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# Socio-economic gaps in subject interest: the mediating role of parental cognitive involvement

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## Abstract

This paper examines the mediating role of parental literacy and numeracy involvement before the child entered school in the relationship between family socio-economic status (SES) and students' interest in reading and mathematics. Causal mediation analysis is applied to international assessment data from the Trends in International Mathematics and Science Study-Progress in International Reading Literacy Study 2011 combined study. Results provide weak support for the subject-specific parental cognitive involvement mediating mechanism in the association between family SES and subject-specific interest. In general, the total association with family SES is not strong and the direct role of parental cognitive involvement in students' interest appears to be more relevant than its role via family SES.

**Keywords:** SES, Subject interest, Literacy involvement, TIMSS, PIRLS

## Background

Equity in education can be conceptualised from different perspectives with different normative and measurement implications (Strietholt and Borgna 2016). From an egalitarian perspective, all inequalities in educational outcomes are regarded as unfair and equity is thus measured through simple dispersion indicators (e.g., standard deviation of academic achievement). From a capability approach, a minimum level of educational attainment is expected and inequalities can therefore be measure through, for example, the percentage of students reaching a basic literacy level (e.g., students performing above proficiency level 2 in the Programme for International Student Assessment [PISA] test). From an equality of opportunity perspective inequalities that are beyond individual control are unfair and equity is measured through the association between educational outcomes and family background characteristics (e.g., family socio-economic status [SES]) or student characteristics (e.g., gender).

International assessment studies like the Progress in International Reading Literacy Study (PIRLS), the Trends in International Mathematics and Science Study (TIMSS), and PISA have contributed valuable data for characterising and comparing different measures of equity in education within and between education systems. Particularly, a great deal of effort has gone into investigating equality of opportunity in relation to family SES.

Willms (2006) has developed an analytical framework for the study of education inequalities with large-scale assessment data. The framework consists of producing a single measure of family socio-economic status (SES) with data on parental education, parental occupations, and family wealth, and examining different aspects of the relationship between family SES and student outcomes. Socio-economic gradients estimated with multilevel modeling techniques summarize the relationship between family SES and student outcomes. They characterise education inequalities within schools, between schools, and between education systems. The socio-economic gradient framework has been adopted by PISA since 2000 (e.g., OECD 2013a). It has also been applied to measure SES and study education inequalities with PIRLS data (Caro and Cortés 2012; Caro and Lenkeit 2012). A number of questions relevant to equity and policy research in education have been addressed using this framework and in related work with international assessment data.

For instance, researches have studied the family cultural mechanisms underlying SES achievement inequalities (Pokropek et al. 2015; Tramonte and Willms 2010), the mediating role of home learning environment in SES achievement gaps (Caro 2015; Park 2008a), changes in the associations between family SES and student achievement (Yang Hansen et al. 2011), regional differences in education inequality (e.g., Caro and Mirazchiyski 2012), whether the association between academic achievement and parent-child communication varies across levels of family SES (Caro 2011; Park 2008b), whether teacher characteristics interact with the student SES (Caro et al. 2016; Luschei and Chudgar 2011), whether family SES accounts for the achievement gap between students with and without migration background (Shapira 2012), and whether the school SES composition has a role in student achievement in addition to the student SES (Caro and Lenkeit 2012; Willms 2003, 2006).

While international assessment studies present limitations for examining education inequalities, for example, in terms of cross-cultural comparability, theoretical implications, and causal interpretation of results (e.g., Caro et al. 2014), these studies have provided valuable empirical evidence on the degree of inequalities, levels of inequalities (e.g., students /schools/education systems), mediating and moderating factors for inequalities, among other aspects that contribute to characterising education inequalities and understanding how inequalities arise and can be reduced.

For the most part, studies have looked at SES gaps in student achievement outcomes and family SES inequalities in metacognitive skills have been less frequently investigated with international assessment data. Equity studies have been criticised for reducing its scope to academic outcomes and current educational theories advocate the study of broader outcomes than student achievement (Creemers and Kyriakides 2008). With this in mind, the present study examines family SES gaps in students' subject-specific interest. Particularly, it examines the mediating role of parental cognitive involvement in the relationship between family SES and students' interest in reading and mathematics.

Mediation is analysed from a causal perspective (Caro 2015; Imai et al. 2010a). Caro (2015) illustrated an application of the causal mediation model in large-scale assessment research by evaluating the mediating role of early literacy activities in the relationship between parental education and reading achievement. The methods in this paper draw extensively on this work to provide benchmarks for the causal interpretation of parental

cognitive involvement mediation effects. The analyses use international assessment data from the TIMSS-PIRLS 2011 combined study. The data contains subject-specific information of parental cognitive involvement before the child entered school (i.e., literacy and numeracy involvement) and subject interest (i.e., reading and mathematics) for the same sample of students in each education system.

### **Achievement motivation and subject-specific interest**

Student motivation is a multidimensional construct which includes components of students' expectations for performance, value or interest ascribed to learning, and emotional or affective engagement (Guthrie et al. 2007; Pintrich and DeGroot 1990). Within social cognitive theory, these three components are an adaptation of Bandura's expectancy-value theory which focuses on the two primary components: expectancy and value (Eccles 2005; Wigfield et al. 2009). The value component is further distinguished into intrinsic value and extrinsic value (Bandura 1989; Wigfield and Eccles 2000).

The distinction between intrinsic and extrinsic motivation for learning plays a dominant role in the conceptualisation of motivation constructs (Schiefele et al. 2012). Extrinsic motivation is derived from external incentives, such as obtaining a good grade in school, whereas intrinsic motivation is derived from enjoyment and interest in a specific topic. Studies find a weak association between extrinsic motivation and student learning, but a positive association between intrinsic motivation and student learning, which is partly explained by greater persistence and intensity of activities conducive to learning (Schiefele et al. 2012; Schunk et al. 2008).

Enjoyment and interest are fundamental for intrinsic motivation (Eccles 2005). Subject-specific interest and object-specific intrinsic motivation are closely overlapping concepts (Schiefele et al. 2012). Both actions triggered by intrinsic motivation and subject-specific interest are characterised by enjoyment and individual valuing (Frenzel et al. 2010). Because subject-specific interest leads to adequate use of learning strategies and deep-level learning it is viewed as conducive to student engagement and learning (Retelsdorf et al. 2011; Schiefele 1996). Students are expected to become more motivated in learning if they value, are interested, and enjoy the subject studied (Meece et al. 2006; Schiefele 2009; Skinner et al. 2008).

Achievement motivation levels vary significantly across cultures (Chiu and Chow 2010; Van de Vijver 2015). For example, different cultural values may promote collectivist interests (e.g. Hong Kong), individualistic interests (e.g., New Zealand), hierarchical relationships (e.g., Russia) and egalitarian relationships (e.g., Sweden). In turn, cultural values acquired through socialisation shape students' beliefs and behaviours relating to achievement motivation. For instance, there is evidence that the association between extrinsic motivation and academic achievement is stronger in collectivist and egalitarian societies (Chiu and Chow 2010).

### **Subject interest effects on learning**

Students' subject interest is likely amongst the most important conditions for a lifelong learner. A number of studies on intrinsic motivation indicate that students' subject interest is positively related to student achievement even after controlling for student's intelligence or prior knowledge (McElvany et al. 2008; Retelsdorf et al. 2011; Schiefele et al.

2012; Taboada et al. 2009; von Maurice et al. 2014). Although most studies have examined the influence of intrinsic motivation on student achievement, the causal direction of this relationship is not necessarily unidirectional from a theoretical viewpoint and evidence of reciprocal effects has been reported in few studies (McElvany et al. 2008; Schaffner et al. 2016; Schiefele et al. 2012).

Research points to different mechanisms for the effect of intrinsic motivation on student achievement, including greater effort in learning, use self-regulation strategies, reading breath and amount, resilience and engagement in the classroom (Deci and Ryan 2002; Greeneet al. 2004; Pintrich and De Groot 1990; Schaffner et al. 2013; Schiefele et al. 2012; Schultz 1993). Students with greater subject interest tend to pose and answer questions, look for new knowledge and stimulating educational environments, whereas less motivated students represent a challenge for the work of educators (Frenzel et al. 2010). International assessment studies too show that students with higher motivational dispositions achieve on average higher reading and mathematics scores across a range of countries (Kirsch et al. 2003; Mullis et al. 2012a, b; OECD 2013b). Further, PISA results suggest that student motivation can partly compensate for a low socio-economic background (Kirsch et al. 2003; Kriegbaum and Spinath 2016).

Meta-analysis reported a correlation of 0.30 between subject interest and academic achievement (Schiefele et al. 1992). The size of the correlation is almost the same than for the correlation of family SES and academic achievement (Sirin 2005). But unlike the family SES attribute, student motivation is viewed as being more amenable to school interventions (Appleton et al. 2006; Jimmerson et al. 2003). In part, that is one reason for the attractiveness of the study of student interest. Furthermore, subject interest appears to be more strongly related to deep-level learning than to surface-level learning. And associations with learning appear to be independent from prior achievement or ability (Schiefele 1996).

### **Antecedents of subject interest**

Student subject interest results from complex and dynamic interactions between students, parents, and schools. Self-determination theory postulates that interactions that fulfil students' psychological needs for autonomy, competence, and social relatedness contribute to positive orientations towards learning (Deci and Ryan 2012; Schiefele 2004). For instance, positive interactions with teachers that promote students' autonomy and explain the relevance of lessons to every day's life are related to higher motivation and active participation in the classroom (Birch and Ladd 1998; Gutman and Sulzby 2000; Pianta et al. 2012). The importance of autonomy for intrinsic motivation and subject interest appears to be universal across different cultures (Chirkov and Ryan 2001; Chirkov et al. 2011; Marbell and Grolnick 2013; Wigfield et al. 2015).

The literature has identified different individual and teacher factors related to subject motivation. Individual factors such as academic values and achievement self-beliefs have shown to influence student engagement and academic achievement (Deci 1992; Eccles et al. 1998; Pintrich 2003; Pintrich and Schunk 2003; Reeve 2005). Teachers can influence student motivation in different ways (e.g., Mottet et al. 2006). Student-teacher relationships characterised by closeness and support (Little and Kobak 2003; Midgley et al. 1989; Pianta et al. 2012) and promoting students' autonomy (e.g., Hardre and

Reeve 2003; Jang et al. 2007) tend to foster student motivation. On the contrary, teachers' false expectations can become self-fulfilling prophecies. Research has also found that teacher's enjoyment and confidence in teaching (Martin 2006) and teacher communication with parents (Kraft and Dougherty 2013) contribute to increasing student motivation.

The majority of studies on the precursors of student motivation have focused on individual and teacher factors. The influences of families and particularly family SES has been studied less frequently.

### ***Parental influences: family SES and parental cognitive involvement***

Parents play a role in student motivation directly via parental relationships with children and indirectly through interactions with schools and teachers. Parental influences on student motivation are channelled through effects on student's competence, autonomy, and social relatedness. For example, parents can influence children's competence, autonomy, and social relatedness with high academic expectations of student's competence and by providing resources that facilitate social relations and autonomy (Fan and Williams 2010; Grolnick et al. 2009; Wigfield et al. 2015). Parental involvement and autonomy support can foster motivational resources and enable children to cope with academic failure (Raftery-Helmer and Grolnick 2015; Wong 2008).

Three forms of parental involvement have been related to student motivation (Grolnick and Slowiaczek 1994): behavioural involvement (e.g., participating in school meetings), cognitive involvement (e.g., early literacy and numeracy stimulating activities), and personal involvement (e.g., academic expectations and interest in school issues). The quality of parent-child interactions is particularly important for achievement motivation (Bempechat and Shernoff 2012). But parents' possibilities for providing time and emotional resources are constrained by their SES (Bempechat and Shernoff 2012; McLanahan 2004; Wigfield et al. 2015).

Parental education and income levels are positively related to the quality and intensity of home learning experiences. Low SES families lack economic resources and parental education levels for translating resources into experiences that stimulate curiosity and intrinsic motivation in children (Bempechat and Shernoff 2012; Van Steensel 2006; Wigfield et al. 2015). Many low SES families also lack time and resources for school involvement, for example, attending school events (Bempechat and Shernoff 2012). Further, stressful events, more likely present in low SES families, tend to affect negatively the family environment and act in detriment of student motivation through, for example, lower parental responsiveness, social support, and emotional resources available for children (Grolnick et al. 2009). Stressful events in low SES families especially undermine mothers' ability to support children's motivation.

Higher SES families tend to possess greater cultural (e.g., classic literature, works of art) and educational resources (e.g., books, DVDs and other media material) at home and are more likely to engage in cognitive stimulating activities with children during the early years in part because of their higher education levels (Caro 2015; Grolnick and Slowiaczek 1994). But rather than the influence of *static* cultural and educational resources, research shows that parent-child cultural interactions and the *dynamic* aspect

of early cognitive stimulation is the main driver of intrinsic motivation and achievement (Gottfried et al. 2015; Tramonte and Willms 2010; Neuman et al. 2014).

Parental cognitive involvement in early childhood such as time invested in shared book reading (e.g., Gottfried et al. 2015), storytelling (e.g., Snow and Dickinson 1990; Weigel et al. 2006), learning the alphabet, numbers, and letters (e.g., Parker et al. 1999), playing rhyming and math games (e.g., Baker et al. 1995; LeFevre et al. 2009; Weigel et al. 2006), and access to cognitively stimulating toys and books (e.g., Gottfried et al. 1998) set the stage for children's cognitive and intrinsic motivation development. Although there is variability in the quality of early activities both across and within SES groups, there is evidence that, in general, children from lower SES families experience less developmentally enhancing activities at home, exposure to books, reading, and verbal interactions with parents in comparison to higher SES children (e.g., Niklas and Schneider 2013; Evans et al. 2000, Gustafsson et al. 2013; Raikes et al. 2006). And that parental cognitive stimulation affects student intrinsic motivation above and beyond the effect of SES (Gottfried et al. 1998).

Cognitive home stimulation (e.g., provision of educational and intellectual activities such as lessons, political and social discussions, and visits to libraries and museums) has been found to positively impact academic intrinsic motivation beyond SES (Gottfried et al. 1998). Interest and enjoyment are fostered to a substantial degree through the students' exposure to and experiences with cognitively stimulating learning activities and the provision of learning materials (Gottfried et al. 1998). Socially disadvantaged children are often deprived of these experiences within their home environments. Motivational characteristics thus represent another weight on the social disadvantage of these children that further negatively affects their academic achievement (Schultz 1993).

It is therefore hypothesised that family SES influences student subject interest via its effect on parental cognitive involvement. Namely, that parental cognitive involvement mediates the association between family SES and student motivation. Further, parental cognitive involvement is expected to affect student motivation directly beyond its influence via family SES.

## Methods

### Data

Data is sourced from the combined TIMSS-PIRLS 2011 study for students in 4th grade (Martin and Mullis 2013). TIMSS-PIRLS 2011 is the first time both studies are administered in the same year, which allow us to compare comprehensive measures of reading and mathematics for the same students as well as to relate academic achievement to student and family characteristics. Sampling was conducted in two stages: schools were sampled in first stage and intact classes in second stage. Twenty-eight education systems with complete data in at least 70% of the SES constituent items were selected for the analysis: Azerbaijan, Austria, Chinese Taipei, Croatia, Czech Republic, Finland, Georgia, Hong Kong, Hungary, Iran, Ireland, Italy, Lithuania, Malta, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, Slovak Republic, Slovenia, Spain, Sweden, United Arab Emirates, United Arab Emirates (Dubai), United Arab Emirates (Abu Dhabi), and Canada (Quebec). The total sample of students in the original sample and analytic sample, the percentage of missing data, correlation matrices, and descriptive statistics are presented Tables 1, 2 and 3 (see Appendix A).

## Variables

### **Student subject interest**

PIRLS and TIMSS developed two scales reflecting interest in subjects: *Students Like Learning Mathematics* and *Students Like Reading*. These scales are referred to as *student mathematics interest* and *students reading interest*. The mathematics scale is based on student responses to the following Likert-type items (1 = agree a lot, 2 = agree a little, 3 = disagree a little, 4 disagree a lot): “I enjoy learning mathematics”, “I wish I did not have to study mathematic”, “Mathematics is boring”, “I learn many interesting things in mathematics”, and “I like mathematics”. The reading scale was created based on students responses to eight statements. In six statements students indicated their degree of agreement (categories as above): “I read only if I have to”, “I like talking about what I read with people”, “I enjoy reading”, “I think reading is boring”, “I would be happy of someone gave me a book as a present”, “I would like to have more time for reading”. In two statements students indicated how often they were doing the following (1 = every day or almost every day, 2 = once or twice a week, 3 = once or twice a month, 4 = never or almost never): “I read for fun” and “I read things that I choose myself”.

### **Parental cognitive involvement**

PIRLS and TIMSS developed two scales reflecting cognitive involvement in subjects: *Early Literacy Activities* and *Early Numeracy Activities*. We refer to these scales as *parental literacy involvement* and *parental numeracy involvement*, respectively. The Parental Literacy Involvement scale is based on parents’ responses to the following activities with the child before he/she entered school on a Likert-type scale (1 = never or almost never, 2 = sometimes, 3 = often): “read books”, “tell stories”, “sing songs”, “play with alphabet toys”, “talk about things you had done”, “talk about what you have read”, “play word games”, “write letters or words”, and “read aloud signs and labels with the child”. The Parental Numeracy Involvement scale is based on parents responses to the following activities with the child before he/she entered school on a Likert-type scale (1 = never or almost never, 2 = sometimes, 3 = often): “say counting rhymes or sing counting songs”, “play with number toys (e.g., blocks with numbers)”, “count different things”, “play games involving shapes (e.g., shape sorting toys, puzzles)”, “play with building blocks or construction toys”, and “play board games or card games”.

### **Family SES**

Parental education, parental occupational status, and home possessions are combined into a single family SES scale using a principal component analysis. Parental education and parental occupational status are measured with the maximum level of education and maximum score in occupational status for either parent. Mother’s and father’s levels of education are self-reported according to the following categories: 1 = some primary, lower secondary or no schooling, 2 = lower secondary, 3 = upper education, 4 = post-secondary but not university, 5 = university or higher. Mother’s and father’s self-reported occupations were converted into occupational status scores following Caro and Cortés (2012). Parental occupation questions followed a categorical approach including following options along with descriptors: (a) has never worked for pay; (b) small business owner; (c) clerk; (d) service or sales worker; (e) skilled agricultural or fishery worker; (f) craft or trade worker; (g) plant or machine operator; (h) general laborers; (i) corporate manager or senior official;

(j) professional; and (k) technician or associate professional. Job categories and descriptors were mapped into the International Socioeconomic Index of Occupational Status (ISEI) scores using the scoring scheme proposed by Ganzeboom et al. (1992).

Home possessions (i.e., computer, study desk, own room, and Internet connection) reported by students were converted into a single scale with a Rasch model. SES was scaled to have a mean of 0 and a standard deviation of 1 across education systems. The distribution of family SES by education system is presented in Fig. 5 (see Appendix A).

### Control variables

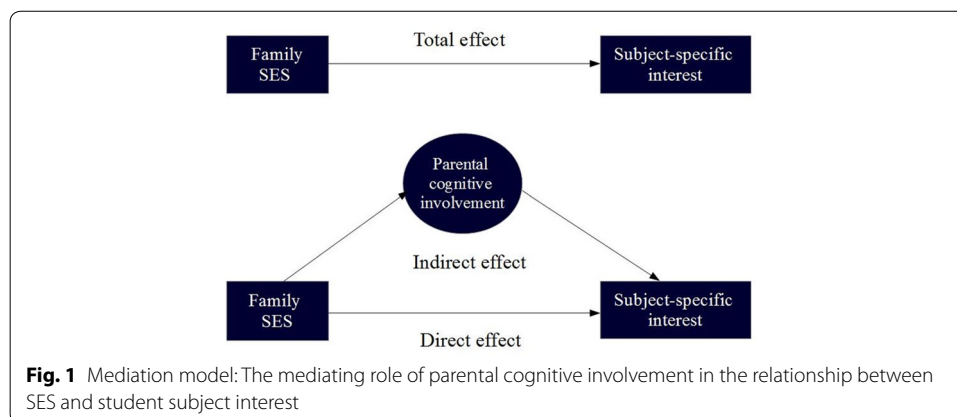
Control variables related to family SES and parental cognitive involvement were reported by parents: student's pre-school attendance (0 = no pre-school, 1 = 1 year or less, 2 = more than 1 year, 3 = 3 years or more), the *Parents Like Reading Scale*, the number of books at home excluding magazines, newspapers or children's books (0 = 0–10, 1 = 11–25, 2 = 26–100, 3 = 101–200, 4 = more than 200), and the number of children's books at home excluding children's magazines or school books (0 = 0–10, 1 = 11–25, 2 = 26–50, 3 = 51–100, and 4 = more than 100). The *Parents Like Reading Scale* reflected parental agreement (1 = agree a lot, 2 = agree a little, 3 = disagree a little, 4 = disagree a lot) with the following Likert-type items: "I read only if I have to", "I like talking about what I read with other people", "I like to spend my spare time reading", "I read only if I need information", "Reading is an important activity in my home", "I would like to have more time for reading", and "I enjoy reading".

TIMSS and PIRLS scales were developed with IRT partial credit models and were scaled to have a mean score of 10 and a standard deviation of 2 across education systems (Mullis et al. 2012).

### Mediation model

The analysis adopted a causal mediation approach (Caro 2015; Imai et al. 2010a, b). Causal mediation analysis represents the integration of traditional mediation analysis (Baron and Kenny 1986; MacKinnon 2008) and the potential outcomes framework (Holland 1986; Rubin, 1974). It establishes benchmarks for interpreting mediation results in causal terms by analysing the sensitivity of mediation effect estimates to the presence of unobserved confounders (Caro 2015).

The mediation model is presented in Fig. 1. The outcome is subject-specific interest ( $Y$ ), the treatment is family SES ( $T$ ), and the mediator is subject-specific parental cognitive





involvement reported retrospectively by parents ( $M$ ). Mediation conditions assume that family SES is significantly related to student interest, the total effect, and that family SES effects on student interest reduce once parental cognitive involvement is included in the model. That is, family SES has an indirect effect on the outcome through the mediator of parental cognitive involvement. Further, it is assumed that the mediator precedes the outcome in chronological order and that the treatment precedes the mediator (Kraemer et al. 2001). It is argued that retrospective data of parental cognitive involvement and relatively time-invariant family SES data make mediation assumptions plausible.

For each student  $i$ , two potential outcomes for the outcome and mediator are considered in the causal mediation framework. Consider, for simplicity, two treatment conditions, assignment to a high SES family ( $T = 1$ ) and assignment to a low SES family, the control condition ( $T = 0$ ), and not a continuous SES scale as in our data. One potential outcome is subject interest resulting from the treatment of being in a high SES family,  $Y_i(1)$ , and another potential outcome is attributed to the control condition of coming from a low SES family,  $Y_i(0)$ . The difference between both outcomes,  $Y_i(1) - Y_i(0)$ , is the individual treatment effect. Equally, the mediator has two potential outcomes for each student,  $M_i(1)$  and  $M_i(0)$ , the level of parental cognitive involvement for a student in a high and low SES family, respectively. Clearly, it is not possible in practice to observe both outcomes for the same student,  $i$ . There is a *counterfactual*, for example the student interest outcome in a low SES family for a student from a high SES family. In this case,  $Y_i(1)$  and  $M_i(1)$  are observed but  $Y_i(0)$  and  $M_i(0)$  are not.

While it is not possible to identify treatment effects at the individual level, average treatment effects can be estimated when participants are randomly assigned to treatment and control conditions or with methodologies that resemble randomised experiments. Similarly, causal mediation analysis produces evidence of average mediation effects and establishes benchmarks for interpreting mediation effects causally. Causal mediation analysis is represented by the following equations,

$$Y_i(T_i, M_i(T_i)) = \alpha_1 + \beta_1 T_i + \xi_1^T X_i + \varepsilon_{i1} \quad (1)$$

$$M_i(T_i) = \alpha_2 + \beta_2 T_i + \xi_2^T X_i + \varepsilon_{i2} \quad (2)$$

$$Y_i(T_i, M_i(T_i)) = \alpha_3 + \beta_3 T_i + \gamma M_i + \xi_3^T X_i + \varepsilon_{i3} \quad (3)$$

where  $\varepsilon_{i1} \sim N(0, \sigma_1)$ ,  $\varepsilon_{i2} \sim N(0, \sigma_2)$ , and  $\varepsilon_{i3} \sim N(0, \sigma_3)$ .  $Y_i(t, m)$  is used to denote the potential outcome and  $Y_i(T_i, M_i(T_i))$ , the observed outcome (i.e., subject-specific interest) given the treatment  $T$  (i.e., family SES) and the mediator  $M$  (i.e., parental cognitive involvement). Control variables are represented by  $X_i$ . Total treatment effects are captured by  $\hat{\beta}_1$ , average direct effects (ADE) by  $\hat{\beta}_3$ , and mediation effects by  $\hat{\beta}_2 \hat{\gamma}$  or  $\hat{\beta}_1 - \hat{\beta}_3$ .

Average causal mediation effects (ACME) are represented by

$$\bar{\delta}(t) = E[Y_i(t_i, M_i(1)) - Y_i(t_i, M_i(0))] \quad (4)$$

ACME captures changes in student interest that would occur if parental cognitive involvement change from the value observed in the control condition (i.e., low SES) to the value observed under the treatment condition (i.e., high SES), while holding the treatment constant.  $\hat{\beta}_2 \hat{\gamma}$  is a valid estimate of the population ACME,  $\bar{\delta}(t)$  if the sequential

ignorability assumption is met (Imai et al. 2010b): (1) the treatment is independent of potential outcomes and potential mediators given observed confounders (i.e., treatment assignment is assumed to be ignorable) and (2) the mediator is ignorable given the actual treatment status and confounders. Regression models control for confounders ( $X_i$ ) related to the mediator, treatment, and outcome in order to satisfy this assumption. This assumption, however, cannot be verified with the data and therefore sensitivity analysis is conducted to evaluate its plausibility.

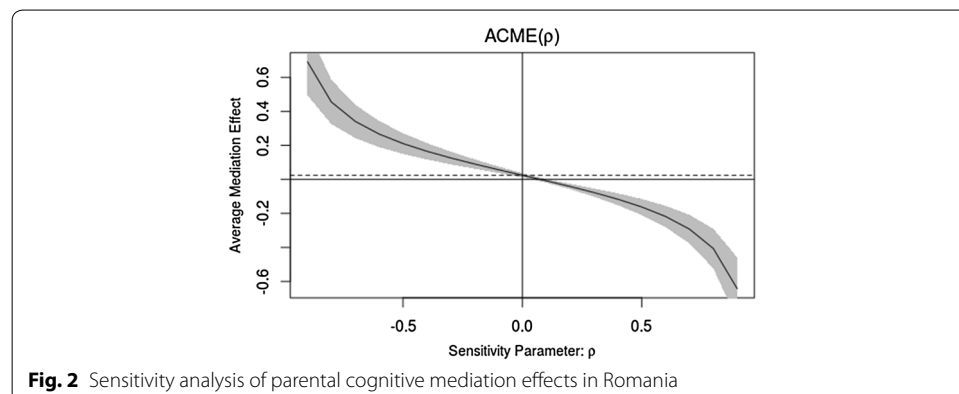
### Sensitivity analysis

Sensitivity analysis evaluates the variability of ACME estimates to departures from the sequential ignorability assumption (Imai et al. 2010b). It examines the extent to which violations of this assumption lead to different results. If mediation results are sensitive to slight violations of the sequential ignorability assumption, mediation results cannot be interpreted as ACME.

For example, Fig. 2 shows sensitivity analysis in Romania for ACMEs of parental literacy involvement in the relationship between family SES and student reading interest. The x-axis represents values in the sensitivity parameter,  $\rho$ , and the y-axis average causal mediation effects. The sensitivity parameter,  $\rho$ , measures the correlation between the error in the mediation model,  $\varepsilon_{i2}$ , and the error in the outcome model,  $\varepsilon_{i3}$  (see Eqs. 2 and 3). This correlation arises if unobserved confounders affect both mediator and outcome variables, because these variables are part of the two error terms. The sequential ignorability assumption means that  $\rho$  is zero. The dashed horizontal line represents ACMEs under the sequential ignorability assumption, that is,  $\hat{\beta}_2\hat{\gamma}$ . Sensitivity analysis evaluates the extent to which  $\hat{\beta}_2\hat{\gamma}$  changes for different values of  $\rho$ , that is, when unobserved confounders potentially introduce bias in the estimation of ACME. Steep curves indicate that ACMEs quickly depart from the sequential ignorability assumption under the presence of confounders.

### Model estimation

Causal mediation and sensitivity analysis were performed by education system using the R package ‘mediation’ (Tingley et al. 2014). Model estimates of Eqs. 1, 2, and 3 take into account sampling weights but not the multilevel structure of the data, because current implemented procedures cannot handle sensitivity analysis for multilevel models. The data was centred around the school mean to purge differences between schools and capture



purely differences between students in family SES, parental cognitive involvement, and student interest within the school.

## Results

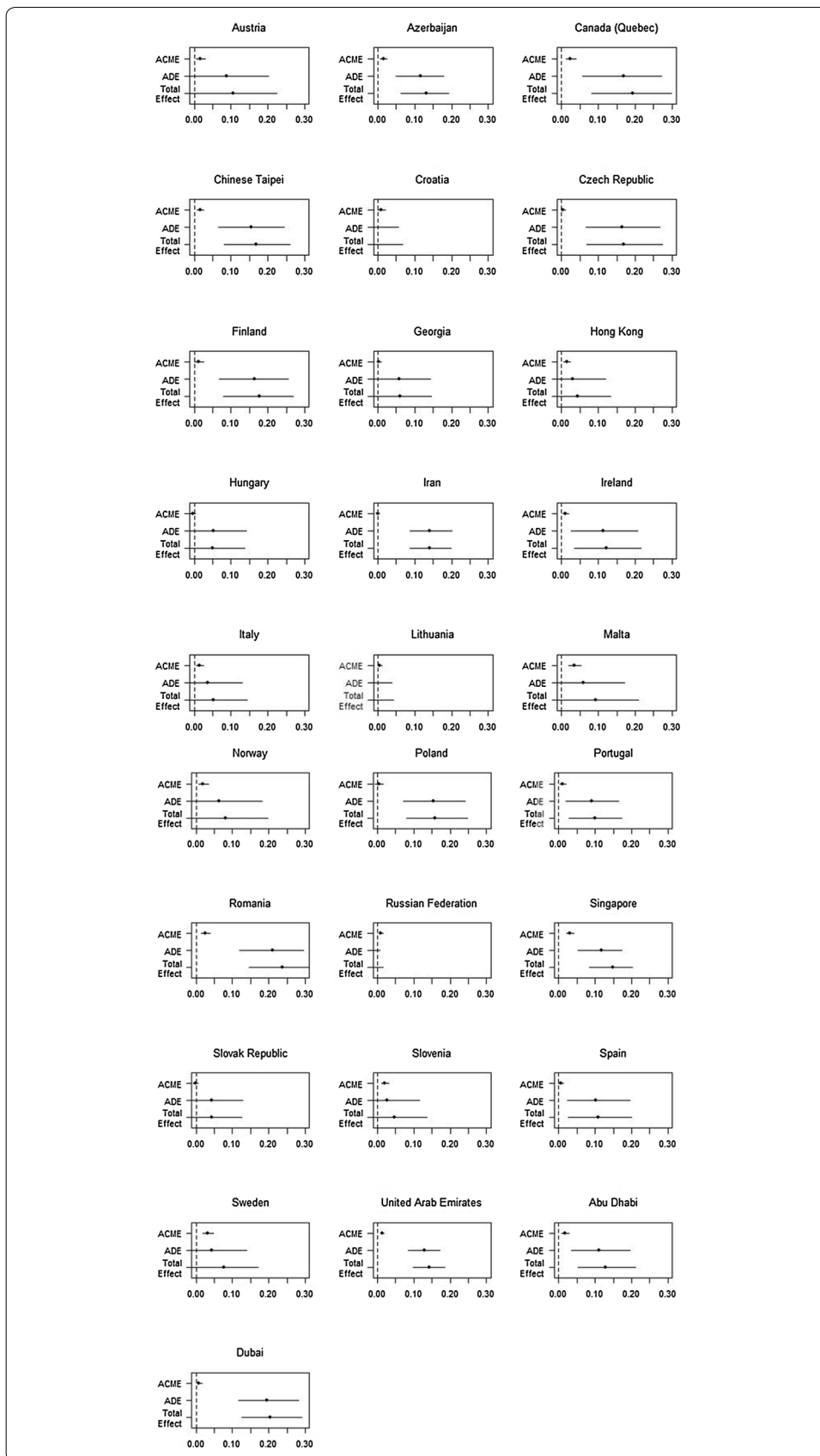
Table 2 in Appendix A records correlations between family SES, parental cognitive involvement, and student interest. On average, the correlation between family SES and student interest is small: 0.04 for mathematics interest and 0.10 for reading interest across education systems. The average correlation between family SES and parental cognitive involvement scales across education systems is slightly larger: 0.16 for parental literacy involvement and 0.13 for parental numeracy involvements. Although the positive correlations are consistent with the causal direction postulated by our mediation model, the size of average correlations provide weak evidence of mediation effects. There is, however, significant variation across education systems. For example, correlations between family SES and parental cognitive involvement are around 0.24 in Chinese Taipei and 0.28 in Romania, whereas correlations between family SES and parental numeracy involvement are 0.06 in Finland and 0.02 in Czech Republic. Correlations were positive across countries but very low. Causal mediation analysis offers stronger evidence of statistical significance of mediation effects after controlling for confounders.

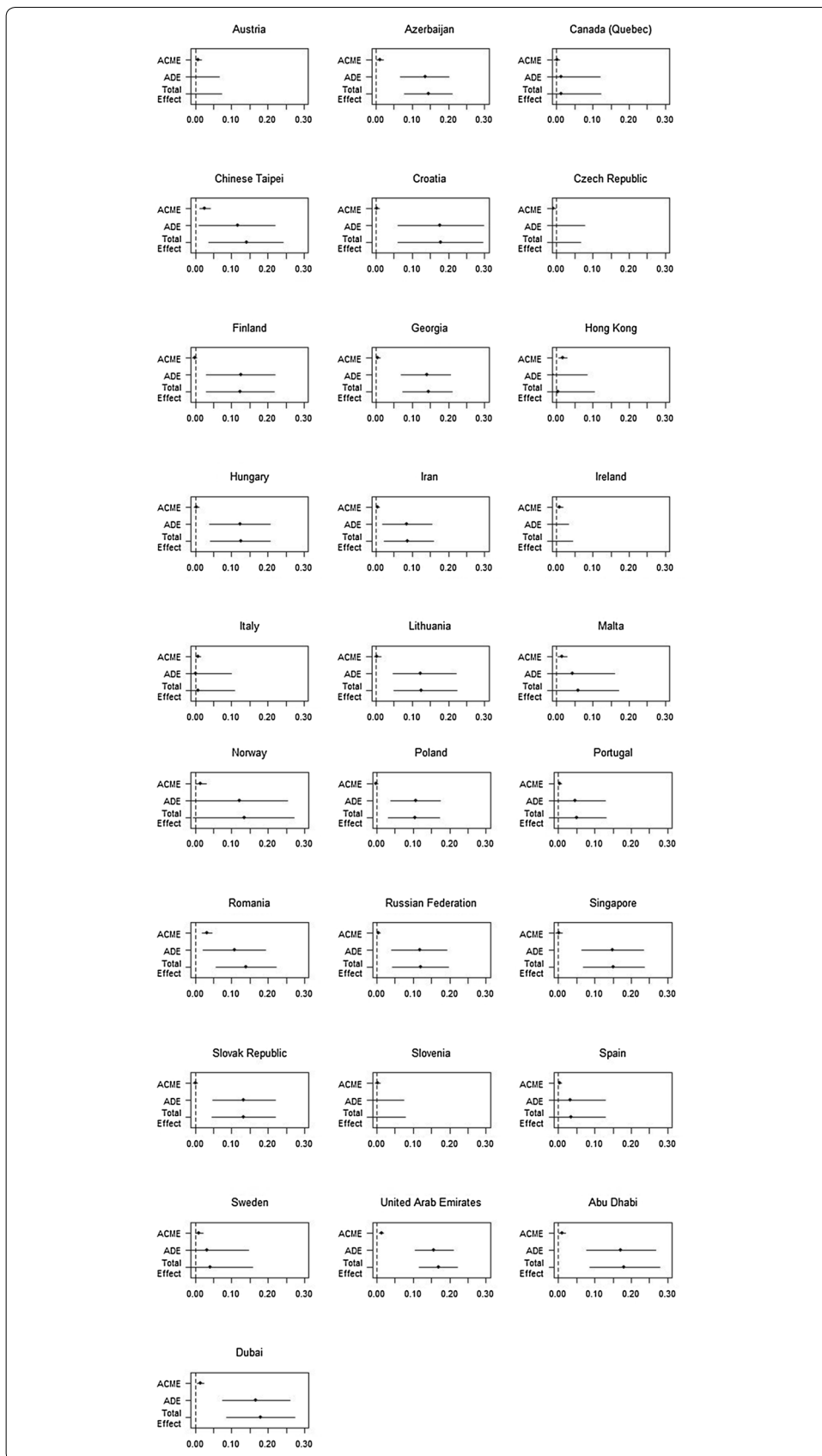
Figures 3 and 4 summarise causal mediation results for the mediating role of parental cognitive involvement in the relationship between family SES and subject-specific interest. Point estimates (dots) and 95% confidence intervals (solid lines) for the average causal mediation effect (ACME) of parental cognitive involvement,  $\hat{\beta}_2\hat{\gamma}$ , the average direct effect (ADE) of family SES,  $\hat{\beta}_3$ , and total effect of family SES,  $\hat{\beta}_1$ , are displayed. Model parameters were defined in Eqs. 1–3. Estimates are in the scale of the dependent variable of subject interest, that is, a mean score of 10 and a standard deviation of 2 across education systems. The total family SES effect, for example, can be interpreted as variation in subject interest for one unit change in family SES. The parental literacy involvement mediating mechanism for reading interest is presented in Fig. 3 and the parental numeracy involvement mediating mechanism for mathematics interest is presented in Fig. 4. The data underpinning Figs. 3 and 4 is presented in Table 4. In addition to total, direct, and mediating SES effects, Table 4 records the percentage of the total family SES effect mediated by the parental literacy and numeracy involvement mechanism.

Figure 3 shows family SES direct, total, and parental literacy involvement mediating effect on student reading interest. The total effect of family SES is significant in 15 education systems out of 28 (see Table 4). The parental literacy involvement mediating mechanism is statistically significant in 11 education system (see Table 4): Azerbaijan, Canada (Quebec), Chinese Taipei, Finland, Ireland, Portugal, Romania, Singapore, United Arab Emirates, Abu Dhabi, and Dubai. The percentage of the SES effect mediated by parental literacy involvement ranges from 3.74% in Dubai to 21.01% in Singapore.

(See figure on next page.)

**Fig. 3** Family SES and student reading interest: total, direct, and parental literacy involvement mediating association. Note. Black dots represent point estimates and solid lines 95% confidence intervals. ACME is the average causal mediation effect  $\hat{\beta}_2\hat{\gamma}$ ; ADE is the average direct effect of family SES  $\hat{\beta}_3$ ; and Total is the total effect of family SES  $\hat{\beta}_1$





(See figure on previous page.)

**Fig. 4** Family SES and student mathematics interest: total, direct, and parental numeracy involvement mediating association. Note. Black dots represent point estimates and solid lines 95% confidence intervals. *ACME* is the average causal mediation effect  $\hat{\beta}_2\hat{\gamma}$ ; *ADE* is the average direct effect of family SES  $\hat{\beta}_3$ ; and *Total* is the total effect of family SES  $\hat{\beta}_1$

In education systems where the total SES effect is significant the largest part of the SES effect is a direct effect and the parental literacy involvement mechanism explains a small proportion of the total SES effect. That is, other mechanisms beyond parental literacy involvement explain the family SES effect on student reading interest.

Figure 4 shows family SES direct, total, and parental numeracy involvement mediating effect on student mathematics interest. The total effect of family SES is significant in 16 education systems out of 28 (see Table 4). The parental numeracy involvement mediating mechanisms is statistically significant in 7 education system (see Table 5): Azerbaijan, Chinese Taipei, Iran, Romania, United Arab Emirates, Abu Dhabi, and Dubai. The percentage of the SES effect on student mathematics interest mediated by parental numeracy involvement ranges from 3.92% in Iran to 22.19% in Romania. But the parental numeracy involvement mechanism cannot fully explain the total family SES in any education system. Compared to the direct effect of SES, the mediating effect explains a smaller proportion of the total effect of SES. That is, other mechanisms not represented by the data explain the total effect of family SES on student mathematics interest in education systems where the total family SES was statistically significant.

On average, the correlation between parental literacy and numeracy involvement is relatively high across education systems ( $\rho = 0.66$ ; see Table 2). But because average correlations between student interest and family SES tend to be larger for student reading interest ( $\rho = 0.10$ ) and the correlation with family SES is larger for parental literacy involvement ( $\rho = 0.16$ ) than for parental numeracy involvement ( $\rho = 0.13$ ), stronger evidence of mediating effects is found for the SES mediating effect of parental literacy involvement on student reading interest (see Table 2).

Figures 6 and 7 in Appendix B present sensitivity analysis for mediating effects in Figs. 2 and 3, respectively. Overall, average causal mediation effects displayed in Figs. 2 and 3 are small and quickly become zero for slight changes in sensitivity parameters. That is, mediation effects are strongly affected by violations of the sequential ignorability assumption.

Up to this point results concentrated on family SES direct and indirect effects. Additionally, Table 5 reports regression coefficients of parental cognitive involvement for regressions of student subject interest, on parental cognitive involvement, SES, and confounders. Results show consistently that parental cognitive involvement is positively associated with subject interest independently of SES and confounders. Particularly, the association between reading subject interest with parental literacy involvement is positive and significant in every education system.

## Discussion

This study has evaluated the mediating effect of parental cognitive involvement in the relationship between family SES and students' subject interest using matched international data from TIMSS-PIRLS 2011. The study has aimed to contribute to research on equity in education and educational research more generally in different ways.

Educational research has been criticised for concentrating almost exclusively on academic achievement outcomes and for the lack of cross-cultural perspectives (Creemers and Kyriakides 2008). The study of family SES associations with subject-specific interest for students living in very different cultural and economic contexts contributes to addressing this criticism. The literature on motivation has largely studied influences of individual and teacher factors, but evidence of family influences is scarce despite theoretical arguments for family SES and parental cognitive involvement influences (Grolnick and Slowiaczek 1994; Raftery-Helmer and Grolnick 2015). This study contributes international evidence of these mechanisms to the knowledge base of educational research.

The analyses look at student interest in two different subjects, reading and mathematics, for the same sample of students in each education system. To the extent that students' experiences and outcomes vary by subject area, the subject-specificity of intrinsic motivation related outcomes and mediating mechanisms of parental literacy involvement and parental numeracy involvement seems appropriate. The study of student motivation in primary school is particularly relevant in light of research suggesting that students' intrinsic motivation for learning declines as they get older, especially for low SES students (Frenzel et al. 2010; Gottfried et al. 2007; Unrau and Schlackman 2006; Wigfield et al. 2015).

The results point to a weak association between family SES and student subject interest. While in some education systems students from higher socio-economic backgrounds report being more interested in reading and mathematics than students from less affluent families, many socio-economically disadvantaged students report being motivated despite family SES barriers. There is, however, significant variation between education systems. For example, family SES is positively related to student reading interest in the United Arab Emirates, Romania, Finland, Czech Republic, Canada (Quebec), but it is not in Croatia, Lithuania, and the Russian Federation. Likewise, family SES is positively related to student mathematics interest in United Arab Emirates, Romania, Slovak Republic, Croatia, Chinese Taipei, Azerbaijan, but it is not in Austria, Czech Republic, Hong Kong, Ireland, and Slovenia.

Associations between family SES and students' subject interest are not affected by school socio-economic stratification because variables were centred around the school mean to purge differences between schools and capture purely within school differences. The results suggest that socio-economically disadvantaged students are not necessarily less motivated and that in some education systems many disadvantaged students are clearly resilient in terms of their interest in reading and mathematics, at least if guided by student self-reports. But results could be affected by social desirability. Research suggests that students from low SES families and in less developed countries tend to report higher motivation for social desirability reasons (Van de Vijver 2015). If that is the case, the association between family SES and interest in reading and mathematics is underestimated in our analysis. And it is possible that family SES plays a more important role

in shaping students' intrinsic motivation across education systems than expected from observed associations with students' and parents' self-reports.

Across education systems, parents from higher SES families slightly tended to be more cognitively involved in children's learning before the beginning of school than parents in lower SES families. Higher SES parents tended to be more cognitively involved in both literacy and numeracy activities with the child. For instance, higher SES parents more often read books, told stories, sang songs, played word games, played with number toys, and played games involving shapes with children than lower SES parents. The association between family SES and parental cognitive involvement, however, was not strong and many parents from low SES backgrounds also reported performing these cognitive stimulating activities with children.

Parental cognitive involvement appeared to somewhat mediate SES inequalities in student subject interest in some education systems (e.g., Singapore, Romania, Chinese Taipei, Quebec, Abu Dhabi, Portugal). That is, higher SES students in these systems seemed to be more interested in learning because parents had been more cognitively involved in children's learning before they entered school. But evidence for the parental cognitive involvement mechanism was weak and significant in less than half of the education systems in the sample. Parental cognitive involvement mediation evidence was stronger for reading interest than for mathematics interest. Parental literacy involvement before the child entered school mediated significant proportions of SES differences in students' self-reported reading interest across education systems. Parental numeracy involvement less consistently mediated family SES effects on students' self-reported mathematics interest. Overall, however, sensitivity analysis indicated that parental literacy involvement and parental numeracy involvement mediation results cannot be interpreted in causal terms.

Despite insufficient support for the parental cognitive involvement mechanism in family SES effects on subject interest, results showed a direct association between parental literacy involvement and student reading interest as well as a direct association between parental numeracy involvement and student mathematics interest independently of family SES (see Table 5). Thus, apart for the potential role of parental cognitive involvement in reducing socio-economic gaps in student motivation, the results suggested that parental cognitive involvement is an effective gateway for influencing student motivation across education systems. This result is consistent with evidence showing that cognitive stimulating interactions between students, parents, and teachers promote students' interest and engagement in learning (e.g., Gottfried et al. 2015). To the extent that student subject interest is positively related to student academic achievement, cognitive stimulating activities with students could have an effect on academic achievement via student motivation, as suggested by recent research with PISA 2012 data indicating a positive and consistent relationship between teachers' cognitively activating strategies student performance in mathematics (Caro et al. 2016).

The direct association between parental cognitive involvement and student subject interest suggests that educational interventions that compensate for lack of cognitive activating experiences at home by providing children with opportunities that stimulate their curiosity and promote their interest in learning in school could positively influence students' motivation. But evidence of family influences in this paper is insufficient to derive specific recommendations for educational policy. And further research is needed to understand family influences on student motivation, the mechanisms underlying



family SES influences, and how family influences interact with students and teachers in shaping students' motivation.

### Limitations

A number of study limitations should be recognised. Motivational outcomes and parental cognitive involvement are self-reported by students and parents. Student subject interest and engagement could more appropriately be measured with observations or ratings from teachers, for example. Further, it is not clear that motivational scales can be compared across different cultures within and between countries. There could be cross-cultural validity issues, for example, due to different response styles of Likert-type items across cultures (Van de Vijver 2015). Observed responses could reflect differences in response styles rather than actual motivation dispositions. For example, research shows that Confucian cultures tend to avoid extreme values and prefer midpoint values of response scales, whereas Latin American students use more frequently extreme response categories (Harzing 2006; Van de Vijver 2015). And that students from low SES backgrounds and less developed countries tend to show more social desirability in responses (Van de Vijver 2015). Differences in subject-interest scores across countries could thus reflect this source of method bias instead of actual differences in subject interest (Artelt 2005; Buckley 2009).

Likewise, SES is not directly comparable across countries. We know from previous research that the weight of home possessions on SES is positive in developing countries but almost zero in high income countries (Caro and Cortés 2012). That is, home possessions surveyed in PIRLS do not discriminate well between higher and lower SES families in high income countries. When coupled with reports of relatively high education levels by parents, SES distributions tend to be negatively skewed, showing little variation at lower SES levels due to lack of valid SES items (e.g., Finland, Norway, the Russian Federation, Sweden, and the United Arab Emirates). Lack of variability in SES items affects the validity of our SES measure and its cross-country comparability.

Comparisons of motivational outcomes and SES scores at the country level have been avoided for this reason. Instead, findings rely on within-country results of mediation analysis. Research shows it is possible to compare across countries differences in within-country associations with motivational outcomes (Artelt 2005). Cross-cultural validity might still represent a limitation for the comparability of associations with family SES and parental cognitive involvement scales across countries.

Another limitation is that retrospective data on parental cognitive involvement could be biased by present knowledge of the child's interests and student achievement as well as by compliance of what is expected from parents. A chronological order beginning from family SES, followed by parental cognitive involvement and ultimately student motivation has been assumed to meet mediation analysis conditions. But retrospective judgements of cognitive stimulating activities before the child entered school might not be accurate and family SES might have changed during the first school years until Grade 4 when the data was collected.

Another limitation is that causal mediation and sensitivity analysis do not take into account the multilevel structure of the data or the missing data mechanism. The implementation of causal mediation analysis in R is relatively new and sensitivity analysis cannot be performed in combination with multilevel modelling. Because models do not

control for prior motivational outcomes, alternative explanations for mediation effects cannot be ruled out. It is possible for reciprocal effects to exist between motivation and parental cognitive involvement. That is, that not only parental cognitive involvement can affect student motivation but also more motivated children might seek and stimulate cognitively activating interactions with parents (Grolnick et al. 2009).

**Authors' contributions**

The article was fully developed by a single author. The author read and approved the final manuscript.

**Acknowledgements**

Not applicable.

**Competing interests**

The author declares that they have no competing interests.

**Availability of data and materials**

The datasets generated and/or analysed during the current study are available in the IEA Data Repository.

**Funding**

No sources of funding are declared.

## **Appendixes**

### **Appendix A: Data descriptive statistics**

See Tables 1, 2 and 3 and Fig. 5.

**Table 1 Sample size and proportion of missing data**

	Final sample size	Student reading interest	Student mathematics interest	Family SES	Parental literacy cognitive involvement	Parental numeracy cognitive involvement	Pre-school attendance	Parents like reading scale of books	Number of books	Number of children's books
Austria	3581	0.00	0.01	0.14	0.06	0.06	0.07	0.04	0.04	0.04
Azerbaijan	2638	0.07	0.15	0.24	0.08	0.11	0.07	0.03	0.03	0.04
Canada (Quebec)	3191	0.01	0.02	0.20	0.11	0.12	0.13	0.11	0.12	0.11
Chinese Taipei	3825	0.00	0.00	0.08	0.01	0.01	0.01	0.01	0.01	0.01
Croatia	4085	0.00	0.00	0.08	0.01	0.01	0.02	0.01	0.01	0.01
Czech Republic	3935	0.00	0.01	0.09	0.03	0.03	0.03	0.03	0.03	0.03
Finland	3984	0.00	0.01	0.10	0.04	0.04	0.05	0.04	0.05	0.05
Georgia	3128	0.03	0.06	0.26	0.03	0.05	0.04	0.03	0.03	0.03
Hong Kong	3027	0.00	0.01	0.14	0.07	0.07	0.10	0.07	0.09	0.07
Hungary	4174	0.00	0.01	0.17	0.05	0.05	0.05	0.05	0.05	0.05
Iran	4657	0.00	0.01	0.14	0.02	0.03	0.03	0.01	0.02	0.02
Ireland	3528	0.01	0.02	0.16	0.06	0.06	0.06	0.06	0.06	0.06
Italy	3307	0.01	0.01	0.16	0.07	0.07	0.07	0.07	0.07	0.07
Lithuania	3730	0.00	0.01	0.16	0.05	0.05	0.05	0.04	0.04	0.04
Malta	2437	0.01	0.02	0.27	0.09	0.09	0.09	0.10	0.09	0.09
Norway	2396	0.01	0.02	0.16	0.08	0.08	0.08	0.09	0.09	0.09
Poland	4300	0.00	0.01	0.10	0.02	0.02	0.02	0.02	0.02	0.02
Portugal	3253	0.00	0.01	0.16	0.05	0.05	0.05	0.05	0.05	0.05
Romania	3908	0.01	0.02	0.12	0.03	0.03	0.04	0.03	0.03	0.03
Russian Federation	3980	0.00	0.01	0.09	0.01	0.01	0.01	0.01	0.01	0.01
Singapore	5399	0.00	0.01	0.11	0.03	0.03	0.03	0.03	0.03	0.03
Slovak Republic	4773	0.00	0.01	0.12	0.02	0.03	0.03	0.03	0.03	0.03
Slovenia	3878	0.00	0.00	0.10	0.04	0.04	0.05	0.04	0.04	0.03
Spain	3246	0.00	0.01	0.17	0.08	0.08	0.09	0.08	0.08	0.08
Sweden	3108	0.01	0.03	0.26	0.13	0.13	0.15	0.13	0.14	0.13
United Arab Emirates	9724	0.01	0.03	0.27	0.09	0.09	0.11	0.09	0.09	0.09
Abu Dhabi	2793	0.01	0.02	0.27	0.07	0.08	0.09	0.07	0.08	0.08
Dubai	4052	0.02	0.03	0.27	0.11	0.11	0.13	0.11	0.11	0.11

**Table 2 Mean and standard deviations**

	Student reading interest		Student mathematics interest		Family SES		Parental literacy cognitive involvement		Parental numeracy cognitive involvement		Pre-school attendance		Parents like reading scale		Number of books		Number of children's books	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Austria	10.04	2.20	9.63	2.11	0.03	0.73	10.09	1.72	10.53	1.59	0.00	0.49	0.06	2.15	0.05	1.08	0.05	1.03
Azerbaijan	10.45	1.62	9.92	1.43	-0.77	1.04	9.53	1.78	9.22	1.79	0.00	0.92	0.06	1.49	0.06	0.97	0.02	0.79
Canada (Quebec)	10.33	2.03	9.71	1.98	0.58	0.70	10.37	1.87	10.51	1.77	0.00	0.73	0.06	1.97	0.03	1.12	0.03	1.02
Chinese Taipei	9.83	1.98	9.16	2.21	-0.02	0.86	8.82	1.86	9.33	2.13	0.01	0.58	0.02	1.66	0.03	1.20	0.04	1.29
Croatia	9.29	2.13	9.02	2.33	-0.10	0.81	10.77	1.76	10.55	1.69	0.02	0.97	0.05	2.09	0.02	1.04	0.01	0.98
Czech Republic	10.05	2.11	9.78	1.93	0.08	0.76	10.34	1.65	11.02	1.55	0.01	0.58	0.03	1.93	0.03	1.06	0.03	0.97
Finland	9.77	2.16	9.24	2.14	0.53	0.77	9.86	1.51	9.56	1.42	0.00	0.72	0.06	2.04	0.03	1.07	0.03	0.97
Georgia	10.94	1.95	11.36	1.49	-0.07	0.97	10.82	1.83	9.71	1.99	-0.01	0.94	0.06	1.64	0.06	1.05	0.02	1.00
Hong Kong	9.78	1.85	9.92	1.96	-0.40	0.95	8.73	1.71	9.18	1.91	0.01	0.48	0.02	1.52	0.02	1.09	0.02	1.11
Hungary	9.87	2.29	9.99	2.02	-0.19	1.08	10.35	1.61	11.25	1.63	0.01	0.33	0.06	1.92	0.05	1.08	0.05	1.06
Iran	10.63	1.75	10.71	1.78	-1.06	1.21	8.97	1.82	9.39	1.90	-0.01	0.77	0.04	1.61	0.00	1.01	0.00	0.93
Ireland	10.45	2.26	9.52	2.09	0.27	0.87	10.92	2.03	10.99	1.92	0.01	0.70	0.09	2.10	0.06	1.12	0.07	1.08
Italy	9.78	1.96	10.03	1.92	-0.30	0.87	10.55	1.73	10.35	1.68	0.02	0.50	0.05	1.72	0.04	1.12	0.03	1.01
Lithuania	10.07	1.92	10.38	1.85	0.09	0.90	10.14	1.67	10.01	1.59	0.01	0.91	0.05	1.92	0.03	1.09	0.02	1.00
Malta	10.33	2.25	10.16	2.04	-0.21	0.94	10.57	1.91	10.53	1.92	0.00	0.36	0.11	2.09	0.07	1.16	0.07	0.95
Norway	9.81	1.89	10.27	2.00	0.74	0.72	10.16	1.75	9.87	1.60	0.02	0.61	0.10	2.04	0.07	1.05	0.05	0.98
Poland	9.75	2.20	10.50	1.88	-0.14	1.02	10.51	1.74	10.85	1.61	0.02	0.98	0.05	1.98	0.04	1.05	0.04	1.00
Portugal	11.01	1.81	10.38	1.70	-0.06	1.01	10.20	1.85	10.03	1.77	0.01	0.82	0.04	1.58	0.05	1.09	0.05	1.04
Romania	10.54	2.16	10.58	1.78	-0.46	1.09	10.37	2.37	10.16	2.35	0.02	0.63	0.03	1.80	0.03	1.03	0.03	0.95
Russian Federation	9.99	1.87	10.44	1.70	0.24	0.83	11.16	1.93	10.95	1.83	0.01	0.91	0.03	1.71	0.01	1.02	0.00	1.00
Singapore	9.82	1.79	9.94	2.05	0.20	0.87	9.50	2.08	9.75	2.13	0.01	0.54	0.04	1.70	0.02	1.13	0.02	1.09
Slovak Republic	9.69	2.11	9.83	1.95	-0.12	0.93	10.55	1.80	11.09	1.77	0.03	0.62	0.04	1.81	0.03	1.01	0.03	0.94
Slovenia	10.03	2.02	9.80	2.00	0.10	0.77	10.69	1.78	10.48	1.65	0.01	0.85	0.03	1.64	0.03	1.07	0.03	1.03

**Table 2 (continued)**

	Student reading interest		Student mathematics interest		Family SES		Parental literacy cognitive involvement		Parental numeracy cognitive involvement		Pre-school attendance		Parents like reading scale		Number of books		Number of children's books	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Spain	10.32	2.07	10.02	1.97	0.07	0.98	10.52	1.75	10.09	1.70	0.01	0.63	0.07	2.02	0.06	1.05	0.06	1.00
Sweden	9.65	1.95	9.87	1.94	0.50	0.78	10.03	1.78	9.47	1.70	0.03	0.60	0.12	2.01	0.06	1.05	0.06	1.00
United Arab Emirates	10.14	1.76	10.45	1.87	0.27	0.93	9.79	1.80	10.08	1.91	-0.01	0.90	0.04	1.58	0.03	1.09	0.01	0.95
Abu Dhabi	10.06	1.68	10.45	1.87	0.14	0.96	9.60	1.72	9.90	1.85	-0.02	0.88	0.05	1.50	0.03	1.09	0.01	0.91
Dubai	10.27	1.87	10.42	1.89	0.50	0.84	10.06	1.87	10.28	1.94	-0.01	0.91	0.04	1.68	0.02	1.09	0.02	1.01

**Table 3 Correlation matrix: variables included in the analysis**

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Austria									
Student reading interest (a)	1	0.11	0.11	0.16	0.08	-0.03	0.15	0.16	0.19
Student mathematics interest (b)	0.11	1	-0.01	0.02	0.06	-0.02	-0.04	-0.02	-0.03
Family SES (c)	0.11	-0.01	1	0.16	0.15	0.09	0.25	0.44	0.39
Parental literacy cognitive involvement (d)	0.16	0.02	0.16	1	0.66	0.01	0.31	0.23	0.26
Parental numeracy cognitive involvement (e)	0.08	0.06	0.15	0.66	1	0.04	0.25	0.19	0.24
Pre-school attendance (f)	-0.03	-0.02	0.09	0.01	0.04	1	0.02	0.04	0.03
Parents like reading scale (g)	0.15	-0.04	0.25	0.31	0.25	0.02	1	0.51	0.38
Number of books at home (h)	0.16	-0.02	0.44	0.23	0.19	0.04	0.51	1	0.67
Number of children books at home (i)	0.19	-0.03	0.39	0.26	0.24	0.03	0.38	0.67	1
Azerbaijan									
Student reading interest (a)	1	0.21	0.07	0.10	0.05	0.00	0.08	0.03	0.05
Student mathematics interest (b)	0.21	1	0.10	0.09	0.07	-0.02	0.07	0.07	0.04
Family SES (c)	0.07	0.10	1	0.17	0.18	0.08	0.20	0.33	0.20
Parental literacy cognitive involvement (d)	0.10	0.09	0.17	1	0.59	0.08	0.29	0.22	0.24
Parental numeracy cognitive involvement (e)	0.05	0.07	0.18	0.59	1	0.12	0.23	0.19	0.21
Pre-school attendance (f)	0.00	-0.02	0.08	0.08	0.12	1	0.01	0.07	0.06
Parents like reading scale (g)	0.08	0.07	0.20	0.29	0.23	0.01	1	0.28	0.21
Number of books at home (h)	0.03	0.07	0.33	0.22	0.19	0.07	0.28	1	0.56
Number of children books at home (i)	0.05	0.04	0.20	0.24	0.21	0.06	0.21	0.56	1
Canada (Quebec)									
Student reading interest (a)	1	0.16	0.10	0.16	0.06	0.00	0.19	0.11	0.14
Student mathematics interest (b)	0.16	1	0.04	0.02	0.07	0.01	0.01	0.01	0.03
Family SES (c)	0.10	0.04	1	0.15	0.07	0.04	0.19	0.26	0.19
Parental literacy cognitive involvement (d)	0.16	0.02	0.15	1	0.66	0.04	0.33	0.20	0.26
Parental numeracy cognitive involvement (e)	0.06	0.07	0.07	0.66	1	0.05	0.23	0.13	0.22
Pre-school attendance (f)	0.00	0.01	0.04	0.04	0.05	1	0.02	0.01	0.01
Parents like reading scale (g)	0.19	0.01	0.19	0.33	0.23	0.02	1	0.41	0.26
Number of books at home (h)	0.11	0.01	0.26	0.20	0.13	0.01	0.41	1	0.52
Number of children books at home (i)	0.14	0.03	0.19	0.26	0.22	0.01	0.26	0.52	1
Chinese Taipei									
Student reading interest (a)	1	0.21	0.17	0.20	0.14	0.03	0.21	0.21	0.22
Student mathematics interest (b)	0.21	1	0.05	0.07	0.08	0.00	0.03	0.04	0.03
Family SES (c)	0.17	0.05	1	0.24	0.25	0.18	0.23	0.42	0.41
Parental literacy cognitive involvement (d)	0.20	0.07	0.24	1	0.70	0.03	0.37	0.32	0.35
Parental numeracy cognitive involvement (e)	0.14	0.08	0.25	0.70	1	0.04	0.27	0.26	0.31
Pre-school attendance (f)	0.03	0.00	0.18	0.03	0.04	1	0.04	0.08	0.09
Parents like reading scale (g)	0.21	0.03	0.23	0.37	0.27	0.04	1	0.38	0.32
Number of books at home (h)	0.21	0.04	0.42	0.32	0.26	0.08	0.38	1	0.69
Number of children books at home (i)	0.22	0.03	0.41	0.35	0.31	0.09	0.32	0.69	1

**Table 3 (continued)**

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Croatia									
Student reading interest (a)	1	0.24	0.04	0.13	0.04	−0.03	0.10	0.07	0.10
Student mathematics interest (b)	0.24	1	0.05	0.04	0.06	0.00	0.00	0.02	0.04
Family SES (c)	0.04	0.05	1	0.13	0.10	0.26	0.22	0.39	0.31
Parental literacy cognitive involvement (d)	0.13	0.04	0.13	1	0.65	0.05	0.33	0.20	0.24
Parental numeracy cognitive involvement (e)	0.04	0.06	0.10	0.65	1	0.06	0.24	0.16	0.20
Pre-school attendance (f)	−0.03	0.00	0.26	0.05	0.06	1	0.10	0.15	0.13
Parents like reading scale (g)	0.10	0.00	0.22	0.33	0.24	0.10	1	0.41	0.29
Number of books at home (h)	0.07	0.02	0.39	0.20	0.16	0.15	0.41	1	0.64
Number of children books at home (i)	0.10	0.04	0.31	0.24	0.20	0.13	0.29	0.64	1
Czech Republic									
Student reading interest (a)	1	0.17	0.10	0.11	0.05	−0.03	0.17	0.11	0.17
Student mathematics interest (b)	0.17	1	−0.02	0.00	0.05	−0.01	−0.01	−0.02	0.00
Family SES (c)	0.10	−0.02	1	0.09	0.02	0.12	0.22	0.37	0.32
Parental literacy cognitive involvement (d)	0.11	0.00	0.09	1	0.58	−0.03	0.25	0.15	0.18
Parental numeracy cognitive involvement (e)	0.05	0.05	0.02	0.58	1	0.03	0.15	0.08	0.14
Pre-school attendance (f)	−0.03	−0.01	0.12	−0.03	0.03	1	0.01	0.04	0.05
Parents like reading scale (g)	0.17	−0.01	0.22	0.25	0.15	0.01	1	0.44	0.38
Number of books at home (h)	0.11	−0.02	0.37	0.15	0.08	0.04	0.44	1	0.63
Number of children books at home (i)	0.17	0.00	0.32	0.18	0.14	0.05	0.38	0.63	1
Finland									
Student reading interest (a)	1	0.17	0.12	0.17	0.06	−0.05	0.16	0.14	0.15
Student mathematics interest (b)	0.17	1	0.02	0.04	0.09	−0.04	0.00	0.00	0.02
Family SES (c)	0.12	0.02	1	0.12	0.06	0.08	0.21	0.32	0.27
Parental literacy cognitive involvement (d)	0.17	0.04	0.12	1	0.66	−0.03	0.29	0.20	0.24
Parental numeracy cognitive involvement (e)	0.06	0.09	0.06	0.66	1	−0.02	0.19	0.14	0.22
Pre-school attendance (f)	−0.05	−0.04	0.08	−0.03	−0.02	1	0.01	0.00	−0.05
Parents like reading scale (g)	0.16	0.00	0.21	0.29	0.19	0.01	1	0.42	0.30
Number of books at home (h)	0.14	0.00	0.32	0.20	0.14	0.00	0.42	1	0.55
Number of children books at home (i)	0.15	0.02	0.27	0.24	0.22	−0.05	0.30	0.55	1
Georgia									
Student reading interest (a)	1	0.27	0.04	0.06	0.06	0.00	0.09	0.03	0.03
Student mathematics interest (b)	0.27	1	0.08	0.05	0.06	0.01	0.05	0.06	0.04
Family SES (c)	0.04	0.08	1	0.09	0.17	0.08	0.19	0.39	0.33
Parental literacy cognitive involvement (d)	0.06	0.05	0.09	1	0.65	0.08	0.26	0.15	0.19
Parental numeracy cognitive involvement (e)	0.06	0.06	0.17	0.65	1	0.06	0.23	0.21	0.24
Pre-school attendance (f)	0.00	0.01	0.08	0.08	0.06	1	0.01	0.03	0.03
Parents like reading scale (g)	0.09	0.05	0.19	0.26	0.23	0.01	1	0.30	0.27
Number of books at home (h)	0.03	0.06	0.39	0.15	0.21	0.03	0.30	1	0.62
Number of children books at home (i)	0.03	0.04	0.33	0.19	0.24	0.03	0.27	0.62	1

**Table 3 (continued)**

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Hong Kong									
Student reading interest (a)	1	0.13	0.09	0.15	0.10	0.02	0.14	0.14	0.19
Student mathematics interest (b)	0.13	1	0.00	0.06	0.09	0.02	0.00	-0.01	0.00
Family SES (c)	0.09	0.00	1	0.18	0.15	0.06	0.16	0.29	0.27
Parental literacy cognitive involvement (d)	0.15	0.06	0.18	1	0.68	0.09	0.31	0.26	0.29
Parental numeracy cognitive involvement (e)	0.10	0.09	0.15	0.68	1	0.09	0.22	0.21	0.25
Pre-school attendance (f)	0.02	0.02	0.06	0.09	0.09	1	0.06	0.03	0.07
Parents like reading scale (g)	0.14	0.00	0.16	0.31	0.22	0.06	1	0.30	0.26
Number of books at home (h)	0.14	-0.01	0.29	0.26	0.21	0.03	0.30	1	0.59
Number of children books at home (i)	0.19	0.00	0.27	0.29	0.25	0.07	0.26	0.59	1
Hungary									
Student reading interest (a)	1	0.21	0.11	0.15	0.10	0.03	0.22	0.12	0.15
Student mathematics interest (b)	0.21	1	0.08	0.06	0.09	0.03	0.04	0.07	0.07
Family SES (c)	0.11	0.08	1	0.11	0.14	0.06	0.30	0.49	0.46
Parental literacy cognitive involvement (d)	0.15	0.06	0.11	1	0.57	0.02	0.23	0.16	0.20
Parental numeracy cognitive involvement (e)	0.10	0.09	0.14	0.57	1	0.04	0.19	0.17	0.24
Pre-school attendance (f)	0.03	0.03	0.06	0.02	0.04	1	0.03	0.10	0.06
Parents like reading scale (g)	0.22	0.04	0.30	0.23	0.19	0.03	1	0.41	0.37
Number of books at home (h)	0.12	0.07	0.49	0.16	0.17	0.10	0.41	1	0.69
Number of children books at home (i)	0.15	0.07	0.46	0.20	0.24	0.06	0.37	0.69	1
Iran									
Student reading interest (a)	1	0.35	0.10	0.08	0.08	0.02	0.11	0.07	0.08
Student mathematics interest (b)	0.35	1	0.07	0.06	0.07	0.02	0.08	0.07	0.06
Family SES (c)	0.10	0.07	1	0.11	0.12	0.17	0.15	0.37	0.26
Parental literacy cognitive involvement (d)	0.08	0.06	0.11	1	0.67	0.16	0.31	0.17	0.22
Parental numeracy cognitive involvement (e)	0.08	0.07	0.12	0.67	1	0.13	0.28	0.17	0.21
Pre-school attendance (f)	0.02	0.02	0.17	0.16	0.13	1	0.06	0.10	0.14
Parents like reading scale (g)	0.11	0.08	0.15	0.31	0.28	0.06	1	0.27	0.22
Number of books at home (h)	0.07	0.07	0.37	0.17	0.17	0.10	0.27	1	0.46
Number of children books at home (i)	0.08	0.06	0.26	0.22	0.21	0.14	0.22	0.46	1
Ireland									
Student reading interest (a)	1	0.17	0.14	0.16	0.07	0.01	0.18	0.17	0.22
Student mathematics interest (b)	0.17	1	0.00	0.03	0.04	-0.02	-0.02	0.00	0.01
Family SES (c)	0.14	0.00	1	0.17	0.12	0.16	0.20	0.32	0.30
Parental literacy cognitive involvement (d)	0.16	0.03	0.17	1	0.70	0.06	0.28	0.24	0.31
Parental numeracy cognitive involvement (e)	0.07	0.04	0.12	0.70	1	0.06	0.22	0.17	0.25
Pre-school attendance (f)	0.01	-0.02	0.16	0.06	0.06	1	0.04	0.05	0.05
Parents like reading scale (g)	0.18	-0.02	0.20	0.28	0.22	0.04	1	0.46	0.33
Number of books at home (h)	0.17	0.00	0.32	0.24	0.17	0.05	0.46	1	0.60
Number of children books at home (i)	0.22	0.01	0.30	0.31	0.25	0.05	0.33	0.60	1



**Table 3 (continued)**

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Italy									
Student reading interest (a)	1	0.15	0.07	0.13	0.03	−0.02	0.11	0.09	0.15
Student mathematics interest (b)	0.15	1	0.00	0.01	0.06	−0.02	−0.05	−0.01	0.01
Family SES (c)	0.07	0.00	1	0.16	0.09	0.11	0.26	0.42	0.30
Parental literacy cognitive involvement (d)	0.13	0.01	0.16	1	0.58	0.05	0.32	0.23	0.26
Parental numeracy cognitive involvement (e)	0.03	0.06	0.09	0.58	1	0.07	0.19	0.14	0.18
Pre-school attendance (f)	−0.02	−0.02	0.11	0.05	0.07	1	0.05	0.10	0.10
Parents like reading scale (g)	0.11	−0.05	0.26	0.32	0.19	0.05	1	0.46	0.35
Number of books at home (h)	0.09	−0.01	0.42	0.23	0.14	0.10	0.46	1	0.60
Number of children books at home (i)	0.15	0.01	0.30	0.26	0.18	0.10	0.35	0.60	1
Lithuania									
Student reading interest (a)	1	0.13	0.06	0.12	0.03	0.01	0.10	0.12	0.18
Student mathematics interest (b)	0.13	1	0.02	0.00	0.08	0.01	−0.01	0.00	−0.01
Family SES (c)	0.06	0.02	1	0.11	0.06	0.16	0.22	0.36	0.36
Parental literacy cognitive involvement (d)	0.12	0.00	0.11	1	0.60	−0.02	0.25	0.15	0.20
Parental numeracy cognitive involvement (e)	0.03	0.08	0.06	0.60	1	0.01	0.16	0.05	0.14
Pre-school attendance (f)	0.01	0.01	0.16	−0.02	0.01	1	0.00	0.02	0.03
Parents like reading scale (g)	0.10	−0.01	0.22	0.25	0.16	0.00	1	0.34	0.29
Number of books at home (h)	0.12	0.00	0.36	0.15	0.05	0.02	0.34	1	0.61
Number of children books at home (i)	0.18	−0.01	0.36	0.20	0.14	0.03	0.29	0.61	1
Malta									
Student reading interest (a)	1	0.22	0.06	0.15	0.09	0.04	0.09	0.07	0.13
Student mathematics interest (b)	0.22	1	0.03	0.05	0.06	0.03	0.00	0.03	0.03
Family SES (c)	0.06	0.03	1	0.20	0.18	0.02	0.16	0.33	0.23
Parental literacy cognitive involvement (d)	0.15	0.05	0.20	1	0.66	0.02	0.35	0.22	0.29
Parental numeracy cognitive involvement (e)	0.09	0.06	0.18	0.66	1	0.02	0.26	0.18	0.23
Pre-school attendance (f)	0.04	0.03	0.02	0.02	0.02	1	−0.01	0.01	0.06
Parents like reading scale (g)	0.09	0.00	0.16	0.35	0.26	−0.01	1	0.33	0.22
Number of books at home (h)	0.07	0.03	0.33	0.22	0.18	0.01	0.33	1	0.50
Number of children books at home (i)	0.13	0.03	0.23	0.29	0.23	0.06	0.22	0.50	1
Norway									
Student reading interest (a)	1	0.19	0.08	0.12	0.01	−0.01	0.14	0.12	0.11
Student mathematics interest (b)	0.19	1	0.04	−0.01	0.04	0.01	−0.03	−0.02	−0.01
Family SES (c)	0.08	0.04	1	0.20	0.16	0.20	0.23	0.36	0.30
Parental literacy cognitive involvement (d)	0.12	−0.01	0.20	1	0.67	−0.01	0.34	0.24	0.30
Parental numeracy cognitive involvement (e)	0.01	0.04	0.16	0.67	1	0.00	0.24	0.18	0.24
Pre-school attendance (f)	−0.01	0.01	0.20	−0.01	0.00	1	0.07	0.16	0.10
Parents like reading scale (g)	0.14	−0.03	0.23	0.34	0.24	0.07	1	0.45	0.35
Number of books at home (h)	0.12	−0.02	0.36	0.24	0.18	0.16	0.45	1	0.63
Number of children books at home (i)	0.11	−0.01	0.30	0.30	0.24	0.10	0.35	0.63	1

**Table 3 (continued)**

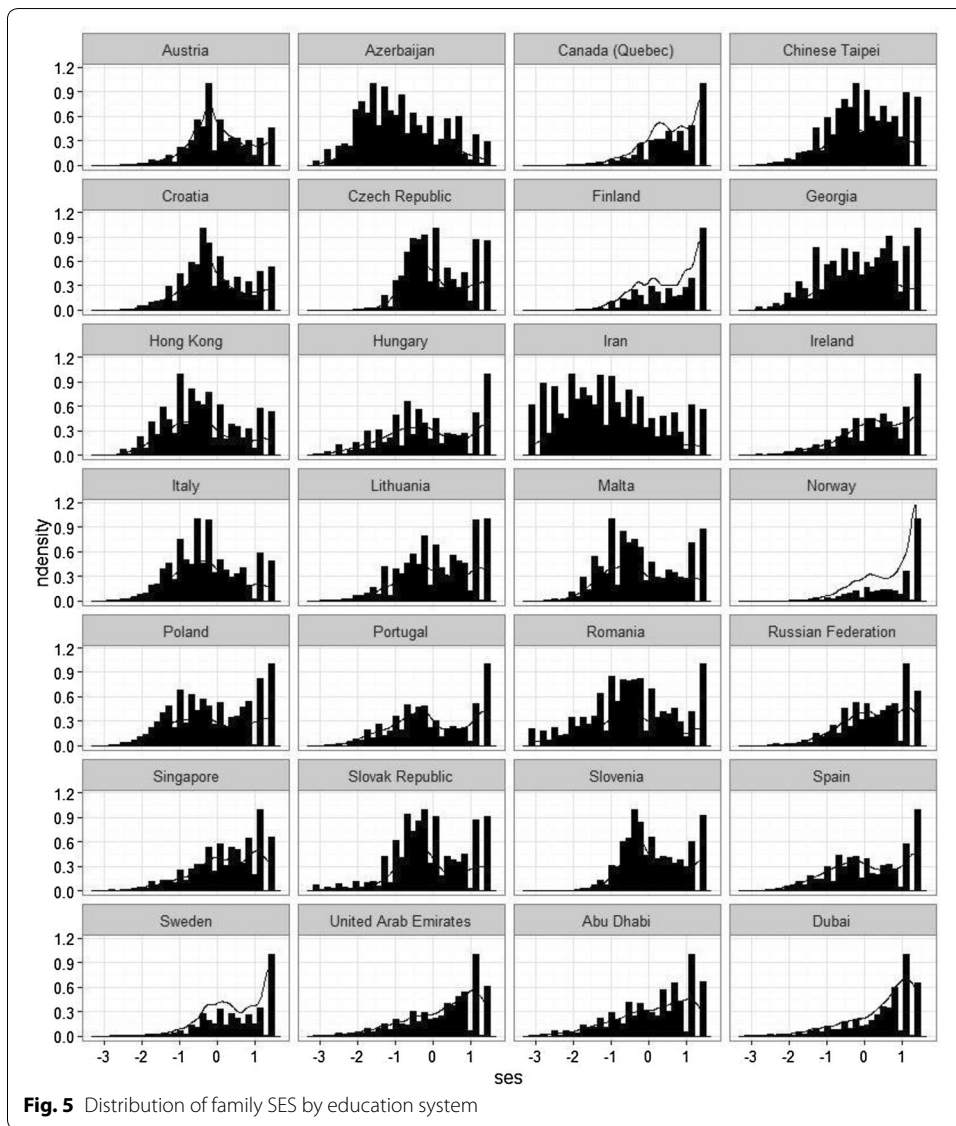
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Poland									
Student reading interest (a)	1	0.21	0.12	0.18	0.08	−0.01	0.14	0.13	0.15
Student mathematics interest (b)	0.21	1	0.03	0.02	0.05	−0.03	−0.01	0.01	0.00
Family SES (c)	0.12	0.03	1	0.16	0.09	0.33	0.25	0.40	0.38
Parental literacy cognitive involvement (d)	0.18	0.02	0.16	1	0.63	0.07	0.32	0.24	0.30
Parental numeracy cognitive involvement (e)	0.08	0.05	0.09	0.63	1	0.05	0.22	0.16	0.22
Pre-school attendance (f)	−0.01	−0.03	0.33	0.07	0.05	1	0.08	0.15	0.15
Parents like reading scale (g)	0.14	−0.01	0.25	0.32	0.22	0.08	1	0.41	0.33
Number of books at home (h)	0.13	0.01	0.40	0.24	0.16	0.15	0.41	1	0.63
Number of children books at home (i)	0.15	0.00	0.38	0.30	0.22	0.15	0.33	0.63	1
Portugal									
Student reading interest (a)	1	0.22	0.09	0.15	0.10	0.03	0.15	0.11	0.13
Student mathematics interest (b)	0.22	1	0.07	0.05	0.09	0.01	0.04	0.06	0.08
Family SES (c)	0.09	0.07	1	0.21	0.18	0.18	0.22	0.44	0.39
Parental literacy cognitive involvement (d)	0.15	0.05	0.21	1	0.69	0.08	0.35	0.25	0.30
Parental numeracy cognitive involvement (e)	0.10	0.09	0.18	0.69	1	0.07	0.26	0.21	0.26
Pre-school attendance (f)	0.03	0.01	0.18	0.08	0.07	1	0.07	0.09	0.10
Parents like reading scale (g)	0.15	0.04	0.22	0.35	0.26	0.07	1	0.36	0.29
Number of books at home (h)	0.11	0.06	0.44	0.25	0.21	0.09	0.36	1	0.59
Number of children books at home (i)	0.13	0.08	0.39	0.30	0.26	0.10	0.29	0.59	1
Romania									
Student reading interest (a)	1	0.31	0.09	0.13	0.09	0.06	0.14	0.07	0.11
Student mathematics interest (b)	0.31	1	0.11	0.13	0.13	0.13	0.09	0.08	0.09
Family SES (c)	0.09	0.11	1	0.27	0.28	0.25	0.30	0.43	0.37
Parental literacy cognitive involvement (d)	0.13	0.13	0.27	1	0.75	0.27	0.42	0.28	0.29
Parental numeracy cognitive involvement (e)	0.09	0.13	0.28	0.75	1	0.28	0.35	0.26	0.28
Pre-school attendance (f)	0.06	0.13	0.25	0.27	0.28	1	0.14	0.14	0.14
Parents like reading scale (g)	0.14	0.09	0.30	0.42	0.35	0.14	1	0.42	0.37
Number of books at home (h)	0.07	0.08	0.43	0.28	0.26	0.14	0.42	1	0.67
Number of children books at home (i)	0.11	0.09	0.37	0.29	0.28	0.14	0.37	0.67	1
Russian Federation									
Student reading interest (a)	1	0.22	0.01	0.11	0.07	−0.06	0.13	0.07	0.11
Student mathematics interest (b)	0.22	1	0.04	0.03	0.03	0.02	−0.01	0.02	0.02
Family SES (c)	0.01	0.04	1	0.13	0.13	0.14	0.16	0.22	0.23
Parental literacy cognitive involvement (d)	0.11	0.03	0.13	1	0.68	0.01	0.29	0.19	0.23
Parental numeracy cognitive involvement (e)	0.07	0.03	0.13	0.68	1	0.04	0.23	0.18	0.24
Pre-school attendance (f)	−0.06	0.02	0.14	0.01	0.04	1	−0.01	0.02	0.01
Parents like reading scale (g)	0.13	−0.01	0.16	0.29	0.23	−0.01	1	0.34	0.27
Number of books at home (h)	0.07	0.02	0.22	0.19	0.18	0.02	0.34	1	0.61
Number of children books at home (i)	0.11	0.02	0.23	0.23	0.24	0.01	0.27	0.61	1

**Table 3 (continued)**

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Singapore									
Student reading interest (a)	1	0.09	0.11	0.18	0.10	0.00	0.19	0.12	0.16
Student mathematics interest (b)	0.09	1	0.03	-0.03	0.00	0.01	-0.03	-0.03	-0.03
Family SES (c)	0.11	0.03	1	0.21	0.18	0.06	0.15	0.24	0.23
Parental literacy cognitive involvement (d)	0.18	-0.03	0.21	1	0.74	0.05	0.37	0.23	0.24
Parental numeracy cognitive involvement (e)	0.10	0.00	0.18	0.74	1	0.08	0.28	0.16	0.19
Pre-school attendance (f)	0.00	0.01	0.06	0.05	0.08	1	0.02	0.05	0.12
Parents like reading scale (g)	0.19	-0.03	0.15	0.37	0.28	0.02	1	0.33	0.25
Number of books at home (h)	0.12	-0.03	0.24	0.23	0.16	0.05	0.33	1	0.52
Number of children books at home (i)	0.16	-0.03	0.23	0.24	0.19	0.12	0.25	0.52	1
Slovak Republic									
Student reading interest (a)	1	0.19	0.08	0.12	0.07	0.01	0.18	0.12	0.16
Student mathematics interest (b)	0.19	1	0.06	0.04	0.07	0.03	0.00	0.04	0.06
Family SES (c)	0.08	0.06	1	0.10	0.08	0.20	0.22	0.39	0.37
Parental literacy cognitive involvement (d)	0.12	0.04	0.10	1	0.62	0.08	0.27	0.17	0.22
Parental numeracy cognitive involvement (e)	0.07	0.07	0.08	0.62	1	0.10	0.22	0.14	0.18
Pre-school attendance (f)	0.01	0.03	0.20	0.08	0.10	1	0.07	0.10	0.13
Parents like reading scale (g)	0.18	0.00	0.22	0.27	0.22	0.07	1	0.38	0.31
Number of books at home (h)	0.12	0.04	0.39	0.17	0.14	0.10	0.38	1	0.63
Number of children books at home (i)	0.16	0.06	0.37	0.22	0.18	0.13	0.31	0.63	1
Slovenia									
Student reading interest (a)	1	0.22	0.07	0.14	0.05	0.01	0.15	0.09	0.12
Student mathematics interest (b)	0.22	1	0.00	0.06	0.07	0.00	-0.01	-0.02	-0.01
Family SES (c)	0.07	0.00	1	0.19	0.13	0.15	0.25	0.37	0.39
Parental literacy cognitive involvement (d)	0.14	0.06	0.19	1	0.67	0.03	0.32	0.21	0.26
Parental numeracy cognitive involvement (e)	0.05	0.07	0.13	0.67	1	0.05	0.25	0.17	0.24
Pre-school attendance (f)	0.01	0.00	0.15	0.03	0.05	1	0.05	0.05	0.10
Parents like reading scale (g)	0.15	-0.01	0.25	0.32	0.25	0.05	1	0.37	0.35
Number of books at home (h)	0.09	-0.02	0.37	0.21	0.17	0.05	0.37	1	0.63
Number of children books at home (i)	0.12	-0.01	0.39	0.26	0.24	0.10	0.35	0.63	1
Spain									
Student reading interest (a)	1	0.20	0.11	0.12	0.05	0.00	0.12	0.11	0.12
Student mathematics interest (b)	0.20	1	0.02	0.02	0.03	0.02	0.01	0.01	0.01
Family SES (c)	0.11	0.02	1	0.17	0.13	0.11	0.23	0.41	0.36
Parental literacy cognitive involvement (d)	0.12	0.02	0.17	1	0.66	0.07	0.37	0.25	0.27
Parental numeracy cognitive involvement (e)	0.05	0.03	0.13	0.66	1	0.07	0.24	0.18	0.23
Pre-school attendance (f)	0.00	0.02	0.11	0.07	0.07	1	0.07	0.11	0.09
Parents like reading scale (g)	0.12	0.01	0.23	0.37	0.24	0.07	1	0.45	0.33
Number of books at home (h)	0.11	0.01	0.41	0.25	0.18	0.11	0.45	1	0.61
Number of children books at home (i)	0.12	0.01	0.36	0.27	0.23	0.09	0.33	0.61	1

**Table 3 (continued)**

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Sweden									
Student reading interest (a)	1	0.18	0.12	0.21	0.10	0.03	0.20	0.13	0.17
Student mathematics interest (b)	0.18	1	0.02	0.04	0.07	-0.02	0.01	-0.02	-0.01
Family SES (c)	0.12	0.02	1	0.22	0.14	0.19	0.30	0.37	0.30
Parental literacy cognitive involvement (d)	0.21	0.04	0.22	1	0.71	0.06	0.38	0.25	0.27
Parental numeracy cognitive involvement (e)	0.10	0.07	0.14	0.71	1	0.04	0.29	0.16	0.18
Pre-school attendance (f)	0.03	-0.02	0.19	0.06	0.04	1	0.09	0.13	0.14
Parents like reading scale (g)	0.20	0.01	0.30	0.38	0.29	0.09	1	0.47	0.33
Number of books at home (h)	0.13	-0.02	0.37	0.25	0.16	0.13	0.47	1	0.60
Number of children books at home (i)	0.17	-0.01	0.30	0.27	0.18	0.14	0.33	0.60	1
United Arab Emirates									
Student reading interest (a)	1	0.27	0.09	0.13	0.08	0.01	0.15	0.09	0.13
Student mathematics interest (b)	0.27	1	0.08	0.06	0.07	0.02	0.03	0.03	0.04
Family SES (c)	0.09	0.08	1	0.13	0.13	0.05	0.14	0.22	0.16
Parental literacy cognitive involvement (d)	0.13	0.06	0.13	1	0.65	0.08	0.31	0.19	0.24
Parental numeracy cognitive involvement (e)	0.08	0.07	0.13	0.65	1	0.07	0.23	0.14	0.20
Pre-school attendance (f)	0.01	0.02	0.05	0.08	0.07	1	0.03	0.06	0.05
Parents like reading scale (g)	0.15	0.03	0.14	0.31	0.23	0.03	1	0.34	0.26
Number of books at home (h)	0.09	0.03	0.22	0.19	0.14	0.06	0.34	1	0.55
Number of children books at home (i)	0.13	0.04	0.16	0.24	0.20	0.05	0.26	0.55	1
Abu Dhabi									
Student reading interest (a)	1	0.29	0.10	0.14	0.09	-0.01	0.15	0.07	0.11
Student mathematics interest (b)	0.29	1	0.09	0.09	0.09	0.00	0.04	0.02	0.04
Family SES (c)	0.10	0.09	1	0.15	0.13	0.06	0.17	0.22	0.16
Parental literacy cognitive involvement (d)	0.14	0.09	0.15	1	0.64	0.10	0.31	0.17	0.21
Parental numeracy cognitive involvement (e)	0.09	0.09	0.13	0.64	1	0.09	0.25	0.13	0.19
Pre-school attendance (f)	-0.01	0.00	0.06	0.10	0.09	1	0.03	0.08	0.06
Parents like reading scale (g)	0.15	0.04	0.17	0.31	0.25	0.03	1	0.34	0.25
Number of books at home (h)	0.07	0.02	0.22	0.17	0.13	0.08	0.34	1	0.53
Number of children books at home (i)	0.11	0.04	0.16	0.21	0.19	0.06	0.25	0.53	1
Dubai									
Student reading interest (a)	1	0.24	0.09	0.14	0.08	0.04	0.17	0.12	0.17
Student mathematics interest (b)	0.24	1	0.06	0.05	0.06	0.03	0.03	0.04	0.04
Family SES (c)	0.09	0.06	1	0.10	0.12	0.05	0.13	0.21	0.15
Parental literacy cognitive involvement (d)	0.14	0.05	0.10	1	0.66	0.05	0.32	0.21	0.27
Parental numeracy cognitive involvement (e)	0.08	0.06	0.12	0.66	1	0.04	0.23	0.15	0.22
Pre-school attendance (f)	0.04	0.03	0.05	0.05	0.04	1	0.02	0.04	0.03
Parents like reading scale (g)	0.17	0.03	0.13	0.32	0.23	0.02	1	0.35	0.28
Number of books at home (h)	0.12	0.04	0.21	0.21	0.15	0.04	0.35	1	0.57
Number of children books at home (i)	0.17	0.04	0.15	0.27	0.22	0.03	0.28	0.57	1



**Appendix B: Mediation results and sensitivity analysis**

See Tables 4, 5 and Figs. 6, 7.

**Table 4 Family SES and subject-specific interest: causal mediation of parental cognitive involvement**

Education system	Student reading interest				Student mathematics interest					
	% Mediated		ACME		% Mediated		ACME			
	Total	Direct	Total	Direct	Total	Direct	Total			
Austria	15.06	0.09	0.10	*	0.02	0.01	0.01	*	-0.06	-0.05
Azerbaijan	11.25	0.12	0.13	*	0.01	0.01	*	0.01	0.14	0.15
Canada (Quebec)	12.30	0.17	0.19	*	0.02	0.00	*	0.00	0.01	0.01
Chinese Taipei	8.90	0.15	0.17	*	0.02	0.03	*	0.03	0.12	0.14
Croatia	-11.76	-0.04	-0.03	*	0.01	0.00	*	0.00	0.18	0.18
Czech Republic	1.98	0.16	0.17	*	0.00	-0.01	*	-0.01	-0.02	-0.03
Finland	6.78	0.16	0.18	*	0.01	0.00	*	0.00	0.13	0.12
Georgia	3.93	0.06	0.06	*	0.00	0.00	*	0.00	0.14	0.14
Hong Kong	24.31	0.03	0.04	*	0.01	0.02	*	0.02	-0.01	0.00
Hungary	-5.05	0.05	0.05	*	0.00	0.00	*	0.00	0.12	0.13
Iran	0.28	0.14	0.14	*	0.00	0.00	*	0.00	0.08	0.09
Ireland	8.03	0.11	0.12	*	0.01	0.01	*	0.01	-0.06	-0.05
Italy	19.82	0.04	0.05	*	0.01	0.01	*	0.01	0.00	0.01
Lithuania	-6.28	-0.04	-0.04	*	0.00	0.00	*	0.00	0.12	0.13
Malta	35.24	0.06	0.09	*	0.03	0.01	*	0.01	0.04	0.06
Norway	21.81	0.06	0.08	*	0.02	0.01	*	0.01	0.12	0.14
Poland	2.95	0.16	0.16	*	0.00	0.00	*	0.00	0.11	0.10
Portugal	9.16	0.09	0.10	*	0.01	0.00	*	0.00	0.05	0.05
Romania	10.45	0.21	0.24	*	0.02	0.03	*	0.03	0.11	0.14
Russian Federation	-15.13	-0.06	-0.05	*	0.01	0.00	*	0.00	0.12	0.12
Singapore	21.01	0.12	0.15	*	0.03	0.71	*	0.00	0.15	0.15
Slovak Republic	-0.73	0.04	0.04	*	0.00	-0.24	*	0.00	0.13	0.13
Slovenia	27.28	0.03	0.05	*	0.02	-1.30	*	0.00	-0.02	-0.02
Spain	5.02	0.10	0.11	*	0.01	2.98	*	0.00	0.03	0.04

**Table 4 (continued)**

Education system	Student reading interest			Student mathematics interest		
	% Mediated	ACME	Total	% Mediated	ACME	Total
Sweden	36.00	0.03	0.08	10.61	0.01	0.04
United Arab Emirates	9.17	0.01	0.14	7.12	0.01	0.17
Abu Dhabi	13.81	0.02	0.13	5.08	0.01	0.18
Dubai	3.74	0.01	0.20	7.47	0.01	0.18

\* Statistically significant ( $p < 0.05$ ). The mediating mechanism is parental literacy involvement for reading interest and parental numeracy involvement for mathematics interest. ACME is the average causal mediation effect  $\hat{\beta}_2\gamma$ . Direct is the direct effect of family SES  $\hat{\beta}_3$ . Total is the total effect of family SES  $\hat{\beta}_3$  and % Mediated is the percentage of the family SES effect mediated by parental cognitive involvement mechanism

**Table 5 Direct association with parental cognitive involvement: unstandardised regression coefficients**

Education system	(1) Student reading interest		(2) Student mathematics interest	
Austria	0.14	*	0.08	*
Azerbaijan	0.08	*	0.04	*
Canada (Quebec)	0.10	*	0.08	*
Chinese Taipei	0.09	*	0.07	*
Croatia	0.13	*	0.07	*
Czech Republic	0.06	*	0.07	*
Finland	0.17	*	0.08	*
Georgia	0.06	*	0.02	
Hong Kong	0.09	*	0.11	*
Hungary	0.12	*	0.10	*
Iran	0.04	*	0.05	*
Ireland	0.07	*	0.08	*
Italy	0.10	*	0.07	*
Lithuania	0.08	*	0.11	*
Malta	0.14	*	0.06	*
Norway	0.07	*	0.05	
Poland	0.17	*	0.07	*
Portugal	0.10	*	0.04	
Romania	0.07	*	0.08	*
Russian Federation	0.06	*	0.02	
Singapore	0.09	*	0.00	
Slovak Republic	0.10	*	0.08	*
Slovenia	0.11	*	0.09	*
Spain	0.08	*	0.06	*
Sweden	0.13	*	0.08	*
United Arab Emirates	0.08	*	0.06	*
Abu Dhabi	0.10	*	0.07	*
Dubai	0.07	*	0.07	*

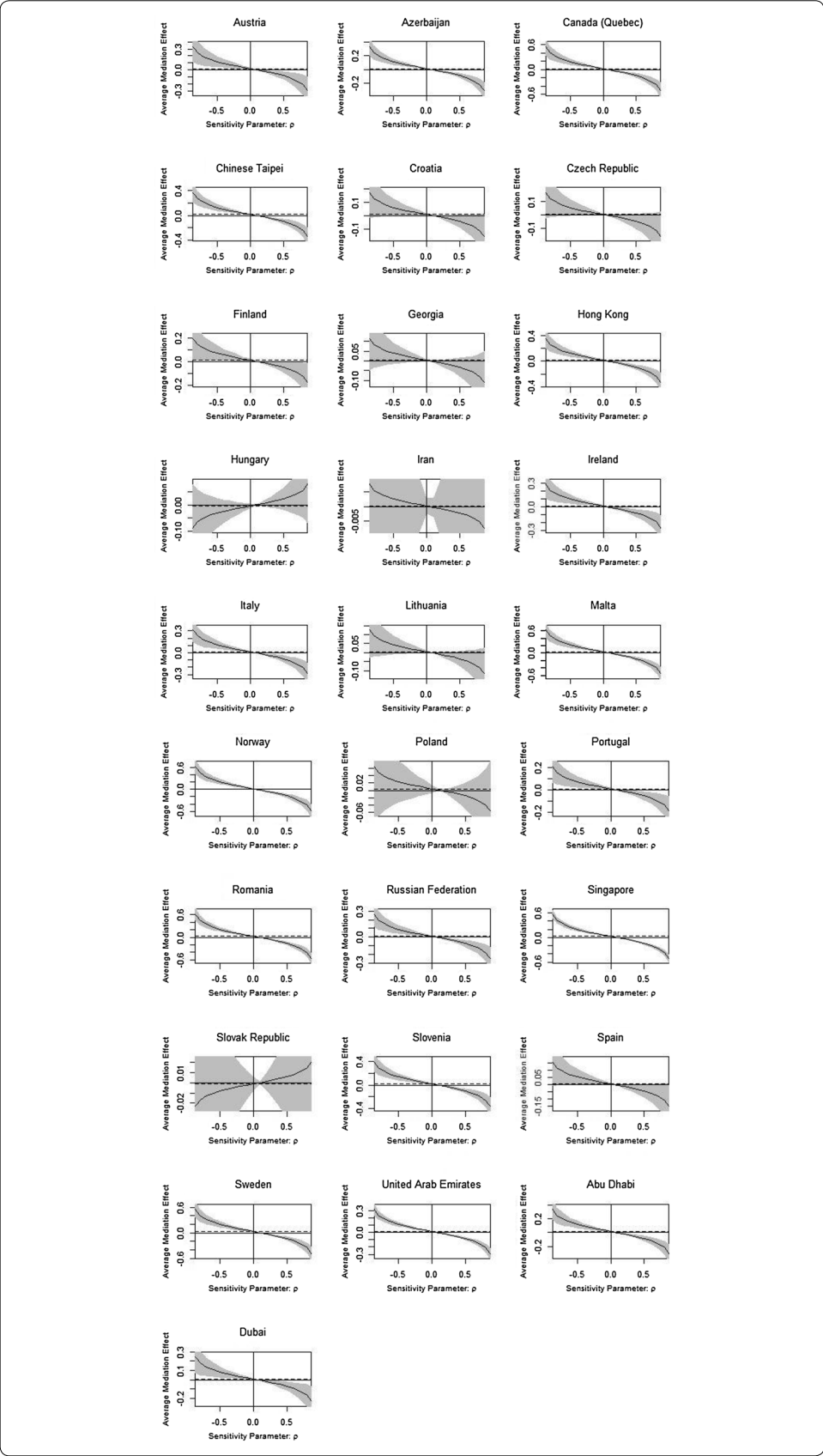
(1) Regression of student interest in reading on SES, parental reading involvement and confounders. (2) Regression of student interest in mathematics on SES, parental numeracy involvement and confounders. Parental involvement coefficients are reported

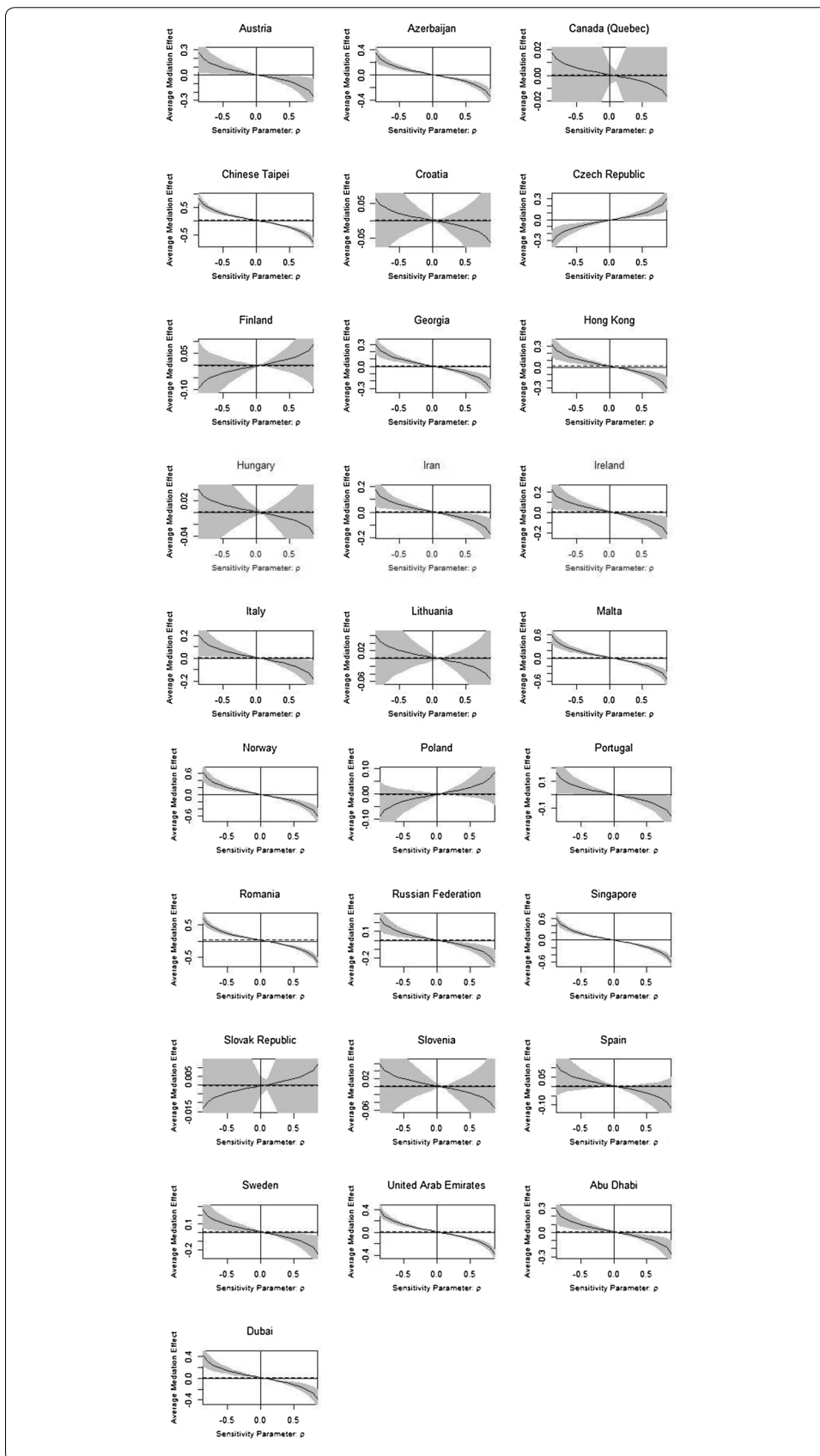
\* Statistically significant ( $p < 0.05$ )

(See figure on next page.)

**Fig. 6** Sensitivity analysis for the mediating effect of parental literacy involvement in the family SES and reading interest relationship







(See figure on previous page.)

**Fig. 7** Sensitivity analysis for the mediating effect of parental numeracy involvement in the family SES and mathematics interest relationship

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 24 March 2018 Accepted: 26 October 2018

Published online: 01 November 2018

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