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Motivational Profiles in Mathematics: What Roles Do Gender, Age, and Parents' Valuing of Mathematics Play?

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ABSTRACT
This study investigated students' motivational profiles in mathematics and the associations of these profiles with students' gender, age, and perceptions of their parents' valuing of mathematics. The study also examined whether students' motivational profile membership was associated with their achievement in mathematics. Survey data were collected from 849 seventh- to tenth-grade students (boys: 54.8%; average age: 14.19) in 108 classes. Data analysis revealed four motivational profiles: a low-motivation profile, a moderate profile, a utility profile, and a high-motivation profile. Girls were significantly more likely than boys to fall into the utility profile or low-motivation profile. Students with these two profiles reported lower achievement in mathematics than students with other profiles. Students' perceptions of their parents' valuing of mathematics were positively associated with the high-motivation profile and negatively associated with all other profiles. The results point to the usefulness of person-centered research approaches in motivational research, which, in this case, identified distinct motivational profiles and their associations with students' gender, mathematics achievement, and perceived parents' valuing of mathematics . This research suggests the need to conduct longitudinal person-centered research and to consider distinct sub-groups of students within mathematics classrooms in educational practice.

KEYWORDS
Mathematics motivation; self-concept of ability; parents' values; gender

Motivational Profiles in Mathematics: What Roles Do Gender, Age, and Parents' Valuing of Mathematics Play?

Research has consistently found stable gender differences in mathematics self-concepts (Marsh, 1989; Marsh & Yeung, 1998) and mathematics task values (e.g., Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002) which favor boys. Although recent research has shown that gender-related differences in student achievement are decreasing in the fields of mathematics and science (Else-Quest, Hyde, & Linn, 2010), existing gender differences in students' mathematics motivation and academic self-concepts contribute to gendered career choices (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006; Watt et al., 2012) and to gender-segregated labor markets (OECD, 2012). This segregation is problematic because, for example, professions that require high mathematical competence provide higher prestige and income (Cejka & Eagly, 1999).

According to Eccles and colleagues' expectancy–value theory (Eccles et al., 1983), the attitudes of socializers shape students' gendered task values and success beliefs by influencing their behaviors (e.g., Simpkins, Fredricks, & Eccles, 2012; Simpkins, Fredricks, & Eccles, 2015). Furthermore, students' interests can be seen as a tool for identity development in adolescence (Kessels & Hannover, 2004). Research (Hannover & Kessels, 2004; Kessels, 2005; Kessels & Hannover, 2006) has revealed that negative prototypes of girls who like mathematics and physics together with peers' social sanctions of gender-untypical interests contribute to girls' withdrawal from these school subjects. Researchers focusing on the social antecedents of gendered motivation (e.g., Frenzel, Goetz, Pekrun, & Watt, 2010; Kessels & Hannover, 2006; Simpkins et al., 2015) often apply variable-centered research approaches. However, person-centered research approaches enable the systematic addressing of inter-individual differences (Bergman, Magnusson, & El Khouri, 2003), and thus could be highly useful when studying gendered mathematics motivation and its social antecedents in greater detail. By clustering students in homogeneous sub-groups, person-centered procedures enable an examination of the way these sub-groups' characteristics interact with learning environments (Seidel, 2006).

While studies have explored distinct motivational profiles in physics (Seidel, 2006) and across domains (Viljaranta, Nurmi, Aunola, & Salmela-Aro, 2009), less is known about motivational profiles in mathematics. Mathematics achievement and coursework can be seen as critical filters for career and major choices (Ma & Johnson, 2008), and therefore it is important to consider students' motivational profiles in this school subject. This study examines students' motivational profiles in mathematics and the associations of these profiles with students' gender, mathematics achievement, and perceptions of their parents' valuing of mathematics.

THE ROLE OF GENDER AND AGE IN MATHEMATICS TASK VALUES

Students' task values are a salient factor in the explanation of gender differences in students' choice behaviors (Eccles, 2005). Eccles and colleagues' expectancy–value model (Eccles et al., 1983; Eccles & Wigfield, 2002) posits that students' (gendered) subjective task values and expectancies of success directly influence their (gendered) performance, persistence, and choices. Subjective task values are defined as the "quality of a task that contributes to increasing or decreasing the probability that an individual will select it" (Eccles 2005, p. 109). Task values can be categorized as interest in and enjoyment of a task (*intrinsic value*), personal importance of doing well at a task (*attainment value*), perception of the task as useful for personal long-term goals (*utility value*), and the negative aspects of engaging in a task (*cost*) (Eccles, 2005; Eccles & Wigfield, 2002). Trautwein et al. (2012) reported similar correlation patterns among the value components in mathematics and English, wherein the highest correlation was found between intrinsic and attainment value. Research has shown that students' intrinsic, attainment, and utility values in mathematics positively affect their achievement in and career plans regarding the subject (for a review see Wigfield & Cambria, 2010). Utility value might therefore function differently from intrinsic value (Bong, 2001; Meece, Glienke, & Burg, 2006). Bong (2001), for example, reported that utility value predicted university students' performance, while intrinsic value predicted future enrollment decisions.

Given the independent functioning of utility and intrinsic value with regard to students' achievement and career plans, we expected to find in the present study distinct mathematics motivational profiles in terms of intrinsic/attainment value and utility value, which have varying effects on students' achievement in mathematics.

Regarding the role of students' individual characteristics, Eccles (2005) states that older students might report a higher utility valuing of learning than younger students. Adolescents need to think about their future career choices, whereas the enjoyment of activities might be more important to younger students' learning. Concerning students' gender, research has shown that, compared with boys, girls often report significantly lower interest (Lazarides & Ittel, 2013; Watt et al., 2012) but similar utility value when involved in mathematics tasks (Watt, 2004; Watt et al., 2012). Gaspard et al. (2015) distinguished a total of 11 task value facets in mathematics and showed that the structure of value beliefs was similar for boys and girls, but that girls reported lower mean levels of intrinsic value and perceived mathematics as less personally important and less useful for both their general and their professional future than boys did.

Theoretically, these gender-related differences in students' task values might be explained by socializers' gender-related ability and domain-specific value beliefs (Eccles, 2005; Eccles et al., 1983). Hannover and Kessels (2004) conceptualize interest development in school as an identity regulation process influenced by domain-specific images and prototypes and demonstrated that these developmental processes are strongly influenced by social sanctions (Kessels, 2005).

Based on the reviewed research, in this study it was expected that boys and younger students would be more likely to display motivational profiles with high levels of mathematics intrinsic value and that these profiles would in turn be positively associated with students' perceptions of their parents' valuing of mathematics.

THE ROLE OF GENDER AND AGE IN ACADEMIC SELF-CONCEPT IN MATHEMATICS

Academic self-concept is viewed as an individual's perception of self in academic sub-areas, formed through interactions with the environment and attributions of the individual's personal behavior (Marsh, Byrne, & Shavelson, 1988). Whilst it has been suggested that students' task values might be especially influential in their career plans (Bong, 2001; Meece et al., 2006), their mathematics self-concepts are known to be positively related to mathematics performance (Marsh, Dowson, Pietsch, & Walker, 2004; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005). Research has shown that students' mathematics self-concepts are reciprocally related to mathematics achievement, although the effect of mathematics self-concepts on subsequent achievement is stronger than the effect of mathematics achievement on subsequent mathematics self-concept (Marsh et al., 2005). Given the strong positive relationship between students' mathematics self-concepts and achievement (Marsh et al., 2005), it was hypothesized in the present study that motivational profiles characterized by high mathematics self-concepts would be associated with high mathematics achievement.

According to Eccles and colleagues' expectancy–value model (Eccles et al., 1983), students' academic self-concept positively influences the development of task values. In particular, students' mathematics self-concept has been shown to positively predict mathematics intrinsic value (Gniewosz, Eccles, & Noack, 2014). Therefore, for this study, it was assumed that students who display high mathematics self-concepts also attribute a high intrinsic value to mathematics.

Research has shown that young children tend to hold positive academic self-concepts that are not strongly correlated with their actual achievement, whereas older children develop more differentiated, domain-specific academic self-concepts, which correspond more closely to their achievements (Marsh, 1989). Students' academic self-concepts, especially in mathematics, are not only age-specific but also gender-specific. Compared with boys, equally high-achieving girls report lower self-concepts in mathematics (Marsh & Yeung, 1998; Nagy et al., 2010). As regards the underlying mechanisms of gender-variant self-concepts, studies revealed that parents reported higher expectations of talent (Yee & Eccles, 1988) and stronger beliefs about ability (Jacobs, 1991) in mathematics for boys. Parents' gendered beliefs shape their support behaviors and lead to children's gendered ability beliefs (Simpkins et al., 2012). In this study, it was expected that girls (Nagy et al., 2010) and older students (Marsh, 1989) would be more likely to have motivational profiles characterized by low mathematics task values and self-concept.

Motivational Profiles

Variable-centered research approaches are often applied in research into the social antecedents of gendered motivation (e.g., Simpkins et al., 2012; Simpkins et al., 2015). These analytical strategies analyze relationships between variables by assuming the homogeneity of student populations. Person-centered research approaches, however, identify distinct sub-groups of students and address the heterogeneity of populations. These strategies might be especially fruitful for motivational research because they enable the exploration of sub-groups of students with different types of motivation (Roeser, Eccles, & Freedman-Doan, 1999; Viljaranta et al., 2009) and the examination of how these motivational sub-groups differ in their interactions with learning environments (Seidel, 2006).

The few existing person-centered studies in motivational research have identified student profiles characterized by distinct levels of task values (Chow, Eccles, & Salmela-Aro, 2012; Viljaranta et al., 2009). In a study of Finnish secondary-school students' task values in six domains,[1] Viljaranta et al. (2009) found six clusters of motivational profiles: multi-motivated, low-motivated, social sciences and mother-tongue-motivated, practical skills and language-motivated, practical skills-motivated, and math and science-motivated. In this study, girls were over-represented in the multi-motivated group and in the practical skills and language-motivated group. Boys, in contrast, were over-represented in the low-motivated group, in the math and science-motivated group, and in the practical skills-motivated group. Chow et al. (2012), in research on Finnish and United States high-school students' task values in three domains,[2] identified three motivational clusters: high math and physical science, moderately low math and physical science, and low math and physical science (U.S. sample); and high math and science, no preference, and low math and science (Finnish sample). Gender was significantly related to motivational cluster membership, with boys being more likely to fall into the high math and physical science group, and significantly less likely than girls to fall into the low math and (physical) science group in both the Finnish and the U.S. samples.

Theoretically, based on Eccles and colleagues' expectancy–value framework (Eccles et al., 1983), it might be assumed that students develop intra-individually differing patterns of task values (Chow et al., 2012; Chow & Salmela-Aro, 2014) owing to different gender-related socialization processes (e.g., Jacobs, 1991) and experiences with socializers in various social contexts (e.g., Simpkins et al., 2015). Peers' social sanctions of gender-untypical interests (Kessels, 2005), together with negative prototypes of girls who are interested in mathematics and science (Kessels & Hannover, 2006), might thereby contribute to particularly low / high and mixed mathematics motivation profiles and to the under-representation of girls in motivational profiles with high mathematics motivation.

Given gendered socialization processes (Eccles et al., 1983; Kessels, 2005) and referring to earlier empirical research (Aunola, Viljaranta, Lehtinen, & Nurmi, 2013; Chow et al., 2012), it was expected in the present study that results would reveal distinct groups of students with high, moderate, and low levels of mathematics task values and self-concept. It was also expected that these profiles would relate differently to students' mathematics-related achievement.

Parents' Valuing of Mathematics

As children's first socializers, parents are of great importance in the development of students' task values (e.g., Frenzel et al., 2010; Simpkins et al., 2012) and self-concepts of ability (Frome & Eccles, 1998). Eccles et al. (1998) describe how parents influence their children's values and beliefs by communicating general and child-specific beliefs both verbally and non-verbally (through behaviors). Strong empirical evidence supports the view that parents' child-specific ability expectations in mathematics can have positive effects on children's mathematics self-concept (e.g., Frome & Eccles, 1998; Gniewosz et al., 2014; Jacobs & Eccles, 1992) and intrinsic value (Gniewosz et al., 2014; Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005). Less is known about the effects of students' perceptions of their parents' valuing of mathematics on children's mathematics task value and self-concept. Regarding the underlying mechanisms, longitudinal research has shown that parents' mathematics values directly influence their child-specific behavior and, consequently, their children's values (Gniewosz, Eccles, & Noack, 2012; Gniewosz & Noack, 2012; Simpkins et al., 2012). Given the links between parents' mathematics-related beliefs and secondary students' self-related competence beliefs and task values in mathematics, the present study investigated whether student-perceived parental valuing of mathematics is significantly related to students' mathematics motivational profiles.

RESEARCH QUESTIONS

1) Which distinct secondary-student motivational profiles can be identified in mathematics classrooms using students' intrinsic, utility, and attainment value and mathematics self-concept as criterion variables?
2) How do the distinct motivational profiles vary in their relationship to students' achievement in mathematics?
3) How do the distinct motivational profiles relate to students' gender, age, and perceptions of their parents' valuing of mathematics?

METHOD

Sample

The study sample consisted of 849 seventh- to tenth-grade students (boys: 54.8%) in 108 classes at secondary schools in Berlin, Germany, who participated in the Berlin Career Exploration and Guidance Study (Ohlemann et al., 2014). Data were assessed in 2014. Participating schools were randomly selected. Students completed self-report questionnaires in their classrooms at the beginning of seventh (20.2%), eighth (24.6%), ninth (23%), and tenth (27.4%) grade (missing: 5.54%). Students' mean age was 14.19 (*SD* = 1.38). The German educational system is characterized by educational tracking. In Berlin, students are streamed after sixth grade at the end of elementary school based on their academic achievement. In this study, only data from the integrated secondary-school track were analyzed. This track provides courses for students of different ability levels, along with cooperative learning relating to performance differentiation through tasks. The majority of participating students reported that German was their mother tongue (58.7%). Socio-economic background was measured by the number of books at home (0–10: 13.4%; 11–25: 25.9%; 206–100 28.9%; 101–200: 12.0%; more than 200: 14.7%). Participation was voluntary, and parental consent was obtained for students under the age of 14, in accordance with local education authority guidelines. Trained research assistants administered questionnaires in the classrooms of participating students, who took approximately 45 minutes to complete the surveys.

Measures

Individual variables. Self-reported grades in mathematics (1 = very good, 2 = good, 3 = satisfactory, 4 = sufficient, 5 = deficient, 6 = insufficient; grades were recoded with high values indicating high grades), students' age, and gender (0 = boys, 1 = girls) were included in the analysis as covariates. When including covariates in the latent profile models, migration background and socio-economic status were controlled for. Students' self-reported mother tongue was used as an indicator of migration background, and the self-reported number of books at home as an indicator of socio-economic status.

Mathematics task values. Students' task values were measured with a scale developed by Steinmayr and Spinath (2010). This consists of three sub-scales examining intrinsic (3 items), utility (3 items), and attainment value (3 items). Students rated these nine items on a 5-point Likert scale, ranging from 1 (does not apply at all) to 5 (fully applies). All three sub-scales showed acceptable internal consistency (intrinsic: α = .947; utility: α =.887; attainment α =.852). An example of an item for intrinsic value is the statement "I have fun doing mathematics"; for utility value, "Things that I learn in mathematics are important for my life in general"; and for attainment value, "It is important to me to do well in mathematics".

Mathematics self-concept. Students' academic self-concept in mathematics was assessed using items from the SESSKO scales developed by Schöne, Dickhäuser, Spinath, and Stiensmeier-Pelster (2002). The 5-point Likert scale for the four items ranged from 1 (items 1 and 4: not at all talented; item 2: worse than previously; item 3: less skilled than my classmates) to 5 (items 1 and 4: highly talented; item 2: better than previously; item 3: much more skilled than my classmates). The scale showed acceptable overall internal consistency (α = .909). An example of an item is the statement "Given what I should know in mathematics, I think I am …" (item 3: 1 – "less skilled than my classmates" to 5 – "more skilled than my classmates").

Perceived parents' valuing of mathematics. Students' perceptions of their parents' valuing of mathematics were measured with a 5-item scale developed by Wendland and Rheinberg (2004). The 5-point Likert scale ranges from 1 (does not apply at all) to 5 (fully applies). The scale showed an acceptable reliability (α = .820). Example items include the statements "My parents think that I will not be able to find a good job after school without good grades in mathematics" and "My parents think that learning for mathematics is more important than learning for other school subjects."

Statistical Analyses

Mplus version 6.21 was used for all analyses (L. Muthén & Muthén, 1998-2010). Given the nested structure of the data and the non-independence of observations, corrections to the standard errors and chi-square test of model fit were obtained using a maximum likelihood estimator with robust standard errors (Type = Mixture Complex; L. Muthén & Muthén, 1998-2010). Full-information maximum likelihood (FIML) estimation was used to handle missing data (L. Muthén & Muthén, 1998-2010).

Data analysis was performed using the following steps:

(1) A series of latent profile analyses was conducted, comparing six models with different numbers of profiles. The model fit indices are shown in Table 2. Cases that had missing values for all variables (n = 2) or for the classroom variable (n = 1) were excluded from the analysis. The criterion variables were standardized to avoid biased results due to differences in standard deviations. The appropriate number of profiles was determined on the basis of a comparison of widely used statistical criteria (Nylund, Asparouhov, & Muthén, 2007): the Akaike information

criterion (AIC: lowest) (Akaike, 1974), Bayesian information criterion (BIC: lowest) (Schwarz, 1978), sample-size-adjusted Bayesian information criterion (aBIC: lowest), entropy (>.80) (Rost, 2006), and adjusted Lo–Mendell–Rubin Likelihood Ratio Test (LMR LRT; *p* value was used to determine whether the null *k*-1 class model should be rejected in favor of the *k* class model). The literature states that when the slope of the plotted information criteria (AIC, BIC, aBIC) curve begins to flatten, little information can be gained to identify additional profiles (L. Muthén & Muthén, 2009).

(2) Gender, age, and student-perceived parents' valuing of mathematics were included as covariates in the latent profile models. Latent profile analysis with covariates is analogous to a multinomial logistic regression approach, using the profile type as the categorical dependent variable and observed covariates as the independent variables (B. Muthén & Satorra, 1995).

(3) The mean differences of mathematics achievement for each profile type were calculated by modelling a latent profile analysis which included mathematics achievement as distal outcome. Students' gender, age, and perception of parents' valuing of mathematics were added as covariates (Clark & Muthén, 2009). Using the model test command in *Mplus,* the statistical significance of the mean differences was tested by Wald chi-square tests of parameter equalities (Kodde & Palm, 1986; B. Muthén & Satorra, 1995).

RESULTS

Descriptive Analyses

To explore the associations between the mathematics task value variables and academic self-concept, intercorrelations were computed, as presented in Table 1. Students' mathematics intrinsic value was positively and significantly associated with all other criterion variables (utility value: r = .54, SE = 0.03, p < .001; attainment value: r = .59, SE = 0.04, p < .001; self-concept: r = .73, SE = 0.04, p <.001). Utility value was significantly associated with attainment value (r = .65, SE = 0.04, p < .001) and mathematics self-concept (r = .39, SE = 0.04, p < .001). Attainment value was significantly associated with mathematics self-concept (r = .50, SE = 0.04, p < .001). Students' attainment value appeared to have the highest mean (M = 3.64, SE = 0.04). The absolute values of skewness and kurtosis for the criterion variables (intrinsic, utility, and attainment value and academic self-concept) ranged from -.59 to .09 and from -.82 to -.23, respectively, indicating no major deviations from normal distributions.

Latent Profile Analysis

The results reveal that the slope of the AIC, BIC, and aBIC information criteria began to flatten after the four-profile solution (see Table 2).
The adjusted LMR LRT test statistics show a non-significant *p* value for the six-class model, suggesting that the five-class model should not be rejected in favor of the six-class model. However, the four-profile solution was identified as the most appropriate one for the data because the differences in information criteria between the four- and five-profile solutions were small, and group differences in the criterion variables were clearer in the four-profile model than in the five-profile model. The profiles are shown in Figure 1. Profiles were labelled on the

basis of the most dominant criterion from students' ratings of mathematics self-concept and interest, utility, and attainment value.

Table 1 - *Means and Intercorrelations of the Criterion Variables*

	M (*SE*)	1	2	3	4
1) Intrinsic value	2.87 (0.05)	--	.54	.59	.73
2) Utility value	3.46 (0.05)		--	.65	.38
3) Attainment value	3.64 (0.04)			--	.50
4) Self-concept	3.00 (0.04)				--

Note: All correlations were significant at p <.001.

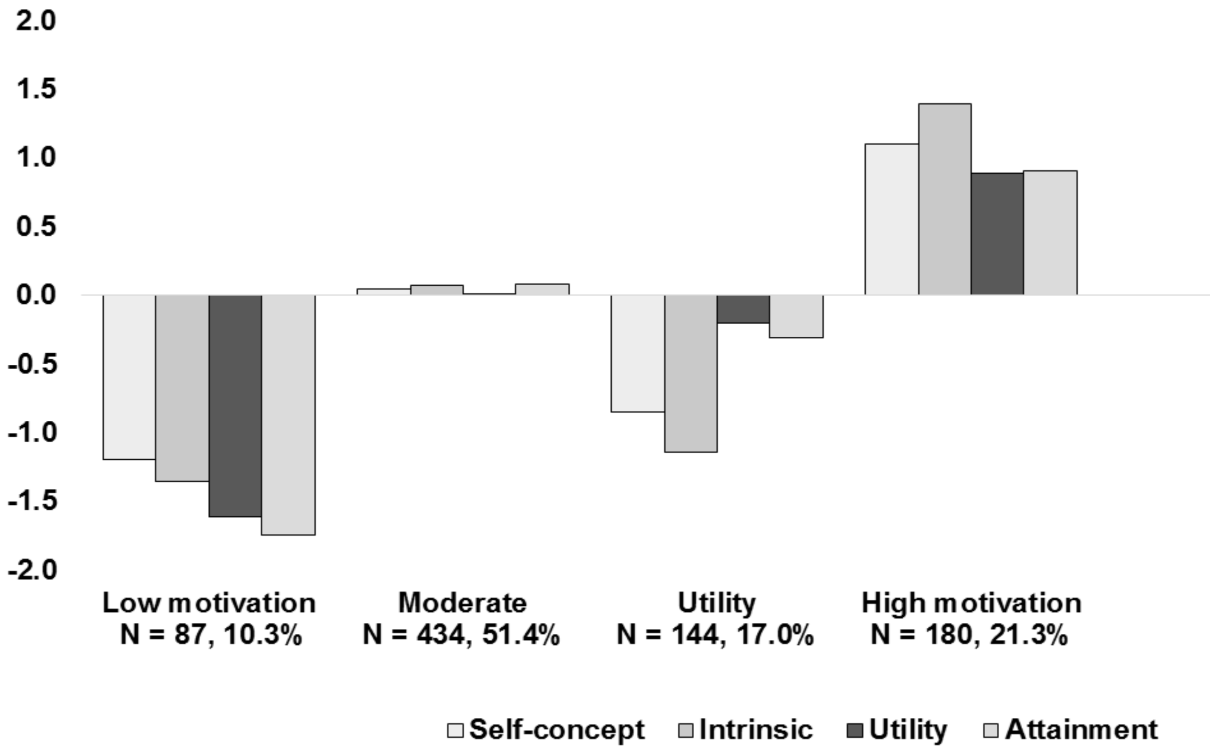

Figure 1. *Latent profile characteristics and prevalence for the four-class model*

As expected, the results reveal a low-motivation profile (profile 1: *n* = 87; 10.3%). Members of this sub-group reported low levels of mathematics self-concept (*M* = -1.19, *SE* = 0.17) and intrinsic (*M* = -1.36, *SD* = 0.08), utility (*M* = -1.61, *SE* = 0.27), and attainment value in mathematics (*M* = -1.75, *SE* = 0.28). Furthermore, the results show a moderate profile (profile 2: *n* = 435; 51.4%), which was the most prevalent pattern. Members of this group displayed intermediate levels of mathematics self-concept (*M* = 0.44, *SE* = 0.05) and intrinsic (*M* = 0.07, *SE* = 0.06), utility (*M* = 0.01, *SE* = 0.06), and attainment value in mathematics (*M* = 0.08, *SE* = 0.05). Again as expected, the results show a mixed pattern, labelled as the utility profile (profile 3: *n* = 144; 17.0%). Students in this profile reported low levels of mathematics self-concept

(*M* = -0.85, *SE* = 0.14) and intrinsic value (*M* = -1.15, *SE* = 0.10) but scores close to the sample mean for utility (*M* = -0.20, SE = 0.30) and attainment value (*M* = -0.31, *SE* = 0.28). As hypothesized, the results also reveal a high-motivation profile (profile 4: *n* = 180; 21.3%), consisting of students who reported high levels of mathematics self-concept (*M* = 1.10, *SE* = 0.06) and intrinsic (*M* = 1.39, *SE* = 0.06), utility (*M* = 0.89, *SE* = 0.06), and attainment value in mathematics (*M* = 0.90, *SE* = 0.05).

Role of Students' Gender, Age, and Perceived Parents' Valuing in Students' Motivational Profile Membership

The high-motivation profile (profile 4) was set as the reference group in the first step of the latent profile analysis with covariates, because students in this sub-group were of especial interest as they reported particularly high motivation in mathematics. In the next steps, alternative parameterization was used. All other motivational profiles were set as reference groups sequentially. The covariates were gender (0 = male; 1 = female; male as referent), age, and student-perceived parents' valuing of mathematics (both grand-mean-centered). Initially, migration background and socio-economic status were also included in the analyses. However, neither variable had a significant association with profile membership, so they were excluded from further analyses. The model fit statistics of the latent profile analyses (LPA) models, which included gender, parents' valuing, and age as covariates, are reported in Table 2.

As hypothesized, girls were less likely than boys to display the high-motivation profile. When using the high-motivation profile (profile 4) as the reference group, girls were more likely than boys to display the low-motivation profile (profile 1: *b* = 1.46, *SE* = 0.38, *p* < .001), the moderate profile (profile 2: *b* = 0.93, *SE* = 0.23, *p* < .001), or the utility profile (profile 3: *b* = 1.34, *SE* = 0.30, *p* < .001). Age was positively associated with membership of the moderate profile (profile 2: *b* = 0.20, *SE* = 0.08, *p* < .05) and, as expected, of the utility profile (profile 3: *b* = 0.32, *SE* = 0.12, *p* < .05). As hypothesized, student-perceived parents' valuing of mathematics contributed significantly to their membership of the high-motivation profile and had a significant negative association with membership of the low-motivation profile (profile 1: *b* = -1.04, *SE* = 0.26, *p* < .001), the moderate profile (profile 2: *b* = -0.35, *SE* = 0.15, *p* < .05), and the utility profile (profile 3: *b* = -0.62, *SE* = 0.30, *p* < .05).

In line with our expectations, when using the low-motivation profile (profile 1) as the reference class, girls were significantly less likely (*b* = -1.46, *SE* = 0.38, *p* < .001) than boys to fall into the high-motivation profile (profile 3). Student-perceived parents' valuing of mathematics was significantly positively associated with their membership of the high-motivation profile (profile 3: *b* = 1.04, *SE* = 0.26, *p* < .001) and moderate profile (profile 4: *b* = 0.69, *SE* = 0.20, *p* = .001).

Table 2

Model Fit Indices for two to six Class Solutions of Students' Motivational Clusters in Mathematics With and Without Covariates (Gender, Age, and Student-perceived Parents' Valuing of Mathematics)

	Without covariates					With covariates				
Number of classes	2	3	4	5	6	2	3	4	5	6
AIC	8424.78	7963.41	7839.02	7739.18	7660.75	7084.68	6680.04	6587.73	6480.96	6307.66
BIC	8486.41	8048.74	7948.05	7871.91	7817.18	7157.77	6789.67	6733.91	6663.68	6526.92
aBIC	8445.12	7991.58	7875.01	7782.99	7712.39	7106.97	6713.47	6632.30	6536.67	6374.51
Entropy	0.725	0.846	0.824	0.825	0.793	0.742	0.852	0.833	0.781	0.921
aLMR	806.988	457.783	130.523	106.677	85.879	818.058	412.787	106.285	120.483	185.767
p	0.000	0.000	0.049	0.015	0.757	0.000	0.001	0.124	0.545	0.001

Note: AIC: Akaike's information criteria; BIC: Bayesian information criteria; aBIC: sample-size-adjusted Bayesian information criterion; aLMR LRT: Lo-Mendell-Rubin adjusted likelihood ratio test.

Table 3. *Class-specific Means and Standard Errors of Mathematics Achievement*

	C1: Low motivation		C2: Moderate		C3: Utility		C4: High motivation	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Mathematics achievement	2.04^{ac}	0.27	3.10^{cd}	0.24	1.30^{bd}	0.43	4.13^{ab}	0.39

Note: Variables with the same superscript are significantly different at p < .05.

Using the utility profile (profile 3) as the reference class, girls were again significantly less likely than boys to be in the high-motivation profile (profile 4: $b = -1.34$, $SE = 0.30$, $p < .001$). As expected, student-perceived parents' valuing of mathematics was significantly positively associated with their membership of the high-motivation profile (profile 4: $b = 0.61$, $SE = 0.30$, $p < .05$).

Using the moderate profile (profile 2) as the reference class, girls were significantly less likely than boys to fall into the high-motivation profile (profile 4: $b = -0.93$, $SE = 0.23$, $p < .001$). Students' age was significantly negatively associated with their membership of the high-motivation profile ($b = -0.20$, $SE = 0.08$, $p < .05$). As hypothesized, student-perceived parents' valuing of mathematics was significantly positively associated with their membership of the high-motivation profile ($b = 0.35$, $SE = 0.15$, $p < .05$).

Mean Differences of Mathematics Achievement across Motivational Profiles

The mean differences across motivational profiles were tested for students' mathematics achievement, controlling for students' gender, age, and perceived parents' valuing of mathematics. The class-specific means and standard errors of students' mathematics achievement are reported in Table 3. The Bonferroni correction was applied to each set of multiple comparisons. The mean of each variable was compared across four groups, so the critical alpha value was $p = .0083$.[3]

In line with our hypotheses, students who had a high probability of belonging to the low-motivation profile (profile 1) reported significantly lower mathematics achievement ($M = 2.04$, $SE = 0.27$) than students with a high probability of falling into the high-motivation profile (profile 4: $M = 4.13$, $SE = 0.39$; Wald χ^2 (1) = 21.71, $p < .001$, $d = -0.50$) or the moderate profile (profile 2: $M = 3.10$, $SE = 0.24$; Wald χ^2 (1) = 8.66, $p = .003$, N = 347, $d = -0.27$).

Students with a high probability of being assigned to the high-motivation profile (profile 4: $M = 4.13$, $SE = .39$, N = 162) reported significantly higher mathematics achievement than students in the utility profile (profile 3: $M = 1.30$, $SE = 0.43$, Wald χ^2 (1) = 19.60, $p < .001$, $d = 0.43$).

Students with a high probability of falling into the moderate profile (profile 2: $M = 3.10$, $SE = 0.24$) reported significantly higher achievement in mathematics than students with a high probability of falling into the utility profile (profile 3: $M = 1.30$, $SE = 0.43$; Wald χ^2 (1) = 12.02, $p < .001$, $d = .28$).

DISCUSSION

Students' Mathematics Motivational Profiles

This study builds on earlier research by identifying distinct motivational profiles within the domain of mathematics, which vary in accordance with students' mathematics task value and self-concept. Going beyond variable-centered research, we not only identified students with particularly low motivation (profile 1: 10.3%) and with particularly high motivation in mathematics (profile 4: 21.3%), but also identified a group of students who belonged to a utility profile (profile 3:

intermediate utility and attainment values and low mathematics intrinsic value and self-concept; 17.0%), as well as students who fall into a moderate profile (profile 2; intermediate levels of the criterion variables; 51.4%). Identifying such distinct student sub-types within mathematics classrooms is fruitful because it enables us to analyze how within-person performance is related to within-person hierarchies of values (Chow et al., 2012; Viljaranta et al., 2009). The person-centered analysis approach used in this study added new information to recent research as it revealed distinct sub-types of student which were characterized by differing levels of task value, and demonstrated that students' gender, age and perceived social context played a significant role in their likelihood of falling into one of these distinct sub-groups.

Concerning the relationship between students' profile membership and their achievement, the results of this study showed that students with utility and low-motivation profiles both reported particularly low levels of achievement in mathematics. This result was not expected because, based on Eccles and colleagues' expectancy–value framework (2005; 1983), it can be assumed that a high valuing of tasks is associated with high levels of performance. However, utility value is the component of students' task values most similar to extrinsic motivation (Eccles, 2005; Wigfield, Tonks, & Klauda, 2009), and previous studies revealed no significant (e.g., Komarraju, Karau, & Schmeck, 2009) or even negative (e.g., Lepper, Corpus, & Iyengar, 2005) relationship between extrinsic motivation and performance. A possible interpretation of the low mathematics achievement scores in the utility profile, then, is that merely valuing mathematics as intermediately useful for personal, long-term goals might not be enough of an incentive to make students perform well in the immediate present.

Interestingly, in this study, the moderate profile with intermediate levels of mathematics self-concept and intrinsic, utility, and attainment value in mathematics was the most prevalent pattern (51.4%). It is well known that students' interest in mathematics declines during adolescence (e.g., Daniels, 2008). However, professions that require greater mathematical competence are associated with high prestige and income (Cejka & Eagly, 1999). Thus, although interest in mathematics in this study may be generally low owing to the age group we focused on, the positive attribution of mathematics-related careers might contribute to the strong tendency of students in this study to fall into the moderate-motivation profile. However, to gain a deeper understanding of students' motivational profiles, further research is needed that also considers domain-specific images and stereotypes (Kessels & Hannover, 2006) or classroom-related influences such as the student-rated practical focus of math lessons (Schreier et al., 2014) as predictors of students' profile membership.

Older students were more likely to belong to the moderate or the utility profile than to the high-motivation profile. This result is in line with earlier research showing that, compared with younger students, older students hold lower mathematics self-concepts (Marsh, 1989) and attribute lower levels of intrinsic value to mathematics (Frenzel et al., 2010).

In this study, girls were more likely than boys to have a low-motivation or a utility profile, which is in accord with earlier findings that girls have lower mathematics self-concepts (Nagy et al., 2010), less overall interest in mathematics (Frenzel et al., 2010; Watt, 2004), and lower general mathematics utility values than boys (Gaspard et al., 2015). The analysis of mean differences revealed that students with a high-motivation profile reported high levels of achievement in mathematics. Thus, girls were more likely to belong to disadvantageous motivational profiles.

Theoretically, an explanation for the gender differences in motivational profiles might be that socializers shape girls' and boys' task values differently by, for instance, sanctioning gender-untypical interests in school (Kessels, 2005) or by communicating gender-specific ability expectations (Bleeker & Jacobs, 2004). The results of this study revealed that high student-perceived parents' valuing of mathematics was associated with the high-motivation profile. Regarding the question of whether these perceived values differed according to students' gender, additional analyses revealed that only in the utility profile did boys perceive higher levels of parents' valuing of mathematics than girls (r = -.322, SE = .144, $p < .05$). Therefore, it might be interesting for future research to explore how socializers' gendered beliefs affect girls' and boys' membership of the other motivational profiles that were found in this study.

LIMITATIONS AND CONCLUSIONS

This study contributes to a better understanding of motivation in mathematics by identifying distinct sub-types of student with different characteristics and values of learning in mathematics. The study provides insights into the relationship of these homogeneous sub-groups to students' gender and achievement in mathematics and their perceptions of their parents' valuing of the subject. Some limitations of this study need to be mentioned, however. First, the cross-sectional data do not allow for drawing conclusions about the causal directions of the examined effects. Earlier research outlined the reciprocal effects of students' task valuing and parents' support (Simpkins et al., 2015), so further longitudinal studies are needed to examine the direction of these effects. Second, regarding validation of the profiles, future studies should include other variables related to students' motivational and cognitive development (e.g., cheating behaviors, helplessness) and investigate how students' motivational profiles predict these outcomes. Third, students' perceived cost was not included in the analyses as our research was based on prior person-centered research on task values which also only included intrinsic, attainment, and utility value (Chow et al., 2012). However, as recent research has outlined the importance of perceived costs for students' achievement (Perez, Cromley, & Kaplan, 2014), future studies need to include them when analyzing students' motivational profiles.

Gaining knowledge about students' gendered motivational profiles helps teachers address the strengths and needs of both girls and boys, for example by applying concepts of differentiated instruction (Spencer-Waterman, 2014), which aim to meet the various needs of students, for example by providing tasks that tap into different motives for learning in mathematics. The results of this study point to a need to consider the heterogeneity of students in secondary-school mathematics classrooms when planning teaching strategies to increase students' motivation in mathematics. The results demonstrate that girls tend to have motivational profiles characterized by low levels of intrinsic value, which are also associated with low levels of achievement in mathematics. Therefore, teaching strategies should address their needs, for example, by the provision of cognitively activating tasks in order to strengthen their enjoyment of and interest in mathematics.

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ENDNOTES

[1] Finnish, foreign languages, mathematics and science, social sciences, music, and physical education
[2] U.S. sample: physics and chemistry, mathematics, English. Finish sample: mathematics and science, Finnish, the arts and physical education
[3] C = k!/[2*(k-2)!] with k = 4

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