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2021-01
Academic Press Inc.
http://hdl.handle.net/10138/352429
Oppermann, E, Vinni-Laakso, J, Juuti, K, Loukomies, A & Salmela-Aro, K 2021, 'Elementary school students' motivational profiles across Finnish language, mathematics and science : Longitudinal trajectories, gender differences and STEM aspirations', Contemporary Educational Psychology, vol. 64, 101927. https://doi.org/10.1016/j.cedpsych.2020.101927

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Elementary school students' motivational profiles across Finnish language, mathematics and science: Longitudinal trajectories, gender differences and STEM aspirations

Elisa Oppermann, Janica Vinni-Laakso, Kalle Juuti, Anni Loukomies, Katariina Salmela-Aro

Contemporary Educational Psychology, Volume 64, 2021

Students' self-concept and task value beliefs are important determinants of students' academic effort, choices, and success (Eccles et al., 1983). The development of student motivation, however, is heterogenous: Students differ in their self-concept and value beliefs across subjects and they also differ in how these beliefs change over time. Previous person-oriented research demonstrated that students can be grouped according to their motivational profiles across different subjects and that those profiles predict students' aspirations and choices (Lazarides, Viljaranta, Aunola, Pesu, & Nurmi, 2016; Lazarides, Dicke, Rubach, & Eccles, 2020; Umarji, McPartlan, & Eccles, 2018). Particularly students' aspirations in STEM fields (Science, Technology, Engineering and Mathematics) have been of high interest in recent years and person-oriented studies have helped explain why some students – especially boys – are more likely to pursue STEM fields than others (Chow, Eccles, & Salmela-Aro, 2012; Dietrich & Lazarides, 2019; Guo, Wang, Ketonen, Eccles, & Salmela-Aro, 2018): STEM-related educational pathways tend to be pursued by students who feel *more* confident in STEM and enjoy learning in these subjects *more* than the same students do in other domains – and boys tend to be overrepresented in this group of students (Chow et al., 2012; Dietrich & Lazarides, 2019; Guo, Wang, et al., 2018). Thus, the intra-individual rank order of motivational beliefs in STEM compared to other domains plays a key role in students' STEM-aspirations and -choices (Eccles & Wigfield, 2020). These findings, however, are largely based on adolescents and little is known about younger students'

motivational profiles as well as the importance of these profiles for students' emerging STEM-aspirations. Students develop motivational beliefs and occupational aspirations at an early age (for a review, see van Tuijl & van der Molen, 2016; Watson & McMahon, 2005) and those beliefs are assumed to shape their subsequent educational choices (Wang & Degol, 2013). From a developmental perspective, it is crucial to gain a better understanding of the emergence of students' motivational hierarchies early on. In this regard, the early elementary school years are particularly interesting as students are just becoming familiar with the different school subjects and, as part of this process, develop motivational beliefs about the subjects as well as individual preferences. Yet, few studies have so far investigated these early cross-subject hierarchies of motivational beliefs among elementary school students. Moreover, it remains unclear how stable students' early hierarchies are, given that younger students' motivational beliefs are still developing and thus assumed to change at a faster rate than older students' motivational beliefs (Wigfield et al., 1997).

The present study aims to fill this gap on elementary school students' motivational profiles and longitudinally examines these profiles in the subjects Finnish language, math and science as well as changes in these profiles from 2nd to 3rd grade (ages 8-9). Furthermore, gender differences in students' profiles and transitions are investigated and both are linked to students' STEM-aspirations in 3rd grade. The study thereby contributes to the research literature in the following ways: First, the study uses a longitudinal design to examine the change and stability of motivational profiles in early elementary school, whereas most studies focused on older students (for the few exceptions, see Nurmi & Aunola, 2005; Viljaranta, Aunola, & Hirvonen, 2016). Second, the subject science is taken into account, in addition to language and math, which can be assumed to be particularly relevant for students' STEM aspirations but has not been included in previous studies in elementary school. Third, students' individual profile memberships are linked to their occupational aspirations in

STEM, which have not been examined in person-oriented studies of young elementary school students. Lastly, the study relies on state-of-the art latent transition analyses (LTA) rather than saved profile memberships, which do not account for measurement error in students' classifications (Asparouhov & Muthén, 2014).

Students' motivation profiles

In the situated expectancy-value (EV) framework (Eccles et al., 1983; Eccles & Wigfield, 2020) students' motivational beliefs are differentiated into outcome expectancies ("Can I do this task?") and subject task value beliefs ("Do I want to do this task?"). The present study focuses on the component of intrinsic value, which refers to students' enjoyment in a particular topic (Eccles & Wigfield, 2020; Eccles et al., 1983), and is assumed to be especially salient among younger children (Wigfield & Eccles, 1992, 1994). Both, expectation of success and subject task values are "situative" in nature, meaning that they are thought to be influenced by the immediate situation (Eccles & Wigfield, 2020). Situative (situation-specific) outcome expectancy beliefs are theoretically differentiated from more stable domain-specific self-concept of ability (Eccles & Wigfield, 2020). Similarly, situative intrinsic task value beliefs are conceptually closely related to the concept of situational interest (Krapp, 2002; Renninger & Su, 2012), and theoretically distinguished from more enduring dispositions to reengage with and enjoy a particular topic (i.e. "individual interest"; Krapp, 2002; Renninger & Hidi, 2011).

These theoretical distinctions are reflected in the measures of students' motivational beliefs, which either focus on more stable, domain-specific motivation (traits) (e.g. Chow & Salmela-Aro, 2011; Gaspard, Wille, Wormington, & Hulleman, 2019; Guo, Wang, et al., 2018; Lazarides et al., 2016; Lazarides et al., 2020; Nurmi & Aunola, 2005; Viljaranta et al., 2016) or on situation-specific motivation that varies from moment to moment (states) (e.g. Dietrich, Moeller, Guo, Viljaranta, & Kracke, 2019; Gray, 2014; Tsai, Kunter, Lüdtke,

Trautwein, & Ryan, 2008). Empirical findings for mathematics show moderate positive correlations between a students' individual (trait) and situational (state) interest in mathematics (Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008), indicating that motivational states and traits are related but may nevertheless diverge in certain situations. For instance, a student may generally express high self-concept and intrinsic value beliefs in mathematics (trait) but may nevertheless have low expectation of success in a certain task in math class and express low situational intrinsic task value – and vice versa. Studying motivational states versus studying motivational traits thus yields different insights: Motivational states capture in-the-moment motivations and can reveal immediate effects of different teaching strategies (Tsai et al., 2008) or explain within-person variation in task engagement (Gray, 2014). In contrast, motivational traits capture more time-invariant beliefs and preferences that can help explain choices that develop and specify over longer periods of time, such as choice of study major (e.g. Gaspard et al., 2019; Lazarides et al., 2020; Umarji et al., 2018) or occupation (e.g. Chow et al., 2012; Guo, Wang, et al., 2018; Lazarides et al., 2020). Nevertheless, students' motivational traits can still change, e.g. when students change their individual subject-specific preferences over the course of a school year. These changes in students' motivational traits are particularly interesting, because they shed light on the development of student motivation. Thus, in line with previous longitudinal person-oriented research (e.g. Gaspard et al., 2019; Guo, Wang, et al., 2018; Lazarides et al., 2020; Viljaranta et al., 2016), the present study examines the stability and change in students' subject-specific self-concept of ability and subject-specific intrinsic value hierarchies.

In line with the assumptions of the EV-framework, self-concept of ability and intrinsic value beliefs have been shown to represent empirically distinct facets even among younger children ages 5-6 (Arens et al., 2016; Mantzicopoulos et al., 2008; Oppermann et al., 2018) as well as among elementary school children (Eccles et al., 1993; Denissen, Zarrett, &

Eccles, 2007). Younger children tend to start school with high intrinsic values and optimistic ability beliefs (Eccles et al., 1993; Oppermann, Brunner, Eccles, & Anders, 2018; Wigfield, Eccles, & Rodriguez, 1998), which decline as students progress thorough elementary school (Eccles et al., 1993; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). These longitudinal findings, however, are based on variable-oriented approaches that focus on mean-level changes, which may not necessarily be similar for all students. Moreover, there is still a lack of understanding of how younger students prioritize subjects and how these cross-subject motivational hierarchies change in early elementary school. The present study thus employs a person-oriented approach to examine children's motivational profiles from 2nd to 3rd grade across the subjects of math, Finnish language and science. Person-oriented approaches focus on individual patterns of criterion variables, such as motivational beliefs in different subjects (Bergman, Magnusson, & El-Khouri, 2003; Nurmi & Aunola, 2005). Specifically, person-oriented studies aim at identifying sub-groups of students that show similar patterns of cross-subject motivational hierarchies. This approach thus accounts for individual differences in motivational hierachies across subjects and allows researchers to examine the proportion of the sample that show a particular pattern, the stability of these patterns and the relation to other variables (Nurmi & Aunola, 2005).

Previous person-oriented studies on students' motivational hierarchies are mostly based on the expectancy-value framework (Eccles et al., 1983) and included students' self-concept of ability and subject task value beliefs – often intrinsic value – in different subjects (Gaspard et al., 2019; Nurmi & Aunola, 2005; Lazarides et al., 2016; Viljaranta et al., 2016); a few studies focused on just one aspect, i.e. only self-concept (Umarji et al., 2018) or only task values (Chow & Salmela-Aro, 2011; Guo, Wang, et al., 2018; Nurmi & Aunola, 2005). Previous studies identified between three and six different groups of students (= profiles) that differed in their cross-subject self-concept and/or values hierarchies (Chow et al., 2012;

Gaspard et al., 2019; Guo, Wang, et al., 2018; Lazarides et al., 2016; Viljaranta et al., 2016; Viljaranta, Nurmi, Aunola, & Salmela-Aro, 2009). The profiles were then interpreted and labelled according to the characteristics that made them unique, which were typically derived from comparing the profile means on the indicator variables (e.g. motivation in the examined subjects) to the mean or median of the entire sample (Chow & Salmela-Aro, 2011; Ehrtmann, Wolter, & Hannover, 2019; Gaspard et al., 2019; Guo, Wang, et al., 2018; Lazarides et al., 2016; Nurmi & Aunola, 2005; Viljaranta et al., 2016) or to the mean of other profiles (Umarji et al., 2018)[1]. For instance, profiles characterized by higher motivation in mathematics than the sample mean, but lower motivation in all other examined subjects than the sample mean were typically labelled "math-motivated" or "high math motivation" (Gaspard et al., 2019; Lazarides et al., 2016; Nurmi & Aunola, 2005; Viljaranta et al., 2016).

These studies identified profiles characterized by high motivation, compared to the sample mean, in all examined subjects (Chow & Salmela-Aro, 2011; Dietrich & Lazarides, 2019; Ehrtmann, Wolter, & Hannover, 2019; Gaspard et al., 2019; Umarji et al., 2018; Viljaranta, Nurmi, et al., 2009) as well as profiles characterized by low motivation across all the examined subjects, as compared to the sample mean (Dietrich & Lazarides, 2019; Ehrtmann et al., 2019; Lazarides et al., 2016; Umarji et al., 2018; Viljaranta, Nurmi, et al., 2009). Moreover, - and more theoretically interesting - many studies found profiles characterized by high motivation in mathematics and/or science and lower motivation in the other examined subjects, compared to the sample mean (Chow et al., 2012; Chow & Salmela-Aro, 2011; Gaspard et al., 2019; Lazarides et al., 2016; Umarji et al., 2018; Viljaranta,

[1] Although a few studies based their profile interpretation on other criteria, such the theoretical mean of the indicator variables (Dietrich & Lazarides, 2019) or the sample mean in one subject only, e.g. English (Chow et al., 2012), close examination of the results suggests that the characteristics and the chosen labels for each profile would still apply even if the authors had chosen to compare the profile means to the empirical sample means instead (Chow et al., 2012; Dietrich & Lazarides, 2019). The following review of the research literature thus includes all studies on students' cross-subject profiles of motivational beliefs.

Nurmi, et al., 2009), as well as high motivation in practical school subjects, such as arts and lower motivation in the other examined subjects, compared to the sample mean (Chow & Salmela-Aro, 2011; Lazarides et al., 2016; Viljaranta, Nurmi, et al., 2009). Across the different samples and age groups examined in previous studies, the high motivation profile often represented (one of) the largest groups in the sample (Chow & Salmela-Aro, 2011; Dietrich & Lazarides, 2019; Lazarides et al., 2016; Nurmi & Aunola, 2005; Viljaranta et al., 2016). The math-motivated or math- and science-motivated profiles were also typically large groups – often the second largest group (Chow et al., 2012; Chow & Salmela-Aro, 2011; Lazarides et al., 2016; Nurmi & Aunola, 2005; Viljaranta et al., 2016). Fewer students tended to belong to subject-specific low-motivation profiles, i.e. low math or low reading groups (Nurmi & Aunola, 2005), or low overall motivation groups (Lazarides et al., 2016; Viljaranta et al., 2016).

The few studies that have investigated motivational profiles among younger students in early elementary school also found high and low motivation profiles across all examined subjects (Nurmi & Aunola, 2005; Viljaranta et al., 2016), as well as profiles characterized by high math motivation or high reading motivation (Nurmi & Aunola, 2005; Viljaranta et al., 2016). Previous studies that investigated elementary school students (e.g. Nurmi & Aunola, 2005; Viljaranta et al., 2016) did not, however, include the subject science. Thus, it remains unclear whether the number and/or characteristics of the profiles change when students motivation in science is included: Does high motivation in math co-occur with high science motivation, analogous to findings by Chow et al. (2012) for adolescents; do highly motivated students in science form their own group or do the groups identified in previous studies remain unchanged when science is included? The first aim of the present study is thus to attend to these questions and examine which groups can be identified among early

elementary school students when the subject science, in addition to language and math, is taken into account as well as how students are distributed among these groups.

Stability of students' motivational profiles over time

Previous longitudinal studies employing a person-oriented approach showed that students' profiles tended to be stable across time among secondary school students (Alexander & Murphy, 1998; Lazarides et al., 2016; Tuominen-Soini, Salmela-Aro, & Niemivirta, 2012). However, younger students' subject-specific motivational beliefs are still developing and change more than older students' subject-specific motivational beliefs (Wigfield et al., 1997), which would lead to less stability in younger students' motivational profiles. In line with this assumption, profile membership showed less stability in studies with students in early elementary school (Nurmi & Aunola, 2005; Viljaranta et al., 2016) than in studies with secondary school students (e.g. Lazarides et al., 2016; Tuominen-Soini, Salmela-Aro, & Niemivirta, 2012). Nevertheless, there was considerable stability even in the elementary school samples, particularly in the more "extreme" profile characterized by high motivation across all examined subjects (Nurmi & Aunola, 2005; Viljaranta et al., 2016): Students in the high motivation profile were unlikely to transition to profiles characterized by low-motivation (Nurmi & Aunola, 2005; Viljaranta et al., 2016). Furthermore, elementary school students in subject-specific low motivation profiles, e.g. low reading or low math motivation profiles, were also unlikely to move to the high-motivation profile (Nurmi & Aunola, 2005; Viljaranta et al., 2016). These findings show that changes in motivational profiles occur in some profiles more than in others – which underlines the importance of studying the development of these motivational profiles early on.

Gender differences in students' motivational profiles

Results of variable-oriented studies repeatedly document gender differences in older children's and adolescents' self-concept and intrinsic value beliefs in math, language and

science: Boys feel more confident and report higher (intrinsic) value beliefs in math and science than girls (e.g. Else-Quest, Mineo, & Higgins, 2013; Gaspard, Häfner, Parrisius, Trautwein, & Nagengast, 2017; Guo, Wang, et al., 2018; Jacobs et al., 2002) whereas girls report higher motivational beliefs in language, e.g. reading and writing (Durik, Vida, & Eccles, 2006; Jacobs et al., 2002; Tuominen-Soini et al., 2012).

In addition to examining mean differences in girls' and boys' subject-specific motivation, person-oriented research can reveal differences in the way girls and boys prioritize subjects. This accounts for the possibility that students' absolute subject-specific motivation may differ from their relative ordering of these subjects. For example, two students may have similar mean self-concept and intrinsic value beliefs in mathematics, but they may differ in how they prioritize mathematics in relation to other subjects. When it comes to making math-related educational choices, one may assume that the student who prioritizes math over other subjects is more likely to choose math than the student who does not prioritize math – although both students had similar mean motivational beliefs in math. In line with this notion, Eccles et al. (1983) suggested that the relative ordering of motivational beliefs across subjects would be a better predictor of educational choices than the absolute subject-specific motivation. Gender differences in the ordering of motivational beliefs across subjects thus help explain gender differences in girls' and boys' educational choices (Chow & Salmela-Aro, 2011; Umarji et al., 2018; Wang & Degol, 2013; Wang, Eccles, & Kenny, 2013).

Person-oriented studies have shown that boys dominated in high-math or high-math-and-science motivation profiles (Chow & Salmela-Aro, 2011; Dietrich & Lazarides, 2019; Ehrtmann et al., 2019; Guo, Wang, et al., 2018; Lazarides et al., 2016; Umarji et al., 2018) which were associated with STEM-related educational choices (Chow & Salmela-Aro, 2011; Umarji et al., 2018), while girls dominated in low math-motivation profiles (Chow et al.,

2012; Chow & Salmela-Aro, 2011; Gaspard et al., 2019; Guo, Wang, et al., 2018) as well as in profiles characterized by high motivation across all examined subjects (Lazarides et al., 2016).

Less is known about gender differences among younger students – particularly in mathematics and science. Whereas in language a number of variable-oriented studies exist that document gender differences in children's self-concept and intrinsic value beliefs in elementary school (Eccles et al., 1993; Guay et al., 2010; Jacobs et al., 2002; Nurmi & Aunola, 2005; Wigfield et al., 1997), results for mathematics and science are inconsistent. Some of the existing variable-oriented studies found gender differences in students' self-concept of ability in math and science in preschool and first grade (Cvencek, Meltzoff, & Greenwald, 2011; Jacobs et al., 2002; Oppermann, Brunner, & Anders, 2019), whereas other variable-oriented studies did not report any gender differences among preschool and early elementary school children (Mantzicopoulos, Patrick, & Samarapungavan, 2008; Vinni-Laakso et al., 2019). With regard to children's task-values, variable-oriented studies found no gender differences in math and science in preschool (Mantzicopoulos et al., 2008; Oppermann et al., 2018) or early elementary school (Arens et al., 2016; Eccles et al., 1993; Jacobs et al., 2002; Viljaranta, Lerkkanen, Poikkeus, Aunola, & Nurmi, 2009). Yet, girls and boys may still differ in the way they prioritize these subjects. In fact, results by Eccles et al. (1993) showed for children in early elementary school that, although boys' and girls' mean motivation in mathematics did not differ, their ordering did: For girls, math was among the subjects that they were least confident in and valued the least, whereas boys rated mathematics near the top of their motivational hierarchy. Similarly, a study by Nölke (2013) showed that preschool boys (ages 5-6) rated science more often than preschool girls as first or second priority, which contrasts previous variable-centered findings (e.g. Mantzicopoulos et al., 2008; Oppermann et al., 2018). Among the few person-oriented studies, Nurmi and

Aunola (2005) found that girls were overrepresented in the low-math-motivation profile and in the high-motivation profile in 1st and 2nd grade, whereas boys were overrepresented in the high-math-motivation profile and the low-reading-motivation profile. Thus, in contrast to variable-oriented findings, gender differences seem to emerge early when individual value hierarchies are examined. However, Nurmi and Aunola (2005) examined students' profiles based on their value beliefs, but not their self-concept of ability. To our knowledge, no study has examined gender differences in early elementary school children's self-concept and value profiles across subjects. Given the fact that gender differences are thought to emerge around this time (Wigfield et al., 1997) and that previous variable-oriented studies yielded inconsistent results, this can be considered a substantial lack in the research lierature. In line with the EV-framework (Eccles et al., 1983), the present study thus accounts for both aspects of children's motivation i.e. their self-concept and intrinsics value beliefs, to examine gender differences in early elementary school children's profiles.

Associations between students' motivational profiles and their STEM aspirations

The EV-framework (Eccles et al., 1983) suggests that students' educational aspirations and choices are developed in a context of alternative options where choosing to pursue a certain subject comes with a cost of opportunity (Chow et al., 2012; Eccles, 1994). Person-oriented approaches allow researchers to account for this by considering how inter-individual motivational hierarchies predict students' (STEM-) aspirations and choices. Previous person-oriented studies did indeed find associations between profile memberships and students' aspirations and choices across different samples and countries (Chow et al., 2012; Gaspard et al., 2019; Guo, Eccles, Sortheix, & Salmela-Aro, 2018; Lazarides et al., 2020; Wang, Eccles, & Kenny, 2013): Secondary school students in profiles characterized by high motivational beliefs in mathematics were, compared to students in other profiles, more likely to report occupational aspirations for physical and IT science jobs (Chow et al., 2012;

Guo, Wang, et al., 2018), to complete advanced math courses in 12th grade (Chow et al., 2012), to choose a STEM major in their studies (Gaspard et al., 2019; Umarji et al., 2018) and to select careers in STEM (Guo, Wang, et al., 2018; Lazarides et al., 2020; Wang et al., 2013). With regard to younger students, previous studies found that elementary school students in profiles characterized by high math motivation showed higher performance in mathematics (Nurmi & Aunola, 2005) and lower performance in reading than students in the other profiles (Viljaranta et al., 2016). These studies thereby focused on performance outcomes and little is known about the influence of motivational profiles on younger students' STEM aspirations.

Studies show that students in early elementary school have already developed occupational knowledge and aspirations for their future careers (van Tuijl & van der Molen, 2016; Vinni-Laakso et al., 2019). From a developmental perspective, childhood is seen as a formative period where children build occupational aspirations based on their knowledge about career options as well as their perceptions of social values and norms, such as gender stereotypes (Auger, Blackhurst, & Wahl, 2005; Hartung, Porfeli, & Vondracek, 2005). As children grow older, these occupational aspirations become more detailed but also more delineated through compromise and circumscription, i.e. elimination of alternative options (Gottfredson, 1981, 1996). Thus, although occupational development is an ongoing process, children's early aspirations are seen as important precursors of children's later aspirations and educational choices. In fact, recent studies have found surprising stability in the general direction of these early occupational aspirations (for a review, see van Tuijl & van der Molen, 2016; Watson & McMahon, 2005). For instance, Archer, Osbourne, DeWitt, Dillon, and Wong (2013) found that the majority of students' STEM- versus non-STEM-aspirations were quite consistent from the end of elementary school (age 10) to secondary school (age 14) (Archer et al., 2013). Consequently, we consider it an important endeavor to gain a better

understanding of how students' intra-individual motivational hierarchies are associated with their STEM-aspirations in elementary school.

The Present Study

The aims of this study were fourfold. First, the study aimed to identify patterns in elementary school students' motivation across the subjects language, math and science. Based on previous findings for secondary school students (e.g. Chow et al., 2012; Chow & Salmela-Aro, 2011; Lazarides et al., 2016; Umarji et al., 2018; Viljaranta, Nurmi, et al., 2009) as well as elementary school students (Nurmi & Aunola, 2005; Viljaranta et al., 2016) we expected to find a motivational profile characterized by high motivation across all subjects and a math-motivated profile. We also assumed that students with lower motivation would group together, however, previous findings were inconsistent as to whether these profiles were characterized by low overall (Viljaranta et al., 2016) or low subject-specific motivation (Nurmi & Aunola, 2005). Therefore, we were not able to form specific hypotheses for this/these profile(s). Moreover, no previous study included the subject science in conjunction with math and language in early elementary school and thus it remained unclear whether including the subject science would change the types of profiles.

Secondly, the stability and change in the identified profiles over one year was examined. Based on previous findings (Nurmi & Aunola, 2005; Viljaranta et al., 2016), we expected the high motivation profile to be more stable than the other profiles.

Third, gender differences in profile memberships were examined. Since no previous person-oriented study has examined gender differences in elementary school children's motivational profiles when self-concept and value beliefs were taken into account, and previous variable-oriented studies yielded inconsistent results, we were unable to form specific hypotheses for this research question.

Lastly, motivational profiles were linked to students' STEM-aspirations. Based on prior results (Chow et al., 2012) and theoretical considerations, we expected that students in high-math and/or high-science motivation profile(s) would be more likely to express STEM-related occupational aspirations.

Method

Sample

Data stemmed from the Finnish longitudinal Study "The development of primary pupils' science related efficacy beliefs and motivation" that started in 2016, when students were in first grade at the age of seven and followed the students with annual data collections until 3rd grade. The present study draws on data from the second and third wave of data collection in 2nd and 3rd grade; the first wave of data collection in 1st grade was not included because it focused on students' motivational beliefs in science only and we were interested in cross-domain comparisons. In 2nd grade, 293 students (58.7% girls) participated in the study and 255 of these students also participated in the third wave in 3rd grade. To compensate for this sample attrition, 90 additional students were recruited for the 3rd wave of data collection in 3rd grade, resulting in a total sample of 345 students in 3rd grade (55.4 % girls). The combined sample for both waves in 2nd and 3rd grade consisted of 383 students (56.7% girls), who were on average 8 years old in wave 2 (2nd grade, M_{age} = 8.17 years, SD = 0.39). Students were nested in 25 classrooms from 7 schools located in the eastern suburbs of Helsinki, which are characterized by mixed levels of socio-economic backgrounds. Data collection took place inside the classrooms and student questionnaire were administered by trained research staff (see Vinni-Laakso et al., 2019 for a detailed report of the procedures). The research project followed strict national ethical guidelines regarding scientific studies of

human subjects set by the Finnish Advisory Board of Research Integrity (TENK[2]), which are in line with the European Code of Conduct for Research Integrity of ALLEA and the General Data Protection Regulation recently issued by the European Commission. The University of Helsinki Ethical Review Board in the Humanities and Social and Behavioural Sciences sanctions these national guidelines (TENK) and provides six descriptions of research designs that require ethical review (see https://www.helsinki.fi/sites/default/files/atoms/files/when_are_ethical_reviews_required.pdf). According to these guidelines, this study did not require ethical review, and therefore, no application was made for an ethics approval. Furthermore, to follow good scientific practice, the research plan was pre-examined and approved by the Education Division of the city of Helsinki. Since the participants of the study were elementary school-aged children, the description of the study and permission forms for participation were sent to the students' parents beforehand. Parental consent was sought, and parents had the opportunity to decline their child's participation in the study. Written informed parental consent was obtained for all the student participants. The data collection was integrated in the students' normal classroom activities. The headmasters and teachers of the participating schools were informed about and agreed to the data collection schedule. The class teacher organized separate activities for the students who did not have permission to participate in the study.

Finnish Context

The Finnish compulsory education consists of one year pre-primary education for 6-year-olds and nine-year basic education for children aged 7-16 years. According to Finnish National Core Curriculum for basic education (NCCBE, 2014) school science refers to

[2] https://www.tenk.fi/en

environmental studies which is an integrated subject comprising the knowledge fields of biology, geography, physics, chemistry, and health education. The objectives of the subject in the second and third grades emphasize the development of environmental awareness, attitudes, values; developing research and working skills; and understanding the meanings of basic concepts, such as processes and structures in nature, the environment, and energy (NCCBE, 2014). In 2nd and 3rd grade students have about 2-3 hours of science education a week. The emphasis in Finnish language and literacy is to enhance students' self-expression and communication skills, verbal awareness, and the basic skills in listening, speaking, and reading (NCCBE, 2014). In Mathematics the goal is to develop students' mathematical thinking skills as logic, precise, and creative. Education ought to be practical and concrete, and students' active role in the classroom is emphasized. Learning is enhanced using information and communication technology (NCCBE, 2014). There is no achievement testing or achievement-related grouping in Finnish elementary school, which makes the Finnish context particularly interesting as students develop motivational beliefs based on their learning experiences and less achievement-related feedback than in other countries.

Measures

The measures of students' domain-specific intrinsic value and self-concept of ability were based on Eccles et al. (1993) scales, which were also developed for elementary school-aged children. Analogous to Eccles et al. (1993), Likert-type visual response formats were used, that ranged from 1 = "Totally disagree" to 5 = "Totally agree," in which 1 was indicated with the smallest star and 5 with the biggest star.

Intrinsic value beliefs. Students were asked to rate their intrinsic values in math, Finnish language and science in grades 2 (T1) and 3 (T2) using the following three items: (1) "I think the subject is fun", (2) "I like to do schoolwork for this subject", and (3) "I just like the subject". A sum score of students' intrinsic value was calculated for each subject. The

reliabilities were 0.84 (grade 2) and 0.89 (grade 3) for mathematics, 0.89 (grade 2) and 0.84 (grade 3) for Finnish language, and 0.85 (grade 2) and 0.90 (grade 3) for science.

Self-concept of ability. Students responded to the following three items (1) "I am good in Math/Finnish/Science", (2) "I am good at schoolwork for this subject", and (3) "The schoolwork for this subject is easy for me". Again, sum scores for each subject were calculated. The reliabilities were 0.76 (grade 2) and 0.84 (grade 3) for mathematics, 0.71 (grade 2) and 0.82 (grade 3) for Finnish language, and 0.63 (grade 2) and 0.81 (grade 3) for science.

Occupational aspirations. Students were asked in an open-ended question about their dream jobs. In third grade, 258 students (67%) named an occupation depicted as their dream job. Students' answers were coded into occupational fields based on ISCO-08 classifications. The encoding strictly followed the coding scheme and was done by a single trained researcher, who is not author of this paper and who was oblivious to the hypotheses of the study. Based on these classifications, two dummy variables were created: (1) STEM (e.g., science, engineering, ICT[3]) versus other fields (e.g., medicine, social science, art, business) and (2) STEM subjects including medicine (in the following referred to as STEM plus medicine "STEM+M") versus other fields (e.g., social science, art, business). The distinction between STEM and STEM+M was made because definitions of "STEM" vary and some definitions do not include medicine (for a discussion, see Heilbronner, 2013; Luttenberger, Steinlechner, Ertl, & Paechter, 2019). Furthermore, a recent study by Dorph, Bathgate, Schunn, and Cannady (2018) found that students did not see careers in medicine as connected to STEM. In fact, students' value beliefs in science were related to their occupational

[3] Examples for students' STEM occupational aspirations are „robot engineer", "engineer", "programmer".

aspirations in STEM but not to their occupational aspirations in medicine (Dorph et al., 2018). Accordingly, in line with the procedure in previous studies (Cannady, Greenwald, & Harris, 2014; Ertl & Hartmann, 2019), we distinguish STEM from STEM including medicine (STEM+M). The STEM coding was based on the list of STEM occupations in the US Department of Labor's O*Net database (Occupational Information Network; O*Net Online, 2020), as this categorization scheme was used in many previous studies (e.g. Dietrich & Lazarides, 2019; Ertl & Hartmann, 2019; Lazarides et al., 2020; Watt et al., 2017) and thus ensures comparability of results with previous findings.

Of the 258 students who named occupational aspirations in 3rd grade, N = 83 (32%) students' occupational aspirations were categorized as STEM+M and N = 31 (12%) students' occupational aspirations were categorized as STEM.

Data preparation. Univariate and multivariate outliers were identified using the criteria suggested by Tabachnick and Fidell (2007). Following these suggestions as well as the procedure used in previous research (Lazarides et al., 2016; Nurmi & Aunola, 2005), we adapted the z-standardized values of all univariate outliers (N = 7 with $z > 3.30$) to the range −3.3 to 3.3 in order to reduce the influence of these outliers (Tabachnick & Fidell, 2007). There were a few multivariate outliers, i.e. cases that showed very unusual response patterns (N = 4 at T1 and N = 4 at T2 with Mahalanobis distance > $\chi^2(6) = 22.458$). As very few outliers can distort the results of classification analyses (Bergman, 1988), these cases were removed from the dataset.

Students' motivational profiles. All models were estimated in Mplus 8.3 (Muthén & Muthén, 1998-2017) using the robust maximum likelihood estimator (MLR) in conjunction with Full Information Maximum Likelihood (FIML) to handle missing data (Enders, 2010). Data from all students who completed at least one measurement point was used (N = 383), rather than a listwise deletion strategy focusing only on students having answered both time

points (N = 255). Using all available information allowed us to maximize sample size in order to converge on proper, replicated solutions and to achieve reasonable generalizability. FIML in conjunction with MLR has been found to result in unbiased parameter estimates in longitudinal studies even with a high percentage of missing data (Enders, 2001; Shin, Davidson, & Long, 2009). To avoid local maximum, all models were analyzed using 500 random sets of start values, 50 iterations, and retained the 50 best solutions for final stage optimization. Analyses were based on *z*-standardized indicator variables.

Consistent with previous studies and recommendations in the research literature (Gillet, Morin, & Reeve, 2017; Ryoo, Wang, Swearer, Hull, & Shi, 2018), we first explored the latent profile solutions at each time point before investigating latent transition models. This ensured the replicability of the longitudinal solutions for each time point in the time-specific subsamples. We evaluated the appropriate number of latent profiles based on the Akaike information criterion (AIC), the Bayesian information criterion (BIC), the sample-size-adjusted Bayesian information criterion (aBIC), and the adjusted Lo-Mendell-Rubin likelihood ratio test (LMR LRT) (Nylund, Asparouhov, & Muthen, 2007). A model with a lower AIC, BIC and aBIC value was considered a better fit to the data. In addition, the theoretical interpretation of the profiles and the number of cases in each profile (should exceed 5% of the sample; see Marsh, Lüdtke, Trautwein, & Morin, 2009) were used as a criterion in model selection, because solely empirical criteria may result in overinterpretation of profiles.

In a second step, we tested for longitudinal measurement invariance of the profile solution across measurement points, in order to ensure that the latent profiles preserve their characteristics over time (Gillet et al., 2017; Ryoo et al., 2018). Measurement invariance was assessed by comparing nested models with and without invariance constraints across

measurement points. To evaluate the invariance constraints, we refer to the likelihood ratio difference test.

Third, we examined the stability in students' profiles and profile transitions from T1 to T2 using latent transition analyses (LTA) (Gillet et al., 2017; Morin & Litalien, 2017).

Fourth, we included students' gender as a covariate in the latent profile models at each time point to test for gender differences in latent profile membership at T1 and T2, respectively. We used the R3STEP command for auxiliary variables implemented in Mplus (Muthén & Muthén, 1998-2017). This approach is recommended by Asparouhov and Muthén (2014) as it fixes the most likely profile memberships for each observation before the auxiliary variable gender is included, thereby preventing the covariate to influence the profile memberships. We report odds ratios, which indicate the increased odds of being in profile *k* relative to the reference profile for each unit change in the covariate, and 95%-confidence intervals. In addition, we tested whether the transition probabilities from T1 to T2 differed by gender. As no automatic procedure is implemented for LTA models in Mplus, we employed the manual 3-step approach as described by Asparouhov and Muthén (2014) to ensure that including gender as covariate did not change the profile solution in our longitudinal LTA model. In the third manual step, we used the KNOWNCLASS function in Mplus to obtain transition probabilities for boys and girls (Muthén & Muthén, 1998-2017).

Lastly, we included students' occupational aspirations at T2 as an outcome variable in the latent profile model at T2 in order to test whether certain profile memberships were associated with STEM as well as STEM+M occupational aspirations. In addition, we tested whether certain transitional patterns from T1 to T2 were associated with students' STEM-related as well as STEM+M occupational aspirations by including students' aspirations at T2 as a categorial outcome variable in each transition in the LTA model.

Results

Descriptive results

Descriptive statistics of the motivational profile indicators across domains are reported in Table 1. Students reported, on average, high self-concept of abilities and high intrinsic value beliefs across the examined subjects. The bivariate correlation between the indicators can be found in table A1 in the appendix.

Students' motivational profiles

Table 2 summarizes the model fit indices for the latent profile models estimated for T1 and T2. Results showed that AIC, BIC, and aBIC consistently declined across the models with more profiles. Although the adjusted LMR likelihood ratio test was significant at both time points for the one- versus two-profile solution, we did not consider the two-profile solution because simple high/low motivation characterization did not provide sufficient descriptions of students' motivational profiles across the three subject areas. The three-profile solution provided more information about students' motivational patterns and showed a substantial increase in model fit based on the adjusted LMR compared to the two-profile solution. This difference barely missed significance at both measurement points. In addition to these empirical criteria, we compared the models based on the number of cases in each profile and the theoretical interpretation of the profile solutions. The four- to six-profile solutions revealed small subgroups (N smaller than 5% of the sample) at T1 that were not clearly interpretable. In contrast, the three-profile solution was clearly interpretable at both time points, as the profile differences in the criterion variables reflected theoretical meaningful differences across domain-specific self-concept and task values. Thus, we selected the three-profile solution.

Profile differences in the z-standardized scales for T1 are shown in Figure 1 (see tables A2 and A3 in the appendix for the standardized and unstandardized mean scores for each profile at T1 and T2). The profiles were labelled according to their mean values on the

six motivation scales compared to the sample mean. The first group showed lower intrinsic value beliefs and lower self-concept in all three subjects compared to mean of the sample and was labeled the *low motivation* profile (26.6% at T1; 17.1% at T2). Note that children in the *low motivation* profile had *relatively* low motivation as compared to the other students in the sample, but they showed moderate motivation on the absolute scales (mean motivational scores ranged from 2.32 to 3.84 on the 5-point Likert scale, see Table A3 the Appendix). The second and largest group showed higher motivational beliefs in all subjects than the sample mean and was therefore labeled the *high motivation* profile (61.8% at T1; 65.5% at T2). The third and smallest group in our sample showed higher math intrinsic value and higher math self-concept scores than the sample mean, but lower motivational beliefs in the other two subjects than the sample mean and was thus labeled the *math-motivated* profile (11.6% at T1; 17.3% at T2). Post hoc comparisons using the Tamhane T2 difference test revealed that the three profiles significantly differed on the large majority of the indicator variables (see Table A3 in the appendix).

Stability of students' motivational profiles over time

Results of measurement invariance testing revealed a small and non-significant difference between the constrained and the unconstrained model, indicating that the characteristics of the latent profiles hold over time (see Table 3).

The profile proportions and transition probabilities for the two measurement times are displayed in Table 4. The results showed that students were most likely to remain in their profiles from T1 to T2. However, students in the math-motivated profile at T1 were nearly as likely to move to the *high motivation* profile as they were to stay in the *math-motivated* profile at T2. Furthermore, students from the *low motivation* profile showed a comparatively high transition probability of .28 to move to the *high motivation* profile.

Gender differences in students' motivational profiles

To test for gender differences in children's motivational profiles at both times points, students' gender was included as a covariate in the latent profile models for T1 and T2, respectively. Results showed that girls were less likely to be in the *math-motivated* profile than in any of the other two profiles at T1. There was no gender difference in the *low motivation* versus the *high motivation* profile ($p > .05$). The pattern of results was the same for T2.

Table 6 displays the transition probabilities from T1 to T2 for boys and girls, respectively. Comparing boys and girls, the transition patterns were mostly very similar. The probability to remain in the *low motivation* profile or to change from the *low motivation* to the *high motivation* profile was about the same for both genders. However, there were some noticeable differences: Girls were more likely to remain in the *high motivation* profile than boys. Boys were more likely to remain in the *math-motivated* profile and they were also more likely than girls to change from the *low-* or *high-motivation* profile to the *math-motivated* profile.

Associations between students' motivational profiles and their STEM aspirations

Lastly, we tested whether students' profile membership at T2 was associated with their STEM aspirations at T2. Results are displayed in Table 7. There were no significant differences between the profiles in students' STEM or STEM+M occupational aspirations. Nevertheless, the odds of students in the *low motivation* and *math-motivated* profiles were – on average – more than twice as high to name STEM aspirations than students in the *high motivation* profile. In fact, the 95%-confidence intervals give more support to the hypothesis that the true value lies above an OR of 1 than they do for the hypothesis of no differences between the profiles (OR = 1). This trend missed statistical significance at $p < .05$.

With regard to the transition probabilities from T1 to T2, results showed no significant associations with students' STEM+M aspirations at T2 (see table 8). Thus,

students' odds to report STEM+M occupational aspirations did not differ between the transition patterns. There was, however, a significant difference with regard to students' STEM aspirations: Students who remained in the *high motivation* profile from T1 to T2 were significantly less likely to name STEM aspirations than students who remained in the *math-motivated* profile from T1 to T2. In fact, the odds of students who were *math-motivated* at both timepoints were six times greater to name STEM aspirations than the odds of students who were characterized by *high motivation* at both times points (OR inverse of 0.17 is 5.88). Moreover, there was a clear trend – which missed statistical significance – showing that the odds of students who remained in the *low motivation* profile from T1 to T2 were nearly three times higher to name STEM aspirations compared to students who remained in the *high motivation* profile. None of the cross-group transitions showed any clear trends, which is likely due to the fact that these transitional patterns were less common in the data and thus only refer to a small number of students, resulting in large confidence intervals and uninterpretable results.

Discussion

The present study contributes to the research by employing a person-oriented approach to longitudinally examine the change and stability in motivational profiles among elementary school students in the subjects of math, Finnish language and science. Previous studies have often focused on older students (Chow et al., 2012; Guo, Wang, et al., 2018; Lazarides et al., 2016) or were limited to the subjects math and language (Nurmi & Aunola, 2005; Viljaranta et al., 2016). Furthermore, the study examined gender differences in elementary school students' profile memberships and associations with their occupational aspirations in STEM.

Students' motivational profiles

Results of the present study revealed that elementary school students could be grouped into three distinct motivational profiles, which were characterized by students with high overall motivation, low overall motivation and high math motivation – compared to the sample mean. The *high motivation* and *math-motivated* profiles were in line with our hypotheses and previous findings for secondary school students (e.g. Chow et al., 2012; Chow & Salmela-Aro, 2011; Gaspard et al., 2019; Lazarides et al., 2016; Umarji et al., 2018; Viljaranta, Nurmi, et al., 2009) as well as elementary school students (Nurmi & Aunola, 2005; Viljaranta et al., 2016). Moreover, similar to findings by Viljaranta et al. (2016), we found a profile characterized by low overall motivation in all three subjects, as compared to the sample mean, in early elementary school. In contrast to previous findings for elementary school students in first and second grade (Nurmi & Aunola, 2005; Viljaranta et al., 2016) we did not find subject-specific low motivation profiles, e.g. low-math or low-language motivation profiles. This may be due to different analyses strategies: In the present study, we used latent transition analyses rather than ISOA (I-States as Objects Analysis; Nurmi & Aunola, 2005) and our criterion for selecting the profiles prevented small profiles represented by less than 5% of the children.

It is important to note that we found the same number and kinds of profiles in 2nd and 3rd grade, which suggests that students' motivational hierarchies did not become more differentiated as they progressed from 2nd to 3rd grade. Moreover, we found fewer profiles than previous studies of older students (e.g. Chow et al., 2012; Chow & Salmela-Aro, 2011; Gaspard et al., 2019; Lazarides et al., 2016; Umarji et al., 2018), which supports the hypothesis that younger students do not yet have as differentiated subject-specific motivational hierarchies as older students do. This may be partly due to age differences, as students need time and experience to develop subject-specific preferences. In addition, the Finnish context may play a role, since there is no achievement testing or achievement-related

grouping in Finnish elementary school, which is why students may take longer to develop subject-specific hierarchies in their self-concept of ability and intrinsic values.

Results of the present study showed that the inclusion of the subject science in conjunction with math and language did not change the profile patterns. Thus, in contrast to findings for secondary school students by Chow et al. (2012), high math and science motivation did not co-occur in the present study. Instead, high science motivation tended to co-occur with high overall motivation, whereas students with low science motivation fell into the groups characterized by low overall motivation or high-math motivation – but they did not form their own group. This finding may be explained by the fact that the subject science in elementary school in Finland is very broad and may thus not produce subject-specific motivational profiles. In fact, science in the early grades of Finnish elementary school typically includes the fields biology, geography, physics, chemistry, and health education. In contrast, Chow et al. (2012) focused solely on physics and chemistry in their study, which are in content more closely related to mathematics. Future studies should therefore ask elementary school students about their motivation in life and physical science in order to gain a better understanding of how their motivation in these topics co-occurs with mathematics motivation.

The high overall motivation and high-math motivation profiles identified in the present study align with previous findings based on samples of older students and students from different countries (e.g. Chow et al., 2012; Chow & Salmela-Aro, 2011; Gaspard et al., 2019; Lazarides et al., 2016; Umarji et al., 2018; Viljaranta, Nurmi, et al., 2009). Specifically, these two profiles could be found in previous Finnish studies for the elementary school grades (Nurmi & Aunola, 2005; Viljaranta et al., 2016), but also among older students in Finland (Chow & Salmela-Aro, 2011; Lazarides et al., 2016), the US (Umarji et al., 2018) and Germany (Gaspard et al., 2019). Building on these findings, would be important to

extend studies on students' motivational profiles beyond Western countries. Motivational beliefs are influenced and shaped through the sociocultural context (Eccles & Wigfield, 2020) and can thus be assumed to differ between cultures (Hofstede, 2001). Future research is are thus required to examine the replicability to these findings in other cultures.

Stability of students' motivational profiles over time

Results of the longitudinal latent transition analyses revealed that students' profile membership was relatively stable over one year – roughly 70% of all students in the sample remained in their profiles from 2nd to 3rd grade. This stability in elementary school students' motivational hierarchies was surprising, given that younger students' motivational beliefs are still developing and assumed to change more than older students' motivational beliefs (Wigfield et al., 1997). Stability was strongest in the *high motivation* profile, which also represented the largest group: 48% of the students in our sample had high motivation in all three examined subjects and stayed in this profile from 2nd to 3rd grade. Our finding, that the *high motivation* profile was the largest and most stable profile, was in line with our hypothesis as well as previous findings for elementary school students (Nurmi & Aunola, 2005; Viljaranta et al., 2016). Moreover, the high proportion of highly motivated students in our sample corroborates results of previous variable-oriented studies showing that younger children typically report optimistic ability beliefs and high intrinsic values in all subjects (Eccles et al., 1993; Oppermann, Brunner, Eccles, & Anders, 2018; Wigfield, Eccles, & Rodriguez, 1998). We did not find evidence of a general decrease in students' motivation in all three subjects in early elementary school (Eccles et al., 1993; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). However, our results neither showed that all students remain highly motivated from 2nd to 3rd grade, as a smaller proportion of the students in the *high motivation* group developed motivation in mathematics only (11%) or lower motivational beliefs in all three subjects (12%).

The smaller *low motivation* and *math-motivated* groups were less stable over one year. Students with low motivational beliefs in all three subjects, as compared to the sample mean, showed moderate stability from 2nd to 3rd grade: Although most students (59%) remained in this *low motivation* profile, a number of students also moved to the *high motivation* (28%) or *math-motivated* profiles (13%). Stability was lowest among students in the *math-motivated* profile; these students were likely to move to the *high motivation* profile, which corroborates previous findings by Nurmi and Aunola (2005). Thus, students' preferences for mathematics in 2nd grade was relatively unstable. However, it is important to note that we also found gender differences showing much higher stability in the *math-motivated* profile among boys than girls.

Gender differences in students' motivational profiles

The gender comparison of students' profile membership showed that girls were underrepresented in the *math-motivated* profile compared to the other two profiles. In addition, girls were less likely to remain in and to move to the *math-motivated* profile, whereas boys were less likely to remain in and to move to the *high motivation* profile – which suggests that gender differences became more enhanced as students progressed from 2nd to 3rd grade. These gendered patterns are in line with studies of older students which showed that girls were underrepresented in high-math or high-math-and-science motivation profiles (Chow & Salmela-Aro, 2011; Dietrich & Lazarides, 2019; Ehrtmann et al., 2019; Gaspard et al., 2019; Lazarides et al., 2016; Umarji et al., 2018). Yet, this is the first person-oriented study to reveal gender differences in elementary school children's self-concept and value profiles in 2nd and 3rd grade. In this regard, it is important to note that girls' underrepresentation in the *math-motivated* profile compared to the *high motivation* profile can be considered an advantage rather than a disadvantage for girls: The *math-motivated* profile was characterized by low motivation in Finnish language, as compared to the sample

mean. In fact, students' motivational beliefs in Finnish language in the *math-motivated* profile were even lower than in the *low motivation* profile. Thus, students – often boys – in the *math-motivated* profile developed high motivational beliefs in mathematics but also alienated themselves from Finnish language quite early. In contrast, students – often girls – in the *high motivation* profile were equipped with high intrinsic value and self-concept beliefs in all examined subjects and thus had the "best" preconditions for successful educational pathways in all three subjects. However, studies based on older students in secondary school do typically find that girls also end up dominating in profiles characterized by low math motivation (Chow et al., 2012; Chow & Salmela-Aro, 2011; Gaspard et al., 2019; Guo, Wang, et al., 2018). Future studies should therefore extend the present longitudinal study until the end of elementary school in order to better understand when and how these gender differences in students' motivational hierarchies emerge.

Associations between students' motivational profiles and their STEM aspirations

With regard to the relations between students' motivational profiles and their STEM aspirations, results revealed a clear trend: Students in the *low motivation* and *math-motivated* profiles were, on average, more than twice as likely to named STEM occupations than students in the *high motivation* profile. Although this difference closely missed significance at $p < .05$, the 95%-confidence intervals give more support the hypothesis of group differences ($OR > 1$) than they do for the hypothesis of no differences between the groups ($OR = 1$). When students' profile membership at both timepoints were taken into account, this trend became stronger and statistically significant: The odds of students who remained in the *math-motivated* profile from 2nd to 3rd grade to name STEM aspirations were six times greater than for students who remained in the *high motivation* profile. In contrast, we found no association between the *math-motivated* profile membership or transition pattern and students' STEM+M aspirations. This may be explained by students' perception of medicine

as not being part of STEM fields (Dorph et al., 2018), which are typically math-intensive fields. Our finding that high math motivation, rather than high science motivation, was associated with STEM career aspirations is in accordance with the idea of students' math motivation to act as a "critical filter" (Ma & Johnson, 2008) for their STEM aspirations and choices (see also Watt et al., 2017). In this regard, our result suggest that particularly the interindividual hierarchy of math motivation compared to students' motivation in other subjects, rather than the absolute level of students' math motivation, mattered: Students in the *high motivation* and *math-motivated* profiles did not differ in their absolute scores on their self-concept and intrinsic value beliefs in mathematics (see table A3), but they differed in their relative ranking of their motivation in mathematics compared to the other two subjects. Students who preferred mathematics over Finnish language and science at both time points were significantly more likely to aspire to STEM careers than students who had high motivational beliefs in all three subjects. In line with this finding, results obtained for older students showed that students in profiles characterized by high motivational beliefs only in mathematics and comparatively lower motivational beliefs in other subjects were most likely to report occupational aspirations for physical and IT science jobs (Chow et al., 2012; Guo, Wang, et al., 2018) and to choose a math-intensive STEM majors in their studies (Gaspard et al., 2019).

This pattern, that STEM careers are mostly aspired and chosen by students with high motivation in mathematics and comparatively lower motivation in other subjects rather than by students with high motivational beliefs in all subjects, has been explained with increased options for the latter group: Students with high self-concept and intrinsic value beliefs in several subjects have the opportunity to weigh the pros and cons of pursuing different educational pathways whereas students who are only motivated in mathematics are more likely to choose math-related educational pathways, since they feel most competent and

interested in mathematics (Wang et al., 2013). Importantly, previous research on older students demonstrated that boys are typically overrepresented in this group characterized by high motivation in mathematics and comparatively lower motivation in other subjects and are thus more likely to aspire to STEM careers (Chow et al., 2012; Dietrich & Lazarides, 2019; Guo, Wang, et al., 2018). The present study suggests that this pattern may start to become apparent in elementary school: Boys were overrepresented in the math-motivated group and they were also more likely than girls to keep their preference for mathematics from 2nd to 3rd grade. A stable preference for mathematics over one year, in turn, was associated with students' occupational aspirations in STEM fields. From a developmental perspective, these findings are highly relevant as the elementary school years can be considered a period where girls and boys develop and specify their motivational beliefs as learners as well as their beliefs about the kinds of occupations that they find interesting and achievable (Watson & McMahon, 2005). The gendered motivational hierarchies found in the present study show that these preferences start to differ between boys and girls in elementary school, which may – over time – contribute to the gender differences found among older students' STEM aspirations and choices (Chow et al., 2012; Dietrich & Lazarides, 2019; Guo, Wang, et al., 2018). More research is thus required to investigate the longitudinal associations between girls' and boys' motivational hierarchies and the development of their STEM aspirations in late elementary school and after the transition to secondary school (Archer et al., 2013).

Limitations

The following limitations of the study should be noted: First, we relied on self-report data. Second, the study focused on a relatively short time span of one year (2nd to 3rd grade) and future studies should include earlier and later measurement points. Younger children's motivation and occupational plans can be expected to develop and shape in elementary school as children gradually become more familiar with the different subjects and develop

individual preferences. Thus, longitudinal studies are particularly important in this time period. Third, we lack detailed information about children's background, e.g. socio-economic status. Fourth, the reliability of the measure of children's science self-concept at T1 was slightly below the recommended ranges (Nunnally, 1978). Fifth, we are well aware of the fact that children's occupational aspirations this early in their educational pathways are likely to change as children grow older and acquire more knowledge about career options as well as about their views as learners. Nevertheless, there is evidence to suggest that the general area of aspirations, i.e. STEM vs. non-STEM, remain relatively stable even until secondary school (Archer et al., 2013). Thus, we consider it important to gain a better understanding of how these early occupational aspirations are shaped by students' motivation.

Conclusions

We would like to highlight two findings of the present study that have important implications for future research. First, our study extended variable-centered results showing high mean ability and subject task value beliefs among younger students (Eccles et al., 1993; Oppermann, Brunner, Eccles, & Anders, 2018; Wigfield, Eccles, & Rodriguez, 1998) by studying the heterogeneity in students' motivational beliefs as well as the heterogeneity in the changes of their motivational hierarchies over one year. Using a person-oriented approach, we were able to identify three distinct groups of children with different motivational profiles – and only one of these groups was characterized by high overall motivational beliefs in all three subjects, as compared to the sample mean. From a developmental perspective, this is an important finding, as it shows that not all young students were highly motivated in all three subjects in early elementary school. Moreover, longitudinal results showed that changes in profile membership from 2nd to 3rd grade occurred mostly among the students with low overall or high motivation in math only, as compared to the sample mean. Thus, whereas students with high motivation in all subjects tended to keep that motivation from 2nd to 3rd

grade, more attention should be paid to the students in the other two groups. Specifically, further longitudinal studies are required to gain a better understanding of when these two profiles emerge and how they develop until the end of elementary school. In addition, future studies should investigate influencing factors that could help explain why some students were able to develop and keep high motivational beliefs in 2nd and 3rd grade whereas other students developed subject-specific or overall lower intrinsic value and ability beliefs in early elementary school. Disentangling the significance of different influences, such as classroom characteristics and instructional practices, on the motivational beliefs of students in different profiles could eventually inform educational practice on how to support students adequately in their motivational development.

Second, we identified gender differences in profile membership: In line with previous findings for older children and adolescents, boys dominated in the profile characterized by high motivation in mathematics only (Chow & Salmela-Aro, 2011; Dietrich & Lazarides, 2019; Ehrtmann et al., 2019; Gaspard et al., 2019; Lazarides et al., 2016; Nurmi & Aunola, 2005; Umarji et al., 2018). A stable preference for mathematics over one year, in turn, tended to be linked to STEM aspirations in the present study. This is an interesting finding which corroborates the pattern of results found for older students. It thus seems reasonable to assume that the gendered patterns found in students' motivational hierarchies may get more pronounced as students progress through school and eventually contribute to the gender differences found in older students' STEM aspirations and choices (Chow et al., 2012; Eccles et al., 1983; Gaspard et al., 2019). However, more research is necessary to test these assumptions. In general, more longitudinal studies are required to investigate the longitudinal trajectories of girls' and boys' motivational profiles from elementary school to secondary school. Understanding the emergence and stability of students' motivational profiles from an

early age can help us understand the development of gender differences in students' (STEM)-pathways.

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Table 1

Means and Standard Deviations of the Motivational Variables

	M Grade 2	SD Grade 2	M Grade 3	SD Grade 3
Math self-concept	4.06	0.84	4.11	0.84
Math intrinsic value	4.05	1.08	4.10	1.05
Finnish self-concept	3.99	0.86	4.03	0.85
Finnish intrinsic value	3.79	1.14	3.83	1.03
Science self-concept	3.88	0.81	3.74	0.86
Science intrinsic value	3.86	1.12	3.55	1.22

Note. $N_{\text{Grade 2}} = 293$; $N_{\text{Grade 3}} = 345$. Range is 1-5.

Table 2

Model Fit Criteria of Latent Profile Analyses at Both Measurement Points

Profiles	AIC	BIC	aBIC	aLMR	p aLMR	Profile size ≤ 5%
T1 (2nd grade, *N* = 293)						
1	4997.49	5041.65	5003.60			0
2	4758.49	4828.42	4768.16	246.79	0.020	0
3	4637.83	4733.51	4651.07	131.35	0.076	0
4	4577.53	4698.97	4594.32	72.49	0.332	1
5	4520.40	4667.61	4540.76	69.37	0.690	2
6	4465.03	4638.00	4488.95	67.68	0.360	2
T2 (3rd grade, *N* = 345)						
1	5913.08	5959.20	5921.14			0
2	5629.47	5702.50	5642.23	290.51	0.000	0
3	5467.04	5566.98	5484.50	172.22	0.059	0
4	5368.45	5495.28	5390.60	109.91	0.404	0
5	5306.73	5460.47	5333.58	73.92	0.352	0
6	5269.15	5449.79	5300.70	50.35	0.489	0

Note. AIC = Akaike's Information Criteria; BIC = Bayesian Information Criteria; aBIC = sample-size-adjusted Bayesian information criterion; aLMR = Lo-Mendell-Rubin adjusted likelihood ratio test; profile size ≤ 5% = the number of groups with equal to or less than 5% of the sample.

Table 3

Results of Longitudinal Measurement Invariance Testing

	LL	AIC	BIC	DF	Diff.LL	Diff.DF	*p*
MI	-4978.56	10033.12	10183.15	38			
non-MI	-4971.37	10054.73	10275.83	56	3.02	18	.866

Note. N = 383. MI = measurement invariance model; non-MI = model without invariance constraints. LL = log likelihood statistics. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; DF = degree of freedom; Diff.LL = the difference of likelihood ratio statistics. Diff.DF = the difference of degrees of freedom.

Table 4

Profile Stability: Percentages and Transition Probabilities (in Parentheses)

	T2 (3rd grade)		
	Low motivation	High motivation	Math-motivated
T1 (2nd grade)			
Low motivation	13.5% (.59)	6.3% (.28)	2.9% (.13)
High motivation	7.1% (.12)	47.5% (.77)	6.9% (.11)
Math-motivated	0.6% (.04)	6.5% (.41)	8.8% (.55)

Note. $N = 383$.

Table 5

Effect of Gender on Latent Profile Membership

	OR	*SE*	*95% CI*
T1 (N = 293)			
Low motivation vs. high motivation	1.23	0.39	[0.67;2.29]
Math-motivated vs. high motivation	0.31***	0.14	[0.12;0.76]
Math-motivated vs. low motivation	0.25***	0.12	[0.09;0.65]
T2 (N = 345)			
Low motivation vs. high motivation	1.37	0.52	[0.65;2.56]
Math-motivated vs. high motivation	0.30***	0.13	[0.13;0.72]
Math-motivated vs. low motivation	0.22***	0.12	[0.08;0.62]

Note. 0 = boys/1 = girls; OR = odds ratios, *SE* = standard error, *95% CI* = 95% confidence intervals, *$p < 0.05$. ** $p < 0.01$, *** $p < 0.001$.

Table 6

Estimated Transition Probabilities by Gender

	T2 (3rd grade)					
	boys			*girls*		
	Low	High	Math	Low	High	Math
T1 (2nd grade)						
Low	.53	.27	.20	.57	.30	.13
High	.08	.72	.21	.12	.83	.05
Math	.02	.41	.57	.07	.52	.42

Note. Low = Low motivation, high = high motivation, math = Math-motivated.

Table 7

Profile Membership at T2 and Occupational Aspirations at T2

	STEM+M		*STEM*	
	OR *(SE)*	*95% CI*	*OR*	*95% CI*
Low motivation vs. high motivation	0.94 (0.41)	[0.41;2.18]	2.55 (1.37)	[0.89;7.33]
Math-motivated vs. high motivation	0.90 (0.38)	[0.38;2.08]	2.11 (1.14)	[0.73;6.08]
Math-motivated vs. low motivation	0.95 (0.53)	[0.32;2.83]	0.83 (0.52)	[0.24;2.81]

Note. N = 345. OR = odds ratios, *SE* = standard error, *STEM+M* = STEM including medicine.

Table 8

Profile Transitions and Occupational Aspirations at T2

	STEM+M		*STEM*	
Transitions from T1 to T2	OR *(SE)*	*95% CI*	OR *(SE)*	*95% CI*
Low -> low vs. low -> high	1.96 (3.07)	[0.09;42.36]	-	
Low -> low vs. high -> low	1.39 (1.28)	[0.23;8.45]	2.94 (3.00)	[0.40;21.71]
Low -> low vs. high -> high	0.74 (0.40)	[0.26;2.14]	2.82 (1.54)	[0.97;8.23]
Low -> low vs. high -> math	2.15 (3.68)	[0.08;61.52]	-	
Low -> low vs. math -> high	1.14 (1.15)	[0.16;8.22]	3.00 (3.77)	[0.26;35.18]
Low -> low vs. math -> math	0.46 (0.39)	[0.09;2.43]	0.48 (0.35)	[0.11;2.02]
Low -> high vs. high -> low	0.71 (1.03)	[0.04;11.36]	-	-
Low -> high vs. high -> high	0.38 (0.52)	[0.03;5.49]	-	
Low -> high vs. high -> math	1.10 (2.37)	[0.02;74.98]	-	
Low -> high vs. math -> high	0.58 (1.07)	[0.02;21.42]	-	
Low -> high vs. math -> math	0.23 (0.34)	[0.01;3.96]	-	
High -> low vs. high -> high	0.54 (0.41)	[0.12;2.36]	0.96 (0.94)	[0.14;6.51]
High -> low vs. high -> math	1.55 (2.96)	[0.04; 65.79]	-	
High -> low vs. math -> high	0.82 (0.98)	[0.08;8.57]	1.02 (1.51)	[0.06;18.56]
High -> low vs. math -> math	0.33 (0.31)	[0.05;2.07]	0.16 (0.18)	[0.02;1.36]
High -> high vs. high -> math	2.90 (4.94)	[0.10;82.25]	-	
High -> high vs. math -> high	1.53 (1.61)	[0.20;12.03]	1.06 (1.33)	[0.09;12.28]
High -> high vs. math -> math	0.61 (0.43)	[0.16;2.39]	**0.17 (0.11)**	**[0.05;0.63]**
High -> math vs. math -> high	0.53 (1.04)	[0.01;24.89]	-	
High -> math vs. math -> math	0.21 (0.44)	[0.00;12.31]	-	
Math -> high vs. math -> math	0.40 (0.50)	[0.04;4.54]	0.16 (0.21)	[0.01;2.45]

Note. N = 383. Low = Low motivation, high = high motivation, math = Math-motivated; OR = odds ratios, *SE* = standard error, *STEM+M* = STEM including medicine. Transition patterns that did not exist in the data could not be tested and are therefore not reported. Note that for some combinations of transition patterns there was no variance in students' STEM aspirations and thus no odds ratios of aspiring to STEM careers could be computed (indicated by "-").

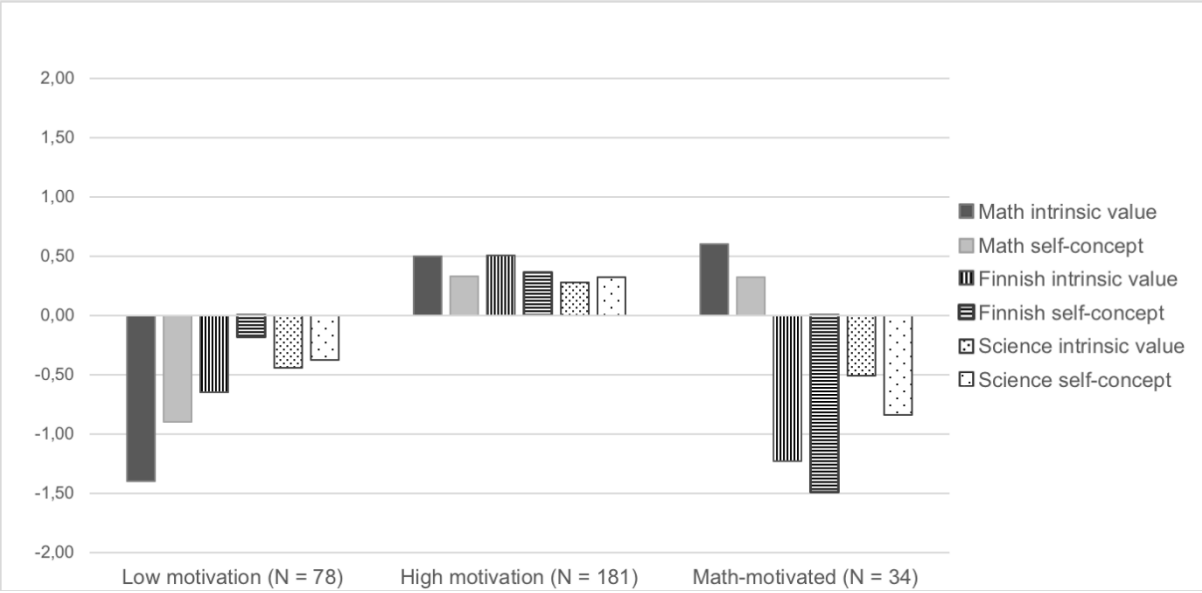


Figure 1. Profiles of students' intrinsic value and self-concept scores at T1 (z-standardized values).

Appendix

Table A1

Bivariate Correlations between the Indicator Variables at Both Measurement Points

		1	2	3	4	5	6
T1 (N = 293)							
1	Math intrinsic value	-					
2	Math self-concept	.58**	-				
3	Finnish intrinsic value	.34**	.12*	-			
4	Finnish self-concept	.05	.21**	.60**	-		
5	Science intrinsic value	.25**	.09	.39**	.11	-	
6	Science self-concept	.16**	.32**	.33**	.46**	.54**	-
T2 (N = 345)							
1	Math intrinsic value	-					
2	Math self-concept	.68**	-				
3	Finnish intrinsic value	.26**	.10	-			
4	Finnish self-concept	.01	.21**	.57**	-		
5	Science intrinsic value	.28**	.07	.37**	.12*	-	
6	Science self-concept	.15	.25**	.25*	.48**	.57**	-

Note. *$p < 0.05$. ** $p < 0.01$, *** $p < 0.001$.

Table A2

Means (M) and Standard deviations (SD) for the Indicator Variables (Standardized Values) by Profile at Both Measurement Points

	Low motivation		High motivation		Math-motivated	
T1 (N = 293)	M	SD	M	SD	M	SD
Math intrinsic value	-1.40	0.68	0.50	0.47	0.60	0.38
Math self-concept	-0.90	0.91	0.33	0.83	0.32	0.76
Finnish intrinsic value	-0.65	0.95	0.51	0.58	-1.23	0.94
Finnish self-concept	-0.18	0.85	0.36	0.76	-1.49	0.99
Science intrinsic value	-0.44	1.07	0.28	0.81	-0.51	1.19
Science self-concept	-0.38	1.00	0.32	0.83	-0.84	1.09
T2 (N = 345)	M	SD	M	SD	M	SD
Math intrinsic value	-1.71	0.76	0.33	0.64	0.37	0.55
Math self-concept	-1.38	0.89	0.25	0.79	0.31	0.69
Finnish intrinsic value	-0.76	0.95	0.50	0.61	-1.23	0.75
Finnish self-concept	-0.33	1.07	0.39	0.71	-1.18	0.86
Science intrinsic value	-0.58	0.97	0.33	0.84	-0.70	1.04
Science self-concept	-0.46	0.93	0.31	0.87	-0.77	0.95

Note. Mean scores are z-standardized.

Table A3

Means (M) and Standard Deviations (SD) for the Indicator Variables (Unstandardized Values) by Profile at Both Measurement Points as well as Significance Test of Mean Differences

	Low motivation		High motivation		Math-motivated	
T1 (N = 293)	M	SD	M	SD	M	SD
Math intrinsic value	2.54	0.73	4.59_a	0.51	4.70_a	0.41
Math self-concept	3.30	0.77	4.33_a	0.69	4.32_a	0.63
Finnish intrinsic value	3.06	1.08	4.38	0.66	2.40	1.07
Finnish self-concept	3.84	0.72	4.29	0.65	2.71	0.87
Science intrinsic value	3.37_a	1.19	4.18	0.91	3.29_a	1.33
Science self-concept	3.58_a	0.81	4.14	0.67	3.21_a	0.88
T2 (N = 345)	M	SD	M	SD	M	SD
Math intrinsic value	2.32	0.80	4.46_a	0.67	4.50_a	0.58
Math self-concept	2.97	0.76	4.33_a	0.66	4.39_a	0.58
Finnish intrinsic value	3.08	0.97	4.36	0.63	2.59	0.77
Finnish self-concept	3.75	0.92	4.36	0.59	3.04	0.74
Science intrinsic value	2.86_a	1.16	3.95	1.02	2.72_a	1.25
Science self-concept	3.35_a	0.81	4.01	0.75	3.08_a	0.82

Note. Range is 1-5. We used the Tamhane T2 posthoc test which is robust to unequal samples sized and variances across groups to test for mean differences. Means within a row sharing the same subscripts are not significantly different at the $p < .05$ level.