LUMAT
International Journal on Math, Science and Technology Education

Research article

Examining motivation profile differences across students' mathematics identity, performance, and parents' attitudes

Pia Ilomanni[1], Jelena Radišić[2] and Anu Laine[1]

[1] University of Helsinki, Finland
[2] Department of Teacher Education and School Research, University of Oslo, Norway

Abstract: Declining development in Finnish students' mathematics performance has highlighted the importance of mathematics competence and motivation research. We used the person-centred approach to investigate Finnish third-, fourth-, and fifth-grade students' mathematics motivation profiles. In addition, we explored differences between the motivation profiles regarding students' mathematics identity, performance, and their parents' mathematics-related attitudes. A latent profile analysis (LPA) based on 304 third-, fourth-, and fifth-grade students' answers revealed three math-related motivation profiles: high motivation, high cost and moderate. Further investigation of the profiles showed that students' higher mathematics identity is represented strongly in the high motivation group, as are students' mathematics performance scores. Parents perceived low mathematics competence as highly expressed in those students belonging to the high cost profile. Results concerning students' broader learning environment and previous results relevant to the Finnish educational system are discussed.

Keywords: mathematics, motivation, identity, primary education, parental attitudes

Correspondence: pia.ilomanni@helsinki.fi

1 Introduction

In many ways, the Finnish education system is oriented towards equality and focused on diminishing student differences, providing equal chances to all. Yet mathematics as a school subject remains to be met with divided stances and is treated with concern by some students and parents. Mathematics attitude and performance differences affect students' willingness to pursue STEM careers and shape their lifelong learning. Mathematics achievement measured in Finnish fourth-grade students has been well above average in international assessments, but research shows that in recent years, the trend curve has been descending (Gurria, 2016; Vettenranta et al., 2020). While the average Finnish student still performs well in mathematics and the overall fluctuation between students' performance has been low, international assessments reveal that the number of students with the highest achievement has dropped significantly.

Meanwhile, the number of the lowest-achieving students increased considerably after

Received 2 April 2024 / Accepted 27 September 2024 / Published 1 October 2024
Published by the University of Helsinki, Finland and LUMA Centre Finland.

the turn of the century (Kupari et al., 2013). These findings reflect a topic that is also prominent in public discourse: the growing concern over the increasing heterogeneity of Finnish students. To stop the descending trend curve of Finnish students' mathematics performance, we need a better understanding of how students engage with mathematics. While previous studies show that motivational aspects explain more about the variance of mathematics performance in Finland than on average in the other OECD countries (Kupari et al., 2013), other studies have found that the Finnish students' mathematics-related motivation is a weaker predictor for their mathematics performance than expected, when compared to other countries (Vettenranta et al., 2020). As we gain a deeper understanding of the latent constructs behind the mathematics motivation of Finnish primary students, we are also better prepared to explore the factors underlying the declining performance trend and the connections between motivational traits and mathematics performance, guiding the development of strategies to address the increasing heterogeneity of the student population. One of the main aims of the comprehensive school curriculum is to support students' positive attitudes and self-perspectives towards mathematics (Finnish National Board of Education, 2014). This study aims to broaden our knowledge of Finnish primary-age students' mathematics motivation by focusing on third-, fourth-, and fifth-grade students' mathematics performance and motivation using a person-centred approach.

Background

Motivation research and, more specifically, motivation concerning the school subject of mathematics has drawn substantial attention (see Middleton & Spanias, 1999; Hannula et al., 2016; Priess-Groben & Hyde, 2017; Schukajlow et al., 2017). Consequently, this has led to diverse theoretical approaches, all aiming to understand what motivates students related to mathematics as a subject. Expectancy-value theory (EVT, Eccles et al., 1983; Wigfield et al., 2015; Eccles & Wigfield, 2020) is particularly widely used in educational research for it provides researchers with a comprehensive and continually elaborated framework that has been supported and fine-tuned for decades by substantial empirical evidence (see Wigfield et al., 2017; Eccles & Wigfield, 2020). EVT describes motivation as a continually malleable internal process comprising expectancies for success and values attributed to the task.

Expectancies comprise individuals' belief in their own abilities to succeed on a task and reflect affective memories, socialisation influences, and self-perspectives. At the same time, values derive from personal goals, tasks perceived difficulty, and interest in the task (Eccles et al., 1993; Wigfield & Eccles, 2000). According to the EVT, task values include attainment, intrinsic value, utility value, and cost. Attainment value incorporates the importance of the task on a personal level and how meaningful the task's execution is for the individual's self-perspective (Wigfield & Eccles, 2020). It can be seen as a measure of how important it is for an individual to do well in tasks regarding different areas of competencies and how they, in some parts, define themselves through that success in that certain area (Wigfield et al., 2017). Intrinsic value can be described as an individual's enjoyment or experienced interest when participating in an activity or a task (Eccles et al., 1983). The utility value can be described as a construct capturing the perceived usefulness of the task and connecting it to an individual's current or future goals and ambitions (Wigfield & Eccles, 2020). Cost value comprises the expenses (e.g., time consumption, effort, giving up on alternative activities, etc.) individual experiences when facing a task, and for that, the cost is recognised as a critical component of choice (Eccles et al., 1983; Wigfield & Cambria, 2010). The choice of how strongly the student is engaging in the task is made after consideration of their' perceived competence concerning task-related perceptions and subjective task values (Jacobs & Eccles, 2000; Simpkins et al., 2015). Among the task values, intrinsic and utility values have been more scrutinised in research than cost and attainment values (Eccles & Wigfield, 2020). The latest revision of the EVT, now referred to as situated expectancy-value theory (SEVT, Eccles & Wigfield, 2020), proposes that more attention should be directed to motivational dimensions' domain specificity, cultural relatedness, and motivations' situational character.

While EVT focuses on the qualities of building motivation, which is task-related and situational, math identity focuses on the subjective personal ground and social environment for which the motivation is being constructed. Personal identification in relation to STEM-related school subjects has been studied in the context of mathematics (Anderson, 2007; Martin, 2009) science (Trujillo & Tanner, 2014) and physics (Hazari et al., 2010). These subject domain identifications have been described as supporting the development of role identities (Burke & Stets, 2009). Mathematics identity forms from a combination of individuals' experience of taking the mathematics subject domain as a part of themselves, perception of being a capable and potential participator in it, investing in being a doer in that area, and pursuing math-related tasks enthusiastically (Darragh, 2013). Another critical perspective the individual uses in forming a mathematics identity is how others surrounding important socialisers, such as parents, teachers, and peers, perceive them with mathematics (Anderson, 2007; Cribbs et al., 2015). Mathematics identity development happens in constant interaction and interplay with the personal identity and the collective social identity, which consists of the shared experiences with the social surroundings and the experiences of belonging (Eccles, 2009; Radisic et al., 2024). Heller (2015) suggests that mathematics identity profoundly impacts students' mathematics-related decision-making processes.

Motivation and mathematics identity have been studied in association with mathematics achievement and performance. Previous empirical studies conclude that motivation is essential to mathematics achievement (Shen, 2002; Gottfried et al., 2007; Guo et al., 2015). It has also been found that with primary students, mathematics achievement and performance are critical elements of building students' beliefs in their abilities (Hannula et al., 2014). Petersen and Hydes' (2017) study concluded that higher perceived competence in mathematics in the fifth grade predicted higher scores in high school five years later. A strong connection between students' perceived competence and valuing mathematics with achievement has been shown previously in the TIMSS context (Hooper et al., 2017). However, the findings regarding the association between achievement and valuing mathematics varied more across countries and different education systems. The research in this field has previously mainly focused on older students' (see Hattie, 2009; Lee & Stankov, 2018), somewhat disregarding primary students. To an extent, this could be due to the fact primary students' motivation and self-perspective are still relatively malleable and mature throughout their school years (Davis-Kean et al., 2008; Cleary & Chen, 2009; Weidinger et al., 2018) while their views on mathematics are yet to stabilise (Hannula & Laakso, 2011).

Age and differences between boys and girls have been widely studied in mathematics motivation research. Perceived competence has been recognised to decrease over the years when students reach early adolescence (Eccles et al., 1993; Wigfield & Eccles, 2002). At the same time, the general decline of different activities' importance and usefulness and gender stereotypical differences in the same context has been acknowledged (Wigfield & Eccles, 1994; see also Eccles, 2009). Boys' competence and self-related beliefs in the mathematics domain tend to be more positive than girls, even in primary age (Niemi & Metsämuuronen, 2010; Mejía-Rodríguez et al., 2020; Keller et al., 2022). In the Finnish context, Niemi and Metsämuuronen (2010) found that students' mathematics-related competence beliefs and attitudes decrease significantly even in the primary stage from third to fifth grade, highlighting gender disparity, with girls having lower competence beliefs and more negative attitudes towards mathematics. In the middle school setting, Guo and colleagues' (2015) empirical findings suggest that in Hong Kong eighth-grade students, EVT-related gender similarities are currently more significant than the differences.

When constructing EVT, Eccles and colleagues (1983) recognised parental support as essential in developing primary pupils' achievement and motivation towards mathematics. Studies show that perceived social support affects mathematics study engagement, achievement, motivation, and academic outcomes (Rueger et al., 2010; Rice et al., 2013; Rautanen et al., 2021). Younger students are especially affected by their parents' mathematics-related beliefs and attitudes (Simpkins et al., 2015; Levine & Pantoja, 2021). According to Eccles and colleagues (1983) hypothesis, there are two types of parents' mathematics-related attitudes—general and child-specific. Some studies have reported findings that connect parents' child-specific mathematics attitudes to students' mathematics attitudes, achievement, and self-perspective (Fan & Chen, 2001; Aunola et al., 2003). Parents' general attitudes' have been found to affect students' attitudes towards mathematics (Usher, 2009; Mohr-Schroeder et al., 2017), although comprehensive research on parents' general mathematics relation to student motivation is lacking. At the same time, it has been suggested that the child-specific mathematics attitudes and beliefs parents reflect on their children have a more significant effect on students' self-perspective as learners than their actual experiences in learning math (Eccles [Parsons], et al., 1982; Aunola, 2001). In this study, we focus on parents' general mathematics-related attitudes, aiming to extend the current knowledge.

Research on mathematics motivation or mathematics education has been largely concentrated on variable-centred approaches that investigate relations between variables in a particular sample. While this approach gains information on the constructs between variables, it is beneficial to explore other possible approaches, especially regarding certain research areas – such as motivation – given the nature of the construct and its wider variance between individuals. With that in mind, a person-centred approach has gained popularity recently because it enables us to assume differences and identify sub-groups that exhibit similar domain-specific behaviour and thinking. The person-centred approach, among which latent profile analysis (LPA) is one of its techniques, allows further characterisation of the profiles by introducing covariates and significance tests, enabling the additional relevant profile differences exploration (Geiser, 2013). The approach has been successfully used in the studies grounded in EVT, describing primary (Radisic & Jensen et al., 2021; Beswick et al., 2023; Lazarides et al., 2018), middle school (Raufelder et al., 2022; Xu, 2022) and high school students (Rogelberg et al., 2021), providing complimentary perspective and broadening previous variable-centred studies results. It has also been found to be a useful method to investigate motivation towards multiple school subjects simultaneously (Opperman et al., 2020; Viljaranta et al., 2016).

Current study

We aim to broaden the scope of previous person-centred studies that have investigated motivation profiles in the EVT context (Dietrich & Lazarides, 2019; Dietrich et al., 2019; Perez et al., 2019; Watt et al., 2019; Opperman et al., 2021) and focus on primary students, for we have not found studies that combine younger students' motivation profile research that includes cost dimension with all the other task values and perceived competence. Earlier research on students' motivation has focused mainly on specific areas of subjective task values (see Hattie, 2009; Lee & Stankov, 2018).

The Finnish basic education system is structured so that when the child turns seven years old, they are all assigned a local public school, near home residence. Primary education has grades 1-6, and single-structure comprehensive school also includes lower secondary grades 7-9. Commonly, in most subjects, the instruction in primary grades is given by the same class teacher, and in grades 7-9, the instruction is given by subject specialists. All the instruction is based upon the contents of the national curriculum that states the contents to be studied and other core objectives for each subject (Opetushallitus [Finnish National Agency for Education], 2014). It emphasises that the nature of mathematics learning is cumulative, and for this reason, a systematic teaching approach is advised. The Finnish system provides an opportunity to investigate student motivation from a perspective of relative consistency and overall quality.

This study aims to investigate students' motivation profiles employing a person-centred approach to understand better how third-, fourth-, and fifth-grade students' mathematics motivation is constructed and how it relates to their performance in mathematics and perceived mathematics identity. In addition, we investigate the link between parents' attitudes towards mathematics and students' motivation profiles to understand better differences in attitude environments and how these promote an environment conducive to learning motivation. We are also interested in finding out if there are age and boy/girl differences when it comes to all the aspects of motivation, for those have been recognised, especially concerning perceived competence that students experience in their early school years (Eccles et al., 1993; Mejía-Rodríguez et al., 2020; Keller et al., 2022).

Research questions

This study addresses the following questions:

1. Which motivation-related profiles can be found among third-, fourth- and fifth-grade students?
   We expect to see diverse and mixed groups and recognise at least one group that consists of highly motivated students (e.g., high on intrinsic value and perceived competence) and another that is not motivated (e.g., low on intrinsic and utility values, high on the cost dimension) similar to the previous studies (Meece & Holt, 1993; Csizer & Dörnyei, 2005; Ratelle et al., 2007).
2. How are students distributed across the profiles regarding different grade levels and between boys and girls within these profiles?
   Previous studies show that younger students have a more positive perceived competence in mathematics that starts to decline when they reach middle school (Eccles et al., 1993; Raufelder et al., 2022). Niemi & Metsämuuronen (2010) found that Finnish students' mathematics-related self-competence beliefs decreased from third to fifth grade, and gender disparity towards boys showed higher competence beliefs but no disparity towards their views of the usefulness of mathematics. Guo and colleagues (2015) suggest that when it comes to mathematics motivation, boy/girl similarities among eighth graders are currently greater than differences among students. Current inconsistency in this field of study underlines the need to examine the relationships during the preadolescence period further.
3. Are there differences between students' profiles concerning performance in mathematics?
   Previous studies have concluded that highly motivated students are more likely to perform well on math problems (Hooper et al., 2017; Petersen & Hyde, 2017).
4. Are there differences between students' profiles concerning mathematics identity?
   Heller (2015) proposed mathematics identity is critical in students' math-related decision-making processes. Task values, intrinsic and attainment values in particular, and success expectancy (via perceived competence) have been connected to a stronger mathematics identity in Finnish students (Radisic et al., 2024). Therefore, we expect to find that the students with strong mathematics identity are

among the highest motivated students and that students with weaker mathematics identity do not display strong motivation in relation to mathematics.

5. How are parents' mathematics-related attitudes distributed between the profiles? Parents have been shown to influence student motivation as socialisers, and therefore, we expect that parental attitudes reflect on the students' motivational constructs to a degree (Rueger et al., 2010; Rice et al., 2013; Rautanen et al., 2021).

Method

Sample

This study draws on the data collected in Finland in the pilot stage of an international research project focusing on students' mathematical motivation (MATHMot). Data were collected during the spring of 2021 on 304 Southern Finnish third-, fourth-, and fifth-grade students from five schools (48.5% girls) and their parents/guardians (N=241). The participating schools are from districts with a diverse socioeconomic population base.

Measures

A trained research assistant collected all the survey data during regular school hours. The scales were carefully introduced, and all scales included a non-coded section for practice use only. The use of Likert scales was demonstrated via examples, and understanding across the classroom was checked before the instrument would be administered. In addition to using practice items, all scales had a graphical depiction of the Likert scales implemented in the design to facilitate comprehension. The students were also encouraged to ask for guidance from the research assistant if they experienced difficulties understanding the items at any time. In addition, each item was read aloud. For background information, the students were asked to choose from pictures which best represent their sex. Each student had the option not to answer the question if not being able to identify with one of the two images offered.

All the survey instruments have been developed by the research team and validated for quality. All survey items were translated to Finnish, following back-translation procedures common to all participating countries within the project. Original translations of all the math items provided by IEA were used in the study.

For the low number of items comprising some of the scales, some of the fit indices do not fall within commonly recommended range for good fit. The RMSEA value is particularly sensitive (Kenny et al., 2015) to the low levels of the degrees of freedom associated with small scale size, as is the χ^2 value (Bentler & Bonet, 1980). Therefore, given the smaller scales used in this study, the overall model fit has been considered good or adequate when taken all fit indices into account.

In the first part of the session, students were asked to complete the Expectancy-value scale (EVS – Peixoto et al., 2023) and Math identity scale. After recess, the students took a math test. Parents' questionnaires were distributed to the students and returned to the designated school contact.

The EVS instrument (Peixoto et al., 2023) comprises five dimensions - intrinsic value (e.g. "Math is one of my favourite subjects"), attainment value (e.g. I care a lot to understand things we learn in mathematics class"), utility value (e.g. "I can learn many useful things by doing math"), cost (e.g. "When I do math I would rather be doing other things") and perceived competence (e.g. "I can easily solve different math problems") – totalling 28 items distributed over 4 points Likert scale (1= never – 4= a lot of times). The model fit was confirmed for the sample used in this investigation, χ^2 (340) =499.822, p>0.001 = 1,47, CFI=0.976, TLI=0.973, RMSEA=0.039, SRMR=0.077, with satisfying composite reliability across the subscales (range 0.759-0.936). The invariance across grades was confirmed with the alignment method (Rudnev, 2019), showing equal loadings for all groups (see Table 3 note).

The mathematics identity scale is built on the previous work of Vincent-Ruz and Schunn (2018) and Miller and Wang (2019) with added items to support the initial subscale and thus comprises six items combining perceived personal mathematics identity ("I think I am a math person ") and perceived and recognised social mathematics identity items ("My teacher sees me as a math person"). The scale is anchored on a 4-point Likert scale (1= never – 4= a lot of times). The model fit was proven adequate for the Finnish data χ^2 (9) =48,524, p>0.001= 5,39, CFI=0.979, TLI=0.966, RMSEA=0.120, SRMR=0.032, with satisfying reliability (0.878).

Math test comprises 12 math problems in grade 3 and 14 problems in grades 4 and 5, covering topics such as numeracy, geometry and data display, aligned with the curricular topics within the Finnish curricula in each grade. All the math items were assessed as suitable by educational experts and practitioners familiar with the contents of the national curriculum. Math problems were derived from the list of released items of TIMSS 2011 (approval IEA-21-061). Each correctly scored item was scored with a one, and the incorrect one with a zero. The total math score was calculated as a ratio between students' correct scores and the total number of math problems comprising the test.

Parents' mathematics-related beliefs and attitudes were assessed using a 9-item attitude scale that consisted of three dimensions – intrinsic motivation (e.g., "I like math"), utility value (e.g., "Math helps me in solving everyday problems.") and perceived competence (e.g., "Math is easy for me"). The model fit was proven adequate for the Finnish data χ^2 (24) =102.539, p>0.001=4,27, CFI=0.984, TLI=,0.976, RMSEA=0.116, SRMR= 0.046, with satisfying composite reliability across the subscales (range 0.785-0.916).

Analysis

Before the main analyses were conducted with *Mplus* (Muthén & Muthén, 2017), descriptive analyses were run with SPSS to find possible outlier cases and missing values and confirm the normal distribution. One case was ruled out due to distinct outlier values. Missing values were less than 5% for the student measure, as for the parents.

Latent profile analysis (LPA) followed. LPA is a latent variable mixture technique used to identify different numbers of profiles or latent subpopulations emerging from a data set and recognise certain specific patterns (latent profiles) amongst the distribution (Ferguson, 2020; Spurk et al., 2020). Five dimensions, intrinsic value, attainment value, utility value, cost and perceived competence, all continuous variables, were used in the LPA to comprise distinct motivation profiles. We assessed two- to seven-profile solutions (k = 2-7). The criteria and cut-off values recommended by Geiser (2013) and Muthén et al. (2012) were used in deciding the number of profiles. These included log-likelihood, degree of freedom, the Akaike information criterion (AIC), Bayesian information criterion (BIC), the sample-size adjusted Bayesian information criterion (SABIC) values, the Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR) and Lo-Mendell-Rubin adjusted LRT test, entropy value, and comparison of the smallest group percentage.

The BCH method can be utilised in dealing with distal outcomes as recommended by Asparouhov et al. (2021), but in this study it rather reflects more immediate variation of continuous structures between the profiles. This included examining links between students' profiles and their math identity, parents' math attitudes and students' math test. R3step method (Asparouhov et al., 2014) was used to explore the differences between boys and girls among the extracted profiles.

Results

Correlations

In the results section, we first show all the correlations between the subscales. Table 1 shows that parents' math-related attitudes (intrinsic motivation, utility value and perceived competence) are positively correlated ranging from .588 (perceived competence and utility value) to .946 (intrinsic motivation and perceived competence), as are the motivational dimensions (intrinsic value, attainment value, utility value and perceived competence) ranging from .711 (intrinsic value and perceived competence) to .854 (intrinsic value and attainment value) except for the cost value, that is negatively correlated with the other motivational dimensions ranging from -.597 (utility value) and -.914 (cost value). Student math identity correlates with all the motivational dimensions ranging from -525 (cost value) to .654 (attainment value). In addition, parents' utility value and students perceived competence are negatively correlated in a level of -.130. The correlation aligns with prior evidence on the association between different task values (e.g., intrinsic value and attainment value, Eccles & Wigfield, 2020), as well as prior validation of the EVS scale (Peixoto et al., 2023). Despite the high correlation between intrinsic motivation and perceived competence within parents' math-related attitudes scale, both were kept due to the different meanings of the underlying items in each subscale and the fact that the subscales could help better understand the variation of the examined student profiles.

Table 1. Correlations between the subscales

	1	2	3	4	5	6	7	8
1. Parents intrinsic motivation								
2. Parents utility value	.665**							
3. Parents perceived competence	.946**	.588**						
4. Student math identity	-.114	-.085	-.111					
5. Student intrinsic value	-.077	-.066	-.083	.613**				
6. Student cost value	.072	.075	0.86	-.525*	-.914**			
7. Student attainment value	-.065	-.055	-.065	.654**	.854**	-.699*		
8. Student utility value	-.059	-.080	-.060	.616**	.747**	-.597*	.914**	
9. Student perceived competence	-.099	-.130*	-.113	.508**	.711**	-.788**	.534**	.478**

Note: *p<.05. **p<.01.

Profiles

For latent profile analysis, we tested two to seven group solutions (k= 2-7) (see Table 2 for fit indices). A three-group model solution was identified as optimal considering the data structure, model indices (see Table 1.), and the theoretical background provided by the EVT and previous person-centred studies on motivation (e.g., Radisic & Jensen, 2021; Rogelberg et al., 2021; Xu, 2022; Beswick et al., 2023).

Table 2. Overview of the evaluated models

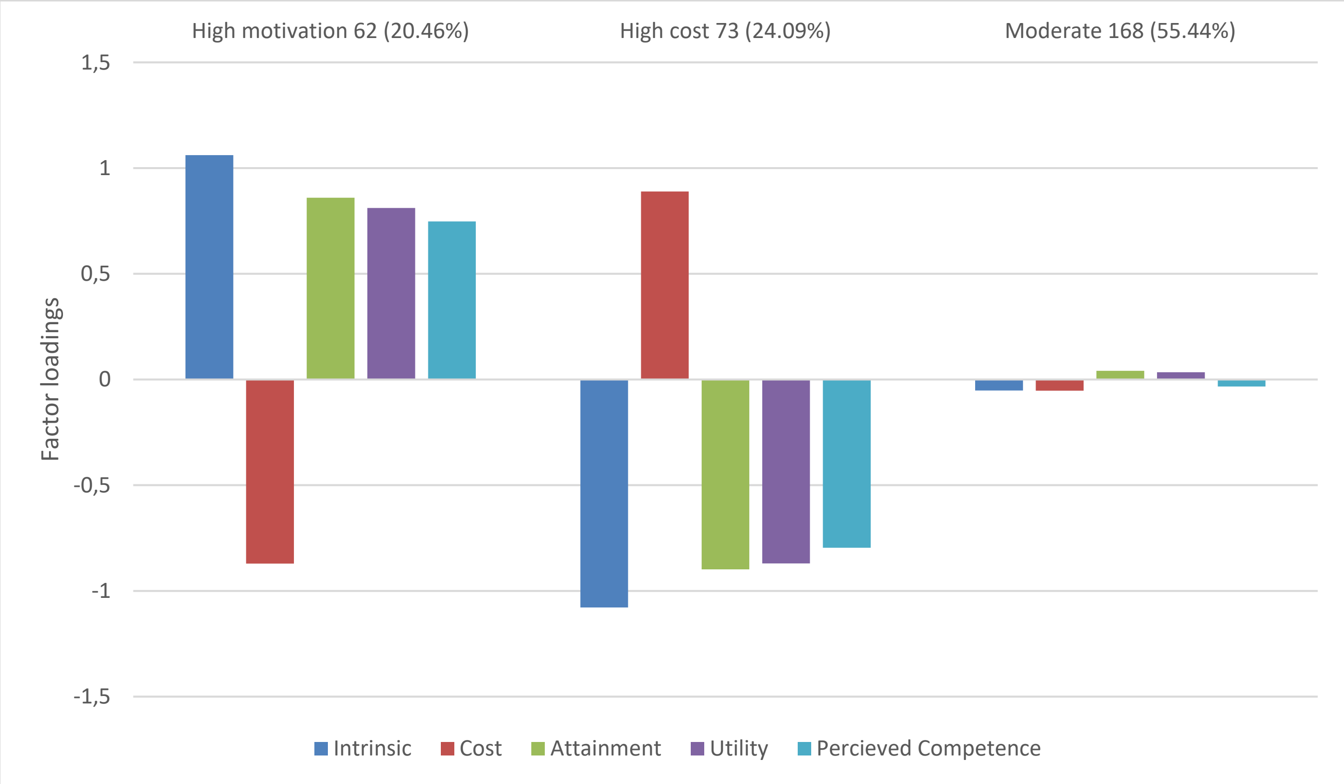
#No.	Log likeli-hood	#fp	AIC	BIC	SABIC	VLMR	BLRT	LMR	Entropy	Smallest group fre-quency
2	-1387.587	16	2807.174	2866.594	2815.85	.001	0	.0012	.870	35.50
3	-1196.837	22	2437.673	2519.375	2449.603	.000	0	.0000	.916	20.80%
4	-1127.773	28	2311.546	2415.53	2326.729	.105	0	.1109	.900	9.50%
5	-1075.887	34	2219.774	2346.04	2238.21	.144	0	.1496	.989	6.90%
6	-1037.41	40	2254.819	2303.369	2176.51	.168	0	.1739	.890	6.50%
7	-996.011	46	2084.022	2254.854	2108.966	.208	0	.2161	.881	6.60%

Note: #No.=number of profiles; #fp =degrees of freedom; BIC=Bayesian Information criterion; AIC=Akaike's Information criterion; SABIC=Sample-size adjusted BIC; LMR=Lo-Mendell-Rubin likelihood ratio test

As Figure 1 shows, the largest student group (55.44%) is comprised of students who showed moderate interest and perceived competence towards mathematics. We labelled this group as the '*Moderate profile'*. These students report experiencing as if they are giving up on something because of mathematics only at times, and their values related to the cost dimension are not highlighted as much as those of other groups. At the same time, moderate levels are also reported for attainment and utility value in connection to mathematics. The defining feature of the moderate profile is that the students in this group do not report strong positive or negative responses towards mathematics as a domain.

Based on their reported perceptions, the two other student groups can be described as opposites (see Figure 1). The '*High Cost'* student group (24.09%) reported apparent disinterest towards mathematics and found mathematics unimportant and useless. Students in this group had somewhat negative perceptions of their own competence in mathematics and reported experiencing elevated costs towards math activities and learning math. The '*High motivation*' student group (20.46%) reported interest towards mathematics and found doing math vital and valuable. Students in this group also reported experiencing elevated levels of perceived competence and engaging in math activities or math learning, which did not induce experiences of cost or expense. See appendix A for raw mean scores of the motivation dimensions across profiles.

Figure 1. Motivation profiles



Note: The figure represents the standardised model results; the y-axis depicts mean factor scores for each dimension involved in the LPA.

Differences between boys and girls and grade distribution

Examination of the boy/girl distribution across motivation profiles revealed no significant differences. See Table 2 for odds-ratio values. Comparing the grades across motivational profiles revealed no significant differences (see Table 3 for details).

Table 3. Odds-ratio being in a profile as a function of student sex

Student profiles	Sex (Boys) Estimate (S.E.)
High cost (HC)	1.942 (.710)
Moderate (MOD)	1.842 (.601)

Note: The reference profile is the High motivation (HM) profile. Significance tests across profile comparisons: HM vs. HC (p =0.070), HM vs. MOD (p=0.061), HC vs. MOD (p=0.858).

Table 4. Crosstabulation comparing grade distribution across motivation profiles

	Highly motivated	High Cost	Moderate
Third graders			
Percent	25.3%	16.8%	57,9%
Frequency	24	16	55
Standardised residual	1.0	-1.4	0.3
Fourth graders			
Percent	21.3%	24.1%	54.6%
Frequency	23	26	59
Standardised residual	0.2	.0	-0.1
Fifth graders			
Percent	15.0%	31.0%	54.0%
Frequency	15	31	54
Standardised residual	-1.2	1.4	-0.2

Note: X^2 (df 4, N = 303) =6.7 p= .148.

Student profiles, math identity and performance

Examining differences across the motivation profiles regarding how students report on their mathematics identity revealed significant differences. Students in the '*High motivation*' group scored highest on the identity scale. The opposite was perceived for the '*High cost*' group. The '*Moderate*' group reported neither high nor low mathematics identity but remained somewhat in the middle (see Table 4 for details).

Differences were also found between students' performance across the profiles. Students in the '*High motivation*' group scored highest on the mathematics test, and the opposite was perceived for the '*High cost*' group (see Table 4 for details).

Examination of differences across the groups shows that even with the math test scores having relatively minor differences, the differences between the '*High motivation*' and the '*High cost*' group were significant, as well as the differences between the '*Moderate*' group and the '*High cost*' group.

Table 5. Math identity and performance in math tests across motivation profiles

Student profiles	Math identity (S.E.)	Math test ratio (S.E.)
High motivation (HM)	.733 (.086)	.638 (.030)
High cost (HC)	-.715 (.072)	.511 (.029)
Moderate (MOD)	.035 (.050)	.603 (.019)

Note: Math test score is a calculated ratio between students' correct scores and the total number of math problems comprising the test. Significance tests across profile comparisons: HM vs. HC (t=166.65, p<.001), HM vs. MOD (t=47.03, p<.001), MOD vs. HC (t=69.8, p<.001); Math test: HM vs. HC (t=9.35, p=.002), HM vs. MOD (t=0.9, p=0.327), MOD vs. HC (t=6.8, p=.009).

Motivation groups and parental math attitudes

There were no significant differences when examining the parents' intrinsic motivation and utility value across the students' motivation profiles. However, parents' self-reported perceived competence in mathematics did show a significant difference between the '*High cost*' and '*Moderate*' groups. Lower perceived competence was reported among the parents of the students belonging to the former (t=4.547, df=2, p=0.033).

Table 6. Parents' math-related attitudes across student profiles

Student profiles	Intrinsic motivation (S.E.)	Utility value (S.E.)	Perceived competence (S.E.)
High motivation	-.069 (.121)	.079 (.097)	-.057 (.131)
High cost	-.208 (.112)	-.066 (.102)	-.234 (.114)
Moderate	.039 (.069)	-.108 (.069)	.060 (.073)

Note: Intrinsic motivation: HM vs. HC (t=.713, p=.398), HM vs. MOD (t=.571, p=.450), MOD vs. HC (t=3.407, p=.065). Utility value: HM vs. HC (t=1.057, p=.304), HM vs. MOD (t=2.359, p=.125), MOD vs. HC (t=.116, p=.734). Perceived competence: HM vs. HC (t=1.039, p=.308), HM vs. MOD (t=.579, p=.447), MOD vs. HC (t=4.547, p=.033).

Discussion and conclusions

The primary aim of this study was to examine the motivation profiles of Finnish third-, fourth-, and fifth-grade students and investigate what kind of differences can be found across the groups regarding other related factors, such as students' mathematics performance, mathematics identity and their parents' attitudes toward math. Three distinctive profiles were identified, among which the moderate profile took the largest share. Coupled with the high cost group, these two profiles account for two-thirds of the sample. Specific features of these profiles include either neutral levels across all motivational dimensions, cost included, or a distinct disinterest, elevated cost, and not valuing mathematics. This result supports earlier findings on Finnish students representing overall lower levels of motivation (Vettenranta et al., 2020). A high motivation profile was also captured (Meece & Holt, 1993; Csizer & Dörnyei, 2005; Ratelle et al., 2007); however, it amounts to one-fifth of the students in our sample. Previous studies that have investigated motivation towards more than one school subject have found that some students are motivated in more than one subject area and express consistent higher motivation throughout, and others tend to be more motivated in subject specific manner (Viljaranta et al., 2016). The large number of students belonging to the moderate profile could imply that they may have stronger motivation in other, more personally meaningful domains. In contrast, their mathematics relationship and domain-related motivation are less meaningful or still underdeveloped.

Our study did not identify a high-interest/high-cost group like some previous studies (Watt et al., 2019). However, the results show that intrinsic value and cost are the most distinctive dimensions that emerge across different motivation profiles. This could suggest that the emerging pressure of the education system is not yet strongly affecting this sample's third-, fourth-, and fifth-grade students.

In all groups, intrinsic value can be recognised as the strongest indicator for motivation, positively and negatively, closely followed by cost dimension that almost mirrors the intrinsic value, followed by attainment, utility value and finally, perceived competence. To enhance Finnish primary students' mathematics motivation, we need to find ways to identify, especially the moderate students, for their motivational traits can be interpreted as somewhat undeveloped and regarding their mathematics performance, they hold plenty of potential to develop motivationally in a more positive direction. We also need to target direct support to high cost students and find ways to increase their positive task values, such as intrinsic value, attainment value, utility value, and perceived competence, as well as lower the experienced cost. Supporting students' mathematics learning is one of the essential practical implementations as the primary stage is a crucial time for constructing personal perceptions of a learner concerning the mathematics domain since the beliefs embedded early on will affect future decisions (Salonen & Hannula, 2022). As the Finnish curriculum states, mathematics as a school subject has highly cumulative nature for the contents to be studied on each grade build on to the contents learned earlier. Therefore, it is crucial to offer a sufficient amount of support from early on to those students who are experiencing elevated costs and expenses and low levels of perceived competence and other personal task values in relation to mathematics as a subject. Finding ways to support the positive development of motivation could be achieved by focusing on making math more relevant to students, pointing out the variety of what math is and preparing more exciting and enjoyable math content that could be further utilised and explored (see also Rosenzweig, 2022; Schukajlow et al., 2023).

Our analysis did not find any substantial differences between the profiles' when observing boy-girl distribution, supporting Guo and colleagues' (2015) previous study stating that concerning motivation, gender similarities are greater than differences. Our findings underline the need for further research concerning the time in preadolescence, where the disparity in this field exists.

Eccles and colleagues (1993), Wigfield and Eccles (2020), and in the Finnish context Niemi and Metsämuuronen (2010) state that students perceived competence in mathematics declines during years leading to middle school. Our study did not find sufficient evidence to support the argument of differences in third-, fourth-, and fifth-grade students' motivational traits. However, it is important to note that this study did not use a longitudinal but a cross-sectional design and person-centred approach.

Students in the *high motivation* group outperformed the *moderate profile*, and these two both outperformed the *high-cost* profile as expected, supporting both previous studies and the EVT framework that states higher motivation in mathematics relates to students' mathematics achievement (Hooper et al., 2017; Petersen & Hyde, 2017). The students in the *moderate* group perform relatively well on average compared to the *high motivation* group students' mathematics performance. This finding is in line with Vettenranta et al.

(2020), who present that Finnish students' mathematics performance is generally at a good level despite their lower level of motivation.

When examining the distribution of mathematics identity across the profiles, we found that the moderate profile students do not seem to have a strong mathematics identity on a positive or a negative note, as a continuum for the profiles' students' other main characteristics. The *high motivation* profile students scored highest on the mathematics identity scale in contrast to *high cost* profile students, who reported very low scores on mathematics identity. Miller and Wang (2019) state that students' mathematics identity could be positively supported with sensitivity to students' psychological needs and paying attention to the quality of feedback given to the students.

Parental influence investigation revealed that the parents of students in the high cost group reported significantly lower perceived competence in mathematics compared to the moderate group. This finding suggests that even non-child-specific general mathematics-related attitudes in parents reflect students' motivation. This finding raises the concern that perceived competence may be a construct that is passed on as a somewhat transferrable trait if not targeted and addressed. Possible interventions should consider including the parents as their weak perceived competencies connected to the least motivated students' motivation constructs. Teachers and other educational professionals should also find ways to address this by sharing information directly with the parents on how to nurture mathematics motivation development and how to avoid harmful practices at home.

It is necessary to recognise that all studies are prone to certain limitations, and this one is no exception. While the sample size of this study is sufficient for methodological purposes, a larger sample could provide us with a more nuanced solution on the profiles and their characteristics.

Another limitation concerns the sample of parents, as not all parents participated in this study, that is, provided answers to the survey. It is possible that, as a result, the sample might present bias. To gain more precise information on these matters, a further study with a larger sample can provide more detailed results.

The formation of motivation is a complex entity, and its building blocks consist of social, cultural and internal factors. To enhance the beneficial environment in nurturing motivation, we need to find ways for students to connect to mathematics meaningfully and help them understand how mathematics is essential in various aspects of life. Additionally, we should support math identity development in schools, assuring students that math is for everyone, while also considering the role that the parents personal relationship plays on this process and its possible transgenerational influence.

Author contributions

P.I.: conceptualisation, data curation, investigation, methodology, formal analysis, visualisation, writing—original draft preparation, writing—review and editing.
J.R.: conceptualisation, methodology, validation, supervision, writing —review and editing, funding acquisition, project administration.
A.L.: conceptualisation, methodology, validation, supervision, writing —review and editing, project administration.

All authors have read and agreed to the published version of the manuscript.

Funding

The research project Co-constructing Mathematics Motivation in Primary Education — A Longitudinal Study in Six European Countries (MATHMot) has received funding from the Research Council of Norway within the FINNUT Programme for Research and Innovation in the Educational Sector (grant number 301033). To finish the research article, Pia Ilomanni received funding through the doctoral research position in the Doctoral Programme in Cognition, Learning, Instruction and Communication (CLIC), University of Helsinki.

Institutional review board statement

The ethical principles of research provided by the Finnish National Board on Research Integrity (TENK) have been followed throughout the study. Regarding the ethics committee, it has been determined that the research adheres to good practices, and a separate statement is not required.

Informed consent statement

Informed consent was obtained from all research participants, also written consent were collected from all underage participants guardians.

Data availability statement

The dataset is currently confidential because it is a part of an ongoing international research project. The dataset used in this study has been anonymised. The complete dataset will be later made available for research purposes through the Finnish Data Archive. Those interested in the data can contact the authors for further information.

Acknowledgements

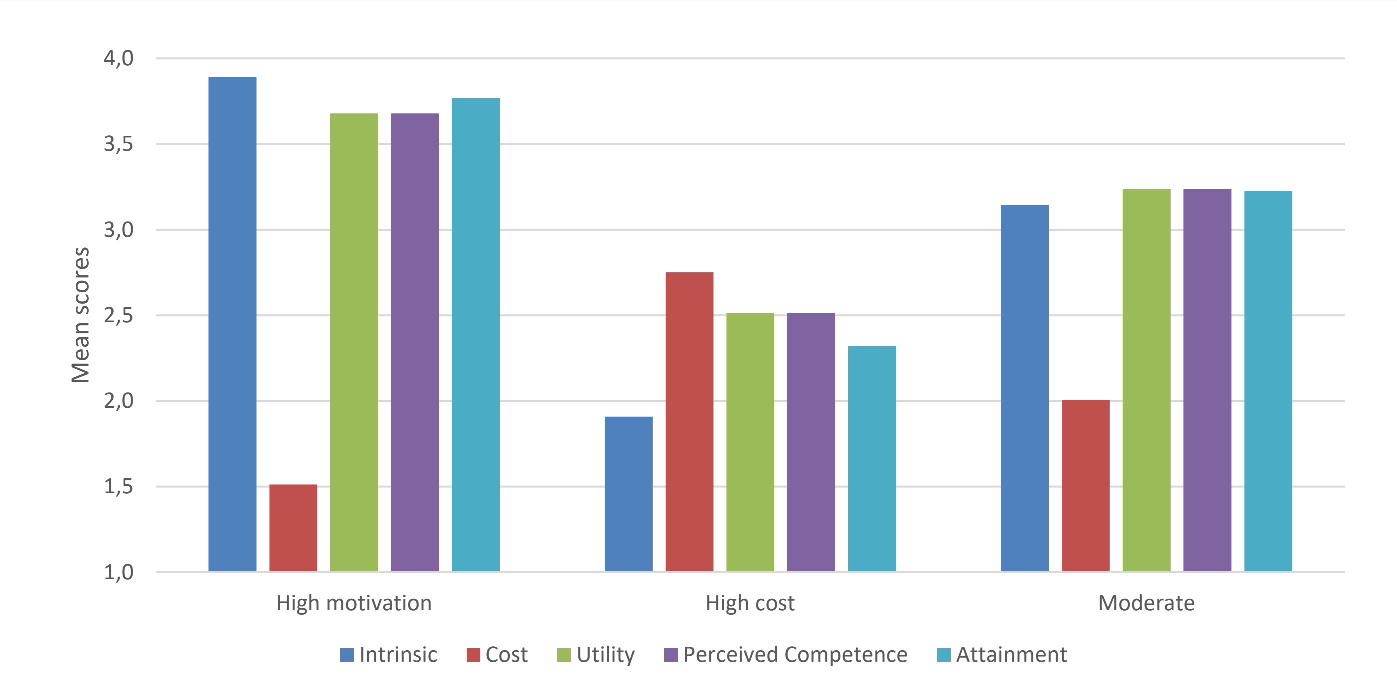
We would like to thank all individuals who contributed to this research project. Our sincere appreciation goes to all the participants for their cooperation and involvement. We would also like to thank all the research assistants, who contributed to this research project. Finally, thanks go to the international research community for support and co-operation during this project.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix A

Figure 2. Mean scores by dimensions



Note: The figure represents the raw mean scores for each dimension involved in the LPA.

References

Anderson, R. (n.d.). Being a Mathematics Learner: Four Faces of Identity.

ASERT, Rice, L., Barth, J. M., Guadagno, R. E., Smith, G. P. A., & McCallum, D. M. (2013). The Role of Social Support in Students' Perceived Abilities and Attitudes Toward Math and Science. *Journal of Youth and Adolescence,* 42(7), 1028–1040. https://doi.org/10.1007/s10964-012-9801-8

Asparouhov, T., & Muthén, B. (n.d.). *Auxiliary variables in mixture modelling: Using the BCH method in Mplus to estimate a distal outcome model and an arbitrary secondary model.* Mplus Web Notes. Retrieved September 16, 2024, from https://www.statmodel.com/examples/webnotes/webnote21.pdf

Asparouhov, T., & Muthén, B. (2014). Auxiliary Variables in Mixture Modeling: Three-Step Approaches Using M plus. *Structural Equation Modeling: A Multidisciplinary Journal*, 21(3), 329–341. https://doi.org/10.1080/10705511.2014.915181

Aunola, K. (n.d.). *Children's and adolescents' achievement strategies, school adjustment and family environment* [University of Jyväskylä]. Retrieved September 16, 2024, from https://jyx.jyu.fi/handle/123456789/41823

Aunola, K., Nurmi, J.-E., Lerkkanen, M.-K., & Rasku-Puttonen, H. (2003). The Roles of Achievement-Related Behaviours and Parental Beliefs in Children's Mathematical Performance. *Educational Psychology*, 23(4), 403–421. https://doi.org/10.1080/01443410303212

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88(3), 588–606. https://doi.org/10.1037/0033-2909.88.3.588

Beswick, K., Watt, H. M. G., Granziera, H., Geiger, V., & Fraser, S. (2023). Boys' motivation profiles in mathematics: Relations with contextual factors, wellbeing and engagement in a boys-only school. ZDM – *Mathematics Education*, 55(2), 315–329. https://doi.org/10.1007/s11858-022-01464-1

Burke, P. J., & Stets, J. E. (2009). Bases of Identities: Role, Group, and Person. In P. J. Burke & J. E. Stets (Eds.), *Identity Theory* (p. 0). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195388275.003.0024

Cleary, T. J., & Chen, P. P. (2009). Self-regulation, motivation, and math achievement in middle school: Variations across grade level and math context. *Journal of School Psychology*, 47(5), 291–314. https://doi.org/10.1016/j.jsp.2009.04.002

Cribbs, J. D., Hazari, Z., Sonnert, G., & Sadler, P. M. (2015). Establishing an Explanatory Model for Mathematics Identity. *Child Development*, 86(4), 1048–1062. https://doi.org/10.1111/cdev.12363

Csizér, K., & Dörnyei, Z. (2005). Language Learners' Motivational Profiles and Their Motivated Learning Behavior: Language Learning Vol. 55, No. 4. *Language Learning*, 55(4), 613–659. https://doi.org/10.1111/j.0023-8333.2005.00319.x

Davis-Kean, P. E., Huesmann, L. R., Jager, J., Collins, W. A., Bates, J. E., & Lansford, J. E. (2008). Changes in the Relation of Self-Efficacy Beliefs and Behaviors Across Development. *Child Development*, 79(5), 1257–1269. https://doi.org/10.1111/j.1467-8624.2008.01187.x

Dietrich, J., & Lazarides, R. (2019). Gendered Development of Motivational Belief Patterns in Mathematics Across a School Year and Career Plans in Math-Related Fields. *Frontiers in Psychology*, 10, 1472. https://doi.org/10.3389/fpsyg.2019.01472

Dietrich, J., Moeller, J., Guo, J., Viljaranta, J., & Kracke, B. (2019). In-the-Moment Profiles of Expectancies, Task Values, and Costs. *Frontiers in Psychology*, 10, 1662. https://doi.org/10.3389/fpsyg.2019.01662

Eccles, J. (2009). Who Am I and What Am I Going to Do With My Life? Personal and Collective Identities as Motivators of Action. *Educational Psychologist*, 44(2), 78–89. https://doi.org/10.1080/00461520902832368

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology,* 61, 101859. https://doi.org/10.1016/j.cedpsych.2020.101859

Eccles [Parsons], J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectations, values, and academic behaviours. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches*. Freeman.

Fan, X., & Chen, M. (2001). [No title found]. Educational Psychology Review, 13(1), 1–22. https://doi.org/10.1023/A:1009048817385

Ferguson, S. L., G. Moore, E. W., & Hull, D. M. (2020). Finding latent groups in observed data: A primer on latent profile analysis in Mplus for applied researchers. *International Journal of Behavioral Development, 44(5)*, 458–468. https://doi.org/10.1177/0165025419881721

Finnish education in a nutshell. (n.d.).

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., Oliver, P. H., & Guerin, D. W. (2007). Multivariate latent change modeling of developmental decline in academic intrinsic math motivation and achievement: Childhood through adolescence. *International Journal of Behavioral Development, 31(4)*, 317–327. https://doi.org/10.1177/0165025407077752

Guo, J., Marsh, H. W., Parker, P. D., Morin, A. J. S., & Yeung, A. S. (2015). Expectancy-value in mathematics, gender and socioeconomic background as predictors of achievement and aspirations: A multi-cohort study. *Learning and Individual Differences, 37*, 161–168. https://doi.org/10.1016/j.lindif.2015.01.008

Hannula, M., & Laakso, J. (2011). *The Structure of Mathematics Related Beliefs, Attitudes and Motivation among Finnish Grade 4 and Grade 8 Students*.

Hannula, M. S., Bofah, E., Tuohilampi, L., & Metsämuuronen, J. (2014). A Longitudinal Analysis of the Relationship between Mathematics-Related Affect and Achievement in Finland. In S. Oesterle, International Group for the Psychology of Mathematics Education, & International Group for the Psychology of Mathematics Education (Eds.), *Proceedings of the 38th conference of the International Group for the Psychology of Mathematics Education and the 36th Conference of the North American Chapter of the Psychology of Mathematics Education: Vancouver, Canada, July 15-20,2014. 3: Susan Oesterle*. International Group for the Psychology of Mathematics Education.

Hannula, M. S., Di Martino, P., Pantziara, M., Zhang, Q., Morselli, F., Heyd-Metzuyanim, E., Lutovac, S., Kaasila, R., Middleton, J. A., Jansen, A., & Goldin, G. A. (2016). Attitudes, Beliefs, Motivation, and Identity in Mathematics Education: An Overview of the Field and Future Directions. In M. S. Hannula, P. Di Martino, M. Pantziara, Q. Zhang, F. Morselli, E. Heyd-Metzuyanim, S. Lutovac, R. Kaasila, J. A. Middleton, A. Jansen, & G. A. Goldin*, Attitudes, Beliefs, Motivation and Identity in Mathematics Education* (pp. 1–35). Springer International Publishing. https://doi.org/10.1007/978-3-319-32811-9_1

Hattie, J. (2008). *Visible Learning* (0 ed.). Routledge. https://doi.org/10.4324/9780203887332

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching, 47(8),* 978–1003. https://doi.org/10.1002/tea.20363

Heller, N. S. (n.d.). *To be or not to be a Math Person: Math Identity Dissonance in Ninth Grade Students*.

Jacobs, J. E., & Eccles, J. S. (2000). Parents, task values, and Real-Life achievement-related choices. *In Intrinsic and Extrinsic Motivation* (pp. 405–439). Elsevier. https://doi.org/10.1016/B978-012619070-0/50036-2

Keller, L., Preckel, F., Eccles, J. S., & Brunner, M. (2022). Top-performing math students in 82 countries: An integrative data analysis of gender differences in achievement, achievement profiles, and achievement motivation. *Journal of Educational Psychology, 114(5),* 966–991. https://doi.org/10.1037/edu0000685

Lazarides, R., Viljaranta, J., Aunola, K., & Nurmi, J.-E. (2018). Teacher ability evaluation and changes in elementary student profiles of motivation and performance in mathematics. *Learning and Individual Differences, 67*, 245–258. https://doi.org/10.1016/j.lindif.2018.08.010

Lee, J., & Stankov, L. (2018). Non-cognitive predictors of academic achievement: Evidence from TIMSS and PISA. *Learning and Individual Differences, 65*, 50–64. https://doi.org/10.1016/j.lindif.2018.05.009

Levine, S. C., & Pantoja, N. (2021). Development of children's math attitudes: Gender differences, key socializers, and intervention approaches. *Developmental Review, 62,* 100997. https://doi.org/10.1016/j.dr.2021.100997

Martin, A. J. (2009). Motivation and Engagement Across the Academic Life Span: A Developmental Construct Validity Study of Elementary School, High School, and University/College Students. *Educational and Psychological Measurement, 69(5),* 794–824. https://doi.org/10.1177/0013164409332214

Meece, J. L., & Holt, K. (1993). A pattern analysis of students' achievement goals. *Journal of Educational Psychology, 85(4)*, 582–590. https://doi.org/10.1037/0022-0663.85.4.582

Mejía-Rodríguez, A. M., Luyten, H., & Meelissen, M. R. M. (2021). Gender Differences in Mathematics Self-concept Across the World: An Exploration of Student and Parent Data of TIMSS 2015. *International Journal of Science and Mathematics Education, 19(6),* 1229–1250. https://doi.org/10.1007/s10763-020-10100-x

Metsämuuronen, J. (n.d.). *PERUSOPETUKSEN MATEMATIIKAN OPPIMISTULOSTEN PITKITTÄISARVIOINTI VUOSINA 2005–2012*.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for Achievement in Mathematics: Findings, Generalizations, and Criticisms of the Research. *Journal for Research in Mathematics Education, 30(1)*, 65. https://doi.org/10.2307/749630

Miller, R. S., & Wang, M.-T. (2019). Cultivating Adolescents' Academic Identity: Ascertaining the Mediating Effects of Motivational Beliefs Between Classroom Practices and Mathematics Identity. *Journal of Youth and Adolescence, 48(10),* 2038–2050. https://doi.org/10.1007/s10964-019-01115-x

Mohr-Schroeder, M. J., Jackson, C., Cavalcanti, M., Jong, C., Craig Schroeder, D., & Speler, L. G. (2017). Parents' Attitudes Toward Mathematics and the Influence on Their Students' Attitudes toward Mathematics: A Quantitative Study. *School Science and Mathematics, 117(5),* 214–222. https://doi.org/10.1111/ssm.12225

Muthén, B., & Asparouhov, T. (2012). Bayesian structural equation modeling: A more flexible representation of substantive theory. *Psychological Methods, 17(3),* 313–335. https://doi.org/10.1037/a0026802

Oppermann, E., Vinni-Laakso, J., Juuti, K., Loukomies, A., & Salmela-Aro, K. (2021a). Elementary school students' motivational profiles across Finnish language, mathematics and science: Longitudinal trajectories, gender differences and STEM aspirations. *Contemporary Educational Psychology*, 64, 101927. https://doi.org/10.1016/j.cedpsych.2020.101927

Parsons, J. E., Adler, T. F., & Kaczala, C. M. (1982). Socialization of Achievement Attitudes and Beliefs: Parental Influences. *Child Development, 53(2),* 310. https://doi.org/10.2307/1128973

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

Perez, T., Wormington, S. V., Barger, M. M., Schwartz-Bloom, R. D., Lee, Y., & Linnenbrink-Garcia, L. (2019). Science expectancy, value, and cost profiles and their proximal and distal relations to undergraduate science, technology, engineering, and math persistence. *Science Education, 103(2),* 264–286. https://doi.org/10.1002/sce.21490

Petersen, J. L., & Hyde, J. S. (2017). Trajectories of self-perceived math ability, utility value and interest across middle school as predictors of high school math performance. *Educational Psychology, 37(4),* 438–456. https://doi.org/10.1080/01443410.2015.1076765

PISA 12: Ensituloksia—Research portal—Converis—University of Jyväskylä. (n.d.). Retrieved September 21, 2024, from https://converis.jyu.fi/converis/portal/detail/Publication/23157615

PISA 2015 Results in Focus (PISA in Focus 67; PISA in Focus, Vol. 67). (2016). https://doi.org/10.1787/aa9237e6-en

Priess-Groben, H. A., & Hyde, J. S. (2017). Implicit Theories, Expectancies, and Values Predict Mathematics Motivation and Behavior across High School and College. *Journal of Youth and Adolescence, 46(6)*, 1318–1332. https://doi.org/10.1007/s10964-016-0579-y

R Anderson. (n.d.). Being a Mathematics Learner: Four Faces of Identity. *Mathematics Educator, 17(1),* 7–14.

Radišić, J., & Jensen, F. (2021). 5. Norske 9.-trinnselevers motivasjon for naturfag og matematikk – en latent profilanalyse av TIMSS 2019. In *Med blikket mot naturfag* (pp. 103–139). Universitetsforlaget. https://doi.org/10.18261/9788215045108-2021-05

Radišić, J., Krstić, K., Blažanin, B., Mićić, K., Baucal, A., Peixoto, F., & Schukajlow, S. (2024). Am I a math person? Linking math identity with students' motivation for mathematics and achievement. *European Journal of Psychology of Education*, *39*(2), 1513–1536. https://doi.org/10.1007/s10212-024-00811-y

Ratelle, C. F., Guay, F., Vallerand, R. J., Larose, S., & Senécal, C. (2007). Autonomous, controlled, and amotivated types of academic motivation: A person-oriented analysis. *Journal of Educational Psychology, 99(4),* 734–746. https://doi.org/10.1037/0022-0663.99.4.734

Raufelder, D., Hoferichter, F., Hirvonen, R., & Kiuru, N. (2022). How students' motivational profiles change during the transition from primary to lower secondary school. *Contemporary Educational Psychology, 71,* 102117. https://doi.org/10.1016/j.cedpsych.2022.102117

Rautanen, P., Soini, T., Pietarinen, J., & Pyhältö, K. (2021). Primary school students' perceived social support in relation to study engagement. *European Journal of Psychology of Education, 36(3),* 653–672. https://doi.org/10.1007/s10212-020-00492-3

Rogelberg, S. L., Starrett, A., Irvin, M. J., & DiStefano, C. (2021). Examining motivation profiles within and across socioeconomic levels on educational outcomes. *International Journal of Educational Research, 109,* 101846. https://doi.org/10.1016/j.ijer.2021.101846

Rosenzweig, E. Q., Wigfield, A., & Eccles, J. S. (2022). Beyond utility value interventions: The why, when, and how for next steps in expectancy-value intervention research. *Educational Psychologist, 57(1),* 11–30. https://doi.org/10.1080/00461520.2021.1984242

Rudnev. (2019, May 1). Alignment method for measurement invariance: Tutorial. *Elements of Cross-Cultural Research*. https://maksimrudnev.com/2019/05/01/alignment-tutorial/

Rueger, S. Y., Malecki, C. K., & Demaray, M. K. (2010). Relationship Between Multiple Sources of Perceived Social Support and Psychological and Academic Adjustment in Early Adolescence: Comparisons Across Gender. *Journal of Youth and Adolescence, 39(1),* 47–61. https://doi.org/10.1007/s10964-008-9368-6

Salonen, R. V., & Hannula, M. S. (2022). Matematiikan osaamistaso ja matemaattisen minäkäsityksen kehitys alakoulusta toiselle asteelle. *LUMAT: International Journal on Math, Science and Technology Education, 10*(1). https://doi.org/10.31129/LUMAT.10.1.1732

Schukajlow, S., Rakoczy, K., & Pekrun, R. (2017). Emotions and motivation in mathematics education: Theoretical considerations and empirical contributions. *ZDM, 49(3),* 307–322. https://doi.org/10.1007/s11858-017-0864-6

Schukajlow, S., Rakoczy, K., & Pekrun, R. (2023). Emotions and motivation in mathematics education: Where we are today and where we need to go. *ZDM – Mathematics Education, 55(2),* 249–267. https://doi.org/10.1007/s11858-022-01463-2

Shen, C. (2002). Revisiting the Relationship Between Students' Achievement and their Self-perceptions: A cross-national analysis based on TIMSS 1999 data. *Assessment in Education: Principles, Policy & Practice, 9(2)*, 161–184. https://doi.org/10.1080/0969594022000001913

Simpkins, S. D. (2015). ABSTRACT. *Monographs of the Society for Research in Child Development, 80*(2). https://doi.org/10.1111/mono.12156

Spurk, D., Hirschi, A., Wang, M., Valero, D., & Kauffeld, S. (2020). Latent profile analysis: A review and "how to" guide of its application within vocational behavior research. *Journal of Vocational Behavior, 120*, 103445. https://doi.org/10.1016/j.jvb.2020.103445

The Performance of RMSEA in Models With Small Degrees of Freedom—David A. Kenny, Burcu Kaniskan, D. Betsy McCoach, 2015. (n.d.). Retrieved September 23, 2024, from https://journals.sagepub.com/doi/10.1177/0049124114543236

Trujillo, G., & Tanner, K. D. (2014). Considering the Role of Affect in Learning: Monitoring Students' Self-Efficacy, Sense of Belonging, and Science Identity. *CBE—Life Sciences Education, 13*(1), 6–15. https://doi.org/10.1187/cbe.13-12-0241

Usher, E. L. (2009). Sources of Middle School Students' Self-Efficacy in Mathematics: A Qualitative Investigation. *American Educational Research Journal, 46*(1), 275–314. https://doi.org/10.3102/0002831208324517

Vettenranta, J., Hiltunen, J., Kotila, J., Lehtola, P., Nissinen, K., Puhakka, E., Pulkkinen, J., & Ström, A. (2020). *Tulevaisuuden avaintaidot puntarissa: Kahdeksannen luokan oppilaiden matematiikan ja luonnontieteiden osaaminen: kansainvälinen TIMSS 2019 -tutkimus Suomessa*. https://jyx.jyu.fi/handle/123456789/73019

Viljaranta, J., Aunola, K., & Hirvonen, R. (2016). Motivation and academic performance among first-graders: A person-oriented approach. *Learning and Individual Differences, 49*, 366–372. https://doi.org/10.1016/j.lindif.2016.06.002

Vincent-Ruz, P., & Schunn, C. D. (2018). The nature of science identity and its role as the driver of student choices. *International Journal of STEM Education, 5*(1), 48. https://doi.org/10.1186/s40594-018-0140-5

Watt, H. M. G., Bucich, M., & Dacosta, L. (2019). Adolescents' Motivational Profiles in Mathematics and Science: Associations With Achievement Striving, Career Aspirations and Psychological Wellbeing. *Frontiers in Psychology, 10*, 990. https://doi.org/10.3389/fpsyg.2019.00990

Weidinger, A. F., Steinmayr, R., & Spinath, B. (2018). Changes in the Relation Between Competence Beliefs and Achievement in Math Across Elementary School Years. *Child Development, 89*(2). https://doi.org/10.1111/cdev.12806

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review, 30*(1), 1–35. https://doi.org/10.1016/j.dr.2009.12.001

Wigfield, A., & Eccles, J. S. (1994). Children's Competence Beliefs, Achievement Values, and General Self-Esteem: Change Across Elementary and Middle School. *The Journal of Early Adolescence, 14*(2), 107–138. https://doi.org/10.1177/027243169401400203

Wigfield, A., & Eccles, J. S. (2002). Students' Motivation During the Middle School Years. In *Improving Academic Achievement* (pp. 159–184). Elsevier. https://doi.org/10.1016/B978-012064455-1/50011-7

Wigfield, A., Eccles, J. S., Fredricks, J. A., Simpkins, S., Roeser, R. W., & Schiefele, U. (2015). Development of Achievement Motivation and Engagement. In R. M. Lerner (Ed.), Handbook of Child Psychology and Developmental Science (1st ed., pp. 1–44). Wiley. https://doi.org/10.1002/9781118963418.childpsy316

Wigfield, A., Rosenzweig, E. Q., & Eccles, J. S. (2017). Achievement values: Interactions, interventions, and future directions. In *Handbook of competence and motivation: Theory and application, 2nd ed* (pp. 116–134). The Guilford Press.

Xu, J. (2023). Taking a person-centered approach to student homework motivation: Combining achievement goal and expectancy-value theories. *Current Psychology, 42*(34), 29893–29904. https://doi.org/10.1007/s12144-022-04044-4