Campos *et al.*
Large-scale Assessments in Education (2025) 13:12
https://doi.org/10.1186/s40536-025-00249-8

Large-scale Assessments in Education

RESEARCH Open Access

Beyond achievement gaps: inequalities in affective components of math learning

Mafalda Campos[1*], Nurullah Eryilmaz[2] and Rolf Strietholt[2]

*Correspondence:
mcampos@ispa.pt

[1] Center for Research in Education (CIE-Ispa), Instituto Universitário de Ciências Psicológicas, Sociais e da Vida, Lisbon, Portugal
[2] International Association for the Evaluation of Educational Achievement, Hamburg, Germany

Abstract

Background: Comparative educational research has studied inequality in educational outcomes through large-scale assessments like PISA and TIMSS, by identifying achievement gaps within social groups (e.g., gender, parental education, and immigrant gaps) to inform investment in intervention programs and educational policies. However, the focus of these studies has mainly been on achievement, neglecting social and affective adaptation factors (e.g., confidence, enjoyment, and value). This paper argues for the inclusion of affective components in studying educational inequalities and analyzes affective gaps using TIMSS 2019 data.

Method: We investigate gender, parental education, and immigration status gaps regarding confidence, enjoyment, and attributed value for math learning. For context, achievement gaps are also analyzed and accounted for with the goal of confirming previous research and to assess its role in affective gaps. Regression analysis across 39 countries in TIMSS 2019 (23 in the case of immigration status) were conducted. Complex sample designs were accounted for using the IDB Data Analyzer, sampling weights, and the Jackknife Replication procedure to compute standard errors, with pooled effect sizes calculated using a random effects model.

Results: Among the key findings, we observe that in the case of gender, a clear general gap benefitting boys was observed in most countries for math confidence, enjoyment, and value. As for parental education, the well-known results concerning achievement are reproduced for the assessed affective components of math learning, that is, students from highly educated parents have a clear tendency to be more confident towards math, and to enjoy and value math learning more. Finally, results are rather mixed in what concerns gaps according to immigration status, as trends vary throughout nations. These results mainly remained when controlling for achievement. At the country level, we found that achievement gaps correlate with confidence gaps but not with enjoyment or value gaps.

Conclusions: Our findings highlight that affective gaps—differences in students' confidence, enjoyment, and value attributed to math—are distinct from achievement gaps and often follow unique patterns across gender, parental education, and immigration status. While achievement gaps may correlate with confidence gaps, they do not align with enjoyment and value gaps, underscoring that affective dimensions of learning cannot be fully understood through achievement data alone. This study sets out to contribute to a more holistic view on academic adaptation when it concerns equalities in the field.

Keywords: Inequality, Affective gap, Achievement gap, Immigration background, Gender, Socioeconomic status

Introduction

Equity in education has been defined as the guarantee that all students are provided with the opportunities to benefit from their educational system, independently of their gender, socioeconomic status (SES), and family background (OECD, 2014). The search for strategies aimed at minimizing inequalities in the educational context is of growing concern for researchers, practitioners, educational establishments and government authorities, and has been set as one of the components of the United Nations Sustainability Goals (United Nations, 2015).

With the aim of monitoring existing gaps, researchers have invested efforts into the understanding of inequality in educational contexts, identifying gaps between students from different genders, immigrant backgrounds and SES (e.g., Strello et al., 2023). Although growing attention has been given to inequalities in education in the last decades, these efforts were predominantly based on achievement-based outcomes. Yet, one would hardly argue against the fact that the adaptation of students to school should not be reduced to their performance. In fact, Ladd (1989) defined school adjustment as a child's success in dealing with all difficulties, demands and tasks offered by the school environment. Additionally, competence is frequently addressed as encompassing not only cognitive components but also motivational aspects, and some come to suggest that measures of competence should entail motivational aspects specific to the cognitive task in hand (Weinert, 1999). This includes emotional and social demands of schooling, to which a student might adapt with more or less difficulty.

In this study, we adopt an approach in which we look into inequalities of outcome instead of inequalities of opportunity, while recognizing that both are relevant. The goal of this study is to give a cross-national overview on the affective gaps on the basis of gender, immigration status and parental education (PE; as an indicator of SES). For the purposes of this paper, we focus on three indicators of math-specific affective adjustment—confidence, enjoyment and value for math learning. We use data from an international large-scale study that surveyed affective factors of eighth graders related to mathematics across 39 countries. The use of representative international data allows us to generalize our findings to some extent and to explore variability in affective gaps across countries.

Educational adaptation: multiple facets

As we have mentioned, educational adaptation encompasses several dimensions that go beyond academic achievement, such as self-concept, motivation, and achievement emotions. While academic achievement refers to the quantitative educational outcomes that result from assessment (e.g., using test scores or marks assigned by teachers), affective and emotional components of learning represent the relationship that students might establish with the school and/or the learning process.

The emotional and affective relationships that students establish with their learning environment and subjects is strongly associated with their achievement, resilience, and

future aspirations (Martin & Rimm-Kaufman, 2015). Recently, a growing number of studies has been focusing on the affective components of learning and its associations with achievement, and a lot of this research makes use of large-assessment datasets such as TIMSS (Trends in International Mathematics and Science Study; e.g., Chen, 2022; Ivanova & Michaelides, 2022; Tze & Li, 2021). However, there seems to be a discrepancy on the number of studies which investigate gaps on achievement, and those focusing on gaps concerning affective components of learning, as the former receives much more attention than the latter.

Several theoretical frameworks focused on motivation have highlighted the importance of achievement emotions, perceived competence, self-concept, and value for the adaptation of students to their learning environment—e.g., Control-Value Theory (CVT; Pekrun, 2006; Pekrun et al., 2007); Self-Determination Theory (SDT; Deci & Ryan, 2000), and the Situated Expectancy-Value Theory (SEVT; Eccles & Wigfield, 2020). While CVT focuses on achievement emotions and their impacts on motivation, learning and performance, and characterizes emotions in terms of perceived control and control value (Pekrun, 2006; Pekrun et al., 2007), SDT examines motivation on a continuum from intrinsic to extrinsic, considering three main psychological needs (autonomy, competence, and relatedness) that need to be met in order for intrinsic motivation to be developed and maintained. In SDT, social and environmental factors are also considered as influencing need satisfaction (Deci & Ryan, 2020). Finally, in SEVT, Eccles and Wigfield (2020) explain motivation in terms of people's expectancies, beliefs and values (attainment, intrinsic, utility and cost), and more recently taking into account the relevance of context in such aspects of motivation.

Social inequality in educational outcomes

Affective components of learning

It is widely recognized that motivational and cognitive performance outcomes are equally important educational outcomes. Nonetheless, studies focusing on social inequality in educational outcomes predominantly examine test performance, while there are comparatively few studies investigating social gaps in motivational outcomes. Although evidence has started to focus on both emotional and motivational aspects of learning, the existing research is still scarce (e.g., Forsblom et al., 2022).

Well-known theories such as CVT, SDT and SEVT address the importance of affective components of learning to guide human behaviour and learning. Albeit each framework takes into account slightly different views on motivation and affective adaptation in the school context and how they relate to educational attainment, some similarities are hardly ignored. For instance, it is clear that a measure of self-concept and/or perception of competence is present and deemed relevant as an indicator of motivation. Additionally, emotional states towards learning are also pointed out as essential aspects for engaging in learning. Another common characteristic in these frameworks is that there seems to be the need for an individual to see value in the subject/task at hand, and/or to see few negative costs associated with it (Deci & Ryan, 2020; Eccles & Wigfield, 2020; Pekrun, 2006; Pekrun et al., 2007).

Large-scale assessment studies such as TIMSS, PIRLS (Progress in International Reading Literacy Study) and PISA (Programme for International Student Assessment), do

not specify the development and usage of their measures upon such theoretical frameworks such as CVT, SDT and SEVT, but some of the common aspects mentioned in the previous paragraph are often taken into consideration in their assessment frameworks. Hence, researchers have been making use of these publicly available data to explore inherent aspects of these theories. Recently, for example, Zhang et al. (2023) tested the factor structure of student science-learning motivation and SDT revealed a good fit to the data, through the usage of scales concerning self-concept, intrinsic value, utility value, and relatedness.

Research on gaps of the affective domain of confidence in particular is rather scarce, although some evidence do show that boys have higher self-reported confidence for math than girls (e.g., Bharadwaj et al., 2016, and more recently Radišić et al., 2024). Hence, there is a clear need for investment in understanding gender, immigration status and SES impacts on students' confidence. As for gender gaps in regard to math enjoyment, some research suggests, just as it is the case for achievement, that boys report higher math enjoyment than girls (e.g., Bharadwaj et al., 2016; Ganley & Lubienski, 2016; Gaspard et al., 2015; Nagy et al., 2006). However, that available evidence is not international and applicable to all countries. The lack of evidence for gaps in math enjoyment among SES and immigration status is also clear and calls for efforts to better identify and comprehend them. As for math value, in the case of gender, research in Germany has demonstrated that boys reported valuing mathematics more than girls, but only for utility regarding future life and job, while no differences were found for utility regarding school, daily life and the social domain (Gaspard et al., 2015). Nevertheless, in terms of sub-group focus on utility value, it seems that very few studies have examined the role of broad attributed value—including utility value—among adolescents belonging to ethnic-racial minorities (e.g., Safavian & Conley, 2016).

It is also worth mentioning that as several theoretical frameworks informed us, affective components of learning mutually influence each other. As a case in point, evidence proposes that students who see themselves as capable of solving math tasks also show more enjoyment and less anxiety (Du et al., 2021; Forsblom et al., 2022; Li et al., 2021; Zivkovic et al., 2023). A negative correlation among interest and anxiety is also often observed (e.g., Zivkovic et al., 2023). Further, in a recent study, Andersen and Smith (2023) observed that students' interest and engagement was the most important factor for their self-concept for both math and science, and even showing more relevance than academic achievement. As for interventions aiming at interest enhancement, it has been suggested that the impact of utility value on interest is dependent on students' expectations of success (e.g., Durik et al., 2015). These findings underscore the complex interplay not only between achievement and motivational and affective aspects of learning but also among the affective domains themselves.

Gaps related to immigration status are among the most understudied, yet they are receiving increasing attention due to the rise in global migration trends. Although not specific to confidence, enjoyment or value, we do know that motivation in general has been a topic of interest in understanding immigrants' adjustment in schools. Some research has observed that students with an immigration background score the same or even higher in self-reported motivation than their peers in different subjects (e.g. Alivernini et al., 2017; Castillo, 2020), which draws attention to the immigrant paradox (e.g.,

Hill & Torres, 2010). This paradox, although strongly recognized amongst the educational community, is still approached with some inconsistency in what concerns both its definition and operationalization (Basarkod et al., 2022). Similarly, motivation is often operationalized in different ways and thus research results and its comparability should be approached and interpreted carefully.

The fact that evidence on the topic is scarce also leads to a lack of knowledge in what concerns cross-cultural differences in affective components of math learning. Research suggests that students' cultural background is of relevance for their attitudes towards math learning (e.g., Abba et al., 2024). Furthermore, more detail is needed in how different nations approach attitudes towards math learning based on SES, gender and immigration status. This information would be valuable in understanding the gaps in this area.

Academic achievement

An achievement gap refers to significant performance differences among groups of students, with some at a disadvantage compared to others. Researchers believe that such gaps arise from systematic inequalities in educational opportunities, as is the case of low household educational attainment, economic inequality, racial inequality (Hung et al., 2020), and early gaps before schooling begins (Morgan et al., 2016). The PISA 2018 report disclosed that nearly 25% of participants did not meet the baseline math competency (Schleicher, 2019), raising the question about whether these competencies are equally distributed among socially defined groups, such as boys versus girls or natives versus non-natives. In fact, recent analysis of PISA 2018 data assessed social inequalities in math achievement (Strello et al., 2023), observing that in most countries boys outperformed girls (although some exhibited the opposite trend). This gender achievement gap has been observed previously in the field of mathematics across several countries (Bharadwaj et al., 2016; Contini et al., 2017; Nagy et al., 2006).

In Strello et al.'s work (2023), it was also observed that achievement gaps were significant between students with low and high SES, in which students with high SES performed better. SES has been recognized for decades as a crucial predictor of achievement (Coleman, 1966; Harwell et al., 2020; Hopfenbeck et al., 2018), with students of higher SES usually achieving higher than their low SES peers (Chmielewski, 2019). According to OECD (2013), SES accounts for about 15% of achievement differences, with some evidence suggesting that this gap is growing (Broer et al., 2019).

Achievement gaps for immigrant students have also been identified, though their direction varies across countries, with many showing no significant differences (Strello et al., 2023). According to Porcu et al. (2023), differences between native and non-natives students in both traditional and new immigrant countries are narrowing but still present.

Cross-national cultural differences ought to be taken into consideration when assessing achievement and achievement gaps, as it might be of importance to explain achievement gaps across countries and concerning gender, SES and immigration status. Previous research has indicated, for example, that students from countries with long-term orientation and low indulgence are more likely to show higher achievement when compared with students from countries with the contrary cultural characteristics (Meng

& Liu, 2022). It has even been suggested that cultural factors can be more effective in explaining performance than economic factors (e.g., Chen & Uttal, 1988; Leung, 2014).

The present study

The exploration of the achievement gap among gender, immigration status and SES is, as we have explored, rather common. However, the exploration of motivational and affective gaps, either according to gender, immigration status or SES is scarce or does not investigate in detail the different affective components—e.g., treating motivation as an unidimensional construct when several theoretical frameworks point it as a multidimensional and complex structure which drive human behaviors and persistence.

Existing research on this topic is limited, as it is often based on non-representative, small-scale samples, making its reproducibility questionable (for a general discussion of this issue, see Open Science Collaboration, 2015). When research is indeed conducted, it focuses on individual social categories or individual affective variables. By utilizing international data, we address the challenge that much of the existing evidence comes from U.S.-based research, aiming for a more global perspective. The international comparative approach also enables us to explore variations in achievement and affective gaps in the context of math learning.

The goal of this study is to offer a cross-national overview of the existing affective gaps towards mathematics using TIMSS 2019 data. We aim to contribute to the literature by giving a generalized overview of existing or non-existing gaps across three affective domain of math-related learning—enjoyment, confidence, and value -, and across groups defined by gender, immigration status and PE (as an indicator of SES). The better understanding of these gaps has the potential to better explain achievement gaps as well as students' motivation in school, and to give different countries an understanding of how their student population relates to the field of mathematics, possibly and partly explaining achievement gaps as well. The analysis of a cross-country variation in social affective gaps is also novel in the literature and is positioned to suggest system level features and policies that could be associated with smaller or larger gaps. It is beyond the scope of this paper to study such factors but variation in gaps is a precondition to study their determinants.

Methods

Participants

In investigating social disparities in affective educational outcomes, we analyze nationally representative data from the International Association for the Evaluation of Educational Achievement's (IEA) Trends in Mathematics and Science Study (TIMSS) 2019. TIMSS assesses the proficiency of fourth and eight grade students in mathematics and science, as well as several aspects of students' home and school, such as home environment and resources, school climate, and students' attitudes towards learning. In the present study, we center our analysis on the TIMSS 2019 dataset for eight grade students on the subject of mathematics.

As for sampling procedures, TIMSS applies a two-stage cluster stratified sampling strategy. In the first stage, schools are sampled with probability proportional to their size (PPS) from the list of all schools in the population that contain eligible students. The

second sampling stage consists of selecting one (or more) intact class from the target grade of each participating school (LaRoche & Foy, 2020). For the purposes of this paper, a total of 39 countries which participated in TIMSS 2019 were included, representing a total of 224,080 students distributed among 7600 schools. Detailed information on the sample descriptive statistics regarding gender, immigration status and parental highest education level can be found in Table 1.

Measures

Educational outcomes

Confidence in Learning Math. The assessment of students' confidence in learning mathematics involved having students indicating their level of agreement on a scale from 1 ("Agree a lot") to 4 ("Disagree a lot") to nine statements (e.g., "I learn things quickly in mathematics" and "I usually do well in mathematics").

Enjoyment in Learning Math. The assessment of students' enjoyment in learning mathematics involved asking them to rate their agreement on a scale from 1 ("Agree a lot") to 4 ("Disagree a lot") for nine statements (e.g., "I like to solve mathematics problems" and "I look forward to mathematics lessons").

Value in Learning Math. The assessment of students' perceived value in learning mathematics involved soliciting their responses on a scale ranging from 1 ("Agree a lot") to 4 ("Disagree a lot") concerning their agreement with nine statements (e.g., "I need mathematics to learn other school subjects" and "It is important to learn about mathematics to get ahead of the world"). Items for each dependent variable can be found in Appendix A.

Achievement in Math. Math achievement in TIMSS 2019 was assessed based on a comprehensive framework developed through the collaboration of participating countries to reflect each national curriculum. In eight grade, the assessment of mathematics achievement is done based on four main areas: number (30%), algebra (30%), geometry (20%) and data and probability (20%). For the purposes of this study, analysis was conducted using TIMSS' plausible values, i.e., a set of multiple imputed proficiency scores representing the range of a students' possible performance if they had completed all assessment items. TIMSS' plausible values are generated through Item Response Theory and a latent regression model incorporating student background data.

For the analytical framework of this study, we chose to use scaled scores for perceptions of liking, confidence, and value in learning mathematics. As detailed in TIMSS 2019 Technical Report (Yin & Fishbein, 2020), the scaling process for these measures involved calibrating the 9 items of each scale across all participating countries using the Rasch partial credit model. Following calibration, weighted maximum likelihood estimation was applied to compute Rasch logit scale scores for all participating countries. Higher scores for confidence, likeness and value are representative of higher reported levels of such measure. Appendix 16A of the TIMSS 2019 Technical Report also present the reliability measures for all the contextual variables used in this study.

Social categories

Gender. Students were asked about their gender with the question "Are you a boy or a girl?". Students' gender is coded as a dichotomous categorical variable, wherein 1

Table 1 Descriptive statistics by country

Countries	Gender N (%)		Immigration Background N (%)		Parents' Highest Education Level (SES) N (%)		Sample N	
	Female	Male	Native	Non-Native	With HE (High SES)	Without HE (Low SES)	Students	Schools
Australia	4505 (49.7)	4555 (50.3)	5832 (64.4)	2305 (25.4)	2968 (32.8)	2777 (30.7)	9060	284
Bahrain	2703 (47.2)	3022 (52.8)	3604 (63.0)	1290 (22.5)	2134 (37.3)	1974 (34.5)	5725	112
Chile	1985 (48.2)	2126 (51.7)	3704 (90.0)	128 (3.1)	1226 (29.8)	2286 (55.6)	4115	164
Chinese Taipei	2450 (49.8)	2465 (50.2)	4564 (92.9)	28 (0.6)	1857 (37.8)	2530 (51.5)	4915	203
Cyprus	1739 (49.4)	1782 (50.6)	2614 (74.2)	698 (19.8)	1541 (43.8)	1070 (30.4)	3521	98
Egypt	3854 (53.5)	3356 (46.5)	5818 (80.7)	205 (2.8)	2169 (30.1)	3781 (51.6)	7210	169
England	1796 (53.4)	1569 (46.6)	2332 (69.3)	552 (16.4)	803 (23.9)	864 (25.7)	3365	136
Finland	2366 (48.5)	2508 (51.5)	4388 (90.0)	236 (4.8)	1646 (33.8)	1393 (28.6)	4874	254
France	1904 (49.1)	1970 (50.9)	2969 (76.6)	557 (14.4)	782 (20.2)	1411 (36.4)	3874	150
Georgia	1609 (48.5)	1706 (51.5)	2985 (90.0)	23 (0.7)	897 (27.1)	1504 (45.4)	3315	145
Hungary	2250 (49.2)	2319 (50.8)	4261 (93.3)	98 (2.1)	1668 (36.5)	2307 (50.5)	4569	154
Iran, Islamic Rep of	2940 (49.2)	3040 (50.8)	5544 (92.7)	217 (3.6)	1281 (21.4)	4382 (73.3)	5980	220
Ireland	1973 (47.9)	2145 (52.1)	3093 (72.1)	626 (15.2)	1338 (32.5)	1572 (38.2)	4118	149
Israel	1931 (51.8)	1800 (48.2)	2926 (78.4)	460 (12.3)	1678 (45.0)	1103 (29.6)	3731	157
Italy	1790 (49.5)	1829 (50.5)	3117 (86.1)	343 (9.5)	898 (24.8)	2169 (59.9)	3619	158
Japan	2278 (51.2)	2168 (48.8)	4222 (95.0)	26 (0.6)	1541 (34.7)	1668 (37.5)	4446	142
Jordan	3307 (46.1)	3869 (53.9)	5343 (74.5)	699 (9.7)	1949 (27.2)	4400 (61.3)	7176	235
Kazakhstan	2188 (49.1)	2265 (50.9)	3881 (87.2)	260 (5.8)	1774 (39.8)	2107 (47.3)	4453	168
Korea, Rep of	1922 (49.8)	1939 (50.2)	3787 (89.1)	8 (0.2)	1750 (45.3)	965 (25.0)	3861	168
Kuwait	2445 (53.8)	2129 (46.5)	3223 (70.5)	717 (15.7)	1569 (34.3)	1545 (33.8)	4574	171
Lebanon	2381 (50.3)	2349 (49.7)	3625 (76.6)	276 (5.8)	1231 (26.0)	2301(48.6)	4730	204
Lithuania	1929 (50.4)	1897 (49.6)	3352 (87.6)	64 (1.7)	1154 (30.2)	1384 (36.2)	3826	194
Malaysia	3702 (52.4)	3363 (47.6)	6103 (86.4)	65 (0.9)	925 (13.1)	3838 (54.3)	7065	177
Morocco	4237 (50.1)	4221 (49.9)	7901 (93.4)	79 (0.9)	895 (10.6)	6147 (72.7)	8458	251
New Zealand	2935 (48.5)	3114 (51.5)	3889 (64.3)	1328 (21.9)	1378 (22.8)	1449 (23.9)	6051	134
Norway	2252 (49.2)	2315 (50.6)	3275 (71.6)	715 (15.6)	2058 (45.0)	806 (17.6)	4575	157
Oman	3342 (49.5)	3409 (50.5)	4940 (73.2)	1075 (15.9)	1756 (26.0)	2943 (43.6)	6751	228
Portugal	1695 (50.2)	1682 (49.8)	2937 (87.0)	241 (7.1)	967 (28.6)	1734 (51.3)	3377	156
Qatar	1899 (48.9)	1985 (51.1)	1596 (41.1)	1744 (44.9)	1708 (44.0)	967 (24.9)	3884	152
Romania	2303 (51.2)	2191 (48.8)	4104 (91.3)	23 (0.5)	1322 (29.4)	2504 (55.7)	4494	198
Russia Federation	1895 (48.6)	2006 (51.4)	3493 (89.5)	172 (4.4)	1731 (44.4)	1533 (39.3)	3901	204
Saudi Arabia	2884 (50.8)	2796 (49.2)	4075 (71.7)	555 (9.8)	1632 (28.7)	2824 (49.7)	5680	209
Singapore	2366 (48.8)	2487 (51.2)	3500 (72.1)	1000 (20.6)	1657 (34.1)	1700 (35.0)	4853	153
South Africa	11,082 (53.2)	9731(46.7)	18,599 (89.3)	579 (2.8)	3731 (17.9)	12,822 (61.6)	20,829	519
Sweden	1945 (48.7)	2050 (51.3)	2900 (72.6)	781 (19.5)	1353 (33.9)	905 (22.6)	3996	150
Turkey	2012 (49.4)	2045 (50.2)	3819 (93.7)	50 (1.2)	507 (12.4)	3250 (79.7)	4077	181
United Arab Emirates	10,991 (49.2)	11,339 (50.8)	9391 (42.0)	9414 (43.0)	7628 (34.2)	6064 (27.2)	22,334	623
United States	4344 (49.9)	4349 (50.0)	5694 (65.5)	1500 (17.2)	3417 (39.3)	2866 (33.0)	8698	273

Table 1 (continued)

Countries	Gender N (%)		Immigration Background N (%)		Parents' Highest Education Level (SES) N (%)		Sample N	
	Female	Male	Native	Non-Native	With HE (High SES)	Without HE (Low SES)	Students	Schools
Total	112,129 (50.0)	111,891 (49.9)	171,400 (76.5)	29,337 (13.1)	66,519 (29.7)	97,782 (43.6)	224,080	7600

represents female and 2 represented male. In regression analysis, the female category was considered the one of reference.

Immigration Status. Even though TIMSS 2019 did not report directly on students' immigration status, this aspect was estimated following OECD (2014) guidelines, using reports on the place of birth of the students' parents and the reports of the students' place of birth. At a more general approach, students were put into one out of two categories: natives (those who had been born in the host country and whose at least one parent was also born in the same country) and non-natives (those who were either born outside of the country as well as their parents, or those who were born in the country but whose parents were born outside of the host country). In this approach for immigration status, non-natives (or students with an immigration background) were coded as 0 while natives were coded as 1. On a more detailed level, students were put into one out of three categories: natives (those who had been born in the host country and whose at least one parent was also born in the same country), second-generation (2G) immigrants (those who were born in the host country but whose parents were born outside the country), and first-generation (1G) immigrants (those who were born outside the country and whose parents were also born outside the country). Within this approach, natives were coded as 0, 2G immigrants were coded as 1, and 1G immigrants were coded as 2.

Parental Education (PE). To assess for PE, used as an indicator of SES, we contrast students whose parents attained university education (ISCED 5) against those with parents possessing less than university education by adopting those two categories. In cases where PE of both parents levels differed, the highest attainment between both parents was considered, wherein even a single parent with university-level education classified the students into the category of parents with university education. Instances with no available information about both parents resulted in marking PE as missing.

Data treatment

All analyses are predicated upon an examination of three distinct forms of social inequality pertaining to student affective skills within the cohort of 39 participating countries in TIMSS 2019. The examined variables include PE, immigration background, and gender, Specifically, analysis focused on estimating significant gaps for math confidence, math enjoyment and math value, and these gaps were separately explored according to gender, PE and immigration status. Achievement gaps were also explored, as a benchmark for the analyses of affective gaps. At a later stage of analysis, immigrant status' gaps were analyzed further by comparing the

belonging to the 1G and the 2G category. For that reason, only countries with at least 100 1G students and at least 100 2G students were a target for analyses according to immigration status, to better account for an adequate sample size suitable for comparisons with native students. Therefore, while 39 countries were analyzed for the existence of gender and PE math-affective gaps, only 23 of these countries were analyzed in the context of math-affective immigrant gaps.

At a first step of analysis, our analytical procedure involved a singular step, wherein we ascertain the three distinct gaps per country through the estimation of regression models for each affective skill. The model employed in this step is outlined as follows:

There is a linear regression equation for each education system used in this study, with one independent variable (X_1) and one dependent variable (Y) considered for each regression model.

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon$$

In this equation:

- Y represents each dependent variable (math confidence, math enjoyment and math value), which we are trying to predict.
- β_0 is the intercept, representing the expected value of Y when all independent variables are set to zero.
- β_1 is the coefficient for each independent variable (X_1). These independent variables are gender, immigration status and PE These coefficients represent the change in Y for an one-unit change in the corresponding independent variable.
- ε represents the error term, accounting for unexplained variation in Y.

At a second stage of analysis, the same regressions were run but accounting for achievement. Hence, at this step, the employed model may be represented as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

In which:

- β_2 is now the coefficient for achievement (X_2). This coefficient represents the change of Y for an one-unit change in the corresponding independent variable.

Our analysis were conducted employing the IDB Data Analyzer (IEA, 2022), with a specific focus on accommodating complex sample designs. We took the complex sample design into account by using sampling weight. Further, we used the Jacknife Replication procedure (JK2) to compute standard errors. All analysis involving plausible values were replicated for each plausible value and the results were combined using Rubin's rules (Rubin, 1987). Pooled effect sizes were calculated in *r* software using the *rma()* function from the *metafor* package (Viechtbauer, 2010) with the Restricted Maximum Likelihood Estimation method. A random effects model was chosen for the calculation of pooled effects to account for the variability of effect sizes between countries, which was previously expected.

Table 2 Pooled effect sizes of regressions ran separately

Educational outcome	Predictor	*β*	*SE*	95% CI Min	95% CI Max	*p*
Confidence	Gender	0.081	0.011	0.059	0.103	≤ 0.001
	Immigration Status	− 0.007	0.014	− 0.034	0.020	0.618
	1G	0.038	0.013	0.014	0.063	≤ 0.050
	2G	0.013	0.009	− 0.005	0.031	0.152
	Parental Education	0.137	0.007	0.124	0.151	≤ 0.001
Enjoyment	Gender	0.052	0.009	0.035	0.069	≤ 0.001
	Immigration Status	− 0.050	0.016	− 0.080	− 0.016	≤ 0.050
	1G	0.075	0.014	0.047	0.103	≤ 0.001
	2G	0.034	0.014	0.014	0.054	≤ 0.001
	Parental Education	0.103	0.008	0.098	0.132	≤ 0.001
Value	Gender	0.039	0.009	0.021	0.057	≤ 0.001
	Immigration Status	− 0.035	0.014	− 0.063	− 0.007	≤ 0.050
	1G	− 0.059	0.011	0.038	0.080	≤ 0.001
	2G	− 0.033	0.007	0.018	0.047	≤ 0.001
	Parental Education	0.085	0.007	0.071	0.100	≤ 0.001
Achievement	Gender	− 0.013	0.010	− 0.032	0.007	0.119
	Immigration Status	− 0.013	0.035	− 0.057	0.082	0.721
	1G	0.061	0.039	− 0.014	0.137	0.113
	2G	− 0.047	0.026	− 0.004	0.097	0.069
	Parental Education	− 0.280	0.010	0.260	0.300	≤ 0.001

Table 3 Pooled effect sizes of regressions when controlling for achievement

Regression	Predictor	*β*	*SE*	95% CI Min	95% CI Max	*p*
Confidence ~ Gender	Gender	0.083	0.010	0.064	0.102	≤ 0.001
	Achievement	0.042	0.015	0.392	0.451	≤ 0.001
Confidence ~ Immigration Status	Immigration Status	− 0.017	0.011	− 0.039	0.005	0.123
	Achievement	− 0.428	0.022	0.384	0.471	≤ 0.001
Confidence ~ Parental Education	Parental Education	0.019	0.006	0.007	0.030	≤ 0.010
	Achievement	0.418	0.015	0.387	0.448	≤ 0.001
Enjoyment ~ Gender	Gender	0.053	0.008	0.037	0.069	≤ 0.001
	Achievement	0.280	0.014	0.253	0.308	≤ 0.001
Enjoyment ~ Immigration Status	Immigration Status	− 0.057	0.016	− 0.087	− 0.036	≤ 0.001
	Achievement	0.283	0.213	0.241	0.325	≤ 0.001
Enjoyment ~ Parental Education	Parental Education	0.000	0.006	− 0.011	0.012	0.976
	Achievement	0.281	0.014	0.254	0.308	≤ 0.001
Value ~ Gender	Gender	0.040	0.009	0.023	0.057	≤ 0.001
	Achievement	0.181	0.012	0.157	0.206	≤ 0.001
Value ~ Immigration Status	Immigration Status	− 0.038	0.014	− 0.067	− 0.010	≤ 0.010
	Achievement	0.173	0.015	0.144	0.201	≤ 0.001
Value ~ Parental Education	Parental Education	0.037	0.006	0.026	0.048	≤ 0.001
	Achievement	0.172	0.012	0.148	0.195	≤ 0.001

Results

Analysis was performed for each affective component of math learning as well as achievement in each of the socially defined groups. Results were mostly heterogeneous

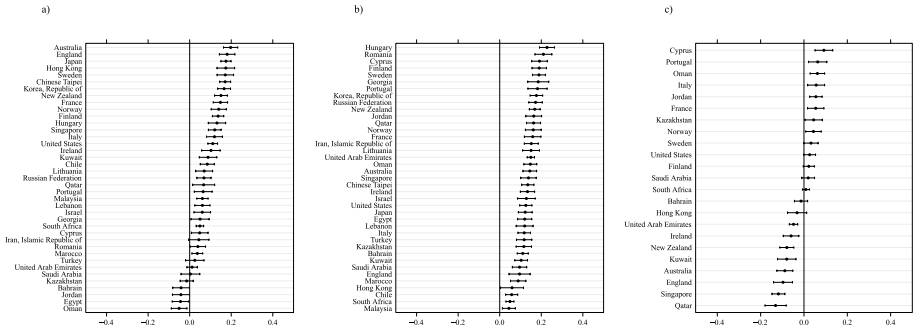

Fig. 1 Affective gaps for gender (**a**), PE (**b**), and immigration status (**c**) as independent variables, and confidence as dependent variable. For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category

in the sense that they varied greatly among countries. The pooled effect sizes are presented in Table 2 and in Table 3. Detailed information on variation per countries is presented below.

Gender gaps

Concerning gender, a significant gap for confidence benefiting boys was observed throughout most countries ($N=30$, 76.9%). Only four countries revealed that girls were significantly more confident in math learning than boys (Oman, Egypt, Jordan and Bahrain), whereas the remaining five countries (12.8%) showed no significant differences (see Fig. 1a and Model 1 of Table 4). When looking into the gender gaps in math confidence when controlling for achievement (see Fig. 2a and Model 2 of Table 4), the trend remains, with a total of 28 countries (71.8%) showing a gap benefitting boys and no country showing the opposite gap.

As for gender gaps concerning math enjoyment, the pattern was similar to the one observed with confidence, as the majority of counties ($N=23$; 59.0%) exhibit a gap benefitting boys, whereas only two countries (5.13%, Cyprus and Malaysia) showed the opposite trend. Around a third of the countries did now show a significant difference ($N=14$, 35.9%) (see Fig. 3a and Model 1 of Table 5). When re-running the analysis with achievement as a predictor as well as gender, the initial major trend persists. Overall, 24 countries (61.5%) reveal an enjoyment gap benefitting boys and only two (5.1%; Malaysia and Portugal) show the opposite trend. Again, about a third of the countries ($N=13$, 33.3%) reveal no significant gap across gender regarding math enjoyment (see Fig. 4a and Model 2 of Table 5).

Finally, in the case of attributed math value, the results show that about half the countries in the analysis ($N=21$, 53.9%) presented that boys showed significantly higher value for math learning than girls, whereas just four countries (10.3%; Malaysia, Morocco, South Africa, and Turkey) showed the opposite trend. About a third ($N=14$, 35.9%) showed no significant effect of gender on math value (see Fig. 5a and Model 1 of Table 6). When taking achievement into account, the patterns for math value remain roughly the same, with 24 countries (61.5%) showing a beneficial gap for boys, four countries (10.3%; Malaysia, Morocco, South Africa, and Turkey)

Table 4 Regression analysis results for confidence regressed on gender (Model 1) and confidence regressed on gender and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Gender*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.197***	0.017	11.30	0.183***	0.016	11.296	0.489***	0.019	26.061
Bahrain	2703	− 0.041*	0.020	− 2.02	− 0.006	0.020	− 0.292	0.319***	0.016	20.216
Chile	1985	0.085***	0.017	4.88	0.062***	0.018	3.360	0.358***	0.018	19.361
Chinese Taipei	2450	0.171***	0.013	12.71	0.176***	0.012	14.255	0.492***	0.012	39.470
Cyprus	1739	0.048*	0.021	2.36	0.059***	0.018	3.298	0.521***	0.015	33.716
Egypt	3854	− 0.044*	0.020	− 2.15	− 0.024	0.018	− 1.285	0.279***	0.017	16.875
England	1796	0.180***	0.019	9.45	0.172***	0.019	9.005	0.426***	0.017	24.414
Finland	2366	0.137***	0.014	9.82	0.151***	0.012	12.431	0.552***	0.015	37.426
France	1904	0.148***	0.018	8.38	0.114***	0.015	7.464	0.554***	0.018	30.848
Georgia	1609	0.050*	0.022	2.24	0.028	0.019	1.461	0.467***	0.019	24.552
Hong Kong	1491	0.174***	0.022	8.02	0.187***	0.021	8.988	0.328***	0.021	15.462
Hungary	2250	0.131***	0.021	6.16	0.089***	0.017	5.289	0.544***	0.014	38.847
Iran, Islamic Republic of	2940	0.044	0.025	1.77	0.075**	0.023	3.265	0.437***	0.016	27.933
Ireland	1973	0.102***	0.023	4.55	0.104***	0.019	5.560	0.426***	0.018	23.555
Israel	1931	0.061**	0.020	2.99	0.035	0.018	1.952	0.385***	0.019	20.281
Italy	1790	0.119***	0.020	6.10	0.077***	0.018	4.350	0.492***	0.018	27.509
Japan	2278	0.175***	0.012	14.09	0.168***	0.012	13.624	0.458***	0.017	26.619
Jordan	3307	− 0.042*	0.021	− 2.01	0.001	0.023	0.052	0.374***	0.016	23.309
Kazakhstan	2188	− 0.014***	0.016	− 0.89	− 0.007	0.016	− 0.430	0.288***	0.022	13.296
Korea, Republic of	1922	0.166***	0.016	10.50	0.154***	0.015	10.168	0.490***	0.011	43.986
Kuwait	2445	0.088***	0.022	4.11	0.098***	0.022	4.408	0.300***	0.024	12.616
Lebanon	2381	0.061***	0.018	3.32	0.048*	0.019	2.527	0.367***	0.023	16.006
Lithuania	1929	0.070***	0.021	3.38	0.065***	0.019	3.447	0.493***	0.017	29.479

Table 4 (continued)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Gender*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Malaysia	3702	0.062***	0.014	4.50	0.072***	0.014	5.297	0.233***	0.021	11.103
Morocco	4237	0.037**	0.013	2.81	0.025	0.013	1.894	0.337***	0.017	20.078
New Zealand	2935	0.151***	0.016	9.64	0.132***	0.018	7.443	0.452***	0.015	30.928
Norway	2252	0.140***	0.019	7.52	0.134***	0.015	8.758	0.621***	0.012	49.710
Oman	3342	− 0.051**	0.019	− 2.65	0.025	0.019	1.280	0.389***	0.015	26.035
Portugal	1695	0.065**	0.022	2.97	0.028	0.018	1.591	0.521***	0.018	28.399
Qatar	1899	0.067*	0.027	2.49	0.077**	0.028	2.796	0.348***	0.021	16.772
Romania	2303	0.040*	0.019	2.10	0.075***	0.017	4.301	0.463***	0.017	27.839
Russian Federation	1895	0.069***	0.018	3.93	0.057***	0.017	3.361	0.424***	0.022	19.527
Saudi Arabia	2884	0.004	0.023	0.15	0.041	0.023	1.787	0.372***	0.018	21.123
Singapore	2366	0.121***	0.016	7.71	0.128***	0.015	8.512	0.405***	0.013	30.389
South Africa	11,082	0.049***	0.009	5.32	0.060***	0.009	6.524	0.261***	0.012	21.059
Sweden	1945	0.172***	0.020	8.46	0.178***	0.016	10.962	0.561***	0.014	39.877
Turkey	2012	0.025	0.023	1.10	0.048**	0.018	2.582	0.465***	0.016	28.640
United Arab Emirates	10,991	0.012	0.013	0.93	0.019	0.011	1.708	0.310***	0.009	35.005
United States	4344	0.111***	0.012	9.39	0.112***	0.013	8.320	0.422***	0.014	31.239

Regressions were run with students with female as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

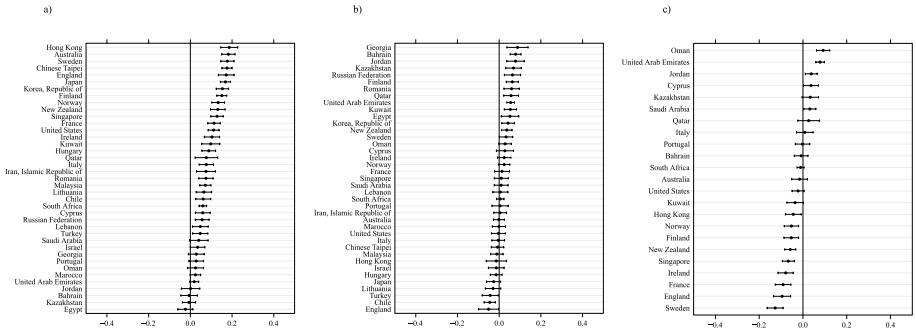

Fig. 2 Confidence gaps for gender (**a**), PE (**b**), and immigration status (**c**), while controlling for achievement. For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category

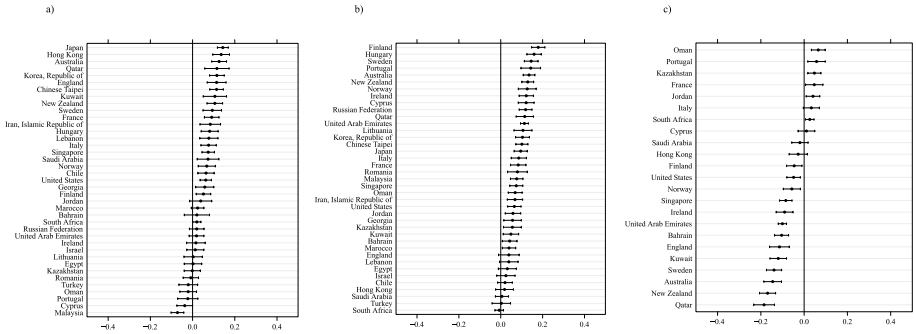

Fig. 3 Affective gaps for gender (**a**), PE (**b**), and immigration status (**c**) as independent variables, and enjoyment as dependent variable. For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category

showing a beneficial gap for girls, and 11 countries (28.2%) showing no significant gap (see Fig. 6a and Model 2 of Table 6).

When looking into achievement, it was observed that only about a third of the countries showed an achievement gap concerning gender ($N=13$; 33.3%) and the tendency was not clear. Specifically, six countries (15.4%) expressed a gender gap benefitting boys, whereas seven countries (18.0%) showed a gap benefitting girls (see Fig. 7a and Table 7).

PE gaps

In all countries, it was observed that children whose at least one parent had a higher education (HE) degree showed higher confidence than their peers (see Fig. 1b and Model 1 of Table 8). However when controlling for achievement, the scenery notably changes. Firstly, only 14 (35.9%) out of the 39 countries show that a higher PE is associated with higher confidence, compared to the totality of the sample when achievement is not considered. Furthermore, and somewhat surprisingly, three countries (7.7%; Chile, England, and Turkey) even show the opposite trend (See Table 2b and Model 2 of Table 8).

Table 5 Regression analysis results for enjoyment regressed on gender (Model 1) and enjoyment regressed on gender and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Gender*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.126***	0.018	7.089	0.115***	0.015	7.595	0.382***	0.017	22.208
Bahrain	2703	0.020	0.031	0.669	0.043	0.030	1.429	0.203***	0.019	10.788
Chile	1985	0.064**	0.020	3.238	0.050*	0.020	2.468	0.210***	0.023	9.151
Chinese Taipei	2450	0.114***	0.016	6.995	0.118***	0.014	8.498	0.418***	0.015	28.149
Cyprus	1739	− 0.037*	0.019	− 1.971	− 0.027	0.018	− 1.539	0.366***	0.019	19.017
Egypt	3854	0.002	0.021	0.093	0.015	0.022	0.675	0.172***	0.021	8.342
England	1796	0.114***	0.023	5.012	0.110***	0.024	4.657	0.234***	0.025	9.521
Finland	2366	0.052**	0.018	2.931	0.063***	0.016	3.969	0.442***	0.019	23.288
France	1904	0.091***	0.018	5.135	0.069***	0.017	4.015	0.347***	0.020	17.013
Georgia	1609	0.058**	0.022	2.636	0.046*	0.021	2.148	0.255***	0.026	9.904
Hong Kong	1491	0.136***	0.020	6.741	0.148***	0.018	8.050	0.308***	0.025	12.372
Hungary	2250	0.081***	0.021	3.944	0.051**	0.018	2.799	0.372***	0.022	16.967
Iran, Islamic Republic of	2940	0.084***	0.025	3.380	0.102***	0.026	3.913	0.261***	0.023	11.182
Ireland	1973	0.016	0.022	0.708	0.017	0.019	0.877	0.324***	0.019	16.983
Israel	1931	0.013	0.021	0.628	0.002	0.020	0.101	0.170***	0.023	7.397
Italy	1790	0.076***	0.018	4.111	0.046**	0.018	2.585	0.348***	0.021	16.235
Japan	2278	0.143***	0.013	10.934	0.138***	0.014	10.040	0.396***	0.017	23.105
Jordan	3307	0.038	0.027	1.438	0.058*	0.028	2.059	0.163***	0.020	8.220
Kazakhstan	2188	− 0.001	0.020	− 0.072	0.002	0.020	0.116	0.162***	0.029	5.524
Korea, Republic of	1922	0.115***	0.018	6.576	0.105***	0.016	6.661	0.391***	0.013	29.753
Kuwait	2445	0.106***	0.028	3.756	0.112***	0.028	3.983	0.172***	0.025	6.898
Lebanon	2381	0.077***	0.022	3.508	0.069**	0.023	2.982	0.219***	0.025	8.851
Lithuania	1929	0.003	0.022	0.128	0.000	0.022	0.020	0.264***	0.023	11.376

Table 5 (continued)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Gender*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Malaysia	3702	− 0.071***	0.015	− 4.650	− 0.062***	0.014	− 4.343	0.209***	0.021	10.054
Morocco	4237	0.024	0.015	1.557	0.015	0.015	0.997	0.250***	0.020	12.808
New Zealand	2935	0.105***	0.019	5.604	0.094***	0.019	4.833	0.285***	0.018	15.987
Norway	2252	0.067**	0.021	3.246	0.064***	0.018	3.477	0.422***	0.016	27.188
Oman	3342	− 0.021	0.020	− 1.020	0.035	0.019	1.850	0.275***	0.017	16.526
Portugal	1695	− 0.023	0.024	− 0.931	− 0.049*	0.022	− 2.220	0.378***	0.022	17.229
Qatar	1899	0.115***	0.029	3.957	0.124***	0.029	4.230	0.252***	0.025	10.204
Romania	2303	− 0.008	0.019	− 0.448	0.015	0.018	0.800	0.302***	0.023	12.857
Russian Federation	1895	0.020	0.018	1.113	0.012	0.017	0.685	0.280***	0.022	13.009
Saudi Arabia	2884	0.073**	0.026	2.789	0.089***	0.027	3.334	0.151***	0.021	7.118
Singapore	2366	0.074***	0.015	4.955	0.080***	0.014	5.548	0.332***	0.015	22.421
South Africa	11,082	0.020*	0.010	2.034	0.025*	0.010	2.502	0.109***	0.015	7.495
Sweden	1945	0.093***	0.022	4.189	0.097***	0.020	4.818	0.342***	0.020	17.347
Turkey	2012	− 0.020	0.023	− 0.891	− 0.008	0.022	− 0.357	0.253***	0.018	13.668
United Arab Emirates	10,991	0.019	0.018	1.043	0.024	0.016	1.535	0.227***	0.010	22.423
United States	4344	0.062***	0.014	4.564	0.065***	0.015	4.309	0.269***	0.019	14.407

Regressions were run with students with female as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

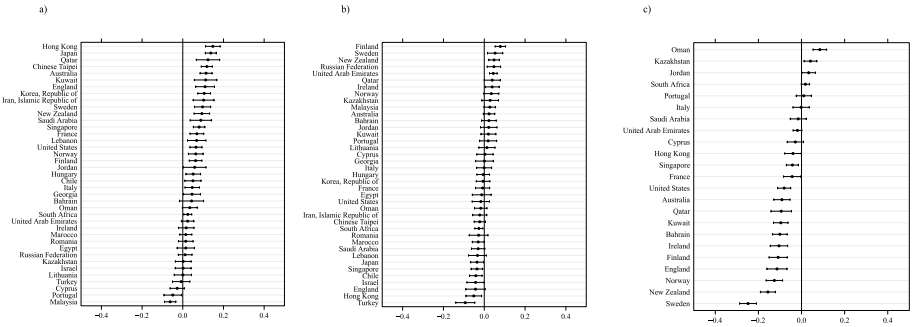

Fig. 4 Enjoyment gaps for gender (**a**), PE (**b**), and immigration status (**c**), while controlling for achievement. For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category

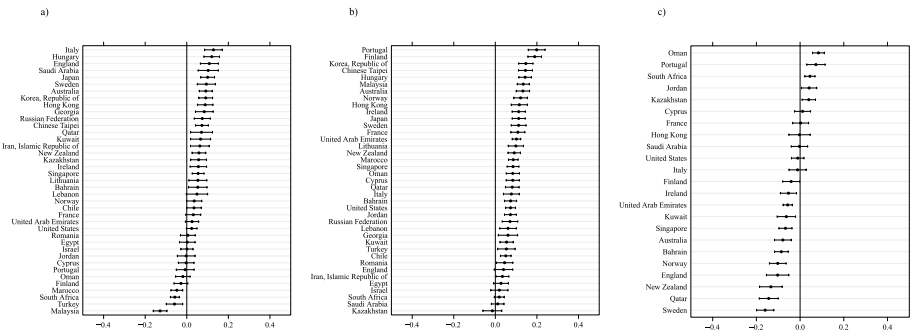

Fig. 5 Affective gaps for gender (**a**), PE (**b**), and immigration status (**c**) as independent variables, and value as dependent variable. For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category

As for the case of enjoyment, it is observed that the majority of countries ($N=33$, 83.6%) show a positive and significant effect signaling that students who have at least one parent who has a HE degree tend to enjoy math more than those who do not, whereas the remaining countries show no significant trend (see Fig. 3b and Model 1 of Table 9). When looking to the PE enjoyment gap while controlling for achievement, once again, the initial tendency substantially changes. In fact, the results become quite mixed, as only six of the countries (15.4%) show a gap benefiting high PE, whereas surprisingly eighth countries (20.5%) show the opposite trend (see Fig. 4b and Model 2 of Table 9).

Looking into PE's gaps in math value, the first step of analysis shows a large tendency for high PE to be associated with higher math value, although not as strong and consistent as it happens with math confidence and enjoyment, as six countries (15.4%) indicated no significant gap in comparison to 33 (84.6%) which did (see Fig. 5b; and Model 1 of Table 10). When controlling for achievement, the initial effect becomes less clear (see Fig. 6b; and Model 2 of Table 10), with now only 23 countries (59.0%) showing a significant effect of PE on math value, and 16 countries (41.0%) showing no effect at all.

Concerning achievement, and as predicted in accordance with previous literature, in all countries with no exception there was a gap in which high PE was associated with higher math achievement (see Fig. 7a and Table 7).

Table 6 Regression analysis results for value regressed on gender (Model 1) and value regressed on gender and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Gender*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.091***	0.016	5.732	0.085***	0.017	5.060	0.219***	0.021	10.608
Bahrain	2703	0.053*	0.023	2.323	0.068**	0.023	2.964	0.131***	0.014	9.076
Chile	1985	0.035	0.018	1.948	0.030	0.018	1.657	0.072***	0.022	3.330
Chinese Taipei	2450	0.073***	0.015	4.722	0.076***	0.013	5.922	0.357***	0.018	19.983
Cyprus	1739	− 0.003	0.019	− 0.149	0.002	0.019	0.087	0.252***	0.020	12.420
Egypt	3854	0.002	0.019	0.123	0.011	0.018	0.617	0.124***	0.020	6.090
England	1796	0.109***	0.022	4.938	0.107***	0.023	4.755	0.070**	0.023	3.010
Finland	2366	− 0.028	0.017	− 1.649	− 0.020	0.016	− 1.233	0.326***	0.018	17.861
France	1904	0.032	0.018	1.727	0.022	0.018	1.222	0.155***	0.019	8.309
Georgia	1609	0.084***	0.022	3.888	0.078***	0.022	3.566	0.136***	0.027	5.135
Hong Kong	1491	0.089***	0.019	4.670	0.098***	0.018	5.476	0.229***	0.026	8.730
Hungary	2250	0.120***	0.019	6.311	0.102***	0.018	5.642	0.229***	0.024	9.648
Iran, Islamic Republic of	2940	0.063**	0.023	2.734	0.072**	0.024	2.981	0.128***	0.021	6.122
Ireland	1973	0.056**	0.020	2.770	0.057**	0.019	2.928	0.203***	0.019	10.885
Israel	1931	0.001	0.015	0.053	− 0.005	0.015	− 0.343	0.089***	0.022	4.086
Italy	1790	0.128***	0.022	5.942	0.116***	0.022	5.377	0.145***	0.024	5.938
Japan	2278	0.100***	0.017	5.957	0.097***	0.017	5.616	0.246***	0.020	12.212
Jordan	3307	− 0.003	0.022	− 0.128	0.014	0.022	0.661	0.150***	0.023	6.518
Kazakhstan	2188	0.057**	0.020	2.919	0.058**	0.020	2.933	0.051*	0.025	2.044
Korea, Republic of	1922	0.091***	0.017	5.396	0.081***	0.015	5.389	0.406***	0.017	23.659
Kuwait	2445	0.066**	0.024	2.714	0.071**	0.023	3.024	0.129***	0.021	6.051
Lebanon	2381	0.049	0.026	1.876	0.041	0.026	1.601	0.205***	0.022	9.279
Lithuania	1929	0.053*	0.022	2.441	0.052*	0.022	2.411	0.133***	0.026	5.167

Table 6 (continued)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Gender*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Malaysia	3702	− 0.128***	0.017	− 7.589	− 0.118***	0.015	− 7.648	0.238***	0.020	11.936
Morocco	4237	− 0.048***	0.014	− 3.303	− 0.056***	0.014	− 4.028	0.213***	0.016	13.391
New Zealand	2935	0.059***	0.017	3.482	0.053**	0.017	3.068	0.125***	0.018	7.016
Norway	2252	0.036	0.019	1.914	0.034*	0.017	1.981	0.225***	0.021	10.626
Oman	3342	− 0.019	0.018	− 1.054	0.021	0.016	1.367	0.208***	0.018	11.296
Portugal	1695	− 0.008	0.022	− 0.352	− 0.029	0.020	− 1.457	0.297***	0.027	10.924
Qatar	1899	0.071**	0.027	2.645	0.076**	0.027	2.814	0.164***	0.029	5.606
Romania	2303	0.005	0.018	0.270	0.017	0.018	0.971	0.171***	0.019	9.129
Russian Federation	1895	0.074***	0.020	3.802	0.070***	0.020	3.508	0.146***	0.021	6.778
Saudi Arabia	2884	0.103***	0.025	4.182	0.112***	0.025	4.494	0.098***	0.021	4.780
Singapore	2366	0.055***	0.014	3.790	0.057***	0.014	4.013	0.141***	0.020	7.024
South Africa	11,082	− 0.057***	0.011	− 5.231	− 0.050***	0.010	− 4.965	0.170***	0.015	11.571
Sweden	1945	0.094***	0.022	4.263	0.095***	0.022	4.349	0.133***	0.023	5.769
Turkey	2012	− 0.059**	0.020	− 2.930	− 0.048*	0.019	− 2.472	0.231***	0.020	11.704
United Arab Emirates	10,991	00.025	0.016	1.551	0.030*	0.014	2.094	0.184***	0.012	15.319
United States	4344	0.024	0.013	1.825	0.024*	0.012	2.010	0.134***	0.016	8.136

Regressions were run with students with female as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

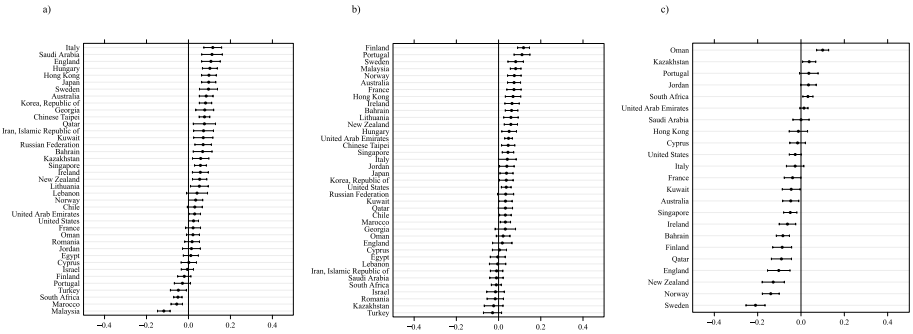

Fig. 6 Value gaps for gender (**a**), PE (**b**), and immigration status (**c**), while controlling for achievement. For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category

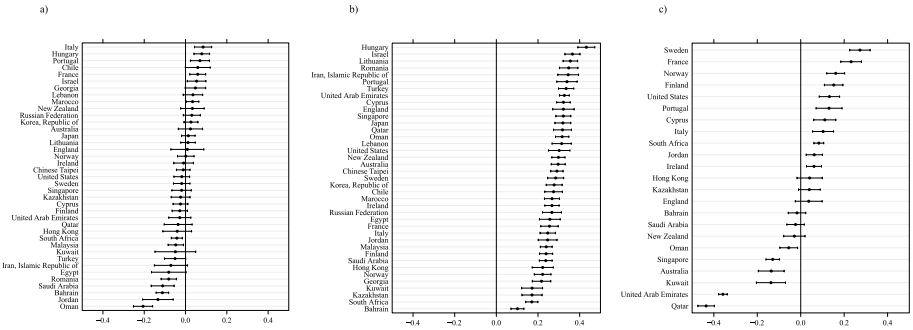

Fig. 7 Achievement gaps for gender (**a**), PE (**b**), and immigration status (**c**). For gender (**a**), regressions were run with female as the reference category; for PE (**b**), regressions were run with low PE as the reference category; For immigration status (**c**), regressions were fun with non-native as the reference category.

Immigration status gaps

With respect to confidence, the results are rather mixed. Of the 16 countries (69.6%) out of 23 that show significant differences, eighth of them are in favor of non-immigrants, whereas the remaining eighth are in favor of immigrant students (see Fig. 1c; and Model 1 of Table 11). When controlling for achievement, results for math confidence remained mixed although changing slightly. Specifically, in five countries (21.7%) natives report higher math confidence than non-natives, whereas in nine countries (39.1%) the opposite is true (see Fig. 2c; and Model 2 of Table 11). Table 12 shows differences in effects according to immigrant generation, that is, presenting the effects separately for 1G and 2G immigrant students.

Concerning math enjoyment (see Fig. 3c; and Model 1 of Table 13), 13 (56.5%) out of the 23 countries in the analysis revealed a gap in which students with an immigrant background enjoy math more than natives. On the other hand, only about a quarter ($N=6$, 26.1%) of the countries showed the opposite trend, while four countries (17.4%) revealed no significant gap. For the case of enjoyment (see Fig. 4c; and Model 2 of Table 13), unlike was the case for its gender and PE gap, controlling for achievement maintained the overall initial observed effect, as 14 countries (60.9%) show a significant gap benefiting students with an immigration background, and only three countries

Table 7 Regression analysis results for achievement regressed on gender, PE and immigration status as in native vs. non-native

Country	N	Gender			PE			Immigrant Status		
		β	*SE*	*t*	*β*	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.024	0.030	0.797	0.297***	0.017	17.290	− 0.136***	0.030	− 4.467
Bahrain	2703	− 0.112***	0.016	− 7.190	0.101***	0.016	6.399	− 0.017	0.021	− 0.833
Chile	1985	0.059	0.031	1.936	0.275***	0.022	12.746	–	–	–
Chinese Taipei	2450	− 0.011	0.017	− 0.652	0.291***	0.015	19.219	–	–	–
Cyprus	1739	− 0.024	0.018	− 1.329	0.322***	0.017	19.432	0.111***	0.026	4.250
Egypt	3854	− 0.081	0.043	− 1.901	0.257***	0.025	10.110	–	–	–
England	1796	0.009	0.041	0.224	0.322***	0.026	12.266	0.037	0.032	1.167
Finland	2366	− 0.028	0.019	− 1.453	0.239***	0.016	14.854	0.152***	0.022	6.941
France	1904	0.059**	0.020	3.005	0.255***	0.021	11.962	0.232***	0.024	9.553
Georgia	1609	0.048	0.025	1.895	0.217***	0.023	9.579	–	–	–
Hong Kong	1491	− 0.040	0.035	− 1.126	0.223***	0.026	8.652	0.041	0.030	1.376
Hungary	2250	0.079***	0.019	4.077	0.432***	0.021	20.790	–	–	–
Iran, Islamic Republic of	2940	− 0.071	0.041	− 1.746	0.345***	0.025	13.550	–	–	–
Ireland	1973	− 0.009	0.024	− 0.377	0.267***	0.017	15.336	0.061***	0.018	3.481
Israel	1931	0.054*	0.023	2.328	0.366***	0.019	19.701	–	–	–
Italy	1790	0.085***	0.021	4.009	0.247***	0.019	13.103	0.103***	0.025	4.187
Japan	2278	0.014	0.017	0.813	0.319***	0.019	16.417	–	–	–
Jordan	3307	− 0.133***	0.037	− 3.559	0.246***	0.023	10.645	0.062**	0.019	3.273
Kazakhstan	2188	− 0.024	0.023	− 1.025	0.171***	0.025	6.925	0.039	0.026	1.547
Korea, Republic of	1922	0.026	0.017	1.518	0.278***	0.020	14.135	–	–	–
Kuwait	2445	− 0.049	0.050	− 0.977	0.172***	0.026	6.675	− 0.137***	0.034	− 4.004
Lebanon	2381	0.036	0.024	1.496	0.314***	0.023	13.401	–	–	–
Lithuania	1929	0.012	0.018	0.689	0.355***	0.018	19.940	–	–	–
Malaysia	3702	− 0.047*	0.019	− 2.490	0.240***	0.014	16.552	–	–	–

Table 7 (continued)

Country	N	Gender			PE			Immigrant Status		
		β	*SE*	*t*	*β*	*SE*	*t*	*β*	*SE*	*t*
Morocco	4237	0.034*	0.015	2.216	0.267***	0.019	14.442	–	–	–
New Zealand	2935	0.033	0.029	1.159	0.298***	0.016	18.590	− 0.029	0.025	− 1.161
Norway	2252	0.001	0.020	0.057	0.222***	0.020	10.884	0.161***	0.021	7.654
Oman	3342	− 0.206***	0.024	− 8.659	0.316***	0.016	19.285	− 0.055**	0.021	− 2.639
Portugal	1695	0.070**	0.024	2.966	0.339***	0.025	13.660	0.130***	0.031	4.273
Qatar	1899	− 0.036	0.034	− 1.042	0.318***	0.022	14.411	− 0.436***	0.019	− 22.447
Romania	2303	− 0.081***	0.019	− 4.300	0.348***	0.023	15.330	–	–	–
Russian Federation	1895	0.030	0.021	1.447	0.267***	0.023	11.508	–	–	–
Saudi Arabia	2884	− 0.111***	0.028	− 3.906	0.237***	0.016	15.115	− 0.024	0.020	− 1.176
Singapore	2366	− 0.019	0.024	− 0.798	0.322***	0.018	17.472	− 0.129***	0.016	− 8.209
South Africa	11,082	− 0.042**	0.014	− 3.082	0.170***	0.015	11.387	0.083***	0.012	7.186
Sweden	1945	− 0.018	0.020	− 0.905	0.285***	0.020	14.497	0.273***	0.024	11.377
Turkey	2012	− 0.050	0.026	− 1.931	0.335***	0.019	17.847	–	–	–
United Arab Emirates	10,991	− 0.028	0.027	− 1.016	0.327***	0.012	27.662	− 0.358***	0.010	− 35.339
United States	4344	− 0.018	0.019	− 0.920	0.302***	0.026	11.512	0.132***	0.024	5.512

For gender, regressions were run with female as the reference category; For PE, regressions were run with low PE as the reference category; For immigration status, regressions were run with non-native as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 8 Regression analysis results for confidence regressed on PE (Model 1) and confidence regressed on PE and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*PE*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.145***	0.017	8.577	− 0.001	0.013	− 0.094	0.495***	0.019	26.595
Bahrain	2703	0.111***	0.014	8.175	0.079***	0.013	5.989	0.312***	0.016	19.489
Chile	1985	0.058***	0.015	3.917	− 0.045***	0.014	− 3.320	0.375***	0.019	19.834
Chinese Taipei	2450	0.135***	0.015	8.975	− 0.008	0.015	− 0.500	0.492***	0.014	34.604
Cyprus	1739	0.192***	0.019	9.970	0.028	0.021	1.330	0.511***	0.018	28.009
Egypt	3854	0.120***	0.017	6.909	0.052*	0.021	2.426	0.268***	0.018	14.837
England	1796	0.096***	0.026	3.675	− 0.051*	0.024	− 2.087	0.445***	0.021	21.103
Finland	2366	0.190***	0.018	10.704	0.063***	0.015	4.279	0.533***	0.016	33.102
France	1904	0.159***	0.020	7.822	0.014	0.018	0.778	0.557***	0.018	30.344
Georgia	1609	0.186***	0.026	7.175	0.088***	0.026	3.417	0.449***	0.021	21.737
Hong Kong	1491	0.059*	0.028	2.105	− 0.014	0.025	− 0.552	0.324***	0.021	15.687
Hungary	2250	0.228***	0.018	12.399	− 0.014	0.014	− 0.992	0.557***	0.016	34.456
Iran, Islamic Republic of	2940	0.152***	0.017	8.892	0.004	0.015	0.290	0.430***	0.016	26.329
Ireland	1973	0.134***	0.018	7.595	0.024	0.016	1.468	0.419***	0.018	23.173
Israel	1931	0.129***	0.021	5.985	− 0.014	0.019	− 0.728	0.393***	0.019	20.394
Italy	1790	0.118***	0.015	7.648	− 0.004	0.016	− 0.283	0.499***	0.018	27.040
Japan	2278	0.123***	0.017	7.279	− 0.027	0.017	− 1.539	0.469***	0.016	30.225
Jordan	3307	0.164***	0.020	8.389	0.078***	0.021	3.690	0.355***	0.017	20.567
Kazakhstan	2188	0.116***	0.019	6.153	0.069***	0.019	3.611	0.276***	0.022	12.528
Korea, Republic of	1922	0.177***	0.015	11.503	0.043**	0.015	2.800	0.482***	0.012	38.616
Kuwait	2445	0.103***	0.016	6.649	0.054***	0.015	3.609	0.288***	0.025	11.395
Lebanon	2381	0.120***	0.021	5.736	0.006	0.018	0.321	0.367***	0.023	15.694
Lithuania	1929	0.151***	0.021	7.335	− 0.029	0.019	− 1.543	0.504***	0.017	29.224

Table 8 (continued)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*PE*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Malaysia	3702	0.044**	0.016	2.785	− 0.011	0.015	− 0.726	0.232***	0.021	10.932
Morocco	4237	0.089***	0.019	4.707	− 0.001	0.016	− 0.077	0.339***	0.016	21.190
New Zealand	2935	0.168***	0.013	12.590	0.037**	0.013	2.865	0.446***	0.016	27.223
Norway	2252	0.162***	0.019	8.343	0.024	0.014	1.693	0.617***	0.014	44.340
Oman	3342	0.148***	0.016	9.329	0.029	0.015	1.885	0.375***	0.015	24.669
Portugal	1695	0.182***	0.023	7.768	0.005	0.020	0.227	0.521***	0.019	27.745
Qatar	1899	0.163***	0.017	9.469	0.057**	0.018	3.187	0.328***	0.022	14.631
Romania	2303	0.210***	0.021	10.164	0.060**	0.019	3.177	0.437***	0.016	26.942
Russian Federation	1895	0.172***	0.016	10.465	0.064**	0.020	3.219	0.408***	0.024	16.854
Saudi Arabia	2884	0.096***	0.018	5.408	0.010	0.017	0.567	0.365***	0.018	20.125
Singapore	2366	0.139***	0.019	7.301	0.010	0.017	0.598	0.399***	0.014	29.136
South Africa	11,082	0.049***	0.010	5.076	0.006	0.009	0.621	0.258***	0.012	20.714
Sweden	1945	0.189***	0.016	11.908	0.033*	0.016	2.042	0.550***	0.016	35.299
Turkey	2012	0.118***	0.019	6.233	− 0.043*	0.020	− 2.176	0.478***	0.017	27.498
United Arab Emirates	10,991	0.150***	0.009	16.546	0.055***	0.009	6.039	0.292***	0.009	32.753
United States	4344	0.126***	0.015	8.422	− 0.003	0.017	− 0.194	0.423***	0.017	24.918

Regressions were run with low PE as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 9 Regression analysis results for enjoyment regressed on PE (Model 1) and enjoyment regressed on PE and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*PE*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.133***	0.016	8.056	0.023	0.014	1.643	0.378***	0.018	21.267
Bahrain	2703	0.073***	0.015	4.980	0.023	0.018	1.252	0.196***	0.019	10.316
Chile	1985	0.050***	0.013	3.879	− 0.041**	0.016	− 2.626	0.225***	0.022	10.123
Chinese Taipei	2450	0.145***	0.017	8.526	− 0.022	0.014	− 1.572	0.423***	0.015	28.173
Cyprus	1739	0.084***	0.016	5.196	0.004	0.020	0.182	0.365***	0.021	17.393
Egypt	3854	0.027	0.018	1.512	− 0.013	0.023	− 0.538	0.174***	0.020	8.729
England	1796	0.039	0.023	1.733	− 0.043	0.024	− 1.787	0.250***	0.027	9.148
Finland	2366	0.189***	0.017	11.424	0.079***	0.013	6.058	0.422***	0.019	22.313
France	1904	0.108***	0.017	6.311	− 0.008	0.018	− 0.467	0.353***	0.021	16.838
Georgia	1609	0.061**	0.024	2.571	0.001	0.022	0.043	0.257***	0.027	9.491
Hong Kong	1491	0.115***	0.020	5.832	− 0.051**	0.020	− 2.616	0.314***	0.025	12.576
Hungary	2250	0.143***	0.015	9.314	− 0.005	0.016	− 0.314	0.378***	0.022	16.829
Iran, Islamic Republic of	2940	0.034*	0.016	2.185	− 0.022	0.018	− 1.251	0.262***	0.023	11.573
Ireland	1973	0.113***	0.016	6.987	0.039*	0.018	2.199	0.314***	0.019	16.111
Israel	1931	0.019	0.021	0.921	− 0.043*	0.021	− 1.990	0.185***	0.023	7.943
Italy	1790	0.077***	0.019	3.989	− 0.001	0.019	− 0.032	0.352***	0.022	15.743
Japan	2278	0.113***	0.016	7.045	− 0.035*	0.016	− 2.216	0.409***	0.019	21.653
Jordan	3307	0.073***	0.014	5.024	0.022	0.021	1.061	0.151***	0.021	7.194
Kazakhstan	2188	− 0.014	0.023	− 0.616	0.029	0.021	1.385	0.157***	0.029	5.445
Korea, Republic of	1922	0.147***	0.017	8.410	− 0.006	0.017	− 0.346	0.395***	0.013	29.465
Kuwait	2445	0.054***	0.016	3.331	0.020	0.019	1.092	0.164***	0.027	6.137
Lebanon	2381	0.061**	0.020	3.028	− 0.033	0.022	− 1.498	0.232***	0.025	9.359
Lithuania	1929	0.099***	0.019	5.288	0.013	0.020	0.645	0.259***	0.023	11.267

Table 9 (continued)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*PE*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Malaysia	3702	0.135***	0.015	9.059	0.027	0.014	1.889	0.205***	0.021	9.722
Morocco	4237	0.086***	0.012	7.383	− 0.029*	0.015	− 1.975	0.258***	0.019	13.531
New Zealand	2935	0.091***	0.015	5.948	0.048***	0.013	3.664	0.274***	0.018	15.146
Norway	2252	0.121***	0.017	7.275	0.035	0.019	1.868	0.415***	0.016	25.626
Oman	3342	0.084***	0.016	5.216	− 0.017	0.016	− 1.101	0.273***	0.017	16.428
Portugal	1695	0.199***	0.021	9.656	0.019	0.021	0.895	0.368***	0.022	16.924
Qatar	1899	0.081***	0.017	4.875	0.039	0.020	1.953	0.235***	0.026	8.979
Romania	2303	0.045*	0.020	2.203	− 0.028	0.023	− 1.182	0.310***	0.024	12.968
Russian Federation	1895	0.071***	0.019	3.704	0.047**	0.017	2.833	0.268***	0.023	11.736
Saudi Arabia	2884	0.011	0.016	0.734	− 0.030	0.017	− 1.793	0.149***	0.022	6.729
Singapore	2366	0.085***	0.014	5.903	− 0.036*	0.015	− 2.455	0.343***	0.015	22.901
South Africa	11,082	0.019	0.012	1.560	− 0.026**	0.010	− 2.639	0.112***	0.015	7.726
Sweden	1945	0.112***	0.018	6.167	0.053**	0.019	2.779	0.326***	0.022	15.148
Turkey	2012	0.053*	0.021	2.481	− 0.093***	0.024	− 3.908	0.284***	0.019	14.969
United Arab Emirates	10,991	0.102***	0.010	9.748	0.044***	0.009	4.700	0.212***	0.011	19.906
United States	4344	0.073***	0.012	6.064	− 0.017	0.022	− 0.764	0.273***	0.023	12.068

Regressions were run with low PE as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 10 Regression analysis results for value regressed on PE (Model 1) and value regressed on PE and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*PE*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	0.133***	0.016	8.056	0.074***	0.016	4.664	0.200***	0.020	9.863
Bahrain	2703	0.073***	0.015	4.980	0.062***	0.015	4.046	0.117***	0.014	8.141
Chile	1985	0.050***	0.013	3.879	0.032*	0.014	2.316	0.065**	0.023	2.864
Chinese Taipei	2450	0.145***	0.017	8.526	0.046**	0.016	2.863	0.343***	0.018	18.572
Cyprus	1739	0.084***	0.016	5.196	0.004	0.017	0.246	0.250***	0.021	11.812
Egypt	3854	0.027	0.018	1.512	− 0.004	0.018	− 0.216	0.124***	0.019	6.447
England	1796	0.039	0.023	1.733	0.018	0.024	0.758	0.066**	0.025	2.620
Finland	2366	0.189***	0.017	11.424	0.118***	0.014	8.256	0.298***	0.018	16.258
France	1904	0.108***	0.017	6.311	0.073***	0.017	4.254	0.137***	0.019	7.371
Georgia	1609	0.061*	0.024	2.571	0.032	0.025	1.299	0.133***	0.028	4.777
Hong Kong	1491	0.115***	0.020	5.832	0.069***	0.019	3.670	0.210***	0.026	8.112
Hungary	2250	0.143***	0.015	9.314	0.050**	0.018	2.845	0.215***	0.027	7.955
Iran, Islamic Republic of	2940	0.034*	0.016	2.185	− 0.009	0.015	− 0.602	0.126***	0.021	5.872
Ireland	1973	0.113***	0.016	6.987	0.064***	0.017	3.709	0.186***	0.020	9.426
Israel	1931	0.019	0.021	0.921	− 0.014	0.021	− 0.682	0.094***	0.022	4.215
Italy	1790	0.077***	0.019	3.989	0.042	0.021	1.946	0.145***	0.026	5.542
Japan	2278	0.113***	0.016	7.045	0.038*	0.016	2.377	0.235***	0.021	11.134
Jordan	3307	0.073***	0.014	5.024	0.039*	0.018	2.227	0.139***	0.026	5.441
Kazakhstan	2188	− 0.014	0.023	− 0.616	− 0.023	0.023	− 1.025	0.053*	0.024	2.207
Korea, Republic of	1922	0.147***	0.017	8.410	0.037*	0.017	2.212	0.397***	0.018	22.613
Kuwait	2445	0.054***	0.016	3.331	0.033*	0.016	2.025	0.121***	0.023	5.363
Lebanon	2381	0.061**	0.020	3.028	− 0.004	0.020	− 0.221	0.208***	0.022	9.315

Table 10 (continued)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*PE*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Lithuania	1929	0.099***	0.019	5.288	0.059***	0.017	3.373	0.112***	0.026	4.310
Malaysia	3702	0.135***	0.015	9.059	0.081***	0.013	6.280	0.224***	0.020	11.158
Morocco	4237	0.086***	0.012	7.383	0.032**	0.013	2.581	0.202***	0.017	12.059
New Zealand	2935	0.091***	0.015	5.948	0.058***	0.016	3.642	0.110***	0.019	5.742
Norway	2252	0.121***	0.017	7.275	0.075***	0.016	4.604	0.208***	0.021	9.832
Oman	3342	0.084***	0.016	5.216	0.022	0.017	1.305	0.197***	0.020	9.999
Portugal	1695	0.199***	0.021	9.656	0.111***	0.019	5.801	0.257***	0.028	9.165
Qatar	1899	0.081***	0.017	4.875	0.033	0.017	1.898	0.151***	0.031	4.905
Romania	2303	0.045*	0.020	2.203	− 0.016	0.020	− 0.797	0.175***	0.019	9.270
Russian Federation	1895	0.071***	0.019	3.704	0.034	0.019	1.750	0.139***	0.022	6.211
Saudi Arabia	2884	0.011	0.016	0.734	− 0.010	0.016	− 0.612	0.090***	0.021	4.207
Singapore	2366	0.085***	0.014	5.903	0.045**	0.014	3.211	0.126***	0.020	6.226
South Africa	11,082	0.019	0.012	1.560	− 0.011	0.012	− 0.889	0.174***	0.015	11.407
Sweden	1945	0.112***	0.018	6.167	0.081***	0.019	4.357	0.110***	0.024	4.595
Turkey	2012	0.053*	0.021	2.481	− 0.029	0.022	− 1.298	0.243***	0.019	12.918
United Arab Emirates	10,991	0.102***	0.010	9.748	0.047***	0.009	5.173	0.168***	0.012	14.263
United States	4344	0.073***	0.012	6.064	0.036**	0.012	3.086	0.123***	0.017	7.237

Regressions were run with low PE as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 11 Regression analysis results for confidence regressed on immigration status as in native vs. non-native (Model 1) and confidence regressed on immigrant status as native vs. non-native and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Immigrant status*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	− 0.088***	0.019	− 4.689	− 0.016	0.018	− 0.849	0.492***	0.019	26.424
Bahrain	2703	− 0.014	0.016	− 0.876	− 0.008	0.016	− 0.521	0.320***	0.016	20.385
Cyprus	1739	0.092***	0.021	4.406	0.036*	0.017	2.097	0.516***	0.016	32.054
England	1796	− 0.097***	0.022	− 4.330	− 0.095***	0.020	− 4.771	0.428***	0.020	21.561
Finland	2366	0.022	0.013	1.702	− 0.053**	0.017	− 3.119	0.555***	0.015	37.464
France	1904	0.054**	0.019	2.820	− 0.091***	0.018	− 4.992	0.583***	0.018	33.320
Hong Kong	1491	− 0.032	0.023	− 1.405	− 0.044*	0.018	− 2.411	0.323***	0.021	15.197
Ireland	1973	− 0.060***	0.018	− 3.233	− 0.079***	0.018	− 4.433	0.429***	0.018	24.063
Italy	1790	0.056**	0.020	2.824	0.008	0.019	0.439	0.497***	0.018	28.154
Jordan	3307	0.055***	0.015	3.746	0.038**	0.014	2.749	0.372***	0.016	22.856
Kazakhstan	2188	0.045*	0.020	2.190	0.034	0.019	1.751	0.287***	0.022	13.261
Kuwait	2445	− 0.080***	0.022	− 3.663	− 0.036	0.019	− 1.860	0.291***	0.025	11.440
New Zealand	2935	− 0.079***	0.016	− 4.832	− 0.058***	0.013	− 4.508	0.455***	0.015	30.557
Norway	2252	0.044*	0.018	2.428	− 0.053**	0.017	− 3.150	0.630***	0.014	45.793
Oman	3342	0.062***	0.017	3.630	0.092***	0.015	5.974	0.391***	0.014	28.067
Portugal	1695	0.063**	0.022	2.938	− 0.002	0.017	− 0.118	0.523***	0.018	28.281
Qatar	1899	− 0.131***	0.025	− 5.295	0.026	0.025	1.038	0.357***	0.022	16.050
Saudi Arabia	2884	0.019	0.015	1.289	0.031*	0.014	2.219	0.369***	0.018	20.803
Singapore	2366	− 0.118***	0.015	− 7.714	− 0.067***	0.014	− 4.792	0.394***	0.013	31.087
South Africa	11,082	0.009	0.008	1.069	− 0.011	0.008	− 1.383	0.260***	0.013	20.719
Sweden	1945	0.032	0.017	1.920	− 0.127***	0.019	− 6.817	0.593***	0.015	39.105
United Arab Emirates	10,991	− 0.048***	0.010	− 4.830	0.078***	0.010	7.902	0.339***	0.010	34.030
United States	4344	0.026	0.014	1.875	− 0.023	0.014	− 1.607	0.425***	0.015	28.595

Regressions were run with students with non-native as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 12 Regression analysis results for confidence regressed on immigration status as in native vs. non-native (Model 1) and confidence regressed immigration status as in first-generation immigrant status vs. second-generation immigrant status (Model 2)

Country	N	Model 1			Model 2					
					2G			1G		
		β	SE	t	β	SE	t	β	SE	t
Australia	4505	− 0.088***	0.019	− 4.689	0.078***	0.018	4.335	0.092***	0.016	5.642
Bahrain	2703	− 0.014	0.016	− 0.876	0.034*	0.014	2.345	0.043**	0.014	3.092
Cyprus	1739	0.092***	0.021	4.406	− 0.034*	0.017	− 2.055	− 0.107***	0.022	− 4.764
England	1796	− 0.097***	0.022	− 4.330	0.083***	0.021	3.982	0.100***	0.024	4.235
Finland	2366	0.022	0.013	1.702	− 0.021	0.017	− 1.279	0.003	0.011	0.245
France	1904	0.054**	0.019	2.820	− 0.051**	0.018	− 2.749	− 0.016	0.021	− 0.743
Hong Kong	1491	− 0.032	0.023	− 1.405	− 0.008	0.023	− 0.342	0.090***	0.024	3.759
Ireland	1973	− 0.060***	0.018	− 3.233	0.036	0.020	1.799	0.061***	0.018	3.353
Italy	1790	0.056**	0.020	2.824	− 0.024	0.021	− 1.125	− 0.029*	0.015	− 1.972
Jordan	3307	0.055***	0.015	3.746	0.010	0.014	0.695	− 0.003	0.014	− 0.212
Kazakhstan	2188	0.045*	0.020	2.190	0.005	0.018	0.272	− 0.011	0.015	− 0.721
Kuwait	2445	− 0.080***	0.022	− 3.663	0.020	0.027	0.758	0.111***	0.029	3.862
New Zealand	2935	− 0.079***	0.016	− 4.832	0.067***	0.012	5.429	0.098***	0.016	5.998
Norway	2252	0.044*	0.018	2.428	− 0.008	0.017	− 0.439	− 0.012	0.018	− 0.644
Oman	3342	0.062***	0.017	3.630	− 0.034***	0.011	− 3.260	0.013	0.019	0.691
Portugal	1695	0.063**	0.022	2.938	− 0.017	0.018	− 0.899	− 0.039*	0.019	− 2.049
Qatar	1899	− 0.131***	0.025	− 5.295	0.040	0.024	1.704	0.134***	0.026	5.099
Saudi Arabia	2884	0.019	0.015	1.289	0.022	0.015	1.480	0.046**	0.014	3.277
Singapore	2366	− 0.118***	0.015	− 7.714	0.099***	0.013	7.884	0.136***	0.018	7.620
South Africa	11,082	0.009	0.008	1.069	− 0.001	0.007	− 0.187	0.031**	0.012	2.607
Sweden	1945	0.032	0.017	1.920	− 0.059**	0.019	− 3.078	0.036	0.019	1.860
United Arab Emirates	10,991	− 0.048***	0.010	− 4.830	0.045***	0.011	4.230	0.090***	0.012	7.713
United States	4344	0.026	0.014	1.875	0.009	0.014	0.648	0.028**	0.011	2.669

For Model 1, regressions were run with students with non-native as the reference category; For Model 2, regressions were run with native students as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 13 Regression analysis results for enjoyment regressed on immigration status as in native vs. non-native (Model 1) and enjoyment regressed on immigrant status as native vs. non-native and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Immigrant status*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	− 0.145***	0.021	− 7.003	− 0.091***	0.019	− 4.78	0.372***	0.018	20.868
Bahrain	2703	− 0.104***	0.017	− 6.302	− 0.100***	0.017	− 5.85	0.196***	0.019	10.518
Cyprus	1739	0.011	0.020	0.538	− 0.029	0.019	− 1.49	0.369***	0.019	19.467
England	1796	− 0.114***	0.023	− 4.927	− 0.114***	0.024	− 4.78	0.236***	0.024	9.661
Finland	2366	− 0.046*	0.018	− 2.510	− 0.108***	0.021	− 5.04	0.455***	0.017	26.773
France	1904	0.047*	0.020	2.290	− 0.043*	0.020	− 2.14	0.362***	0.021	17.078
Hong Kong	1491	− 0.027	0.021	− 1.271	− 0.039*	0.020	− 2.02	0.304***	0.025	12.382
Ireland	1973	− 0.090***	0.020	− 4.537	− 0.105***	0.021	− 5.09	0.329***	0.019	17.671
Italy	1790	0.033	0.019	1.757	− 0.002	0.019	− 0.10	0.352***	0.021	16.497
Jordan	3307	0.041*	0.016	2.541	0.033*	0.016	2.05	0.154***	0.020	7.678
Kazakhstan	2188	0.047**	0.015	3.074	0.041**	0.015	2.73	0.160***	0.029	5.451
Kuwait	2445	− 0.120***	0.019	− 6.176	− 0.096***	0.017	− 5.63	0.153***	0.026	5.916
New Zealand	2935	− 0.169***	0.019	− 8.877	− 0.156***	0.018	− 8.82	0.281***	0.018	15.948
Norway	2252	− 0.057**	0.020	− 2.816	− 0.126***	0.019	− 6.47	0.442***	0.016	27.615
Oman	3342	0.065***	0.016	4.026	0.085***	0.016	5.30	0.274***	0.016	16.909
Portugal	1695	0.057**	0.020	2.812	0.011	0.018	0.59	0.373***	0.022	17.133
Qatar	1899	− 0.185***	0.024	− 7.580	− 0.094***	0.024	− 3.88	0.207***	0.026	8.049
Saudi Arabia	2884	− 0.020	0.019	− 1.021	− 0.015	0.019	− 0.80	0.142***	0.021	6.662
Singapore	2366	− 0.085***	0.015	− 5.818	− 0.043**	0.014	− 3.00	0.325***	0.015	22.122
South Africa	11,082	0.026**	0.010	2.602	0.018	0.010	1.84	0.106***	0.015	7.303
Sweden	1945	− 0.139***	0.018	− 7.765	− 0.248***	0.020	− 12.49	0.407***	0.019	21.905
United Arab Emirates	10,991	− 0.101***	0.010	− 10.256	− 0.019	0.010	− 1.83	0.219***	0.011	20.278
United States	4344	− 0.049**	0.016	− 3.062	− 0.080***	0.015	− 5.22	0.277***	0.019	14.331

Regressions were run with students with n as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 14 Regression analysis results for enjoyment regressed on immigration status as in native vs. non-native (Model 1) and enjoyment regressed immigration status as in first-generation immigrant status vs. second-generation immigrant status (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*2G*			*1G*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	− 0.145***	0.021	− 7.003	0.111***	0.018	6.061	0.139***	0.020	7.126
Bahrain	2703	− 0.104***	0.017	− 6.302	0.075***	0.014	5.244	0.107***	0.020	5.304
Cyprus	1739	0.011	0.020	0.538	0.023	0.024	0.960	− 0.028	0.016	− 1.759
England	1796	− 0.114***	0.023	− 4.927	0.090***	0.020	4.406	0.116***	0.029	4.020
Finland	2366	− 0.046*	0.018	− 2.510	0.023	0.014	1.709	0.066***	0.015	4.324
France	1904	0.047*	0.020	2.290	− 0.052**	0.019	− 2.758	0.004	0.024	.159
Hong Kong	1491	− 0.027	0.021	− 1.271	0.011	0.023	0.503	0.063***	0.017	3.835
Ireland	1973	− 0.090***	0.020	− 4.537	0.053**	0.019	2.796	0.084***	0.019	4.494
Italy	1790	0.033	0.019	1.757	− 0.020	0.021	− 0.926	0.000	0.016	− 0.009
Jordan	3307	0.041*	0.016	2.541	− 0.028*	0.013	− 2.180	0.012*	0.006	2.243
Kazakhstan	2188	0.047**	0.015	3.074	− 0.008	0.015	− 0.524	0.000	0.016	0.018
Kuwait	2445	− 0.120***	0.019	− 6.176	0.071***	0.021	3.365	0.128***	0.017	7.500
New Zealand	2935	− 0.169***	0.019	− 8.877	0.129***	0.015	8.616	0.184***	0.020	9.301
Norway	2252	− 0.057**	0.020	− 2.816	0.052*	0.021	2.481	0.095***	0.019	5.029
Oman	3342	0.065***	0.016	4.026	− 0.035**	0.011	− 3.170	0.015	0.018	0.864
Portugal	1695	0.057**	0.020	2.812	− 0.014	0.019	− 0.780	− 0.021	0.017	− 1.248
Qatar	1899	− 0.185***	0.024	− 7.580	0.078***	0.022	3.487	0.208***	0.025	8.446
Saudi Arabia	2884	− 0.020	0.019	− 1.021	0.031*	0.014	2.238	0.042**	0.013	3.127
Singapore	2366	− 0.085***	0.015	− 5.818	0.064***	0.014	4.488	0.110***	0.016	6.944
South Africa	11,082	0.026**	0.010	2.602	− 0.005	0.010	− 0.528	0.023*	0.011	2.059
Sweden	1945	− 0.139***	0.018	− 7.765	0.028	0.018	1.530	0.187***	0.018	10.330
United Arab Emirates	10,991	− 0.101***	0.010	− 10.256	0.070***	0.009	7.822	0.130***	0.012	10.590
United States	4344	− 0.049**	0.016	− 3.062	0.048***	0.014	3.328	0.075***	0.013	5.914

For Model 1, regressions were run with students with non-native as the reference category; For Model 2, regressions were run with native students as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

(13.0%; Jordan, Kazakhstan, and Oman) reveal the opposite trend, and around a quarter of the countries ($N=6$, 26.1%) show no significant gap in enjoyment between natives and non-natives. In fact, the inclusion of achievement only decreased the number of countries with a gap benefiting natives ($N=3$) and increased by one the number of countries benefitting non-natives in regard to math enjoyment. Table 14 shows differences in effects according to immigrant generation, that is, presenting the effects separately for 1G and 2G immigrant students.

When looking into the differences between natives and non-natives in terms of their attributed math value (see Fig. 5c; and Model 1 of Table 15), three quarters ($N=17$; 73.9%) of the countries considered for analysis reveal significant differences. However, as said, these are mixed. While the majority of these 17 countries suggested that non-natives attributed more value to math ($N=12$; 52.2%), five countries reveal the opposite trend (21.7%). Controlling for achievement did not lead to a major change in the initial observed trend (see Fig. 6c; and Model 2 of Table 15), with 12 countries (52.2%) still showing a significant gap benefiting non-natives, and now three countries (13.0%; Kazakhstan, Oman, and South Africa) with a gap benefiting natives. Table 16 shows differences in effects according to immigrant generation, that is, presenting the effects separately for 1G and 2G immigrant students.

Finally, about three quarters of the analyzed countries (N = 17; 73.9%) revealed an achievement gap, but once again results showed lack of consistency across nations. In 11 countries (47.8%) natives showed higher achievement than non-natives, whereas in six countries (26.1%) the opposite was seen to be true. As for 1G immigrant students, they do show an advantage in achievement compared to native students in nine countries (39.1%), however, the opposite is true for seven countries (30.4%). When looking into 2G immigrant students, these show higher achievement in 12 countries (52.2%), whereas the opposite is true for five countries (21.7%) (see Fig. 7a and Table 7).

When interpreting the results on immigration gaps, it is important to consider that the meaning of the migration variable varies across countries. Characteristics of the country of origin, race, and reasons for migration differ both at the individual level and between countries. In this study, we provide an initial approach, acknowledging that the variation in immigration-related results highlights the need for further research and more differentiated analyses.

Correlation between gaps

Figure 8 shows the correlation trends among gaps. Only two associations stand out as statistically significant. For both value ($r=-0.54$, $p\leq0.01$) and enjoyment ($r=-0.59$, $p\leq0.01$), there is a negative and significant correlation between the immigrant and gender gap. This means that in countries in which non-natives show higher value and enjoyment towards math, there is a tendency for boys to also report higher levels of value and enjoyment. More detailed graphs on correlations between gaps, with visualization for each country correlation, can be found in Fig. 9. Figure 10 also allows for the exploration of all 12 gaps explored in our analysis, in a summed-up view. Overall, we highlight: (a) a positive and significant correlation between the achievement and confidence gap for all predictors—meaning that when there is a gap benefitting boys, natives and high PE students in achievement, there tends to be one benefitting boys,

Table 15 Regression analysis results for value regressed on immigration status as in native vs. non-native (Model 1) and value regressed on immigrant status as native vs. non-native and achievement (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*Immigrant status*			*Achievement*		
					β	*SE*	*t*	*β*	*SE*	*t*
Australia	4505	− 0.079***	0.020	− 4.025	− 0.047*	0.019	− 2.484	0.215***	0.020	10.829
Bahrain	2703	− 0.086***	0.016	− 5.398	− 0.084***	0.015	− 5.421	0.122***	0.014	8.686
Cyprus	1739	0.011	0.019	0.603	− 0.016	0.018	− 0.860	0.253***	0.020	12.494
England	1796	− 0.103***	0.026	− 3.935	− 0.103***	0.026	− 3.899	0.072**	0.024	2.972
Finland	2366	− 0.041*	0.020	− 2.063	− 0.087***	0.022	− 3.890	0.338***	0.017	20.346
France	1904	0.002	0.019	0.130	− 0.039*	0.020	− 1.989	0.166***	0.019	8.571
Hong Kong	1491	− 0.003	0.025	− 0.105	− 0.012	0.022	− 0.555	0.226***	0.026	8.635
Ireland	1973	− 0.053**	0.019	− 2.840	− 0.062**	0.019	− 3.206	0.206***	0.018	11.147
Italy	1790	− 0.012	0.020	− 0.581	− 0.027	0.021	− 1.316	0.158***	0.024	6.491
Jordan	3307	0.041*	0.018	2.324	0.035	0.018	1.919	0.147***	0.023	6.309
Kazakhstan	2188	0.040*	0.016	2.547	0.038*	0.016	2.442	0.048	0.025	1.920
Kuwait	2445	− 0.063**	0.021	− 2.941	− 0.045*	0.021	− 2.153	0.120***	0.022	5.419
New Zealand	2935	− 0.134***	0.026	− 5.073	− 0.128***	0.026	− 4.906	0.122***	0.018	6.708
Norway	2252	− 0.102***	0.019	− 5.266	− 0.140***	0.020	− 7.033	0.246***	0.021	11.627
Oman	3342	0.084***	0.014	6.104	0.100***	0.014	7.060	0.211***	0.018	11.627
Portugal	1695	0.072***	0.021	3.408	0.036	0.022	1.656	0.291***	0.027	10.835
Qatar	1899	− 0.144***	0.022	− 6.533	− 0.090***	0.024	− 3.820	0.122***	0.032	3.849
Saudi Arabia	2884	− 0.003	0.019	− 0.156	0.000	0.019	0.008	0.088***	0.021	4.250
Singapore	2366	− 0.067***	0.015	− 4.403	− 0.049**	0.015	− 3.198	0.134***	0.020	6.661
South Africa	11,082	0.045***	0.012	3.800	0.032**	0.012	2.715	0.169***	0.015	11.315
Sweden	1945	− 0.160***	0.020	− 7.887	− 0.210***	0.022	− 9.390	0.189***	0.022	8.730
United Arab Emirates	10,991	− 0.057***	0.011	− 5.321	0.014	0.010	1.447	0.189***	0.012	15.853
United States	4344	− 0.011	0.015	− 0.746	− 0.027	0.014	− 1.911	0.137***	0.017	8.237

Regressions were run with students with an immigrant background as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 16 Regression analysis results for value regressed on immigration status as in native vs. non-native (Model 1) and value regressed immigration status as in first-generation immigrant status vs. second-generation immigrant status (Model 2)

Country	N	Model 1			Model 2					
		β	*SE*	*t*	*2G*			*1G*		
					β	*SE*	*T*	*β*	*SE*	*t*
Australia	4505	− 0.079***	0.020	− 4.025	0.066***	0.017	3.978	0.109***	0.018	6.047
Bahrain	2703	− 0.086***	0.016	− 5.398	0.032	0.017	1.840	0.086***	0.014	6.256
Cyprus	1739	0.011	0.019	0.603	0.018	0.021	0.823	− 0.016	0.018	− 0.928
England	1796	− 0.103***	0.026	− 3.935	0.074***	0.019	3.799	0.106***	0.020	5.347
Finland	2366	− 0.041*	0.020	− 2.063	0.053***	0.015	3.483	0.044*	0.020	2.223
France	1904	0.002	0.019	0.130	− 0.005	0.020	− 0.257	0.023	0.018	1.260
Hong Kong	1491	− 0.003	0.025	− 0.105	0.014	0.019	0.735	0.067**	0.022	3.031
Ireland	1973	− 0.053**	0.019	− 2.840	0.051**	0.018	2.764	0.065***	0.013	4.822
Italy	1790	− 0.012	0.020	− 0.581	0.015	0.019	0.777	0.025	0.020	1.254
Jordan	3307	0.041*	0.018	2.324	0.000	0.021	0.016	0.015	0.010	1.411
Kazakhstan	2188	0.040*	0.016	2.547	− 0.007	0.015	− 0.483	− 0.003	0.020	− 0.127
Kuwait	2445	− 0.063**	0.021	− 2.941	0.039**	0.014	2.785	0.068***	0.019	3.653
New Zealand	2935	− 0.134***	0.026	− 5.073	0.095***	0.025	3.754	0.151***	0.020	7.446
Norway	2252	− 0.102***	0.019	− 5.266	0.090***	0.015	6.022	0.097***	0.025	3.795
Oman	3342	0.084***	0.014	6.104	− 0.020*	0.010	− 1.972	− 0.006	0.016	− 0.398
Portugal	1695	0.072***	0.021	3.408	− 0.025	0.014	− 1.761	− 0.025	0.021	− 1.227
Qatar	1899	− 0.144***	0.022	− 6.533	0.063***	0.018	3.537	0.139***	0.023	6.036
Saudi Arabia	2884	− 0.003	0.019	− 0.156	0.031*	0.014	2.180	0.030	0.015	1.943
Singapore	2366	− 0.067***	0.015	− 4.403	0.032*	0.016	2.019	0.095***	0.014	6.851
South Africa	11,082	0.045***	0.012	3.800	− 0.006	0.009	− 0.661	0.021	0.015	1.414
Sweden	1945	− 0.160***	0.020	− 7.887	0.092***	0.022	4.211	0.149***	0.018	8.073
United Arab Emirates	10,991	− 0.057***	0.011	− 5.321	0.056***	0.010	5.810	0.090***	0.013	7.140
United States	4344	− 0.011	0.015	− 0.746	0.023*	0.011	2.141	0.043***	0.011	3.940

For Model 1, regressions were run with students with non-native as the reference category; For Model 2, regressions were run with native students as the reference category

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

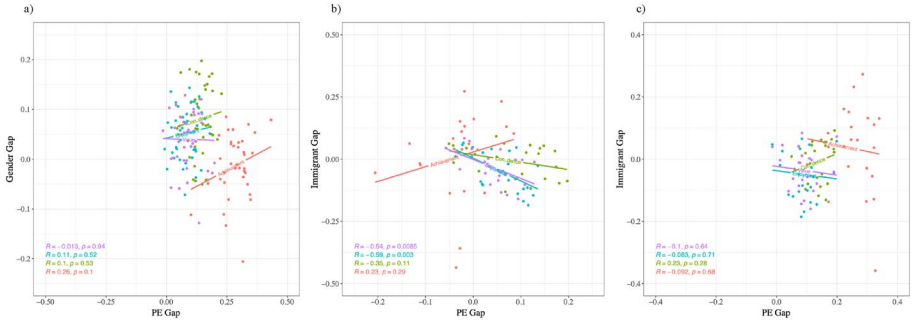

Fig. 8 Correlations between gender and PE (**a**), gender and immigration status (**b**), and PE and immigrant status (**c**) gaps concerning achievement, math confidence, math enjoyment and math value. Axis ranges differ between figures **a**–**c** due to varying coefficient extremes in each correlation analysis. Each image has been scaled appropriately to accurately reflect its respective range of correlation values

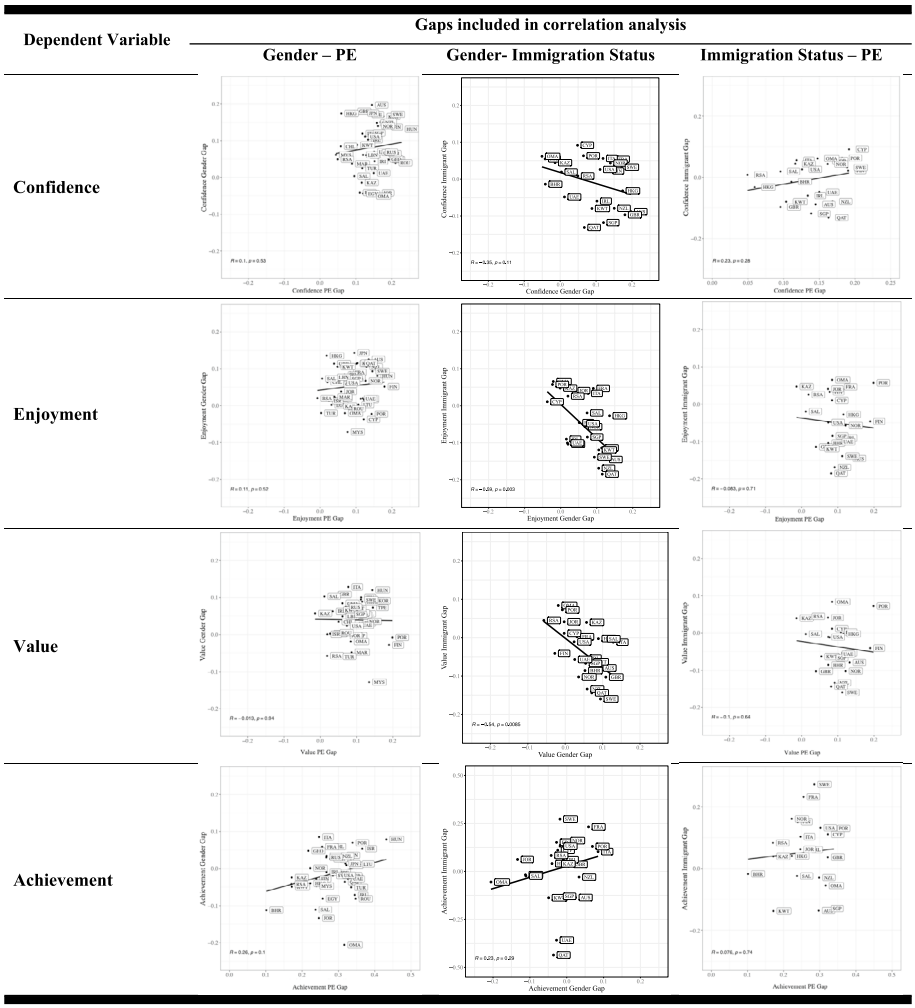

Fig. 9 Correlations between gaps for each confidence, enjoyment, value, and achievement. Axis ranges differ between figures due to varying coefficient extremes in each correlation analysis. Each image has been scaled appropriately to accurately reflect its respective range of correlation values

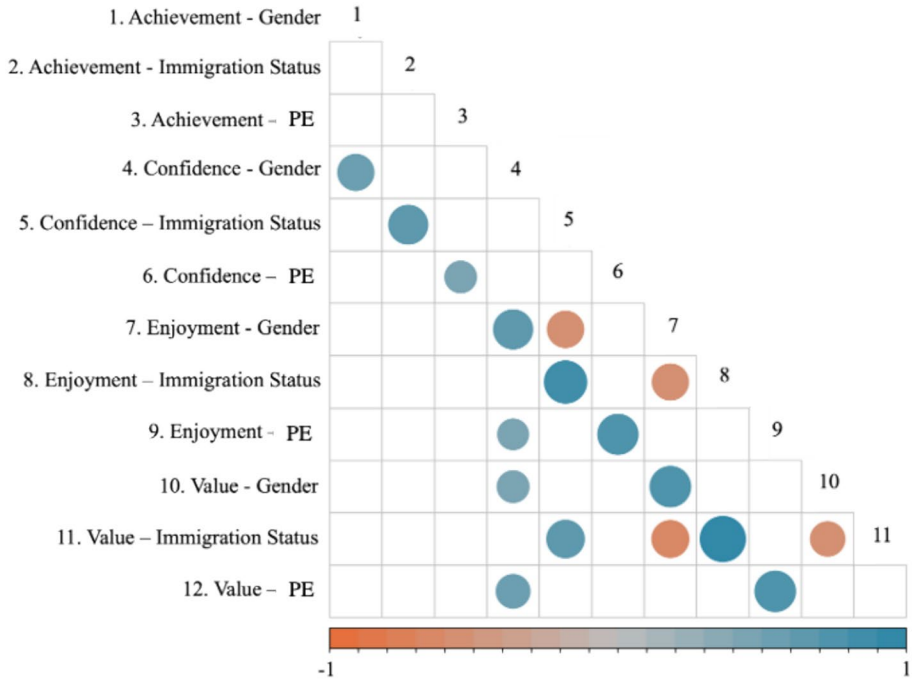

Fig. 10 Significant correlations between all 12 analyzed gaps. Negative significant correlations are presented in red and positive significant correlations are presented in blue; the size of the circle corresponds to the level of significance of the correlation (smaller circles: $p \leq 0.05$; medium circles: $p \leq 0.01$; biggest circles: $p \leq 0.001$)

natives and high PE students (respectively) in confidence as well; (b) a positive and significant correlation between the enjoyment and confidence gaps for each predictor; and (c) a positive and significant correlation between the enjoyment and value gaps for each predictor.

Discussion

The goal of this study was to investigate existent math affective gaps within social groups, based on gender, SES (in this case, using PE as an indicator), and immigration status, while similarly assessing and controlling for achievement gaps. Partly, we aimed at exploring the extent to which the researched academic achievement gap is mirrored in affective skills—a learning domain that has been relatively understudied. This investigation seeks to contribute to the existing literature by addressing the scarcity of research into affective gaps related to gender, SES, and immigration status, and by doing it cross-nationally. We start by discussing the observed results of math affective gaps and end generally looking into the achievement gaps.

Math confidence

Although the exploration of confidence gaps is scarce, previous research suggests that boys reveal higher confidence than girls (e.g., Bharadwaj et al., 2016; Radišić et al., 2024; Rodríguez et al., 2020). Our results were in accordance with such expectation, since about three quarters of the participating countries showed that boys significantly reported higher confidence than girls. Only Bahrain, Jordan, Egypt, and Oman showed the opposite trend. Whereas some might argue that this result would be

explained by higher achievement due to their highly positive associations—which has been extensively reported in previous literature (e.g., Du et al., 2021; Huang, 2011; Lee et al., 2022; Recber et al., 2018; Usher & Pajares, 2009)—our findings seem to partly refute such argument. Firstly, our results regarding achievement were not clear on a strong advantage for boys with TIMSS 2019 data for the eighth grade—while only six countries showed higher math achievement for boys, a total of 30 countries showed higher confidence for boys. This suggests some sort of imbalance in boys' perceived competence and their actual obtained achievement. Secondly, our second phase of analysis included controlling achievement, and even when doing so, 28 out of 39 countries still demonstrated higher confidence for boys, and a positive and significant pooled effect. Our results might be related to the Dunning-Kruger Effect (DKE), which refers to a cognitive phenomenon characterized by a mismatch between perceived and actual competence. The DKE might be revealed in two main ways: those students with low ability/knowledge that overestimate their competence; and those with high ability/knowledge but who underestimate their competence (e.g., Kruger & Dunning, 1999). It has also been reported that the DKE is especially prone to be found among low-achievers (Hansen et al., 2024). Concerning gender, some evidence has suggested that boys tend to overestimate their performance more than girls (e.g., Boekaerts & Rozendaal, 2010), although results are rather inconclusive as there is also significant research reporting no significant differences between genders (e.g., Tashiro et al., 2021). On top of that, we also know that some cultures (such as those characterized as being more collectivist) are more patriarchal in nature and hold views that are more traditional towards gender, therefore leading to higher gender inequality favoring males over females (e.g., Dormekpor, 2015). In this context, these types of cultures recur to the process of socialization that promote the idea that mathematics is a subject "for boys" and that girls do not have the capacities to be good at it (Meece & Scantlebury, 2006), which could partly explain the imbalance of math confidence between genders. Another explanation might be found in theories of personality. Overall, we find that boys consistently report higher self-assessments than girls in mathematics-related affective variables. This result aligns with research on gender differences in personality traits, which indicates that women tend to score higher on neuroticism (e.g., Schmitt et al., 2017). However, as in our study, these differences vary across countries. The extent to which early gender gaps in subject-specific attitudes are reinforced, as well as the role of general personality traits— which are themselves shaped by cultural factors—remain important questions for future research.

As for PE, it was observed that when not controlling for achievement, there was a consistent gap in all countries in which students with high PE (i.e., in this case, students with at least one parent with a HE degree) revealed higher math confidence. However, when controlling for achievement, the scenery changed, with only about a third of the countries maintaining such effect (however, the positive and significant pooled effect was kept). These findings were rather interesting, as they suggest that a big part of PE's effect on math confidence might be due to the obtained achievement, possibly because these students have higher access to educational resources (e.g., Bradley et al., 2003), tend to have less experiences that foster reading acquisition (e.g.,

Buckingham et al., 2013), and have, overall, more economic, social and human capital to help their development and educational path (e.g., Bradley & Corwyn, 2002).

Immigration status presented a varied picture, with some countries favoring native students in confidence, others showing the opposite trend, and some displaying no significant gap. The results remain similar even when controlling for achievement. This landscape underscores the intricate dynamics of sociodemographic factors in shaping students' math confidence. We also highlight that migration trends as well as cultural views on immigration vary across nations, and this might partly explain the variation in these results.

Math enjoyment

Looking into differences in math enjoyment having gender as a predictor, a prevalent gender-based enjoyment gap favouring boys was observed in the majority of countries, as was previously suggested by existing research (e.g., Bharadwaj et al., 2016; Ganley & Lubienski, 2016; Gaspard et al., 2015; Nagy et al., 2006). Only one country—Malaysia—revealed that girls enjoyed math learning significantly more than boys. This trend is maintained when controlling for achievement, although positive emotions towards math have been showed to be positively associated with higher achievement (Forsblom et al., 2022; García et al., 2016; Raccanello et al., 2018), which means that this relationship is likely not fully explicative of the existing gender gap for math enjoyment.

The enjoyment gap between students of parents with and without HE demonstrated a general trend in which for most countries, students whose parents had at least one HE degree showed higher enjoyment toward math learning. In particular, nine countries showed no significant gap in this regard, while the remaining revealed a gap benefitting students of parents with a HE degree. However, this trend becomes less clear when controlling for achievement, which might suggest that part of the reason why students of parents without HE enjoy math less is due to their lower achievement, or vice-versa. The described results suggest that math enjoyment is not as dependent on PE and math confidence, as we observed that there were nine countries in which there was no gap in math enjoyment when comparing students of low and highly educations parents (in comparison to no countries with no gap for the case of confidence). We recommend that some investment is made in understanding why such gap is not observed in these countries, as means to understand possible mechanisms that might be helping to buffer the PE enjoyment gap in these countries.

As for immigration status, we saw that there was some variability of results, but that in more than half the countries in the analysis (56.5%), non-natives enjoyed math more than natives, with this pattern being stronger for 1G immigrants. On the other hand, six countries had a gap benefitting natives and the remaining revealed no significant gap. Accounting for achievement didn't change this trend considerably, and in fact showed one more country benefitting non-natives and three less countries benefitting natives, strengthening the advantage of non-natives in math enjoyment in most countries.

Math value

In the analysis of the value gaps, notably, the gender-based value gap predominantly favored boys in around half the participating countries, and the opposite trend was only

significant in four countries. This complements the limited existing research (e.g., Gaspard et al., 2015). When taking achievement into account, the pattern did not change much, with the only change being the addition of new three countries showing a gap benefitting boys. However, we highlight that for math value the benefit for boys is not as clear as is the case for confidence.

Additionally, the value gap between students of parents with and without HE indicated a widespread positive association of high PE with math value, emphasizing that students with higher PE consistently attribute higher value to math. However, it is worth noting that a few countries did not exhibit a significant difference in this aspect, introducing variability in the association between PE and attributed value of math. When controlling for achievement, the initial effect is slightly diminished, but the general pattern remains.

Regarding the immigration gap, once again diverse patterns were evident, with some countries favoring native students, others showing a positive gap for non-natives, and some displaying no significant gap. The mixed patterns of results remained similar even when controlling for achievement. These findings accentuate the multifaceted nature of how students from different backgrounds attribute value to mathematics. More research is needed to complement these results, as there is a lack of evidence looking into attributed math value within minority communities (Safavian & Conley, 2016).

Even though the goal of this study was to explore general and universal trends concerning affective gaps for math learning, we nevertheless underscore a few clear national trends. In particular, we can see that only one country consistently shows no gender gap in all three affective components: the United Arab Emirates. We also see that for this country, the gender achievement gap is also not significant. In this sense, we can highlight the United Arab Emirates stands out as showing gender equality for both the achievement and affective component of math-learning, based solely on these results of TIMSS 2019.

Finally, and in what concerns immigration status, we have observed that this is the social grouping that leads to less consistent gaps among different nations. Yet, there are specific countries that seem to benefit natives for all three affective components of learning: Oman, Portugal, Kazakhstan, and Jordan. In these countries, natives are consistently more confident, show more enjoyment and value math more than non-natives. However, in Oman, non-natives achieve better than natives, whereas in Kazakhstan there is no achievement gap in this regard. As for Portugal and Jordan, in these countries natives also achieve higher than non-natives. Hence, we highlight both Portugal and Jordan as two countries in which students with an immigrant background are especially disadvantaged, both in terms of math achievement and their affective relationship with math learning. While these results are evident in absolute figures, we should note that immigration patterns differ across countries and this may affect our results, and the way we consider comparability between nations, as one might fall into the error of comparing different cultures and realities biasedly. Factors such as cultural differences and immigration trends will lead to different realities and possibly explain differences between countries.

Again, one should point out that these results are only stemming from TIMSS 2019 data and replications should be conducted in order to draw conclusions more confidently. Moreover, when it comes to gaps related to immigration status and country

comparison, it is extremely important for future research to consider the relevance of different migration trends and patterns which highly differ across nations. Migration trends, including the SES of migrants and the level of support available to them, might influence the integration of non-natives into national education systems. By considering these factors, future studies could better inform system-level policies that aim to reduce disparities in mathematics education, both in terms of academic achievement and a positive affective adaptation.

The analysis of correlations between gaps was also quite interesting and allowed for the detection of specific phenomenon. Firstly, we saw that the immigrant gap and gender gap for both enjoyment and value are negatively correlated with one another—which means, in general, that in countries in which students with an immigrant background show higher enjoyment and value attributed to math, tend to also show a gap benefitting boys (see Fig. 8). This result suggests the possibility of the existence of a profile of countries characterized by the presence of a gap benefitting boys and non-native students in what concerns math value and enjoyment. It might be useful for future research to explore what specific factors in these countries lead to such trend—by conducting, for instance, qualitative research aiming at understanding affective experiences in math learning and analyzing it by both gender and immigration status. Additionally, the variation of these correlations among different countries, as show in Fig. 9, also suggests that this trend is not universal, which highlights the importance of context-specific situations and solutions. Although the exploration of correlations between these gaps gives us insights about the possible interactions between the affective outcome and social variables, a better methodology to address this research question would include investigating interaction effects between different social variables. This could include, for example, investigating how the effects of immigration status on affective outcomes might vary across different levels of SES, or how gender gaps in affective components of math learning might differ between native and non-native students. Such interaction analysis has the potential of discerning specific subgroups of students who might be more at risk than others as well those who are more resilient. Moreover, this approach may be able to provide specific information for different nations and identify which educational systems might be more beneficial for subgroups of immigrant students, potentially guiding future educational policies and interventions. We highlight the need for investigation looking into this research question.

Furthermore, when crossing all analysed gaps, we can find more relevant patterns. Explicitly, we observe that achievement gaps are positively and significantly correlated with confidence gaps, for all predictors; however, this does not happen for both value and enjoyment. In other words, according to our results, countries where there is an achievement gap tend to be the same in which there is a confidence gap for all three predictors (i.e., gender, PE, and immigration status). Likewise, countries in which there is an enjoyment gap tend to be the same in which there is a confidence gap for each predictor; and in the countries where there is an enjoyment gap, there tends to be a value gap for all predictors. In this sense, we can have a general overview of the main interactions between achievement, confidence, enjoyment, and value in what concerns math. Specifically, we see that achievement mostly correlates positively and significantly with confidence; confidence, besides achievement, correlated positively and significantly with

enjoyment; and enjoyment, besides confidence, correlated positively and significantly with value.

Finally, we also assessed the achievement gaps in the different social groups, as to investigate to what extent they replicated previous literature. Overall, two-thirds of countries showed no significant gender gap in math achievement. Countries with a gap varied in direction, showing no consistent trend. These findings diverge from prior studies (Bharadwaj et al., 2016; Contini et al., 2017; Nagy et al., 2006; Strello et al., 2023), that suggested a consistent male advantage, though most of these studies focused on single countries. On the other hand, all countries showed a PE gap, consistent with evidence that higher SES correlates with better math achievement (Broer et al., 2019; Chmielewski, 2019; Strello et al., 2023). This highlights the importance of policies supporting low-SES students to close achievement gaps. Finally, immigration status effects were mixed. About three-quarters of countries displayed gaps, with two-thirds favouring native students (e.g., Cyprus, Finland, France) and one-third favouring non-natives (e.g., Australia, Kuwait, Qatar). Notably, EU countries predominantly showed a gap favouring natives.

Regional patterns and potential cultural explanations

While this study is largely exploratory, certain patterns emerge that raise important questions for future research. Previous work by Johansson and Strietholt (2019) on mathematics performance profiles identified clusters of countries with distinct strengths and weaknesses in different mathematical subdomains. For example, English-speaking and Nordic countries constituted a cluster that exhibited different performance patterns compared to post-Soviet countries. The authors attributed these differences to cultural factors reflected in national curricula. Similar regional clustering has been observed in other studies, such as gender disparities in mathematics achievement, where boys tend to outperform girls in most countries—except in several Arab states, where the gap is reversed (e.g., Hastedt, 2016; Neuschmidt et al., 2022). Our findings provide preliminary evidence for such well-documented regional patterns. In many countries, we observe gender gaps favoring boys in mathematics-related affective factors, whereas these gaps tend to be smaller in Arab countries, aligning with earlier findings on achievement disparities (Hastedt, 2016). Additionally, in the context of immigration, we identify clusters of countries where migration-related gaps follow consistent trends. In English-speaking and Nordic countries, for instance, migration gaps tend to be larger and generally disadvantage immigrant students.

These regional patterns highlight the need for further research to explore the underlying institutional and cultural factors that shape these differences. Our findings shine a light on the potential impacts on culture in understanding math achievement as well as math affective components of learning across gender, SES and immigration status. Hofstede's (1980, 2010) cultural dimension theory divides culture into multiple dimensions: power distance, individualism/collectivism, masculinity/femininity, uncertainty avoidance, long-term and short-term orientation, and indulgency/restraint. Picking up on these terms, for instance, Hu et al. (2018) observed that countries with long-term orientation (nations which value the importance of virtues that lead to rewards in the future, like perseverance and resilience) tend to show higher math

achievement. As for affective aspects of math learning, as expected, not much research has been conducted, but some academics have explored the impacts of belonging to more individualistic or collectivistic nation on math enjoyment, motivation and self-efficacy (e.g., Bong et al., 2014; Diener et al., 2003; Mullis et al., 2016; Scheor et al., 2013). Yet, more research is paramount to draw more reliable conclusions on the subject of cultural aspects cross-nationally and their relevance in explaining math affective and academic gaps, and therefore we highlight the importance of this topic being strongly addressed in future research.

Limitations and contributions

When interpretating our results one should be careful not to draw conclusions without precautions. Our study draws from only one international large-assessment dataset and results ought to be replicated before confidently identifying them as established trends and/or phenomenon. Plus, our analyses rely on self-reported data which are subjective and potentially influenced by social desirability and cultural norms. Furthermore, this study is a cross-sectional study, meaning that we cannot establish causal relationships from the performed regression analysis. We should also consider that this investigation focuses on inequalities of outcome instead of inequalities of opportunity, and it would be interesting to reinforce our results by performing similar analysis in the context of opportunity, as this would allow for a more complete understanding of the processes and systemic factors contributing to the observed inequalities. Additionally, our research design does not account for within-school differences, which are likely to partly explain affective experiences of students. Nevertheless, our design and results contribute significantly to the existing literature on affective components of math learning and inequalities in education. Its novel approach to inequality beyond achievement follows a crescent trend looking to a more holistic approach to school adjustment and recognizing cross-country variation due to cultural and systemic differences. Future research should replicate these analyses with more diverse data, both national (looking, for instance, at between- and within-school differences) and international, and address the above-mentioned limitations to further extend the knowledge about affective and achievement inequalities in math learning amongst different social groups.

Conclusion

In conclusion, our examination of math-related affective gaps manifested intricate patterns across confidence, enjoyment, and attributed value. The gender disparities observed in confidence and enjoyment, with boys generally holding a clear advantage, highlight potential challenges in fostering gender-equitable learning experiences. PE was positively associated with confidence and enjoyment levels, emphasizing the role of PE in shaping students' affective experiences toward math learning. Moreover, the nuanced immigration-related gaps underscore the need for context-specific interventions to better address the diverse dynamics within different countries.

When juxtaposed with the well-documented achievement gap, our findings unveil a comprehensive portrait of students' math-related experiences. Affective gaps provide additional layers of understanding, showcasing how students' confidence, enjoyment and attributed value contribute to their overall engagement with the subject. Acknowledging

and addressing these affective gaps alongside the academic achievement is crucial for devising effective educational strategies that promote both learning outcomes and positive affective experiences in mathematics. This holistic perspective offers valuable insights into the multifaceted nature of educational disparities and informs targeted interventions to enhance students' overall math experiences.

Since we examined affective gaps using standardized measures from an international perspective, we can—to some extent—compare the results across countries, and observe significant variations in these gaps between countries. We interpret these findings as an indication that explanatory variables for affective differences are, at least partially, situated at the institutional level. Countries differ in terms of their culture, the role of affective variables in national curricula, and the characteristics of their education systems. While investigating which country-level characteristics correlate with or explain affective gaps was not the focus of this study, the substantial variation observed across countries underscores the need for further comparative research on this issue.

Appendix A. Items for dependent measures

	TIMSS item code
Math enjoyment	
1. I enjoy learning mathematics	BSBM16A
2. I wish I did not have to study mathematics	BSBM16B
3. Mathematics is boring	BSBM16C
4. I learn many interesting things in mathematics	BSBM16D
5. I like mathematics	BSBM16E
6. I like any schoolwork that involves numbers	BSBM16F
7. I like to solve mathematics problems	BSBM16G
8. I look forward to mathematics lessons	BSBM16H
9. Mathematics is one of my favorite subjects	BSBM16I
Math confidence	
1. I usually do well in mathematics	BSBM19A
2. Mathematics is hard for me than for my classmates	BSBM19B
3. I am just not good at mathematics	BSBM19C
4. I learn things quickly in mathematics	BSBM19D
5. Mathematics makes me feel nervous	BSBM19E
6. I am good at working out difficult mathematics problems	BSBM19F
7. My teacher tells me I am good at mathematics	BSBM19G
8. Mathematics is harder for me than any other subject	BSBM19H
9. Mathematics makes me confused	BSBM19I
Math value	
1. I think learning mathematics will help me in my daily life	BSBM20A
2. I need mathematics to learn other school subjects	BSBM20B
3. I need to do well in mathematics to get into < university > of my choice	BSBM20C
4. I need to do well in mathematics to get the job I want	BSBM20D
5. I would like a job that involves using mathematics	BSBM20E
6. It is important to learn about mathematics to get ahead of the world	BSBM20F
7. Learning mathematics will give me more job opportunities when I am an adult	BSBM20G
8. My parents think that it is important that I do well in mathematics	BSBM20H

	TIMSS item code
9. It is important to do well in mathematics	BSBM20I

Acknowledgements
The authors thank the IEA and the TIMSS & PIRLS International Study Center for making the TIMSS 2019 data available for research purposes; and the IEA for funding the WERA Visiting Research Award 2023.

Author contributions
MC, NE and RS did the analysis plan; MC developed the literature review; MC and NE conducted the analysis; MC, NE and RS discussed and defined interpretation topics for the obtained results; MC wrote the main manuscript and prepared the figures and tables; NE and RS contributed to the manuscript writing and revised the manuscript. All authors reviewed the manuscript and agreed to its submission to the current journal.

Funding
Foundation for Science and Techology (FCT), funding references UI/BD/154346/2023, UIDB/04853/2020 and UIDP/04853/2020.

Data availability
The datasets generated and analyzed during the current study are available in the TIMSS 2019 International Database, accessible at https://timss2019.org/international-database/. The public use version of the database is freely available for download, while a restricted use version with additional variables can be obtained by contacting the IEA through its Study Data Repository.

Declarations

Competing interests
The authors declare no competing interests.

Received: 15 November 2024 Accepted: 31 March 2025
Published online: 21 April 2025

References

Abba, H. I., Usman, A., Bello, F. A., & Sheriff, A. (2024). The impact of cultural and social factors on learning mathematics among students of higher institution of Katsina state. *International Journal of Progressive Research in Engineering Management and Science, 4*(11), 733–744.

Alivernini, F., Manganelli, S., Cavicchiolo, E., Girelli, L., Biasi, V., & Lucidi, F. (2017). Immigrant background and gender differences in primary students' motivation toward studying. *The Journal of Educational Research*. https://doi.org/10.1080/00220671.2017.1349073

Andersen, I. G., & Smith, E. (2023). Gender differences in math and science academic self-concepts and the association with female climate in 8th grade classrooms. *The Journal of Early Adolescence*. https://doi.org/10.1177/02724316231188682

Basarkod, G., Marsh, H. W., Parker, P. D., Dicke, T., & Guo, J. (2022). The immigrant paradox and math self-concept: An SES-of-origin-country hypothesis. *Learning and Instruction, 77*, 101539. https://doi.org/10.1016/j.learninstruc.2021.101539

Bharadwaj, P., Giorgi, G. D., Hansen, D., & Neilson, C. A. (2016). The gender gap in mathematics: Evidence from Chile. *Economic Development and Cultural Change, 65*(1), 141–166. https://doi.org/10.1086/687983

Boekaerts, M., & Rozendaal, J. S. (2010). Using multiple calibration indices in order to capture the complex picture of what affects students' accuracy of feeling of confidence. *Learning and Instruction, 20*(5), 372–382. https://doi.org/10.1016/j.learninstruc.2009.03.002

Bong, M., Hwang, A., Noh, A., & Kim, S. (2014). Perfectionism and motivation of adolescents in academic contexts. *Journal of Educational Psychology, 106*(3), 711–729. https://doi.org/10.1037/a0035836

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology, 53*, 371–399. https://doi.org/10.1146/annurev.psych.53.100901.135233

Bradley, R. H., Corwyn, R. F., McAdoo, H. P., & Coll, C. G. (2003). The home environment of children in the United States Part I: Variations by age, ethnicity, and poverty status. *Child Development, 72*(6), 1844–1867. https://doi.org/10.1111/1467-8624.t01-1-00382

Broer, M., Bai, Y., & Fonseca, F. (2019). Socioeconomic achievement gaps: Trend results for educational systems. In S. Hegarty & L. Rutkowski (Eds.), *IEA research for education* (pp. 35–70). Springer.

Buckingham, J., Wheldall, K., & Beaman-Wheldall, R. (2013). Why poor children are more likely to become poor readers: The school years. *Australian Journal of Education, 57*(3), 190–213. https://doi.org/10.1177/0004944113495500

Castillo, W. (2020). Do elementary students reading motivation levels differ by racial/ethnic and/or immigrant background? *Journal of Latinos and Education, 22*(2), 669–680. https://doi.org/10.1080/15348431.2020.1805615

Chen, C., & Uttal, D. (1988). Cultural values, parents' beliefs, and children's achievement in the United States and China. *Human Development, 31*, 351–358. https://doi.org/10.1159/000276334

Chen, X. (2022). The effects of individual- and class-level achievement on attitudes towards mathematics: An analysis of Hong Kong students using TIMSS 2019. *Studies in Educational Evaluation, 72*, 101113. https://doi.org/10.1016/j.stueduc.2021.101113

Chmielewski, A. K. (2019). The global increase in the socioeconomic achievement gap, 1964 to 2015. *American Sociological Review, 84*(3), 517–544. https://doi.org/10.1177/0003122419847165
Coleman, J. S. (1966). *Equality in educational opportunity*. U.S. Department of Health, Education.
Contini, D., Tommaso, M. L. D., & Mendolia, S. (2017). The gender gap in mathematics achievement: Evidence from Italian data. *Economics of Education Review, 58*, 32–42. https://doi.org/10.1016/j.econedurev.2017.03.001
Deci, E. L., & Ryan, R. M. (2000). The "what" and the "why" of goals pursuits: Human needs and self-determination of behavior. *Psychological Inquiry, 11*, 227–268. https://doi.org/10.1207/S15327965PLI110401
Diener, E., Oishi, S., & Lucas, R. E. (2003). Personality, culture, and subjective well-being: Emotional and cognitive evaluations of life. *Annual Review of Psychology, 54*, 403–425. https://doi.org/10.1146/annurev.psych.54.101601.145056
Dormekpor, E. (2015). Poverty and gender inequality in developing countries. *Developing Country Studies, 5*(10), 76–102.
Du, C., Qin, K., Wang, Y., & Xin, T. (2021). Mathematics interest, anxiety, self-efficacy and achievement: Examining reciprocal relations. *Learning and Individual Differences, 91*, 102060. https://doi.org/10.1016/j.lindif.2021.102060
Durik, A. M., Shechter, O. G., Noh, M., Rozek, C. S., & Harackiewicz, J. M. (2015). What if I can't? Success expectancies moderate the effects of utility value information on situational interest and performance. *Motivation and Emotion, 39*(1), 104–119. https://doi.org/10.1007/s11031-014-9419-0
Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social, cognitive, and socio-cultural perspective on motivation. *Contemporary Educational Psychology, 61*, 101859. https://doi.org/10.1016/j.cedpsych.2020.101859
Forsblom, L., Pekrun, R., Loderer, K., & Peixoto, F. (2022). Cognitive appraisals, achievement emoticons, and students' math achievement: A longitudinal analysis. *Journal of Educational Psychology, 114*(2), 346–367. https://doi.org/10.1037/edu0000671
Ganley, C. M., & Lubienski, S. T. (2016). Mathematics confidence, interest, and performance: Examining gender patterns and reciprocal relations. *Learning and Individual Differences, 47*, 182–193. https://doi.org/10.1016/j.lindif.2016.01.002
García, T., Rodríguez, C., Betts, L., Areces, D., & González-Castro, P. (2016). How affective-motivational variable and approaches to learning predict mathematics achievement in upper elementary levels. *Learning and Individual Differences, 49*, 25–31. https://doi.org/10.1016/j.lindif.2016.05.021
Gaspard, G., Dicke, A. L., Flunger, B., Brisson, B. M., Hafner, I., Nagengast, B., & Trautwein, U. (2015). Fostering adolescents' value beliefs for mathematics with a relevance intervention in the classroom. *Developmental Psychology, 51*, 1226–1240. https://doi.org/10.1037/dev0000028
Hansen, K., Thorsen, C., Radišić, J., Peixoto, F., Laine, A., & Liu, X. (2024). When competence and confidence are at odds: A cross-country examination of the Dunning-Kruger effect. *European Journal of Psychology of Education, 39*, 1537–1559. https://doi.org/10.1007/s10212-024-00804-x
Harwell, M., Maeda, Y., Bishop, K., & Xie, A. (2020). The surprisingly modest relationship between SES and educational achievement. *The Journal of Experimental Education, 85*(2), 197–214. https://doi.org/10.1080/00220973.2015.1123668
Hastedt, D. (2016). *Mathematics achievement of immigrant students*. Springer.
Hill, N., & Torres, K. (2010). Negotiating the American dream: The paradox of Aspiratons and achievement among Latino students and engagement between their families and schools. *Journal of Social Issues*. https://doi.org/10.1111/j.1540-4560.2009.01635.x
Hofstede, G. H. (2010). The GLOBE debate: Back to relevance. *Journal of International Business Studies, 41*, 1339–1346. https://doi.org/10.1057/jibs.2010.31
Hoftstede, G. H. (1980). *Culture's consequences: International differences in work-related values*. Sage Publications.
Hopfenbeck, T. N., Lenkeit, J., Masri, Y., Cantrell, K., Ryan, K., & Baird, J. A. (2018). Lessons learned from PISA: A systematic review of peer-reviewed articles on the Programme for International Student Assessment. *Scandinavian Journal on Educational Research, 62*(3), 333–353. https://doi.org/10.1080/00313831.2016.1258726
Hu, X., Leung, F., & Teng, Y. (2018). The influence of culture on students' mathematics achievement across 51 countries. *International Journal of Science and Mathematics Education, 16*, 7–18. https://doi.org/10.1007/s10763-018-9899-6
Huang, C. (2011). Self-concept and academic achievement: A meta-analysis of longitudinal relations. *Journal of School Psychology, 49*(5), 505–528. https://doi.org/10.1016/j.jsp.2011.07.001
Hung, M., Smith, W. A., Voss, M. W., Franklin, J. S., Gu, Y., & Bousanga, J. (2020). Exploring student achievement gaps in school districts across the United States. *Education and Urban Society, 52*(2), 175–193. https://doi.org/10.1177/0013124519833442
IEA (2022). Help Manual for the IEA IDB Analyzer (Version 5.0). Retrieved October 10th 2023 from www.iea.nl
Ivanova, M., & Michaelides, M. P. (2022). Motivational components in TIMSS 2015 and their effects on engaging teaching practices and mathematics performance. *Studies in Educational Evaluation, 74*, 101173. https://doi.org/10.1016/j.stueduc.2022.101173
Johansson, S., & Strietholt, R. (2019). Globalised student achievement? A longitudinal and cross-country analysis of convergence in mathematics performance. *Comparative Education, 55*(4), 536–556.
Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognising one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77*(6), 1121–1134. https://doi.org/10.1037/0022-3514.77.6.1121
Ladd, G. W. (1989). Children's social competence and social supports: Precursors of early school adjustment? In B. H. Schneider, J. Attili, J. Nadel, & R. Weissberg (Eds.), *Social competence in developmental perspective* (pp. 271–291). Klumer Academic Publishers.
LaRoche, S., & Foy, P. (2020). Sample implementation in TIMSS 2019. In O. Martin, M. Von Davier, & I. V. S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 technical report* (p. 9.1-9.261). Boston College, TIMSS & PIRLS International Study Center.
Lee, J., Lee, H. J., & Bong, M. (2022). Boosting children's math self-efficacy by enriching their growth mindsets and gender-fair beliefs. *Theory into Practice, 61*(1), 35–48. https://doi.org/10.1080/00405841.2021.1932156

Leung, F. K. (2014). What can and should we learn from international studies on mathematics achievement? *Mathematics Education Research Journal, 36*, 579–605. https://doi.org/10.1007/s13394-013-0109-0

Li, Q., Cho, H., Cosso, J., & Maeda, Y. (2021). Relations between students' mathematics anxiety and motivation to learn mathematics: A meta-analysis. *Educational Psychology Review, 33*(3), 1017–1049. https://doi.org/10.1007/s10648-020-09589-z

Martin, P. D., & Rimm-Kaufman, S. E. (2015). Do student self-efficacy and teacher-student interaction quality contribute to emotional and social engagement in fifth grade math? *Journal of School Psychology, 53*(5), 359–373. https://doi.org/10.1016/j.jsp.2015.07.001

Meece, J. L., & Scantlebury, K. (2006). Gender and schooling: Progress and persistent barriers. In J. Worrell & C. Goodheart (Eds.), *Handbook of girls' and woman's psychological health* (pp. 283–291). Oxford University Press.

Meng, J., & Liu, S. (2022). Effects of culture on the balance between mathematics achievement and subjective well-being. *Frontiers in Psychology, 13*, 894774. https://doi.org/10.3389/fpsyg.2022.894774

Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher, 45*(1), 18–35. https://doi.org/10.3102/0013189x16633182

Mullis, I. V., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 international results in mathematics*. Boston College, TIMSS & PIRLS International Study Center.

Nagy, G., Trautwein, U., Baumert, K., Koller, O., & Garret, J. (2006). Gender and course election in upper secondary education: Effects on academic self-concept and intrinsic value. *Educational Research and Evaluation, 12*(4), 323–345. https://doi.org/10.1080/13803610600765687

Neuschmidt, O., Issa Al-Maskari, Z. S., & Beyer, C. W. (2022). A non-western perspective on ILSAs: The case of the Gulf states. *International handbook of comparative large-scale studies in education: perspectives, methods and findings* (pp. 1021–1049). Springer International Publishing.

OECD. (2013). *Excellence through equity: Giving every student the chance to succeed: Results from PISA 2012*. OECD Publishing.

OECD. (2014). *PISA 2012 technical report*. OECD Publishing.

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science, 349*(6251), aac4716. https://doi.org/10.1126/science.aac4716

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*(4), 315–341. https://doi.org/10.1007/s10648-006-9029-9

Pekrun, R., Frenzel, A. C., Goetz, T., & Perry, R. P. (2007). The control-value theory of achievement emotions: An integrative approach to emotions in education. In P. A. Schutz & R. Pekrun (Eds.), *Emotion in Education* (pp. 13–36). Academic Press.

Porcu, M., Sulis, I., Usala, C., & Giambona, F. (2023). Will the gap ever be bridged? A cross-national comparison of non-native students' educational achievements. *Journal of Population Sciences*. https://doi.org/10.1186/s41118-023-00199-5

Raccanello, D., Hall, R., & Burro, R. (2018). Salience of primary and secondary school students' achievement emotions and perceived antecedents: Interviews on literacy and mathematics domains. *Learning and Individual Differences, 65*, 65–79. https://doi.org/10.1016/j.lindif.2018.05.015

Radišić, J., Buchholtzm, N., Yang-Hansen, K., Liu, X., & Kaarstein, H. (2024). Do teachers' beliefs about the nature and learning of mathematics affect students' motivation and enjoyment of mathematics? Examining differences between boys and girls across six countries. *European Journal of Psychology of Education, 39*, 1587–1613. https://doi.org/10.1007/s10212-024-00809-6

Recber, S., Isiksal, M., & Koç, Y. (2018). Investigating self-efficacy, anxiety, attitudes and mathematics achievement regarding gender and school type. *Anales De Psicología, 34*(1), 41–51. https://doi.org/10.6018/analesps.34.1.229571

Rodríguez, S., Valle, A., Gironelli, L., Guerrero, R., Regueiro, B., & Estévez, I. (2020). Performance and well-being of native and immigrant students: Comparative analysis based on PISA 2018. *Journal of Adolescence, 85*, 96–105. https://doi.org/10.1016/j.adolescence.2020.10.001

Rubin, D. B. (1987). *Multiple Imputation for Nonresponse in Surveys*. John Wiley & Sons Inc.

Safavian, N., & Conley, A. (2016). Expectancy-value beliefs or early-adolescents Hispanic and non-Hispanic youth: Predictors of mathematics achievement and enrollment. *AERA Open, 2*(4), 1–17. https://doi.org/10.1177/2332858416676733

Schleicher, A. (2019). *PISA 2018: Insights and interpretations*. OECD Publishing.

Schmitt, D. P., Long, A. E., McPhearson, A., O'Brien, K., Remmert, B., & Shah, S. H. (2017). Personality and gender differences in global perspective. *International Journal of Psychology, 52*(1), 45–56. https://doi.org/10.1002/ijop.12265

Shneor, R., Camgoz, S. M., & Karapinar, P. B. (2013). The interaction between culture and sex in the formation of interpreneurial intentions. *Enterpreneurship and Regional Development, 25*(9–10), 781–803. https://doi.org/10.1080/08985626.2013.862973

Strello, A., Strietholt, R., & Steinmann, I. (2023). Mind the gap… but which gap? The distinctions between social inequalities in student achievement. *Social Indicators Research, 170*, 399–425. https://doi.org/10.1007/s11205-023-03196-5

Tashiro, J., Parga, D., Pollard, J., & Talenquer, V. (2021). Characterising change in students' self-assessments of understanding when engaged in instructional activities. *Chemistry Education Research and Practice, 22*(3), 662–682. https://doi.org/10.1039/D0RP00255K

Tze, V., & Li, J. (2021). Should science be a subject that we should keep our mind cool? A systematic evaluation using TIMSS 2015 data. *Motivation and Emotion, 45*, 377–396. https://doi.org/10.1007/s11031-021-09880-8

United Nations (2015). *Transforming our world: The 2030 Agenda for Sustainable Development* (A/RES/70/1). Retrieved October 10th 2023 from https://www.refworld.org/legal/resolution/unga/2015/en/111816

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Educational Psychology, 34*(1), 89–101. https://doi.org/10.1016/j.cedpsych.2008.09.002

Viechtbauer, W. (2010). Conducting meta-analysis in R with the metafor package. *Journal of Statistical Software, 36*(3), 1–48. https://doi.org/10.18637/jss.v036.i03

Weinert, F. E. (1999). *Concepts of Competence*. Contribution within the OECD Project Definition and Selection of Competencies: Theoretical and Conceptual Foundations (DeSeCo). Neuchatel: Bundesamt für Statistik (pp. 3–34)

Yin, L., & Fishbein, B. (2020). Creating and interpreting the TIMSS 2019 context questionnaire sclaes. In M. O. Martin, M. Von Davier, & I. V. S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 Technical Report* (p. 9.1-9.261). Boston College, TIMSS & PIRLS International Study Center.

Zhang, F., Bae, C. L., Broda, M. D., & Kroenka, A. C. (2023). Factor structure of student science-learning motivation: Evidence from TIMSS U.S. Data. *Sustainability, 15*(17), 13230. https://doi.org/10.3390/su151713230

Zivkovic, M., Pellizzoni, S., Doz, E., Cuder, A., Mammarella, I., & Passalunghi, M. C. (2023). Math self-efficacy or anxiety? The role of emotional and motivational contribution in math performance. *Social Psychology in Education, 26*, 579–601. https://doi.org/10.1007/s11218-023-09760-8

Publisher's Note