.330)*
	Professionali*Valle D'Aosta				10.482 (7.062)				8.686 (5.427)
	Licei*Piemonte				9.339 (2.711)*				1.930 (2.744)
	Professionali*Piemonte				5.274 (3.437)				3.509 (3.257)
	Licei*Liguria				0.827 (2.794)				–5.022 (2.961)
	Professionali*Liguria				–4.519 (3.544)				–2.500 (3.351)
	Licei*Lombardia				17.642 (2.499)*				12.408 (2.449)*
	Professionali*Lombardia				10.694 (3.144)*				9.419 (3.043)*
North East	Licei*Veneto				13.647 (2.571)*				8.744 (2.627)*
	Professionali *Veneto				9.217 (3.268)				8.703 (2.977)
	Licei*Friuli Venezia Giulia				5.236 (2.722)*				–3.002 (3.001)
	Professionali*Friuli Venezia Giulia				0.041 (3.990)				2.271 (3.258)

(Continued)

Table A3. (Continued)

		GIRL				BOY			
		model 1	model 2	model 3	model 4	model 1	model 2	model 3	model 4
	Licei*Emilia Romagna				4.092 (2.705)				–0.263 (2.699)
	Professionali*Emilia Romagna				–0.627 (3.412)				–3.615 (3.164)
	Licei*Bolzano				–8.691 (3.581)*				–10.936 (4.166)*
	Professionali*Bolzano				14.798 (12.986)				–4.485 (18.781)
	Licei*Trento				15.302 (2.778)*				4.492 (2.892)
	Professionali*Trento				0.000 (0.000)				0.000 (0.000)
Centre	Licei*Toscana				8.802 (2.362)*				6.453 (2.716)*
	Professionali*Toscana				6.106 (3.442)				4.457 (3.086)
	Licei*Umbria				3.872 (2.584)				–1.158 (2.843)
	Professionali*Umbria				9.471 (4.394)*				5.874 (3.553)
	Licei*Marche				16.707 (2.105)*				8.861 (2.708)*
	Professionali*Marche				14.523 (3.160)*				9.831 (3.062)*
South	Licei*Abruzzo				11.376 (3.612)*				0.643 (3.838)
	Professionali*Abruzzo				17.095 (4.155)*				14.741 (3.898)*
	Licei*Molise				17.224 (2.866)*				11.554 (3.250)*
	Professionali*Molise				5.522 (5.037)				9.970 (4.451)*
	Licei*Campania				14.279 (2.574)*				8.842 (2.495)*
	Professionali*Campania				18.380 (3.308)*				21.888 (2.921)*
	Licei*Puglia				16.484 (2.662)*				11.493 (2.695)*
	Professionali*Puglia				17.701 (3.447)*				18.049 (3.364)*
South and Islands	Licei*Basilicata				23.501 (3.023)*				13.654 (3.188)*
	Professionali*Basilicata				17.225 (4.356)*				26.068 (3.676)*
	Licei*Calabria				15.082 (2.967)*				2.687 (2.930)
	Professionali*Calabria				13.134 (3.804)*				13.482 (3.620)*
	Licei*Sicilia				3.089 (2.759)				–6.181 (2.768)*
	Professionali*Sicilia				19.093 (3.577)*				19.183 (3.099)
	Licei*Sardegna				4.723 (3.348)				–3.539 (3.370)
	Professionali*Sardegna				9.353 (4.210)*				15.885 (3.886)
	*-2*loglikelihood*			*317200.312*	*317201.373*	*166.111,759*	*164.779,859*	*164.783,585*	*164.369,116*

Source: our elaboration on INVALSI data.