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Students' socioeconomic status and teacher beliefs about learning as predictors of students' mathematical competence

Eeva S. H. Haataja[1] · Markku Niemivirta[2] · Marja E. Holm[3] · Pia Ilomanni[1] · Anu Laine[1]

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Abstract
The learning context, consisting of the school children's families, teachers, and peers, has effect on their mathematics learning. The concern of students' socioeconomic status (SES) affecting negatively their learning outcomes is increasing worldwide. This study investigates whether Finnish elementary school students' SES affects their mathematical competence and success expectancy on individual and class levels. Additionally, the role of teachers' beliefs on mathematics learning and class composition on the mathematics competence and success expectancy on the class level is explored. To analyze the nested data from student questionnaires and mathematics tests, and their teachers' questionnaires, we used multilevel structural equation modelling with two levels (1, individual; 2, class). The results indicate that on the individual level, the gender and SES affect students' mathematical competence and success expectancy in mathematics. On the class level, the teacher's evaluations of academic class composition predicted students' mathematical competence, and the teachers' constructivist beliefs of mathematics learning and class composition regarding students' special needs predicted students' success expectancy. We conclude that students with disadvantaged SES need support on success expectancy to flourish in mathematics. On the class level, this support can be conveyed through teachers' constructivist pedagogical beliefs.

Keywords Class composition · Mathematics learning · Motivation · Socioeconomic status · Structural equation modeling · Teacher beliefs

✉ Eeva S. H. Haataja
eeva.haataja@helsinki.fi

1 University of Helsinki, Helsinki, Finland

2 University of Eastern Finland, Joensuu, Finland

3 Finnish Institute for Health and Welfare, Helsinki, Finland

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Introduction

Elementary school students' mathematics motivation is shaped by both their school and home contexts (Simpkins et al., 2015). Already the original publication of the expectancy-value theory (EVT) acknowledged the established knowledge on the role of parents' and teachers' beliefs and expectations on students' confidence and competence at both the individual and cultural levels (Eccles, 1983). However, parents and teachers do not affect the student's learning only through their conceptions.

On one hand, parents' education, occupation, and income affect the socioeconomic status (SES) of their family, which in turn influences their children's values, goals, and performance (Eccles & Wigfield, 2020). On the other hand, teachers' beliefs about mathematics learning have an impact on the pedagogy and instruction that takes place in the classrooms (Swars et al., 2018). In school, the students are also surrounded by peers, and the SES class composition has been found to affect the social relationships in classrooms (Hansen et al., 2021). To close the gap in learning outcomes between high- and low-SES students, there is a need to better understand the relationship between school children's socioeconomic backgrounds and mathematics teaching (Li et al., 2021).

Students' choices during their school years affect not only their instant well-being but also their possibilities in adulthood. According to the EVT, these choices are affected by the socio-cultural context of the students, e.g., material resources at home and parents' activities and beliefs (Simpkins et al., 2015). The need for studies on the role of the family in shaping students' mathematics motivation in different countries is recognized (Niehues et al., 2020; Simpkins et al., 2015). School children's understanding of themselves as learners of mathematics has appeared to be complex and malleable (Bonne & Johnston, 2016), which underlines the importance of investigating the formation of mathematical motivation in the elementary school and contexts affecting this process. Students' mathematics competence and motivation develop in the complex context of their families, peers, and teachers. This study examines how the individual students' SES and home language, the class composition, and the teacher's beliefs on mathematics learning affect Finnish elementary school students' mathematical competence and success expectancy in mathematics. The study investigates 3rd and 4th grade students from 47 schools that represent the socioeconomic variety of schools in Finland. The Finnish school system can be characterized as egalitarian with public schools, a wide understanding of students with special needs, and autonomous teachers. However, multiculturalism is a relatively new feature in Finnish society, and the school system is still adapting to the needs of students with non-native language backgrounds (Hammerness et al., 2017).

Student's success expectancy

The EVT was originally developed as a comprehensive motivation theory to connect the students' motivational attributes with their cultural surroundings and personal history, which are conceptualized as mediators of the person's expectancies and values. With regard to mathematics, even first-grade students are able to distinct their expectancies from the values they relate to the domain (Wigfield & Eccles, 2000). However, these concepts do not develop in a vacuum. According to the EVT, students interpret their past experiences and adopt the socialization influences to form their motivational beliefs in terms of their domain-specific competence perception and values in general and in relation to specific tasks (Eccles, 1983; Nuutila et al., 2018; Wigfield & Eccles, 2000). Students' motivation, especially during the elementary school years, develops in interaction with their socio-cultural home context (Simpkins et al., 2015). People place higher attainment value on those tasks that are consistent with their social identity, especially the messages from parents and teachers and the appropriateness of participating in activities depending on the belonging to a social group (Eccles & Wigfield, 2020).

Of the two main components of EVT, competence perceptions and values, the former has been studied from various perspectives with a focus on different constructs, including self-confidence, self-concept, self-efficacy, and success expectancy (Nuutila et al., 2018). Wigfield and Cambria (2010) state that students' success expectancy, which refers to a person's expectation of future success in a task (Eccles et al., 1993), is "among the strongest psychological predictors of performance." Additionally, the effect has been found to be reciprocal, as the experiences of proficiency also affect the person's expectations. The success expectancy is in relation to the person's interest in the task, as some self-competence is always needed for the interest to develop, and this interest affects the person's task-related behaviors in turn (Nuutila et al., 2018).

Success expectancy is closely related to Bandura's (1986) concept of self-efficacy that refers to a person's confidence in their capacity to execute certain actions to achieve defined outcomes (Bandura, 1986). Empirically, success expectancy and self-efficacy can be used as equivalent, future-oriented predictive constructs (Eccles & Wigfield, 2020; Nuutila et al., 2018). However, among children, the stronger prediction may even go from learning outcomes to confidence in ability than vice versa (Talsma et al., 2018). In this study, we use the concept of success expectancy and define it as one factor in mathematics motivation. Our literature review ("Socioeconomic status and mathematics motivation and competence" section) includes research on students' expectations of their success in mathematics that has been investigated through neighboring concepts such as self-confidence.

In the recent revision of the EVT, Eccles and Wigfield (2020) have highlighted the situational nature of the attributes related to the theory. They specify that the model moves from the macro-level, the cultural context of the student, to very situational processes of decision-making, such as the success expectancy in specific tasks (Eccles & Wigfield, 2020). The most reliable way of investigating these beliefs is to approach them situationally from a task-specific viewpoint. Individual task-related items on students' success expectancy have been found useful in measuring a more general confidence in one's mathematics competence (Nuutila et al., 2018). Studies with young students commonly use a simple measure that asks them to estimate their item-specific self-confidence on succeeding in performing the task (e.g., Kleitman & Stankov, 2007; Margraf & Pinquart, 2016). The task-specific expectancies can be supported with pedagogy that pays attention both to psychological considerations and domain-specific, content-focused learning (Bonne & Johnston, 2016). Additionally, the consistency of task-related success expectancy can be seen to reflect the stability of mathematical motivation in general (Nuutila et al., 2018).

Socioeconomic status and mathematics motivation and competence

Students' success expectancy tends to become more realistic and stable towards middle childhood, and the beliefs of the parents and teachers influence this development, especially during the first school years (Eccles et al., 1993; Wigfield et al., 1997). Careful pedagogy can improve the success expectancy of low-SES students and enhance their motivation and interest in studying mathematics (Ball et al., 2019). However, recent research has presented conflicting evidence on the impact of the background factors influencing students' mathematical motivation. Some studies have indicated that the school community has more effect on students' mathematical motivation than the parents' beliefs (Niehues et al., 2020; Simpkins et al., 2015), whereas others conclude that the parents' self-perceptions and attitudes and the students' interpretations of them affect the students' expectancies and values of mathematics more than the teachers' beliefs (Aunola et al., 2003; Eccles, 1983).

Even though the role of parents' beliefs in the development of children's motivation is the highest regarding leisure activities, mathematical affects and competencies are also influenced by the family background (Simpkins et al., 2015). Parents' mathematical beliefs are in a positive connection ($\beta = .24$, $p < .001$) to students' success expectancy in mathematics, and these beliefs serve as a moderator between SES and mathematics success expectancy (Niehues et al., 2020).

Parents of higher SES are more involved in their children's schooling, and especially in countries with competitive school systems, this affects the students' mathematics performance (Niehues et al., 2020). This influence grows stronger as the child grows up and the difficulty of school mathematics increases, which highlights the importance of parents' help and model (Simpkins et al., 2015). However, in Germany, the effect was found to be high even in early childhood education, in which the family's SES determines children's mathematical achievements more than pedagogy in education (Thiel, 2012). Research indicates that more research is needed to understand this phenomenon among students from families of different socioeconomic, ethnic, cultural, and national backgrounds (Simpkins et al., 2015).

A recent study on Chinese fourth-graders indicated that the significance of high-quality cognitive activation is higher for the mathematics self-efficacy of students from lower SES backgrounds. This effect is directly evident on the motivational outcomes of mathematics teaching, which indirectly affect the cognitive learning outcomes. In other words, a teacher's emphasis on mathematical cognitive activation plays a significant role for students who lack academic support from home (Li et al., 2021). However, a study among young American students (preschool and first grade) incorporated a time variable to the model examining the effect of teaching on mathematics learning, indicating that the amount of time spent on mathematical activities in school was more important than the type of cognitive activation for the goal of equalizing the mathematical skills of high and low-SES students (Desimone & Long, 2010).

French fourth-grade students' mathematics competence was found to be in a positive connection ($\beta = .32$, $p < .001$) to their SES, and this was mediated by their self-efficacy. When self-efficacy was controlled for, the effect of SES on competence became nonsignificant (Wiederkehr et al., 2015), which indicates that the lower status in school does not affect the students' learning but their motivational beliefs. However, a recent Finnish study found a clear connection between students' SES and mathematics grades ($B = .26$, $p < .001$) with a sample of 4794 lower secondary students (Pulkkinen & Rautopuro, 2022).

A Nordic study including Finland found the SES composition of the class to affect the teacher-student relationships (Hansen et al., 2021). Supportive teacher-student relationship benefits students' performance and success expectancy in mathematics, especially on the class level (Mikk et al., 2016; Sakiz et al., 2012). The effects of individual students' SES and language background compared to the effects of the class composition have been found to partly differ. An international comparative study indicated that peer composition plays a significant role in children's mathematics learning outcomes. Coming from a different SES than most of the peers in class is detrimental for children of low SES, but diverse backgrounds of classmates can be beneficial for students with high SES (Chudgar et al., 2013).

Additionally, the SES and the proficiency of the language of the instruction have a clear impact on individual students' success in mathematical word problems that often include wide vocabulary and complex language (Abedi & Lord, 2001). However, in the context of collaboration in mathematics learning, heterogeneous language background composition of groups may even benefit the student learning due to more careful help from the native students to their non-native peers (Mouw et al., 2019).

The students' SES also affects students' success expectancy and mathematics competence through school selection and teacher practices (Niehues et al., 2020). The elementary school teachers' practices in mathematics classrooms have been found to differ depending on the SES of their students and classes (Li et al., 2021). The school systems sort children into schools based on their neighborhood or other qualities, such as cognitive abilities, and thus reproduce the social classes of the children (Weininger & Lareau, 2003). As a worst-case scenario, the schools turn social differences into individual disadvantages by teaching the students, during the school path, to attribute their difficulties to their personal characteristics rather than to their socioeconomic context (Wiederkehr et al., 2015). However, the students' mathematics competence is not predetermined in any school, as with a focus on high-quality teaching, schools in disadvantaged neighborhoods can flourish (Muijs et al., 2004).

Teachers' beliefs about mathematics learning

Teachers' mathematics-related beliefs have been widely investigated for decades. Although no agreement on the definition of beliefs has been established (Leder, 2019), there are some aspects with fair consensus. Beliefs can be defined as personal philosophies that teachers hold (Liljedahl et al., 2021), and they are either conscious or unconscious (Markic et al., 2008).

Mathematics teachers' beliefs include beliefs about the nature of mathematics and beliefs about mathematics teaching and learning (Ernest, 1989; Thompson, 1992). Beliefs about learning include teachers' beliefs about the role that students have in their own learning and perceived characteristics of "good" learning (Ernest, 1989; Thompson, 1992). The former one includes teachers' beliefs about what behavior and mental activities are involved in mathematics learning, and the latter one includes beliefs about what learning activities are appropriate and desirable (Chan & Elliott, 2004; Ernest, 1989; Thompson, 1992).

Teachers' beliefs about mathematics learning can be differentiated into two views, (1) a knowledge transmission (or "traditional") view, in which students learn by receiving knowledge from teachers (passively), and (2) a constructivist view, in which the learner is active, and the teacher facilitates students' knowledge construction (Teacher Education and Development Study in Mathematics [TEDS-M] framework: Blömeke & Kaiser, 2014; Tatto et al., 2008). Some studies have recognized a third category, labeled transitional view or mixed model (Caleon et al., 2018; Yang et al., 2020), in which teachers with transitional beliefs express some elements of both the constructivist and transmissive views (Yang et al., 2020).

Beliefs form different structures. Green (1971) argued that there are three dimensions of belief structures: the quasi-logical relation between beliefs, the central-peripheral dimension, and the premise that beliefs are held in clusters. This means that some (i.e., more central) beliefs tend to receive more attention (Rokeach, 1968) and have more power to influence teacher's actions (Pajares, 1992) and that it is possible to hold two incompatible, inconsistent beliefs without internal conflict (Cross, 2009). For example, Lui and Bonner (2016) observed that teachers held at the same time constructivist beliefs about mathematics teaching and learning, but traditional beliefs about the nature of mathematics.

Teachers' beliefs have an impact on how they teach mathematics and promote students' mathematical learning (Hughes et al., 2019; Kutaka et al., 2018). Beliefs influence teachers' thinking and behavior and consequently affect their instructional decision-making and their use of curriculum materials (Swars et al., 2018). In practice, this means that teachers with constructivists' views tend to activate and facilitate students to construct their own knowledge by emphasizing conceptual understanding and reasoning, whereas teachers with transmissive beliefs tend to consider students as passive recipients who reproduce ready-made knowledge gained from the teacher or textbooks. Constructivist beliefs were found to be positively related to instructional quality and student achievement, whereas transmissive beliefs were found to have negative effects on both of these outcomes in Voss et al. (2013). Based on their results, beliefs had especially an effect on the learning support teachers gave to their students.

Research questions

To understand how the elementary school students' background, class composition, and teachers' beliefs predict students' success expectancy and competence in mathematics, we investigated the following research questions:

1. How do Finnish third and fourth-grade students' language background and SES predict their success expectancy and mathematical competence?

   Based on the previous literature, we expected students with a non-native language background and lower SES to display lower success expectancy and mathematical competence.
2. How do Finnish classroom teachers' beliefs about mathematics learning and classroom composition (SES, academic achievement, and special needs) predict the class's mathematical competence and success expectancy?

   Based on the previous literature, we expected the individual SES and language background to predict competence in word problems (better performance in word problems among students with higher SES and native language background) and academic and special needs class composition to predict success expectancy and overall mathematics competence (lower mathematics competence in classes with higher share of students with academic difficulties or special needs). We also expected that teachers' constructivist beliefs predicted positively mathematical competence at the class level.

Methods

Participants

This study was part of an 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 the spring of 2022 in 47 schools around Southern Finland. The sample of this study consists of 1772 3rd (n = 872) and 4th (n = 900) grade students and their teachers (n = 95). Written consent was collected from the teachers and legal caregivers of the students, and the participation was voluntary for all teachers and students throughout the measurement.

Measures

This study combines data from teacher questionnaires, student questionnaires, and students' mathematics tests. The teacher questionnaire data consisted of items measuring class composition and teachers' beliefs about mathematics learning (Laschke & Blömeke, 2013). For valid interpretations on SES on both classroom and individual levels, we included both students' own evaluation on their SES and teachers' evaluation on the SES class composition, as the student-reported SES reflects on their own experience and the teachers can evaluate the diversity of the class as a whole, from the perspective of the instructional needs of the class. The students filled in questionnaires and completed mathematics tasks during two mathematics lessons. All the variables are presented in Table 1 and described in the following sections.

Class composition

The class composition items measured the teachers' perceived knowledge of how many of the students in their class had a lower socioeconomic status (SES), had difficulties in achieving the academic objectives in school (low achieving), or needed support from special education teachers (special needs). The teachers evaluated all these variables on a Likert scale (0 = none, 1 = 1–10%, 2 = 11–30%, 3 = 31–60% of the students).

Teacher beliefs on mathematics learning

For measuring teachers' epistemological beliefs on teaching and learning of mathematics, we used ten items from the *TEDS-M Capturing Beliefs* scale (Laschke & Blömeke, 2013), which reflected teachers' beliefs of mathematics learning benefitting from teacher-centered instruction (transmissive beliefs, e.g., *Students learn mathematics best by attending to the teacher's explanations*) or student-centered, active learning (constructivist beliefs, e.g., *Teachers should allow pupils to figure out their own ways to solve mathematical problems*). The structural validity of the scales with this sample was examined with confirmatory factor analysis using weighted least square mean and variance adjusted estimation due to ordered

Table 1 Measures of latent constructs and variables

Questionnaire	Scale	Variables
Teacher	Class composition	SES Low achieving Special needs
	Beliefs on mathematics learning	Transmissive Constructivist
Student	Demographic questions	Gender SES (number of books at home) Language
	Mathematical competence	Word problems Arithmetic fluency
	Success expectancy	Success expectancy

categorical variables. A two-factor model following the hypothesized structure resulted in an acceptable fit to the data, $\chi^2(34) = 53.84$; $p = .017$; CFI = 0.97; RMSEA = 0.07; SRMR = 0.07. For the main analyses, mean scores with McDonald's ω of .65 and .77 for transmissive and constructivist beliefs, respectively, were calculated based on the factor solution.

Students' demographic questions

We used data from the demographic questions of the students questionnaires: gender (0 = female, 1 = male), self-perception of the frequency of using the language of instruction (Finnish or Swedish) at home (1 = never, 2 = sometimes, 3 = almost always, 4 = always; language), and of the number of books they have at home (1 = none or very few, 2 = one shelf, 3 = one bookcase, 4 = two bookcases, 5 = three or more bookcases; SES). These items are an established method to measure young students' language background and SES (e.g., Chudgar et al., 2013; Hansen et al., 2021).

Students' mathematical competence and success expectancy

Students' mathematical competence was measured with two tests, an arithmetic fluency test and a word problem test. These two tests were combined, as the Finnish national curriculum emphasizes both solid arithmetic skills and applications of these skills in problem tasks in the first grades of elementary school (EDUFI, 2014). The arithmetic fluency is understood to form the baseline of the most relevant mathematics competence in the first school years and therefore commonly used as a measurement for identifying students with mathematical learning disabilities (Mazzocco et al., 2008), whereas the word problems can be seen to differentiate the competence in problem solving and understanding contextual information in the mathematics subject.

The arithmetic fluency test consisted of addition and subtraction tasks with whole numbers between 0 and 20 (grades 3 and 4) and multiplication with whole numbers between 0 and 12 (grade 4; the arithmetic fluency test; Klausen & Reikerås, 2016). Each of these task categories included 45 tasks (2 min each).

The word problem test included 12 problems for the third-graders (25 min) and 14 for the fourth-graders (30 min). The problems were retrieved from TIMMS (Trends in International Mathematics and Science Study; Approval IEA-22-022) problem packages. They depicted the Finnish curriculum and were used to measure the students' competence in applying the school mathematics in different contexts.

After each word problem, the students evaluated how confident they were about having answered correctly on the task items. Similar measures have been used widely (e.g., Kleitman & Stankov, 2007; Pajares & Miller, 1995). For this evaluation of success expectancy, a Likert scale (1–4) was used with emojis (from sad = *not at all confident* to happy = *very confident*) helping the students to reflect on their situational self-perception of mathematical success expectancy.

Data analyses

To answer our research questions addressing predictions at both student and class levels, we used multilevel modeling within the structural equation modeling framework as implemented in the Mplus statistics software (version 8.8; Muthén & Muthén, 1998–2017). More specifically, following the nested structure of our data, we specified a random intercept regression model with students at level 1 (within) and classes (teachers) at level 2 (between), as illustrated in Fig. 1.

At the student level, direct effects were specified from the demographic factors gender, language, and SES on students' scores on arithmetic fluency and word problems, while success expectancy was set to mediate the effects of background factors on math performance. At the class level, direct effects were specified from factors reflecting classroom composition (i.e., the share of students from socioeconomically disadvantaged homes, of low academic achievement, and with special needs) as well as teachers' beliefs of mathematics learning (i.e., transmissive and constructivist beliefs) on students' mathematical competence and success expectancy.

A maximum likelihood estimator with robust standard errors was used for the analysis, and model fit was evaluated using the comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root means square residual (SRMR) along with the χ^2-statistic, with cutoff values for acceptable fit greater than 0.90 for CFI, and less than 0.08 for RMSEA and SRMR (Marsh et al., 2004).

Results

Descriptive and preliminary results

Descriptive statistics for all variables are reported in the Appendix. An inspection of correlations between student-level variables (Table 2) showed students' scores on word

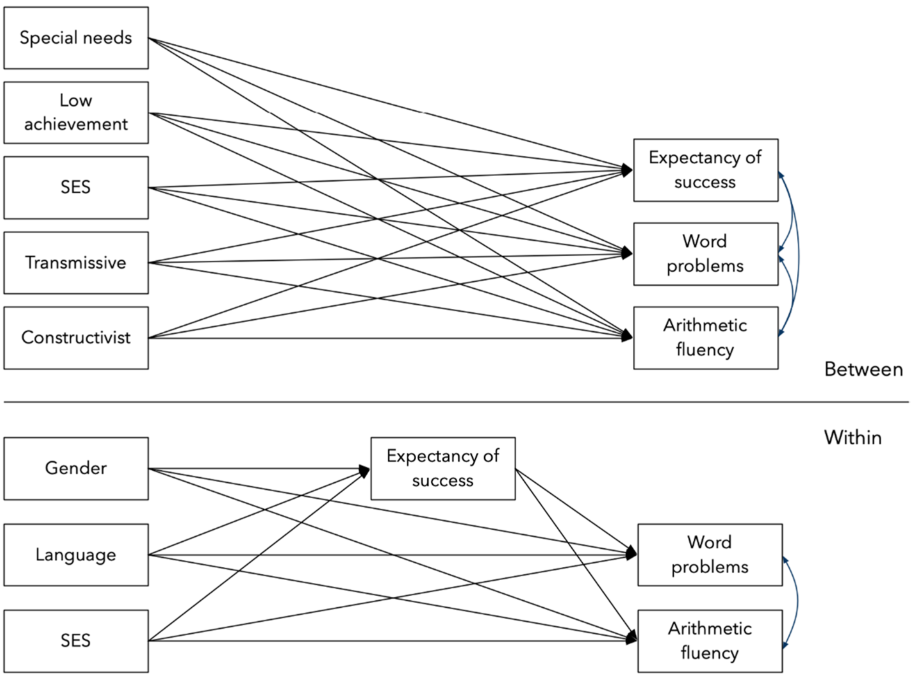

Fig. 1 Specified random intercept regression model with student- and class-level predictions

Table 2 Correlations between student-level variables

	Success expectancy	Word problems	Arithmetic fluency	Gender	Language
Success expectancy	—				
Word problems	.46***	—			
Arithmetic fluency	.35***	.50***	—		
Gender	.21***	.11***	.19***	—	
Language	.04	.16***	.08***	.00	—
SES	.19***	.30***	.19***	−.03	.23***

*$p < .05$, **$p < .01$, ***$p < .001$

Table 3 Correlations between class-level predictors

	Special needs	Low achievement	SES	Transmissive
Special needs	—			
Low achievement	.68***	—		
SES	.52***	.52***	—	
Transmissive	.10	.01	−.21*	—
Constructivist	−.10	−.08	−.02	−.33**

*$p < .05$, **$p < .01$, ***$p < .001$

problems and arithmetic fluency to relate to each other as well as with the success expectancy. Also, gender and SES correlated with all math measures, suggesting boys and students with higher SES perform slightly better and display somewhat higher success expectancy than girls and students with lower SES, respectively.

As to correlations between class-level predictors (Table 3), factors representing classroom composition were mutually correlated. That is, according to teachers' views, classes with more students from socioeconomically disadvantaged homes also include more students of low academic achievement and with special needs, and vice versa. Additionally, teachers' transmissive beliefs had a negative correlation with classes of low SES, indicating that in classes of several students from a disadvantaged background, the teachers did not report having transmissive beliefs of mathematics learning.

Predictions of students' math performance and success expectancy

Before estimating our model, we first calculated ICCs and design effects to assess the extent of variance at the class level, and, consequently, the relevance of multilevel modeling. The ICCs for success expectancy, word problems, and arithmetic fluency were .030, .099, and .124, respectively, with corresponding design effects of 1.48, 2.60, and 3.00. Hence, although the level of variation was not particularly high at the class level, the planned two-level model seemed appropriate.

The model fit the data well, $\chi^2(2) = 1.125$; $p = .560$; CFI = 1.00; RMSEA = .00; SRMR = $.006_{within}/.005_{between}$. Significant effects are illustrated in Fig. 2, and all effects are reported in Table 4.

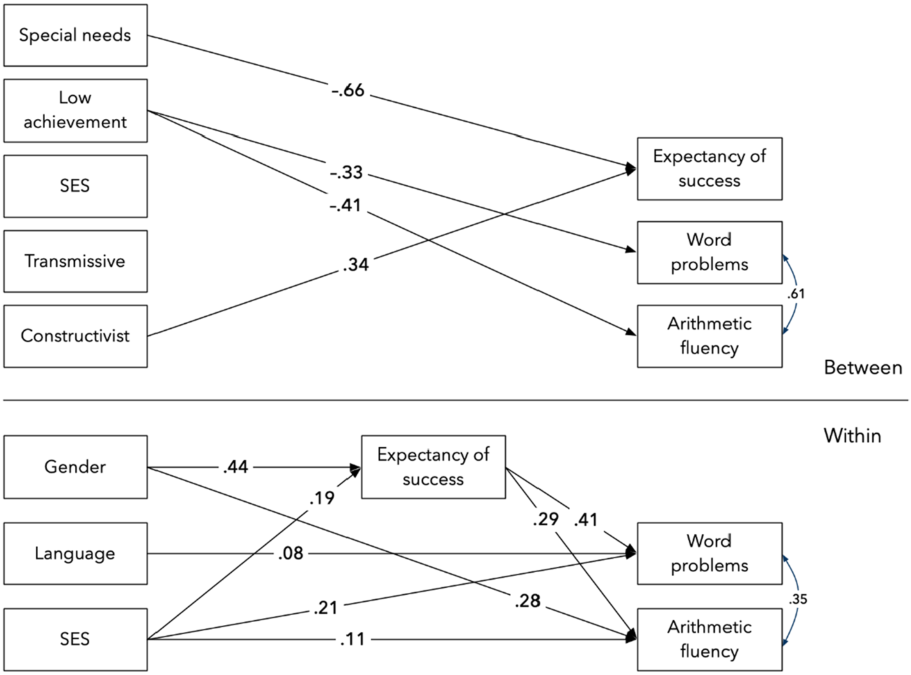

Fig. 2 Significant unstandardized effects from the two-level random intercept regression model

At the student level, both word problems and arithmetic fluency were predicted positively by the success expectancy and SES, while word problems were additionally predicted by language background and arithmetic fluency by gender. In other words, the higher success expectancy and higher SES were associated with better math performance, boys received higher scores than girls on arithmetic fluency, and more frequent use of the language of instruction (Finnish/Swedish) at home was linked with somewhat better performance on word problems.

Success expectancy was predicted by gender and SES, thus suggesting boys and students with higher SES to have higher expectancies than girls and students with lower SES, respectively. Interestingly, although gender was not directly connected with word problems, its indirect effect through success expectancy was significant (β = .18, z = 5.75, p < .001), thus displaying a mediating effect favoring boys. In contrast, SES had an indirect effect on word problems through success expectancy (β = .08, z = 5.74, p < .001) in addition to its direct effect. Arithmetic fluency, in turn, was indirectly predicted by both gender (β = .13, z = 5.34, p < .001) and SES (β = .06, z = 4.93, p < .001) in addition to their direct effects. Altogether, the model explained around 9%, 27%, and 16% of the variance in success expectancy, word problems, and arithmetic fluency, respectively. Tables 5 and 6

Regarding class-level predictions, the share of students with low academic achievement was negatively predictive of performance in both word problems and arithmetic fluency, thus suggesting that classrooms with a higher share of students with lower academic achievement displayed inferior math performance. Success expectancy, in contrast, was negatively predicted by the share of students with special needs and positively by the teacher's constructivist belief of math learning. In other words, the success expectancy was

Table 4 Unstandardized effects from the multilevel model

	Success expectancy			Word problems			Arithmetic fluency		
	est.	*se.*	*p*	*est.*	*se.*	*p*	*est.*	*se.*	*p*
Within									
Gender	0.28	0.04	< .001	0.09	0.07	.229	0.26	0.04	< .001
Language	0.02	0.02	.365	0.12	0.04	.004	0.04	0.02	.107
SES	0.11	0.02	< .001	0.27	0.03	< .001	0.09	0.02	< .001
Success expectancy				0.90	0.06	< .001	0.42	0.05	< .001
Between									
Special needs	–0.09	0.04	.014	–0.09	0.14	.489	0.01	0.09	.925
Low achievement	–0.02	0.04	.696	–0.19	0.10	.042	–0.17	0.07	.013
SES	0.04	0.04	.240	0.04	0.09	.675	0.00	0.06	.982
Transmissive	0.08	0.08	.323	0.00	0.21	.988	–0.01	0.14	.940
Constructivist	0.08	0.04	.036	0.10	0.10	.311	0.08	0.10	.425

lower in classes with a higher teacher-reported share of students with special needs and higher in classes with teachers emphasizing a constructivist belief of mathematics learning.

Discussion

This study is part of a project that aims to explore the complex learning context constructed by the families, peers, and teachers of elementary school students. We examined the predictors of Finnish elementary school students' mathematical competence and success expectancy from two perspectives: students' background on the individual and teachers' beliefs about mathematics learning and class composition on the class level.

First, the effect of students' individual SES on their mathematical competence and self-evaluated success expectancy in mathematics was significant. The results from the multilevel model indicate that students' SES affects their learning and expectations of learning in mathematics. Students' own evaluation of the number of books at their home predicted significantly all the measured variables: students' success in mathematical word problems, arithmetic fluency, and success expectancy in mathematics. This finding is aligned with the ongoing worrying discussion on the Finnish school system not being as egalitarian as it was hoped and supposed to be (e.g., Hansen et al., 2021; Pulkkinen & Rautopuro, 2022).

Instead, the students' language background was not a significant predictor of mathematical competence or success expectancy. The only statistically significant but still very weak connection was found between students' home language and their success in word problems. This is understandable, as these problems were presented in written form in the language of instruction and comprehending them may be more difficult for students from non-native backgrounds. The weak effect may result from the differences in understanding the written tasks. However, the participating students with non-native language backgrounds represent the diversity of immigrants in Finland. For example, people with an Estonian background form a large minority, and the Estonian language is relatively similar to the Finnish language. In the future, it would be important to investigate whether the results would differ from these, with a sample focused on students from refugee backgrounds, for example.

As a limitation of this study, the number of books at home was only an estimate of household possessions and did not comprehensively describe the students' SES. However, this is a commonly used estimate (cf. Chudgar et al., 2013; Hansen et al., 2021), and it was connected to all the measured variables. Therefore, we can interpret that individual students' SES does affect not only their mathematical learning in school (word problems and arithmetic fluency) but also their success expectancy when doing mathematics. Unlike many other countries, Finnish families do not choose the schools for their children and the non-competitive nature of the school system does not underline the significance of parent involvement in students' learning (cf. Niehues et al., 2020). Nevertheless, despite these egalitarian structures of the Finnish school system, the SES was found to affect elementary students' mathematics learning and success expectancy, which, according to Nuutila et al. (2018), further affects the development of students' motivation to study mathematics.

The results on the second research question indicated that the class-level SES did not predict the students' success expectancy in mathematics or their competence in mathematics. This suggests that, on the classroom level, the teachers are able to mitigate some of the disadvantaging effects of students' low socioeconomic background. Additionally, competition or high-stakes assessment is not characteristic of Finnish elementary education, which may help in bridging the students of different backgrounds in the same classes (cf. Niehues et al., 2020).

However, on the individual level, the students' SES affected their mathematical competence and success expectancy. These findings are aligned with previous research indicating that individual students' SES affects both mathematical success expectancy and competence (e.g., Wiederkehr et al., 2015). A Finnish study using parents' education and family possessions as indicators of students' SES found a similar connection between SES and mathematics competence (Pulkkinen & Rautopuro, 2022) as our study with student-reported SES. We suggest that future research could investigate how much this effect on the teacher-assessed mathematical competence of the students is dependent on the students' affective attributes, such as success expectancy, rather than cognitive attributes, such as arithmetic fluency. There is a significant need for emphasis on pedagogical practices in future research to understand the details of teachers' possibilities to mitigate the effect of SES on students' mathematics learning and motivation (Thiel, 2012).

The teachers' evaluation of their students' low academic achievements and their needs for special education were the strongest predictors on the class level, but the effects of these perceptions were distinct from each other. The classes including many students with a need for special education had a lower success expectancy in mathematics. The classes with a high proportion of low academic achievers had lower scores on the arithmetic fluency test. This indicates a strong validity of the teachers' evaluations of their classes: students who need special education have lower success expectancy in mathematics, and the teachers know whether their students have difficulties in completing even the basic arithmetic tasks successfully.

Finally, we estimated whether the teachers' beliefs about mathematics learning influenced this model. Most of the teachers reported high agreement with the items on constructivist beliefs and low agreement with the items on transmissive beliefs, especially those teachers who taught classes of low SES. The constructivist beliefs, which were common among the participants, predicted students' success expectancy. We interpret it as promising that the constructivist beliefs shared by the majority of the sample of Finnish teachers predict better success expectancy in the class. At the same time, this factor was not in direct relation to the students' mathematics competence that was measured with rather traditional mathematics tasks. Teachers' beliefs tend to affect their day-to-day instruction and use of learning materials (Swars et al., 2018). Therefore, in the future, we wish to add different kinds of tasks (e.g., collaborative, open problem tasks, or mathematical modeling) to compare whether these teacher beliefs and the class composition have effect on more social and creative aspects of mathematics learning.

Additionally, we found a negative correlation between classes with more students of low SES and teachers believing that transmissive instruction is beneficial for mathematics learning. This is of importance, as the school context has a significant impact on the students' mathematics motivation (Niehues et al., 2020). As the students cannot determine their SES, school, or teacher, and individual low SES is found to affect success expectancy and mathematics learning negatively, it is pivotal to provide these children with teachers of up-to-date knowledge on motivational aspects in mathematics education. Understanding the mechanisms behind this finding should be addressed in future research: are the teachers' beliefs shaped by their perceptions of their students' struggles, or are the teachers with constructivist beliefs more willing to work in schools placed in disadvantaged neighborhoods?

The teachers' beliefs did not predict the mathematical competence of elementary school students in our model. The amount of mathematics instruction has been suggested to be more significant than the nature of the pedagogy for supporting young students from disadvantaged SES to achieve the learning goals in mathematics (Desimone & Long, 2010). However, with high-quality pedagogy, the teachers can influence the students' success expectancy in mathematics (cf. Li et al., 2021). Future research could continue comparing this finding with participant samples from different countries to see whether this is a global or national characteristic of elementary school teachers.

To conclude, low SES predicts Finnish elementary school students' mathematical competence and success expectancy on the individual level, but on the class level, the peer SES composition did not have any effect. Instead, the teacher's beliefs about mathematics learning and the teachers' evaluation of the academic composition in their class (students' need for special education and low academic achievements) had a clear effect on the cognitive and motivational outcomes of the students. Therefore, we conclude that by implementing pedagogy based on constructivist beliefs and providing support for individual students in need, elementary school teachers have the possibilities in improving the success expectancy and thus closing the gap between the learning outcomes of students from distinct SES. Most importantly, this underlines the need for municipal officers to collaborate with teachers and schools to direct resources of mathematical and other kinds of special support to those classes that the teachers indicate to be at substantial risk of falling behind in learning objectives.

Appendix

Table 5 Descriptive statistics for class-level predictors

Variable	*N*	*M*	*Md*	*SD*	*Min*	*Max*	*Skewness*	*Kurtosis*	Share of students in class			
									None	1–10%	11–30%	31–60%
Classroom composition												
Special needs	94		2	0.85	0	3	0.14	−0.75	6 (6.4 %)	39 (41.5 %)	32 (34.0 %)	17 (18.1 %)
Low achievement	95		2	0.78	0	3	0.01	−0.37	8 (8.4 %)	39 (41.1 %)	39 (41.1 %)	9 (9.5 %)
SES	91		1	0.86	0	3	0.51	−0.21	16 (17.6 %)	47 (51.6 %)	19 (20.9 %)	9 (9.9 %)
Beliefs of learning												
Transmissive	94	1.63		0.33	1.00	2.50	0.11	−0.53				
Constructivist	93	3.48		0.46	1.25	4.00	−1.36	4.52				

Table 6 Descriptive statistics for student-level variables

Variable	*N*	*M*	*Md*	*SD*	*Min*	*Max*	*Skewness*	*Kurtosis*
Success expectancy	1289	2.76		0.66	1.00	4.00	−0.26	−0.32
Word problems	1744	5.42		1.47	0.07	9.45	0.35	0.26
Arithmetic fluency	1759	2.66		0.96	0.00	4.50	0.07	−0.69
Gender	1754							
Female	886 (50.5%)							
Male	868 (49.5%)							
Language (speaks Finnish/Swedish at home)	1756		4	0.99	1	4	−0.93	−0.53
Never	112 (6.4%)							
Sometimes	349 (19.9%)							
Almost always	269 (15.3%)							
Always	1026 (58.4%)							
SES (Number of books)	1744		3	1.07	1	5	−0.07	−0.47
None or very few (0–10 books)	101 (5.8%)							
Enough to fill one shelf (11–25 books)	289 (16.6%)							
Enough to fill one bookcase (26–100 books)	702 (40.3%)							
Enough to fill two bookcases (101–200 books)	409 (23.5%)							
Enough to fill three or more bookcases (more than 200)	243 (13.9%)							

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Declarations

Conflict of interest The authors declare no competing interests.

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Eeva Haataja, Faculty of Educational Sciences, University of Helsinki, Finland. Email: eeva.haataja@helsinki.fi

Current themes of research:

Motivation in mathematics education, teachers' professional development and teacher education, nonverbal classroom interaction, mathematical problem solving

Representative publications in the field of Psychology of Education:

Haataja, E., Chan, M. C. E., Salonen, V., & Clarke, D. (2022). Can noncomplementarity of agency lead to successful problem solving? A case study on students' interpersonal behaviors in mathematical problem-solving collaboration. *Learning and Instruction, 82*, [101657]. https://doi.org/10.1016/j.learninstruc.2022.101657

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Markku Niemivirta, School of Applied Educational Science and Teacher Education, University of Eastern Finland, Finland. Email: markku.niemivirta@uef.fi

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.

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Marja Holm, Department of Public Health and Welfare, Finnish Institute for Health and Welfare, Helsinki, Finland. Email: marja.holm@thl.fi

Current themes of research:

Motivation and achievement emotions in mathematics education, individual and contextual mechanisms of mathematics performance and emotions

Representative publications in the field of Psychology of Education:

Holm, M.E., Korhonen, J., Laine, A., Björn, P.M., & Hannula, M. (2020). Big-fish-little-pond effect on achievement emotions in relation to mathematics performance and gender. *International Journal of Educational Research, 104*, 101692. https://doi.org/10.1016/j.ijer.2020.101692
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Pia Ilomanni, Faculty of Educational Sciences, University of Helsinki, Finland. Email: pia.ilomaki@helsinki.fi

Current themes of research:

Motivation profiles in primary school mathematics education, mathematics motivation in relation to mathematics identity and parental attitudes

Most relevant publications (in the field of psychology of education):
No previous publications

Anu Laine, Faculty of Educational Sciences, University of Helsinki, Finland. Email: anu.laine@helsinki.fi

Current themes of research:

Motivation and affect in mathematics education, teaching and learning problem solving, students' mathematical knowledge and its development

Most relevant publications (in the field of psychology of education):

Peixoto, F., Radišić, J., Krstic, K., Hansen, K., Laine, A., Baucal, A., Sörmus, M. & Mata, L. (accepted). Contribution to the Validation of the Expectancy-Value Scale for Primary School Students. *Journal of Psychoeducational Assessment.*

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