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‘Am I to blame because my child is not motivated to do math?’: Relationships between parents’ attitudes, beliefs and practices towards mathematics and students’ mathematics motivation and achievement

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Abstract
Research on parental involvement is broad and specifies diverse kinds of parental practices that have specific associations with children’s learning outcomes. However, the involvement of parents in education, the dynamics of parent–child interactions and the actions and practices they employ and their impact on student’s motivation and achievement are intricate processes characterised by numerous intervening variables that require further clarification.

In this study, we aimed to examine the association between parental beliefs and involvement and their children’s motivation and mathematics achievement. Data were collected from 8071 third- and fourth-graders from six European countries and their parents. Students fulfilled the Expectancy-Value Scale, self-reporting on motivational aspects towards mathematics and performed two math tests to assess their performance. Parents also reported on their math attitudes, mindsets and involvement practices with their children.

Data analysis was performed using structural equation modelling. Several theoretically meaningful associations were found in the tested model, showing the detrimental impacts of a fixed mindset on parents’ practices. Furthermore, we found significant relationships between parents’ attitudes towards mathematics, their practices and students’ perceptions of math-related values and cost. Finally, associations between parental practices, the child’s outcomes and the association between children’s mathematics motivation and achievement were also observed. Some implications are presented, particularly concerning interventions with parents.

Keywords Parental involvement · Math motivation · Parental mindset · Parental practices

Over the past few decades, the research concerning students’ motivation and achievement has underlined the importance of socialisers for establishing an association between motivation and performance. Parenting represents one of the main lines of research in this field, which is sustained both by conceptual models and evidence of how parents’ behaviour and

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beliefs impact their children's motivation to learn and do well in school (e.g. Dinkelmann & Bluff, 2016; Eccles, 2007; Eccles & Wigfield, 2020; Gonida & Cortina, 2014; Nalipay et al., 2021). In the present paper, we address this issue in the context of mathematics learning in primary school (i.e. grades three and four) by looking into the association between parents' practices and beliefs and students' motivation and academic achievement.

Parental involvement in education

Parental involvement in education can be defined as a multidimensional construct comprising both home-based/parent-centred (e.g. help in school homework, provision of learning opportunities, parent–child communication) and school-based/school-centred (e.g. attendance at school meetings or other activities organised by the school community) involvement (Hoover-Dempsey et al., 2005; Jay et al., 2018). We use the term 'parental involvement' to refer to home-based/parental-centred practices.

The topic of parent involvement in education and its benefits has been established as an essential field of research over the past few decades, as can be seen in the number of meta-analytic systematic reviews on the topic (e.g. Jeynes, 2022; Kim, 2020; Ma et al., 2016; Tan et al., 2020). For instance, Higgins and Katsipataki (2015) integrated evidence from 13 review papers with meta-analyses conducted between 2001 and 2012, concluding that parental involvement consistently benefits young students' attainment. Overall, the research has shown that parental involvement can make a significant difference in their children's academic achievement, engagement and motivation, as well as in their behavioural, social and emotional adjustment. Moreover, research has indicated that different types of parental involvement can have diverse effects on students' outcomes, with a current broad field of study trying to understand and comprehensively identify and explain these different impacts (Barger et al., 2019; Boonk et al., 2018; Kim, 2020). Various conceptual models of parental involvement have been developed, emphasising the interdependence of the several of the actors involved (e.g. parents, children, teachers and schools), as well as the dynamics developed between them (Eccles & Harold, 1996; Epstein, 2011; Grolnick & Slowiaczek, 1994; Hoover-Dempsey et al., 2005). Among these, Eccles and Harold's (1996) proposed model presents a holistic and enlarged framework in which parental involvement is recognised as a result of parents', teachers' and children's characteristics and as a predictor of several children's outcomes, such as motivation, efficacy, performance and beliefs. This model was later reanalysed into the model of parents' socialisation of motivation, focusing on parents' and their socialisation's contribution to their children's motivation and achievement (Eccles, 2007; Eccles & Wigfield, 2020). The model points to parents' activity-specific behaviours (e.g. teaching strategies, provision of opportunities to learn) as more proximal determinants of children's outcomes (e.g. beliefs, values, performance), while parents' general beliefs (e.g. general and specific values) and parents' child-specific beliefs (e.g. perception of a child's abilities) are seen as more distal contributing factors. All these constituents are proposed as influencing each other and evolving interdependently over time (Eccles & Wigfield, 2020). In a longitudinal study, Simpkins et al. (2012) supported Eccles' model (Eccles, 2007; Eccles & Wigfield, 2020), showing that parental beliefs predicted children's motivational beliefs and that parents' behaviours mediated this relationship. Yet as for parents' beliefs, the authors focused on perceptions of children's ability, importance for each domain (e.g. sports, music, math and reading) and self-efficacy, but not on beliefs regarding the nature of learning in a particular domain, such as mathematics.

In fact, within the parents' general belief system, we can include parents' mindsets about their children's abilities. Usually, these beliefs are referred to as fixed and growth mindsets (Dweck & Yeager, 2019). The approach contributes to the view that those who believe that a particular competence is innate (i.e. those with a fixed mindset) will tend to adopt behaviours that reinforce this belief (e.g. having performance goals, avoiding challenges, showing low persistence and perceiving high effort as demonstrating low ability). On the other hand, those who believe that a particular competence can be improved (i.e. those with a growth mindset) adopt efforts as a tool to improve their ability. For them, goals are challenging, and obstacles are seen as important information about learning processes (Dweck, 2015; Dweck & Yeager, 2019; Yeager & Dweck, 2020) .

A few studies focused on the role of parents or their mindset in understanding their children's mindset, behaviour, motivational orientations and(or) performance. These scarce examples showed that, more than parents' general mindsets about intelligence, some other factors predict their children's mindsets, well-being, motivational features or performance. These include parents' praises, beliefs about failure and their interactions in the process or reactions about products (Gunderson et al., 2018; Rowe & Leech, 2018; Schleider et al., 2016; Tao et al., 2022) . Some research, however, pointed out the importance of parents' mindsets for children's outcomes, such as Andersen and Nielsen (2016), who showed a negative relationship between parents' fixed mindsets and children's reading performance. Therefore, further research should investigate the role of parents' mindsets in their children's academic outcomes.

Parents' beliefs, attitudes and practices of math learning

Research concerning math achievement and motivation frequently analyses the role of parental attitudes and beliefs in the motivational orientations of their children (Cheung & Kwan, 2021). For instance, Mohr-Schroeder et al. (2017) observed that parents' attitudes towards mathematics predicted their children's attitudes towards the subject. Likewise, Šimunović and Babarović's (2020) review highlighted the role of parents' beliefs, concluding that parents' values, self-efficacy perception of children's ability, and parents' expectations for children's achievement help explain students' achievement motivation and performance. However, Fiskerstrand (2022) recently conducted a literature review, concluding that most research exploring parental involvement in math outcomes focuses exclusively on achievement, performance and skills. The author concluded, however, that the research on affective aspects suggests that affective expressions of parental involvement (e.g. expectations, attitudes and values) are also essential to understanding their children's learning processes and behaviour.

On the other hand, as the model of parents' socialisation of motivation proposes (Eccles, 2007; Eccles & Wigfield, 2020; Simpkins et al., 2012), the effects of parents' beliefs and attitudes on children's motivation and performance are mediated by parents' practices. In this sense, research has shown that schools that effectively develop activities encouraging parents to engage with their children at home learning activities offer significant gains in the number of math-proficient students (e.g. Sheldon & Epstein, 2005), thus highlighting the importance of subject-specific family involvement if schools intend to increase students' performance in specific domains. Rodriguez et al. (2017) assessed how parents' support in math predicted their fifth- and sixth-grade children's motivational beliefs and mathematics achievement, observing that perceived parental involvement was positively associated with both outcomes. Parents' support was related to students' concerns about their image and negatively predicted math achievement because those children who need more support are those struggling academically and are less autonomous. Math achievement was directly and positively explained by parents' expectations and children's math self-efficacy, and parents' interest in progress was positively related to children's mastery goals and math utility values.

One of the common ways of characterising parental practices is by classifying them as controlling or noncontrolling (or autonomy supportive). When parents try to intrude directly with children's thoughts, feelings and behaviours, these constitute involvement in control practices (e.g. Barber, 1996). In contrast, noncontrolling practices are characterised by mere encouragement for the child to find their way to think, feel and behave in what concerns a specific domain (e.g. Grolnick & Ryan, 1989). Dinkelmann and Buff (2016) showed that how children perceived parental support and involvement was crucial—although parent-perceived control adversely affected children's competence beliefs and achievement in mathematics, the parent-perceived structure was most important for children's intrinsic value. Moreover, parent-perceived warmth influenced children's motivational features and math achievement. Similarly, Silinskas and Kikas (2019a, 2019b) observed that students' perceptions of parents' help as controlling was related to lower performance and task persistence. In contrast, when this help was perceived as supportive, it was associated with increased task performance.

Also, concerning specific types of parental involvement, in a study with fifth- and eighth-graders, Gonida and Cortina (2014) showed that diverse types of parental involvement (i.e., autonomy support, control, interference and cognitive engagement) related differentially with students' motivational orientations and achievement and that the adopted type of parental involvement depended on their own motivational orientations and efficacy beliefs about the child.

The expectancy-value theory of achievement motivation

The expectancy-value theory (EVT) is a widely known motivation framework among educational researchers that serves as theoretical support for understanding task engagement in achievement-related contexts (Eccles & Wigfield, 2002, 2020; Eccles et al., 1983). This framework postulates that expectancies and values directly influence performance, persistence and task choices. Expectancies for success are defined as individuals' beliefs about their immediate or long-term success in upcoming tasks. Expectancies are thought to be influenced by task-specific beliefs, which are, in turn, influenced by individuals' perceptions of other people's perceptions and expectations, their affective memories and their interpretation of previous achievement outcomes. Concerning values, these can be of different kinds and can tap into various reasons why individuals engage in tasks.

This framework specifies four components of task value: attainment value (i.e. the personal importance of doing well on the task because the tasks provide opportunities to confirm or not aspects of one's actual or ideal self-schema), intrinsic value (i.e. the enjoyment the individual gets from engaging in the activities and the interest of the individual in the subject), utility value (i.e. the way individuals think about how a task relates to current and future goals) and costs (i.e. the negative aspects of engaging in the task, such as lost opportunities for choosing to engage in the task and the effort needed to succeed). The authors proposed that utility value portrays the more 'extrinsic' reasons for engaging in a task and that age and maturation can influence the weighting of these different components of subjective task value, becoming more sophisticated and personalised over time (Eccles

& Wigfield, 2020). For several decades, EVT has been used to understand structural, cultural and contextual variables looking to explain students' motivation, characterise the features of motivational profiles, explore changes throughout school education, understand the role of parents' and teachers' beliefs, actions and interactions on motivational features and changes, among others (e.g., Jiang et al., 2018; Perez et al., 2014; Petersen & Hyde, 2017; Shin et al., 2022; Simpkins et al., 2012; Šimunović et al., 2018; Trautwein et al., 2012).

Research on the STEM domains using Programme for International Student Assessment (PISA) data has also shown that parents' utility value perceptions predicted their children's achievement, both with a direct effect and through an association with children's utility value (Nalipay et al., 2021), with results being similar across several regions and countries. Similarly, Šimunović et al. (2018) observed that parents' utility value predicted children's value, though this was partly through the mediation of children's perceptions of parents' encouragement of STEM interests.

Current study

The present study analyses the relationships between parents' attitudes and mindsets towards mathematics, parents' self-reported practices and their children's mathematics motivation and achievement. Regarding the mindset, the literature on this topic is rather generic and imprecise, not considering the specificity of parents' mindsets about math or eventual relationships with their math involvement practices with children and attitudes about mathematics. Concerning parental attitudes towards mathematics, considerable research has been conducted, yet it mainly focuses on their anxiety. Furthermore, not much of the literature investigates other features or aims to study the relationship between parents' attitudes and their involvement in math-related practices at home.

The relationships between parental involvement in math and children's motivation and math achievement have been established. However, as Fiskerstrand (2022) pointed out, most research has exclusively focused on math achievement, and only a few studies on affective learning components suggested that parental expectations, attitudes and values are essential but not yet very well explored.

The literature has supported children's early experiences with math and their parents' attitudes and practices as having a significant impact on later students' achievement (e.g. Bradley & Corwyn, 2016; Martin & Lazendic, 2018) . Additionally, some research has suggested that math motivation declines over schooling (e.g. Gottfried et al., 2013; Spinath & Steinmayr, 2008). However, even though some longitudinal studies have been conducted, adding a cross-national perspective is crucial because different educational systems might impact how mathematics motivation progresses. Although the goal was not to compare different educational systems, our model's measurement invariance between countries allowed us to estimate similar patterns among the participating countries and strengthen the established relationships from an international perspective.

Even though the model of parents' socialisation of motivation (Eccles, 2007; Eccles & Wigfield, 2020) presents a general overview that allows for a global comprehension of parental involvement's complexity, there is still a lack of integrated research that simultaneously considers parents' mindsets, attitudes and involvement practices about mathematics and(or) investigates how these relate to or even predict children's motivational orientations and math achievement. Without complex models integrating the various aspects of parental involvement, researchers can hardly establish which components stand out as more relevant—and, consequently, more worthy of investment. Further, the existing evidence does not necessarily focus only on mathematics learning but frequently on several domains simultaneously. Considering this, we argue that more data are needed to fully comprehend the complexity of the associations between parental involvement and students' outcomes. Building on the previously explored literature, we can expect several patterns from our analysis, which we describe below. The previously mentioned findings showed the detrimental effects of fixed mindsets (e.g. Dweck & Yeager, 2019; Yeager & Dweck., 2020). Research on parents' mindsets and their impact on children's motivational orientations has suggested that, in addition to parents' general mindsets about intelligence, it is essential to tap into their practices (Gunderson et al., 2018; Rowe & Leech, 2018; Schleider et al., 2016; Tao et al., 2022). In the present study, we expect that a fixed mindset is negatively related to parents' attitudes towards mathematics and with parent practices that highlight the goals of math (e.g. intrinsic value), as well as practices that encourage their children's confidence, actions and effort (e.g. support, structure) (H1).

Beliefs represent a broad concept that can vary widely. The present study refers to a fixed mindset as part of the parental belief system. Research has shown that parental beliefs and attitudes play an essential role in their children's attitudes, motivational orientations and performance (Cheung & Kwan, 2021; Mohr-Schroeder et al., 2017; Šimunović & Babarović, 2020). Research has also highlighted that these relationships can be mediated through different variables, such as children's perceptions of parents' values and encouragement (Šimunović et al., 2018) or parents' practices (Gonida & Cortina, 2014; Simpkins et al., 2012). In this sense, we hypothesise that positive parental attitudes towards mathematics align with their involvement in practices that promote children's engagement with mathematics and their perceptions of math values (H2).

Theoretical frameworks and general research have underlined that parental involvement in schooling can benefit students, parents and schools (Eccles & Harold, 1996; Epstein, 2011; Jeynes, 2022; Kim, 2020; Tan et al., 2020). Moreover, the literature on parental practices that support their children in specific school domains has suggested that this support can have effects on students' motivation and achievement in such subjects (e.g. Kiss & Vukovic, 2020; Sheldon & Epstein, 2005; Wu et al., 2022). In the present study, we aim to observe one set of controlling practices (i.e. structure practices) and two groups of noncontrolling practices (i.e. support practices and intrinsic value-promoting practices) regarding math parental involvement. We predict that parental noncontrolling math-related involvement practices (i.e. support- and intrinsic value-promoting practices) are positively related to students' motivational characteristics towards mathematics (i.e. perceived competence and intrinsic value) and negatively related to students' cost perception. The opposite is expected for more controlling parental practices (i.e. structure) (H3). Moreover, we expect that practices emphasising cost are negatively associated with the student's perceived competence, intrinsic value and math achievement and positively related to the student's perception of cost (H4).

EVT states that involvement in tasks (i.e. choice, performance and engagement) has two main proximal determinants: expectancies for success and task values. Based on the literature (e.g., Eccles & Wigfield, 2020; Jiang et al., 2018; Trautwein et al., 2012; Petersen & Hyde, 2017), we hypothesise that students' perceived competence and subjective task values are positively related to math achievement, except for cost, which is expected to be negatively associated with it (H5).

These hypotheses were tested using structural equation modelling (SEM). Figure 1 presents the theoretically proposed model in which the hypothesised relationships between the variables are included.

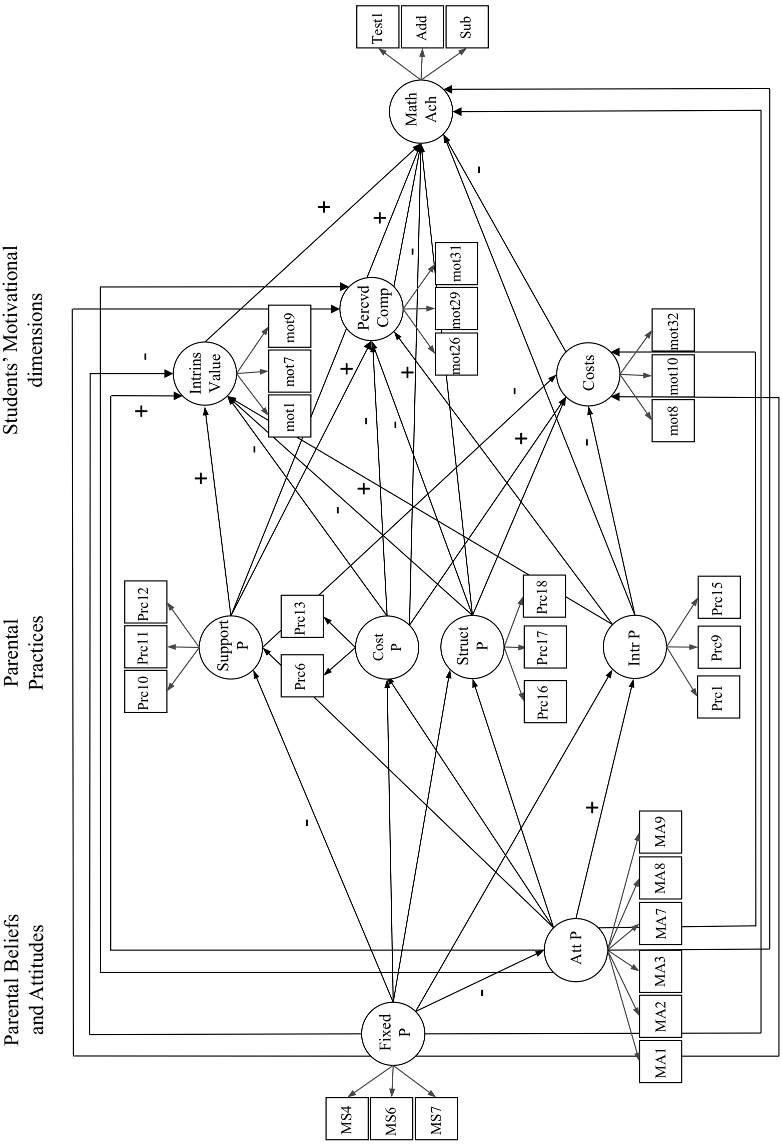

Fig. 1 Proposed model for the relationships between parents' mindset, attitudes and practices with students' motivational dimensions and math achievement. *Note*: Cost P = parental cost-emphasising practices; Struct P = parental practices structuring learning; Support P = parental practices supporting learning; Intr P = parental practices promoting intrinsic value; Fixed P = fixed parental mindset; Attit P = parental attitudes towards maths; Percvd Comp = students' perceived competence; Intrins Value = students' intrinsic value; Math Ach = students' math achievement

Methods

Participants

The data came from international longitudinal research focused on the development of mathematics motivation in primary education—co-constructing mathematics motivation in primary education–a longitudinal study in six European countries (MATHMot for short)—funded by the Research Council of Norway (grant number 301033). The current investigation gathered data from the first wave of the MATHMot project, collected in 287 schools across the six participating European countries, totalling 11,782 grade 3 and 4 students. The research design also included parents, and given the focus of the present paper, only students whose parents responded to the survey were included. Thus, the final sample consisted of 8071 students in third ($n=3892$) and fourth grade ($n=4179$), of which 51.7% were girls. Likewise, 8071 parents participated. Students' ages ranged from 8 to 13 years old ($M=9.6$, $SD=0.82$), and they came from Estonia ($n=1671$, from 45 schools), Finland ($n=1187$, from 47 schools), Norway ($n=1131$ from 51 schools), Portugal ($n=1859$ from 45 schools), Serbia ($n=1578$ from 52 schools) and Sweden ($n=645$ from 47 schools).

Most of the parents were employed (89.2%), female (80.1%) and had a level of education higher than level 3, 'Upper to Secondary Education', according to the International Standard Classification of Education. Table 1 presents detailed information about the participants.

Measures

All measures, except those used for the assessment of math achievement, were developed or adapted within the MATHMot project.

Parents' mindset

Parents' mindset regarding mathematics learning was assessed by three items referring to a fixed mindset (e.g. 'Math is something a child either understands or not'). Parents rated each statement on a Likert scale, which varied from 1 ('Disagree') to 4 ('Agree').

Parents' attitudes

Parents' attitudes regarding mathematics were assessed on a single scale composed of six items, which they rated on a Likert scale varying from 1 ('Disagree') to 4 ('Agree'). Two aspects reflecting positive attitudes towards mathematics were included: intrinsic value (e.g., 'I like math') and perceived competence (e.g., 'Math is easy for me').

Parents' practices

Parental practices were assessed using a scale composed of items representing four factors: practices promoting intrinsic value (3 items, e.g. 'I show my child how fun math can be'), cost-emphasising practices (2 items, e.g. 'I say to my child that math can be very demanding'.), structure practices (3 items, e.g. 'I help my child to organise work when

Table 1 Participants' descriptives by country

	Estonia	Finland	Norway	Portugal	Serbia	Sweden	Total sample
Students' age (*M, SD*)	10.05 (0.72)	9.82 (0.72)	8.90 (0.69)	9.21 (0.76)	9.70 (0.65)	9.88 (0.71)	9.6 (0.82)
Students' sex *(N, Valid %)*							
Male	799 (48.0)	556 (47.2)	572 (50.7)	899 (48.9)	760 (48.5)	287 (44.8)	3873 (48.3)
Female	867 (52.0)	622 (52.8)	556 (49.3)	941 (51.1)	807 (51.5)	353 (55.2)	4146 (51.7)
Students born in the country *(N, Valid %)*	1623 (97.5)	1079 (91.4)	1034 (91.5)	1642 (88.6)	1540 (98.6)	607 (94.3)	7525 (93.2)
Parent 1's sex[a] *(N, Valid %)*							
Male	391 (23.5)	290 (24.8)	378 (33.6)	344 (18.8)	0(0) [b]	190 (29.7)	1593 (19.9)
Female	1275 (76.5)	879 (75.2)	747 (66.4)	1487 (81.2)	1560 (100)	449 (70.3)	6397 (80.1)
Parent 2's sex *(N, Valid %)*							
Male	803 (71.2)	683 (73.4)	612 (64.8)	973 (52.3)	1526 (100)	410 (69.7)	5007 (78.5)
Female	325 (28.8)	247 (26.6)	333 (35.2)	290 (15.6)	0(0)	178 (30.3)	1373 (21.5)
Level of education for Parent 1 *(N, Valid %)*[c]							
Compulsory/ primary education	117 (7.1)	37 (3.1)	47 (4.2)	359 (20.1)	239 (15.5)	17 (2.7)	816 (10.3)
Upper secondary education	702 (42.5)	278 (23.6)	215 (19.4)	679 (38.1)	560 (36.4)	177 (27.6)	2611 (33.0)
College and undergraduate studies	465 (28.2)	347 (29.5)	398 (35.8)	547 (30.7)	554 (36.0)	242 (37.8)	2553 (32.3)
Master's degree and above	367 (22.2)	514 (43.7)	451 (40.6)	199 (11.2)	185 (12.0)	205 (32.0)	1921 (24.3)
Level of education for Parent 2 *(N, Valid %)*							
Compulsory/ primary education	127 (11.1)	55 (5.7)	66 (7.0)	344 (27.3)	285 (19.1)	27 (4.6)	1426 (20.6)
Upper secondary education	561 (49.1)	254 (26.5)	208 (22.0)	468 (37.1)	659 (44.2)	235 (39.8)	2385 (34.5)
College and undergraduate studies	267 (23.4)	246 (25.7)	320 (33.9)	311 (24.6)	418 (28.1)	169 (28.6)	1731 (25.1)
Master's degree and above	187 (16.4)	402 (42.0)	350 (37.1)	139 (11.0)	128 (8.6)	159 (26.9)	1365 (19.8)
Parents' employability							
Parent 1 employed *(N, Valid %)*	1467 (90.6)	1073 (91.6)	1036 (93.2)	1529 (84.1)	1330 (87.0)	603 (94.1)	7038 (89.2)
Parent 2 employed *(N, Valid %)*	1016 (94.2)	873 (94.0)	870 (94.0)	1109 (89.7)	1384 (94.8)	528 (90.7)	5780 (93.0)

[a]Parents were given the opportunity of answering their questionnaire by identifying Parent 1 and Parent 2, or just one parent. One survey was received per household. While parents could provide answers together, they could still give their individual sociodemographic information. In most cases, one parent per household answered the survey

[b]Aligned with legal practices in Serbia, the questionnaire specified that mothers should fill in information for Parent 1 while fathers should fill in the information for Parent 2

[c]Not all parents reported their educational level

learning math') and support practices (3 items, e.g. 'I help my child with strategies on how to learn math'). Parents rated each statement on a Likert scale ranging from 1 ('Never') to 4 ('Often').

Students' motivation

Grounded in EVT (Eccles et al., 1983; Eccles & Wigfield, 2020), students' motivation for mathematics was assessed with three scales from the Expectancy-Value Scale (Peixoto et al., 2023): intrinsic value (3 items, e.g. 'Doing math makes me happy'), relative costs (3 items, e.g. 'I do not like spending my energy doing math') and perceived competence (3 items, e.g. 'I can easily solve different math problems'). Students rated each item on a scale ranging from 1 ('A lot of times') to 4 ('Never'). Positive-worded items were reversed so that a high score on this scale and its factors revealed high levels of the assessed dimension.

Students' math achievement

Two math tests were used as achievement measures. The first (Math test 1) comprised 12 (in grade 3) or 14 (in grade 4) tasks taken from the pool of released TIMSS 2011 grade 4 items (IEA approval 22/022). Items constituting the grade 3 and grade 4 tests covered major curricular topics in each participating country. Each correct answer was assigned a point. Math test 1 scores were estimated with the Rasch measurement model using all items included in both tests (third and fourth grade), with seven items serving as linking items. This score was initially estimated on a scale with an average score of 500 and a standard deviation of 100. The second test assessed arithmetic fluency (Klausen & Reikerås, 2016) and included a set of arithmetic operations concerning addition and subtraction. Students had 45 arithmetic operations for addition and 45 for subtraction and had 2 min to complete as many addition operations, as well as 2 min to complete as many subtraction operations as possible. Correct answers were scored with 1 point for the addition and subtraction tasks, and the total task score was obtained by summing up all points. For the actual analyses, Math test 1 scores were rescaled to a mean of 5 and standard deviation of 1, and the addition and subtraction tasks were rescaled by dividing the total score by 10 to ensure better convergence.

Procedure

Following the relevant legislative procedures in each country upon ensuring the school's participation, informed consent was signed by the participants' (i.e. students') legal guardians. Trained researchers collected data during a regular school session in the spring of 2022. Students filled out the questionnaires individually, and before doing so, they were told that they were not being assessed and that their participation had no impact on their school achievement evaluation. The administrator explained how to fill out the instruments by doing practice items with the students, allowing them to ask any questions about their study participation. After the students finished the survey, they were asked to take the parents' questionnaires home and bring them back to the teacher once completed. Data from parents and their children were linked with a unique code. After the parents filled out the questionnaire, the responsible teacher or school contact returned these to the researchers in a secure envelope. Parents could also complete the surveys digitally (i.e. via a link provided on the initial page of the paper survey). Parents' participation was voluntary, and they were told that students would not be excluded from the study if they had not returned the questionnaire. Only parents who indicated on the consent form that they would like to complete the survey received a copy.

Data analyses

Data were analysed through SEM in MPlus 8 (Muthén & Muthén, 1998–2017) using the weighted least square mean and variance adjusted (WLSMV) estimator because of the ordinal nature of most variables (Brown, 2015). To assess global model fit, we used the comparative fit index (CFI), the root mean square error of approximation (RMSEA) and the standardised root mean squared error (SRMR) because of the chi-square's sensitivity to sample size. For CFI, we considered values above 0.90 and 0.95 to show acceptable and very good fit, respectively. We considered RMSEA and SRMR values below 0.08 acceptable and below 0.06 as very good fit (Brown, 2015; Hu & Bentler, 1999; Kline, 2016).

Considering that we intended to test a model with participants from six different countries who would be answering all measures in six different languages, we tested measurement invariance to ensure the appropriateness of looking at predictions for the entire sample. Because of the complex model and WLSMV estimation for ordered categorical indicators, we followed respective recommendations (Muthén & Asparouhov, 2002; Wang & Wang, 2020) and employed a top-down strategy in invariance testing. That is, we began with the most restrictive model in which all factor loadings and thresholds, as well as covariances and predictive effects, were held invariant across countries and then, based on modification indices, released those parameters that were flagged for considerable noninvariance across the countries. To assess reliability, we used ordinal alpha (Gadermann et al., 2012; Zumbo et al., 2007) and composite reliability for the ordinal variables in the model. Reliability was assessed with composite reliability and McDonald's ω for math achievement.

Results

We started by testing the hypothesised model (Fig. 1), in which we assumed full measurement invariance. Residual correlations were specified for items reflecting parents' intrinsic value and perceived competence in mathematics to better account for the two aspects of their mathematics-related attitudes (i.e. representing specific factors within the construct). However, this model resulted in an undesirable suppression effect for students' math interests, likely because of some collinearity (i.e. the positive bivariate correlation between math interest and math performance changed to a negative prediction). To remove this bias, we tested another model in which we specified a common factor for the students' intrinsic value and perceived competence items, with additional free correlations between the respective residuals similar to parents' math attitudes. This common factor represented students' mathematics motivation, with two incorporated facets.

This modified model, still assuming full measurement invariance, showed an adequate fit: χ^2 (3084) = 11,418.53, $p < 0.001$, CFI = 0.951, RMSEA = 0.045 [0.044, 0.046], SRMR = 0.058. Nevertheless, intending to obtain a more stable solution, we released three parameters (i.e. two of them referred to reversed items of the parents' attitudes scale and the other to the Math 1 achievement score) based on the information given by modification indices, which led to a better fit: χ^2 (3049) = 10,269.58, p < 0.001, CFI = 0.958, RMSEA = 0.042 [0.041, 0.043], SRMR = 0.055. This was the model used as the basis for further analysis.

Table 2 presents the correlations between the variables in the model and reliabilities of the measures used in the model. Both manifested and latent correlations were almost all significant, mainly because of the large sample size, ranging from − 0.45 to 0.53 for the manifest correlations and from − 0.69 to 0.70 for the latent correlations. All measures presented acceptable reliability. The lowest value was for the composite reliability of academic achievement, which can be considered adequate because we were using the measures within latent variable methods (Kline, 2016).

Figure 2 shows the significant relationships between the variables in the model. Starting with parents' fixed mindset, we observed that it was positively related to parents' practices (except the support dimension) and negatively associated with parents' attitudes towards mathematics and students' math achievement. The strongest associations were observed with parents' cost-emphasising practices and attitudes towards mathematics.

Parents' attitudes towards mathematics were significantly associated with parents' practices (except for practices structuring learning), students' motivation dimensions and math achievement. Although these associations were positive for parental practices promoting intrinsic value and support, students' motivation and academic achievement, they were negative for parents' cost-emphasising practices and the students' cost dimension. The strongest association of parental attitudes towards mathematics was with practices promoting intrinsic value.

Parental practices differed in how they related to costs perceived by the child, the obtained motivation dimension and math achievement. Specifically, cost-emphasising practices, support and structuring learning practices were negatively associated with motivation. Practices promoted intrinsic value were positively related to it. Regarding the relationship with cost perceived by the child, only cost-emphasising practices and structuring learning were significantly and positively associated with cost. Finally, regarding math achievement, only practices structuring learning were shown to be significant, presenting a negative association.

Regarding the costs perceived by the child and obtained motivation dimension, students' costs were negatively associated with mathematics achievement, whereas motivation was positively related. The relationship between motivation and math achievement was the strongest relationship in the model.

Overall, the relationships in the model accounted for 38.5% of the variance in math achievement, 14.7% in parents' cost-emphasising practices, 14.2% in parents' practices promoting intrinsic value, 10.1% in students' motivation, 9% in parents' attitudes towards maths, 7.5% in students' perception of cost, 1.6% in parents' practices of support and 1.2% in parents' practices of structuring learning.

Discussion

The main goal of the present study was to test a model that could relate the diverse components of parental involvement (i.e. mindset, attitudes and practices) to students' motivation and mathematics achievement. Based on prior research and the theoretical frameworks guiding the present study, we established different hypotheses, looking into the ways parents' mindset (H1), attitudes (H2), noncontrolling and controlling practices (H3) and cost-emphasising practices (H4) related to students' indicators (i.e. motivation components

Table 2 Correlations and reliabilities for the variables included in the model

		1	2	3	4	5	6	7	8	9
1	Cost_P		0.366***	0.281***	0.209***	0.279***	−0.162***	−0.109***	0.154***	−0.181***
2	Struct_P	0.502***		0.534***	0.448***	0.140***	0.008	−0.098**	0.150***	−0.305***
3	Support_P	0.400***	0.675***		0.493***	0.029*	0.114***	−0.069**	0.084**	−0.182***
4	Intr_P	0.310***	0.518***	0.699***		0.042**	0.274***	0.024*	0.040**	−0.140***
5	Fixed_P	0.359***	0.107***	−0.059***	−0.032		−0.171***	−0.045**	0.089**	−0.125***
6	Attit_P	−0.232***	−0.049***	0.125***	0.369***	−0.297***		0.180***	−0.115***	0.105***
7	Mot	−0.193***	−0.138***	−0.089***	0.062***	−0.072***	0.258***		−0.448***	0.297***
8	Costs	0.208***	0.190***	0.096***	0.017	0.105***	−0.179***	−0.687***		−0.265***
9	Math_Ach	−0.272***	−0.298***	−0.205***	−0.078***	−0.180***	0.230***	0.526***	−0.430***	
	Ordinal α	0.79	0.83	0.79	0.73	0.73	0.91	0.87	0.73	–-
	McDonald's ω	–	–	–	–	–	–	–	–	0.82
	CR	0.81	0.84	0.80	0.73	0.83	0.89	0.84	0.73	0.67

Coefficients below the main diagonal are latent correlations based on structural equation modelling. Coefficients above the main diagonal are manifest correlations. *Cost_P* parental practices emphasising costs, *Struct_P* parental practices structuring learning, *Support_P* parental practices supporting learning, *Intr_P* parental practices promoting intrinsic value, *Fixed_P* fixed parental mindset, *Attit_P* parental attitudes towards maths, *Mot* motivation, *CR* composite reliability

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

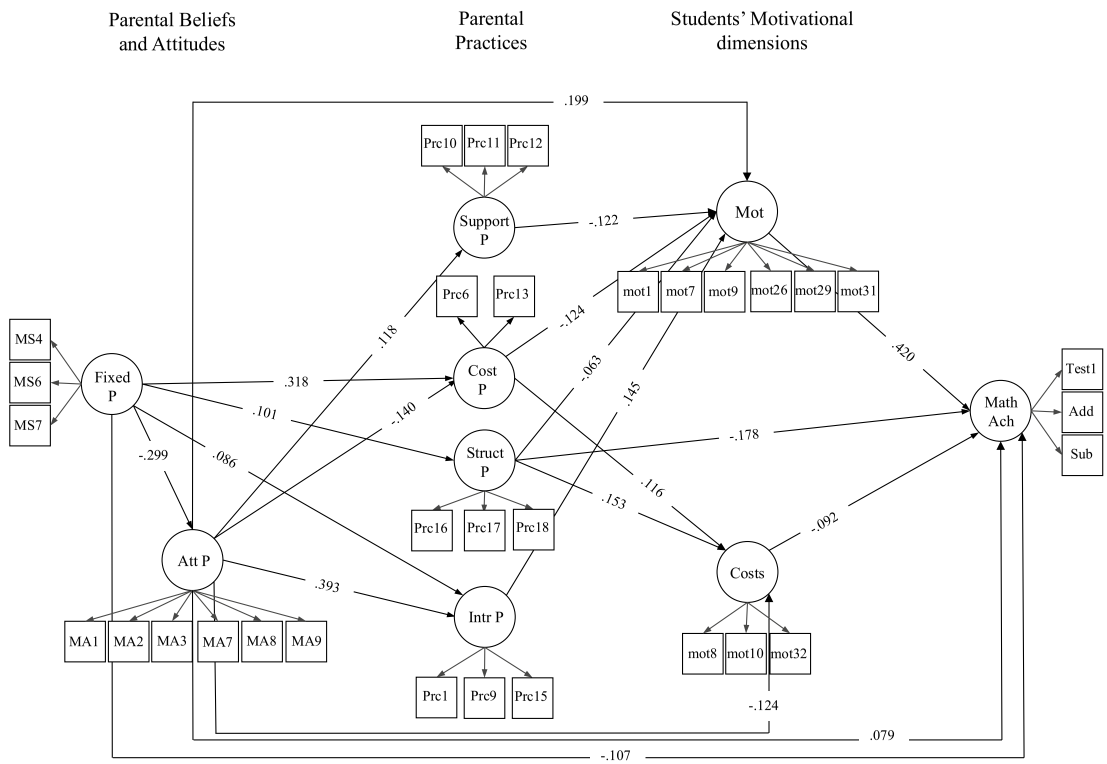

Fig. 2 The final model of the relationships between parents' mindset, attitudes and practices with students' motivational dimensions and math achievement. *Note*: For clarity of the figure, only significant relationships are shown, and correlations are omitted. Parents' practices dimensions are correlated as well as students' motivations dimensions. The coefficients presented are standardised linear regression coefficients. Cost P = parental cost-emphasising practices; Struct P = parental practices structuring learning; Support P = parental practices supporting learning; Intr P = parental practices promoting intrinsic value; Fixed P = fixed parental mindset; Attit P = parental attitudes towards maths; Mot = students' motivation; Math Ach = students' math achievement

and(or) achievement). Furthermore, our last hypothesis (H5) focused solely on the students' reported measures and was concerned with the relationships between motivation and achievement and perception of cost and achievement.

Associations between parents' mindsets and practices

Our first hypothesis stated that a fixed mindset from parents would be negatively related to their attitudes towards mathematics and supporting and structuring practices. This hypothesis was partially confirmed regarding the negative relationship between a fixed mindset and parents' attitudes towards mathematics but not regarding the remaining expected relationships. Considering that a belief in ability characterises a fixed mindset as an innate and fixed gift in which setbacks are usually attributed to low ability and because a fixed mindset tends to be associated with the avoidance of challenges (Dweck, 2015; Dweck & Yeager, 2019; Yeager & Dweck, 2020) , this negative association can be explained by the fact that our operationalisation of attitudes towards math included items tapping into perceived competence and intrinsic value. On the other hand, the positive relationships between a fixed mindset and structuring practices and those promoting intrinsic value were somewhat unexpected. Yet this finding could be partially explained by the considerations of Haimovitz and Dweck, in which they argued that 'adults' mindsets may not be the primary variable shaping adults' behaviour towards children because these mindsets may not typically be activated in key situations' (2017, p. 1851).

Moreover, these associations were weak, and the percentage of variance explained in both practices was small. Interestingly, the association with cost-emphasising practices was the strongest among the associations between the fixed mindset and other variables in the model, which can be considered one of the detrimental impacts of parents' fixed mindset. Finally—and corroborating previous research that negatively related parents' fixed mindsets with academic performance (e.g., Andersen & Nielsen, 2016)—our findings showed a negative association between parents' fixed mindsets and mathematics achievement.

Parental attitudes and practices

We also hypothesised that positive parental attitudes towards mathematics would align with their involvement in practices promoting children's engagement with math and children's perceptions of math-related values (H2). Indeed, we observed positive associations between parental attitudes and parents' support practices and those practices that promote students' intrinsic value, reinforcing previous research in the field (Green et al., 2007; Hoover-Dempsey et al., 2005; Kiss & Vukovic, 2020; Simpkins et al., 2012). Combined with the findings supporting hypothesis H1, these results reinforce the critical role of beliefs and attitudes in explaining parents' decision-making to get involved and the actions they take. It is imperative to stress that the association between parents' attitudes and parental practices promoting intrinsic values was one of the highest associations in the model. The findings also showed negative relationships between parents' attitudes towards mathematics and cost-emphasising practices, indicating that more positive attitudes towards math are associated with fewer practices, hence emphasising the costs of being involved in math tasks. Globally, it seems that more positive attitudes lead parents to engage in ways that support their children, accentuating the intrinsic value of mathematics to the detriment of involvement focused on negative math features and difficulties. Research has also highlighted other aspects that might increase parents' involvement, such as the parents' motivation and sense of efficacy. It has also been suggested that efficacy beliefs are associated with parental practices through mediating positive and negative affect (e.g. Falanga et al., 2023). These results suggest that future research should focus on the motivational, affective and behavioural aspects of parental relationships with specific school domains—such as mathematics—and their potential impact on involvement to better understand the complex dynamics that go into parental involvement in their children's learning processes. It is also important to point out that, when interpreting our research results, one must not confuse parental practices' scores with a high quality of parental practices because the reported high frequency of certain practices does not guarantee their quality. Items with the verb 'help' can facilitate an understanding of this issue because one would hardly argue against the fact that different parents might interpret 'helping' in various ways, which will vary in their quality. The assessment and reflection on the definition of high-quality practices are outside the scope of the present paper. However, it is important to have this notion present when interpreting the results stemming from measures such as ours.

Associations between parental involvement and students' motivations and achievement

Regarding the direct association of parents' attitudes and children's perception of math value, several studies have shown that direct relationships between parents' beliefs and attitudes and their children's motivation and attitudes can be weak because, in most cases, these are mediated by parental practices and(or) their perceptions by the child (e.g. Simpkins et al., 2012; Šimunović et al., 2018). Our results indicated the same pattern of weak associations between parents' attitudes towards mathematics and students' motivation and the costs perceived by the children. In particular, the results showed a positive relationship between parents' positive attitudes and students' perceptions of math value and a negative association with students' perception of cost, here conceived of as the negative aspects of engaging in the task (Eccles & Wigfield, 2002, 2020). Cheung and Kwan (2021) have already identified a similar effect among young children and their parents' attitudes; their research showed an association between parents' perceived importance of different goals of early mathematics learning and their kindergarten children's approach and avoidance motivation to learn mathematics. Our results also extend the findings of Nalipay et al.'s (2021) study, in which parents' perceptions of utility value predicted their children's utility value in the scientific domain. All these findings suggest that parents' perspectives about math values, goals and learning seem to have a significant role in children's mathematical development, attitudes, values and even achievement (Mohr-Schroeder et al., 2017; Šimunović & Babarović, 2020).

Our third hypothesis (H3) predicted a positive association between parental noncontrolling math involvement practices and students' motivational characteristics towards mathematics (i.e. perceived competence and intrinsic value) and negatively related to students' cost perception. Indeed, parental practices promoting mathematics' intrinsic value were associated with their children's mathematics motivation. Here, intrinsic value-promoting practices are those in which parents look to promote a view of math as interesting, fun and enjoyable. Therefore, with such practices, parents are not looking to control the child but instead to promote child's own intrinsic motivation. We also expected a negative relationship between cost-emphasising practices and students' motivation and academic achievement and a positive association between these practices and students' perception of costs (H4). Our results showed that parental cost-emphasising practices were associated with children's perceptions of math costs and negatively associated with motivation, as expected. Unexpectedly, support-oriented practices showed a negative association with children's motivation (contrary to what was proposed in H3), whereas structure-oriented practices were positively associated with children's perceptions of math costs. The support dimension of practices was initially conceived of as noncontrolling; however, our own classification of these practices as noncontrolling was flawed, or our participants perceived them as controlling. Looking at the first possibility, the items involved in the assessment support practices could lead to different interpretations for parents. For example, there are many ways of 'helping' a child. Although the initial formulation of the item 'I help my child with strategies on how to learn math' had in mind an autonomous and noncontrolling way of helping, one might argue that some parents did not interpret the verb 'help' in the same way. Another explanation is the possibility of parents not recognising their actions as controlling if their intentions are not as such. Finally, Dinkelmann and Bluff (2016) study supported an additional possible justification, showing that the relationship between practices and students' motivation and achievement was mediated by how children perceived these practices, and children might perceive what parents reported as support practices as instead being controlling.

Similar to other research studies, perceived controlling practices appear to be associated with lower intrinsic value and students' lower math performance (Oh et al., 2022; Silinskas & Kikas, 2019a, 2019b). Parents whose children are struggling with math may also try to help create more structured ways to support and monitor them. This can also explain the observed negative association between parental structuring practices and children's math achievement, as also highlighted by Rodriguez et al. (2017), with parents' help negatively predicting their children's math achievement.

Furthermore, we can hypothesise that students struggling with mathematics are precisely those who receive more support from parents and whose parents are more concerned about structuring learning activities related to mathematics. This idea is in line with the results obtained by Silinskas and Kikas (2019b), who observed that students with lower math skills perceived more support and simultaneously more control by their parents. These results illustrate that diverse parental involvement activities can be associated differently with children's motivational characteristics, hence reinforcing previous research (Gonida & Cortina, 2014; Kiss & Vukovic, 2020; Rodriguez et al., 2017).

Motivation and achievement

Our last hypothesis (H5) assumed that, although students' motivation was positively related to math achievement, students' perception of math costs was negatively associated with it. The findings have confirmed these expectations because the dimension defined as motivation revealed a positive association with math achievement, while this association was negative for perceived cost. As supported by EVT (Eccles & Wigfield, 2020), cost taps into the negative aspects of engaging in math tasks, such as too much effort, anxiety or the loss of opportunities to do other things. Children with high scores in perceived cost observe math-related effort and engagement as something negative and, therefore, avoid it or do not engage, negatively affecting their achievement (Jiang et al., 2018; Perez et al., 2014; Trautwein et al., 2012). Our mathematics motivation items combined competence beliefs and task values statements. The positive association between motivation and academic achievement corroborates previous findings in multiple academic domains and across different age groups (e.g. Hulleman et al., 2010; Perez et al., 2014; Trautwein et al., 2012). It also stresses the importance of promoting intrinsic values among students and of providing opportunities to increase their self-perception of competence.

In conclusion, our results showed an association of parental beliefs and attitudes with parental practices and students' motivational orientations and achievement. The cross-sectional and correlational nature of the study makes the direction of the relationships in the model arbitrary, precluding any causal inference about the associations observed because the direction of such associations could be opposite to the ones presented in the model. Nevertheless, previous longitudinal research (e.g. Simpkins et al., 2012) showed that parents' beliefs predicted parental practices. This evidence supports the assertion that parents' beliefs and attitudes predict parents' practices and not vice versa. Regarding the associations between parental involvement components (e.g. attitudes, beliefs and practices) and children's motivation and achievement, the direction of the relationships is merely indicative because even though parents' involvement affects children's motivation and achievement (Silinskas & Kikas, 2019a; Simpkins et al., 2012), children's motivation-related indicators and achievement also affect parents' involvement (Silinskas & Kikas, 2019a, 2019b).

Limitations and future research

Despite having data from parents and students and even though the students' data included self-report and direct performance measures, some limitations should be acknowledged. First and foremost, as has already been mentioned, the present research's cross-sectional and correlational design did not allow for causal inferences. Multiple models could fit the data equally, as well as the one presented, with differences in the direction of the proposed associations. Nevertheless, previous research and theoretical frameworks supported the direction of the relationships previously discussed, even though most were also correlational and cross-sectional. Considering the difficulty of experimental studies in this field of research, future developments should address this issue by using longitudinal designs with multiple waves of data collection for parents and children. A second limitation is that we only accounted for measures of parental practices, while some research has shown that the effects of parental practices' effects are mediated by children's perceptions of those practices (Dinkelmann & Bluff, 2016; Šimunović et al., 2018). In this sense, what matters is not what parents solely do or what they say they do but rather how children perceive those practices. Future investigation using the MATHMot dataset will allow for this exploration. A third limitation is rooted in the fact that parental practices were exclusively assessed through self-report measures. Using other measures to evaluate parental practices (e.g. observation, vignettes) could provide more accurate assessments and be less prone to social desirability. A fourth limitation relates to the fact that we did not control for the gender of parents when reporting on their attitudes and practices towards math. Our questionnaire allowed parents to answer either by themselves or together and did not separate the attitudes and practices of female versus male parents. One of the most productive procedures would be to ask each parent to fill out a questionnaire, which, however, holds additional risks in obtaining answers from the parents. In addition, because our goal did not include the differentiation of outcomes observing gender for the parents or the students, we did not consider this covariate in the model. Future studies should further explore differences at the parental level by assessing differences in the associations of attitudes and practices between female and male parents and at the student level by differentiating outcomes for male and female students. Finally, it is worth highlighting the cross-national nature of the collected data, meaning that parents from different national and cultural backgrounds participated in the present study. Our main research interest was to look at a global and complex model of relationships between parental involvement and children's mathematics motivation and achievement. However, we did not analyse the data separately by country. Nonetheless, inspired by the recently updated Situated Expectancy-Value Theory (Eccles & Wigfield, 2020), which highlights the importance of cultural aspects of students' motivation, it should be recognised that cultural and societal beliefs concerning parental involvement might differ among countries. Furthermore, different countries have different educational systems that might be receptive to parental participation in children's education. Cultural differences might also lead to differences in students' outcomes (e.g. Quaye & Pomeroy, 2022). Although only a few studies have been conducted, to the best of our knowledge, on this matter (see, for instance, Borgonovi & Montt, 2012; Hartas, 2015), we must recognise that the results of our study might not be applicable to all countries. Future studies could focus on multigroup analysis and a more cross-national comparative perspective on the associations of parental involvement on their children's motivation towards and achievement in mathematics. To better comprehend both the directionality and complexity of the relationships between parental involvement and students' math outcomes (i.e. cognitive and noncognitive), future studies would also benefit by better presenting the results of existing research that established well-designed causal effects between parental involvement and outcomes at the student level. In addition, more in-depth analysis at the parental level would allow for a better comprehension of which attitudes and practices positively affect mathematics outcomes at different age levels or are more detrimental concerning gender, ethnicity and(or) other covariates.

Implications and conclusions

The current study had a firm foundation, given its ample sample size and testing of a model that best fits the data collected from six European countries. The latter paves the way for future research that could focus on country variations and investigation of particular cultural differences in fostering students' motivation within the home environment. Such an endeavour would aim for a more robust theoretical foundation that could produce a more sound hypothesis and possibly improve the current model.

The present study's main finding is the link between parents' mindsets, attitudes and practices. Fixed mindsets have detrimental impacts on parental practices (i.e. showing a strong association with cost-emphasising practices). In contrast, parents' positive attitudes show positive effects (e.g. a strong connection with practices promoting intrinsic value). These findings have important implications for intervention with parents in that they should focus on mindset shifts and promoting positive attitudes towards the subject. Andersen and Nielsen's (2016) study provided evidence for an intervention using a growth mindset approach, which was effective, especially for parents who had a fixed mindset before the intervention. A second important finding is that different types of parental practices are associated differently with children's motivation and achievement and that practices promoting intrinsic value are positively associated with children's motivation, which includes both perceived competence and intrinsic value. These findings highlight the fact that, while promoting parental home involvement in specific domains (Boonk et al., 2018; Jeynes, 2022; Kim, 2020; Kiss & Vukovic, 2020), schools should emphasise the use of practices that promote the intrinsic value of mathematics while avoiding cost-emphasising practices. Education professionals seeking to encourage parents' involvement in schooling should use examples showing the subject (e.g., math, language, chemistry, history) as exciting and enjoyable as a way to promote intrinsic value. When it comes to trying to encourage practices at home, research has pointed to the adequacy of schools, suggesting hands-on activities as homework and considering that these kinds of activities can promote intrinsic value (Rosenzweig et al., 2022), as opposed to any activities that would solely emphasise the costs of math-related activities and learning.

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Francisco Peixoto

Current themes of research:

Academic motivation, academic emotions, parental involvement in education, self-concept and self-esteem, teachers' identity, resilience and well-being.

Relevant Publications:

Peixoto, F., Radišić, J., Krstić K., Hansen, K.Y., Laine, A., Baucal, A., Sõrmus, M., Mata, L. (2023). Contribution to the validation of the Expectancy-Value Scale for primary school students. *Journal of Psychoeducational Assessment, 41*(3), 343-350. https://doi.org/ 10.1177/07342829221144868.

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Goos, M., Pipa, J., & Peixoto, F. (2021). Effectiveness of grade retention: A systematic review and meta-analysis. *Educational Research Review*, *34*, 100401, https://doi.org/10.1016/j.edurev.2021.100401.

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Lourdes Mata

Current themes of research:

Current themes of research aimed at understanding childhood development and learning, namely affective and motivational variables, and the role of family involvement in the quality of education.

Relevant Publications:

Pacheco, P., & Mata, L. (2022). Family literacy: Perspectives and challenges for the preschool-family relation. In A. P. Almeida & S. Esteves (Eds), *Modern reading practices and collaboration between schools, family, and community* (pp. 174-201). IGI Global. http://dx.doi.org/10.4018/978-1-7998-9750-7.ch008.

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Monteiro, V., Mata, L., & Santos, N. (2021). Assessment conceptions and practices: Perspectives of primary school teachers and students. *Frontiers in Education*, 6:631185. https://doi.org/10.3389/feduc.2021.631185.

Mata, L., Pedro, I., & Peixoto, F. (2018). Parental support, student motivational orientation and achievement: Effects of emotions. *International Journal of Emotional Education, 10*(2), 77-92. https://files.eric.ed.gov/fulltext/EJ1197565.pdf.

Mafalda Campos

Current themes of research:

Ethnic-racial identity; minorities in education; math motivation; adaptation to higher education.

Relevant Publications:

Campos, M., Peixoto, F., Bártolo-Ribeiro, R., & Almeida, L. (2022). Adapting as I go: An analysis of the relationship between academic expectations, self-efficacy, and adaptation to higher education. *Education Sciences, 12*(10), 658. https://doi.org/10.3390/educsci12100658.

Teresa Caetano

Current themes of research:

Co-constructing mathematics motivation in primary education.

Relevant Publications:

No previous publications.

Jelena Radišić

Current themes of research:

Motivation for learning, academic emotions, resilience, teacher competence, teacher instructional practices.

Relevant Publications:

Radišić, J., Nortvedt, G. A., & Runde, R. K. (2023). Relationships Between Mathematics Self-Beliefs, Exposure to ICT In School, and Achievement on PISA 2012 Paper- and Computer-Based Mathematics Assessments. In C. Martin, B. Miller, & D. Polly (Eds.), *Technology Integration and Transformation in STEM Classrooms* (pp. 223-246). IGI Global. https://doi.org/10.4018/978-1-6684-5920-1.

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Radišić, J. & Baucal, A. (2018). Teachers' reflection on PISA items and why they are so hard for students in Serbia. *European Journal of Psychology of Education*. *33*(3), 445-466.

Markku Niemivirta

Current themes of research:

Developmental relationships between motivation, learning, and well-being. Situational dynamics between motivation and performance. Individual and contextual predictors of motivation, particularly in mathematics.

Representative publications in the field of Psychology of Education:

Juntunen, H., Tuominen, H., Viljaranta, J., Hirvonen, R., Toom. A., & Niemivirta, M. (2022). Feeling exhausted and isolated? The connections between university students' remote learning experiences, motivation, and psychological well-being during the COVID-19 pandemic. *Educational Psychology, 42(10),* 1241–1262.

Mononen, R., Niemivirta, M., Korhonen, J., Lindskog, M., & Tapola, A. (2022). Developmental relations between mathematics anxiety, symbolic numerical magnitude processing and arithmetic skills from first to second grade. *Cognition and Emotion, 36(3)*, 452–472.

Nuutila, K., Tapola, A., Tuominen, H., Molnár, G., & Niemivirta, M. (2021). Mutual relationships between the levels of and changes in interest, self-efficacy, and perceived difficulty during task engagement. *Learning and Individual Differences, 92*, 102090.

Tuominen, H., Niemivirta, M., Lonka, K., & Salmela-Aro, K. (2020). Motivation across a transition: Changes in achievement goal orientations and academic well-being from elementary to secondary school. *Learning and Individual Differences, 79*, 101854.

Ståhlberg, J., Tuominen, H., Pulkka, A.-T., & Niemivirta, M. (2019). Maintaining the self? Exploring the connections between students' perfectionistic profiles, self-worth contingency, and achievement goal orientations. *Personality and Individual Differences, 151*, 109495.

Niemivirta, M., Pulkka, A.-T., Tapola, A., & Tuominen, H. (2019). Achievement goal orientations: A person-oriented approach. In K. A. Renninger, & S. E. Hidi (Eds.), *The Cambridge Handbook of Motivation and Learning* (pp. 566–616). Cambridge: Cambridge University Press.

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