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Growth trajectories of self-concept and interest in mathematics and language – Individual differences and cross-domain relations

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Background: Motivational beliefs seem to decline for many during adolescence. Although this may reflect a mismatch between students' needs and the secondary schools' resources, general declines may also stem from increased dimensional comparison processes: students' motivational beliefs tend to become increasingly domain-specific during adolescence. Yet, inter- and intraindividual differences in students' co-developmental processes of self-concept and interest across domains have rarely been studied.
Aim: This study examined what kinds of developmental trajectories of self-concept and interest in mathematics and L1 can be identified among adolescents across lower-secondary education, and whether trajectories and cross-domain relations differ between genders.
Sample: We followed 612 students across Grades 7–9 (13–15-year-olds).
Methods: Growth mixture models were applied to identify distinct motivational trajectories of math and L1 self-concept and interest across Grades 7–9. Multi-group growth models were used to compare growth trajectories and cross-domain relations between genders.
Results: Students' development in math and L1 motivation were rather homogenous across grades 7–9, and many experienced declines in their motivation after entering Grade 7. Yet, there was a clear differentiation across domains among girls: their L1 motivation was significantly higher than their math motivation. For both boys and girls, several negative cross-domain relations between math and L1 motivation were detected.
Conclusion: The findings should be considered when supporting students' motivation in schools. Dimensional comparisons coupled with gendered stereotypes may unnecessarily hinder some students from engaging in math and aspiring for math-related career alternatives, despite having high performance in math.

1. Introduction

According to prominent theories of motivation such as expectancy-value theory (Eccles & Wigfield, 2020), students' competence perceptions and interests are considered key predictors of students' academic aspirations and choices, and various achievement-related behaviors (i.e., academic performance) (Wigfield et al., 2020). Yet, during secondary education, when adolescents are in the process of making important decisions about their future, students' motivation seems to decline on average (Archambault, Eccles, & Vida, 2010; Gaspard, Lauermann, Rose, Wigfield, & Eccles, 2020; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). Some have argued that the negative trends in students' motivation may reflect a misfit between their needs and the resources provided by the lower-secondary school environment (Eccles & Roeser, 2009).

However, changes in their motivation may also be rooted in increasing intraindividual differentiation in competence perceptions and interests across domains (Möller, Zitzmann, Helm, Machts, & Wolff, 2020; Wan, Lauermann, Bailey, & Eccles, 2021). As adolescents become increasingly aware of their abilities and their interests become more specialized, they likely maintain high self-concept and interest in only a few domains, while disengaging from others. Such differentiation seems to occur particularly between mathematical and verbal domains (Möller et al., 2020; Wan et al., 2021). Yet, although there is likely to be variation in the direction and rate of change in students' competence perceptions and interests, few studies have considered the inter- or

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intraindividual differences in students' motivational trajectories across domains. Given also some persistent gender differences in both mathematics and language (L1) domains (Guo, Wang, Ketonen, Eccles, & Salmela-Aro, 2018; Guo, Marsh, Morin, Parker, & Kaur, 2015; Jacobs et al., 2002; Marsh, Ellis, Parada, Richards, & Heubeck, 2005), it seems relevant to take gender into account while studying such developmental processes. Complementing previous research, the aim of this study was to examine what kinds of developmental trajectories of self-concept and interest in mathematics and L1 can be identified among adolescent students across lower secondary education. In addition, we aimed to study whether adolescents' developmental trajectories and cross-domain relations between mathematics and L1 self-concept and interest differ between boys and girls.

1.1. Dimensional comparisons and gendered motivational beliefs

As students grow older, especially around the adolescent years, their competence perceptions and interests tend to become increasingly differentiated across domains (Wan, Lauermann, Bailey, & Eccles, 2023). This differentiation seems to occur particularly between math and language (L1) domains, as reflected in declining correlations between math and L1 competence perceptions over the school years (Wan et al., 2021) and is thought to be rooted in intraindividual dimensional comparison processes. Initially, Marsh developed the external and internal frame of reference model (I/E: Marsh, 1986) to explain findings that students tend to report higher motivation in either math or verbal domains, despite performing well in both (Möller et al., 2020). According to the I/E model, students make external (social) comparisons while comparing their performance in one domain to other students' performances, which would explain the positive relations commonly found between performance (e.g., math) and corresponding competence perception (e.g., math self-concept). However, students also make internal (dimensional) comparisons; they evaluate their performance in one domain (e.g., math) in relation to another (e.g., L1), sometimes leading to negative predictions between performance and competence perceptions across domains. Hence, if students consider themselves to be good at math, they may develop lower L1 self-concept, and vice versa (Möller, Pohlmann, Köller, & Marsh, 2009).

Several studies have since confirmed the assumptions proposed by the I/E model (Möller et al., 2020; Wu, Guo, Yang, Zhao, & Guo, 2021), and it has been suggested that dimensional comparison processes explain not only the relations between performance and self-concept, but also the relations between various psychologically related constructs across domains (e.g., between domain-specific value-beliefs) (Arens, Schmidt, & Preckel, 2019; Guo, Parker, Marsh, & Morin, 2015; Möller & Marsh, 2013; Wigfield, Eccles, & Möller, 2020). For example, Guo et al. (2018) studied the developmental relations between value beliefs in the domains of math and science and Finnish through growth modeling and found that initial high values in Finnish were negatively related to the growth rates of math values, and vice versa.

Cross-domain comparison processes are also assumed to be one of the main reasons behind gender differences in students' motivational beliefs and educational and career choices, and studies consistently show that boys tend to report higher self-concept and interest in mathematics, whereas girls tend to value verbal domains more (Guo et al., 2018; Guo, Marsh, et al., 2015; Jacobs et al., 2002; Marsh et al., 2005). Overall, these gender differences may be due to the fact that both self-concept and interest represent personal beliefs and values that are prone to stereotypical identifications and biases (Eccles, 2009). Students' beliefs about what they should be good at and which values are desirable within their reference group are shaped by stereotypical expectations and values of their culture, parents, teachers, and peer groups (Cvencek, Meltzoff, & Greenwald, 2011; Master, 2021; Tomasetto, Mirisola, Galdi, & Cadinu, 2015). One of the most influential reference groups students identify with is gender, and math, for example, is still often considered a "male subject" (Cvencek, Kapur, & Meltzoff, 2015). It has also been suggested that gender-role activities grow more prominent during adolescence as students try to conform more to gender-role stereotypes (Eccles, 1987; Hill & Lynch, 1983).

1.2. Development of self-concept and interest

Several studies have demonstrated an average decline in students' competence perceptions and interests across the school years, and these have been found in both math and L1 domains (Archambault et al., 2010; Gaspard et al., 2020; Jacobs et al., 2002). For example, Fredricks and Eccles (2002) and Jacobs et al. (2002) studied development of math and English self-concept and interest across grades 1–12. They found that math self-concept and interest continued to decline across grades (Fredricks & Eccles, 2002; Jacobs et al., 2002), whereas L1 self-concept and interest followed a decline that leveled off towards adolescence (Jacobs et al., 2002). Both studies also found that the development of students' motivational beliefs seemed to differ between genders. Fredricks and Eccles (2002) showed that gender predicted changes in mathematics self-concept, as girls' perceptions of their math ability declined at a slower rate than boys', resulting in similar competence beliefs in math at the end of high school. Jacobs et al. (2002) found that girls' self-concept in the L1 domain declined more slowly and steadily over time than boys'.

Neither Fredricks and Eccles (2002) nor Jacobs et al. (2002) found a gender effect on the rate of change in math or L1 interest. Yet, more recently, Guo et al. (2018) found that boys were more likely than girls to show an increase in math and science values across upper secondary education, whereas girls were more likely to show an increase in language and social studies values and declines in math value.

Generally, shifts in students' motivational beliefs may likely be rooted in developmental changes related to adolescence (e.g., entering puberty), increased academic demands during secondary school, and a mismatch between the developmental stage of the students and the support provided by the educational environment (Eccles & Roeser, 2009). However, some of the negative changes may stem from increased dimensional comparisons (Gaspard et al., 2020; Wigfield et al., 2020). Through differentiation, students begin to specialize in some domains and disengage from others during adolescence. As a result, they are likely to maintain high competence and value beliefs in only a few selective domains. Thus, while this may show up as an average decline in students' self-concept and interest in the group as a whole, there is likely to be variation in the direction and rate of change. Yet, most previous studies investigating the development of students' motivational beliefs have focused on average group-level trends (Fredricks & Eccles, 2002; Marsh et al., 2018), or studied cross-domain relations for the whole sample (Arens et al., 2019; Viljaranta, Tolvanen, Aunola, & Nurmi, 2014). Longitudinal, person-centered studies focusing on identifying distinct developmental motivational trajectories among students are scarce or have only studied the development of a single (e.g., math: Musu-Gillette, Wigfield, Harring, & Eccles, 2015) or one general academic domain (academic self-concept: Guay et al., 2022).

Guo et al. (2018), however, utilized growth mixture modeling to study developmental trajectories of intrinsic value in language (Finnish), social studies, and jointly in math and science among upper secondary students (16–18-year-olds). They identified three trajectory profiles: a group of students with high intrinsic value in all domains that decreased over time, a group with relatively low initial value beliefs in all domains, but with an increasing math and science trajectory, and lastly, a group with substantially distinct developmental trajectories across domains: increasing intrinsic value in Finnish and social subject but decreasing math and science value. Another study using a similar approach was reported by Gaspard et al. (2020), and they also identified distinct trajectory profiles of math and L1 self-concept and intrinsic value (studied separately). They found that the majority of students belonged to a moderate math decline/stable L1 self-concept profile across grades 1–12, while another profile showed a moderate math decline but a strong L1 self-concept decline. While studying intrinsic value, three profiles were detected: strong math and moderate L1 decline, a moderate math decline and strong L1 decline, and one profile with stable intrinsic value in both math and L1. In sum, these findings highlight that both inter- and intraindividual differences in domain-specific motivational beliefs may be detected among students.

1.3. The present study

The development of students' competence perceptions and interests and cross-domain relations have been relatively well-studied over the years, but research gaps still exist. Although findings highlight the importance of investigating students' self-concept and interests jointly across domains, relatively few have utilized growth modeling techniques to study the co-developmental processes of students' motivational beliefs across domains. Even fewer have adopted person-centered approaches, although there are indications that both inter- and intraindividual differences in students' self-concept and interest trajectories exist. In addition, considering some consistent gender differences in both mathematics and L1, it seems relevant to investigate whether such differences might be rooted in dimensional comparison processes between genders.

To complement prior knowledge, the aim of this study was to explore both inter- and intraindividual differences in students' trajectories of mathematics and language (L1) self-concept and interest across lower secondary education. We utilized both latent growth models (LGM) and growth mixture modeling (GMM) techniques, as these approaches are able to capture both average trends in students' self-concept and interest, inter-individual differences among students (e.g., qualitatively distinct developmental profiles of self-concept and interest), and also, intraindividual differences (different developmental trends across math and L1 domains within students). The following research questions were addressed:

First (RQ1), we wanted to examine what kinds of trajectory profiles of self-concept and interest in mathematics and L1 could be identified among adolescents across lower secondary education. Based on assumptions proposed by dimensional comparison theory (Möller & Marsh, 2013; Wan et al., 2023; Wigfield et al., 2020), we expected that intraindividual differences in students' motivational beliefs across domains would be detected among students. In other words, students were expected to experience a decrease only in one academic domain (e.g., math), whereas the other domain (e.g., L1) would remain stable or even increase, or vice versa (H1a). Also, based on findings by Guo et al. (2018) and Gaspard et al. (2020), inter-individual differences among students were also expected to emerge (H1b). We expected to find distinct developmental profiles of math and L1 motivation, for example, some profiles showing an increase in math self-concept and interest, while they might decline for others. However, due to the scarcity of previous person-centered studies, no specific hypotheses were set for the distinct profiles.

Second (RQ2), we wanted to examine whether adolescents' developmental trajectories and cross-domain relations between mathematics and L1 self-concept and interest differed between genders. We expected to find different developmental trajectories of math and L1 motivation for boys and girls. Based on previous findings, we expected that boys would have higher levels of math self-concept and interest, and more favorable development in math motivation as compared to girls (H2a, Guo et al., 2018). Girls, on the other hand, were expected to show higher levels and more positive development in L1 self-concept and interest (H2b, Guo et al., 2018).

Furthermore, based on the I/E model and dimensional comparison processes, we expected to find negative cross-domain relations between the initial levels of self-concept and interest in one domain (i.e., intercept) and the developmental rate of the other domain (i.e., slope), even when controlling for students' achievement in both domains (Arens et al., 2019; Marsh, 1986) (H2c). However, as cross-domain relations between math and L1 self-concept and interest growth rates have rarely been studied separately for boys and girls, no specific hypotheses were set regarding potential gender differences in these relations.

2. Methods

2.1. Participants and procedure

Data came from a longitudinal research project FRAM [Students' well-being and learning in future society] at the Åbo Akademi University. Five public lower secondary schools from different regions of Swedish-speaking[1] areas of Finland participated in the data collection. APA ethical standards and the guidelines of the Finnish National Board on Research Integrity (TENK) were carefully followed in the conduct of the whole project. Participation in the study was voluntary, informed consent forms were collected from the student's parents, and the participants were assured of the confidentiality of their responses. In Finland, lower secondary education spans from Grade 7 to Grade 9, after which the students can make an important decision about whether they opt for vocational or general upper secondary education. In this study, students first participated at the beginning (T1, fall 2016, $M_{age} = 13.3$, $SD = 0.39$) and the end (T2, spring 2017) of seventh grade and were followed up again at the beginning (T3, fall 2018) and end (T4, spring 2019, $M_{age} = 15.8$, $SD = 0.39$) of ninth grade, that is, the last year of comprehensive school. All measures were conducted by trained research assistants during school hours in students' own classrooms. All students who participated at least once were included in this study, resulting in a total of 612 students (50.3% boys), representing approximately 18% of the Swedish-speaking sub-population in Finland within this grade level. Of the total sample, 95% of students participated at least twice in the measurement points and Little's MCAR tests revealed that the missing data patterns of the four time points were missing completely at random (MCAR) (χ^2 (2458) = 2553.952, $p = 0.087$). The maximum likelihood approach with robust standard errors implemented in Mplus was used to deal with missing data.

2.2. Measures

2.2.1. Self-concept and interest

Self-concept and interest in both mathematics and L1 were assessed at all four measurement points with Marsh's (1992) Self Description Questionnaire I (SDQ I, see also Arens & Hasselhorn, 2015; Pinxten, Marsh, De Fraine, Van Den Noortgate, & Van Damme, 2014). Three items per domain captured students' individual interest (e.g., *I like math/Language arts*) and three items per domain captured students' self-concept (e.g., *I am good at math/Language arts*), both domains referring to the school subjects. The students were asked to evaluate how well the statements described them using a five-point Likert scale ranging from one (false) to five (true). The reliability estimates (Cronbach's alpha) for each variable and time point ranged between 0.88 and 0.95 (see Appendix, Table A1) and were thus all considered good or excellent.

2.2.2. Performance

Students' performance in mathematics and L1 were represented by students' teacher-rated grades in both domains. The grades represent students' overall performance within that school year, with respect to the criteria provided by the national curriculum. The grades were collected directly from the school register. T-tests were initially performed in SPSS to identify any gender differences in students' performance at the beginning (seventh grade) and at the end (ninth grade) of

[1] Swedish is the second official language in Finland, spoken by 5.3% of the population. Finnish and Swedish-speaking schools follow the same national curriculum.

lower secondary education (Table A2 in the Appendix). Girls had higher grades in math and L1 both at the beginning and at the end of lower secondary education. Grades in math and L1 from seventh grade were therefore used as covariates when evaluating gender differences in the development of students' motivational beliefs.

2.3. Data analysis strategy

2.3.1. Preliminary analyses

Descriptive statistics, correlations, and internal consistencies of all measures at each time point are reported in Table A1 in the Appendix. Furthermore, cross-sectional confirmatory factor analyses (CFA) were conducted on all measures to verify the structural validity of the constructs (Table 1). Measurement invariance (Table A3 and A4 in the Appendix) of self-concept and interest in mathematics and L1 over time and between genders was confirmed through longitudinal and multiple group CFAs. All CFAs were performed in Mplus, and in all analyses, chi-square (χ^2), the comparative fit index (CFI; a recommended value close to > 0.95), the Tucker–Lewis Index (TLI; a recommended value close to > 0.95), the root mean square error of approximation (RMSEA; a recommended value close to < 0.05), and standardized root mean squared residual (SRMR; recommended value < 0.08) were used as model-fit indices (Marsh, Hau, & Wen, 2004).

2.3.2. Main analyses

To examine the developmental trajectories of self-concept and interest in mathematics and L1, we will estimate a series of latent growth models (LGM) within the structural equation modeling framework (Duncan, Duncan, & Strycker, 2013). In these models, latent factors representing the initial level (intercept) and change over time (slope) are estimated based on repeated observed measures. Here, the slope will be specified by fixing the loadings of observed variables from Time 1 to Time 4 to 0, 1, 4, and 5, respectively, to account for the intermediate time differences between measurement points (representing fall and spring in both seventh and ninth grade). Both linear and quadratic slopes will be estimated to take into account possible non-linear trends. The onset of the slope will be estimated by constraining the loadings of all time points on the intercept factor equal to one. All analyses will be conducted in Mplus (version 8).

Next, based on the latent growth model chosen in the first step (linear and/or quadratic growth trajectories for each construct), a series of growth mixture models (GMM) will be estimated to determine the presence of unobserved sub-groups of individuals who exhibit different patterns of change in self-concept and interest in mathematics and L1 from seventh to ninth grade (RQ1). In other words, GMMs will be conducted to explore the extent to which distinct trajectory classes of self-concept and interest in mathematics and L1 can be identified based on the latent intercept (i.e., initial level) and slope (i.e., rate of change) factors so that each class defines a different trajectory over time. Models will be compared with increasing numbers of classes, and comparisons across models will be based on the Bayesian information criterion (BIC) fit statistics, the Vuong–Lo–Mendell–Rubin (VLMR) likelihood ratio test, and entropy values. A lower BIC value is considered to provide a better fit to the data, and a resulting p-value of less than 0.05 for VLMR suggests that the estimated model is preferable over the reduced model (Lo, Mendell, & Rubin, 2001). The entropy value ranges from 0 to 1, with values > 0.70 indicating good classification accuracy. Furthermore, the usefulness and interpretableness of the latent classes (e.g., the number of individuals in each class) will also be considered when choosing the best fitting model.

Regarding the second aim (RQ2), in case we identify several trajectory classes in the initial GMMs, gender will be added to the GMM models as a covariate to determine the effect of gender on distinct trajectory profiles. In case a single-profile solution describes the data best, a multigroup latent growth model will be estimated to investigate whether boys' and girls' developmental trajectories and cross-domain relations between self-concept and interest in math and L1 differ. Students' grades in math and L1 will also be included as covariates to account for the effect of students' performance on the initial level and rate of change of their motivational beliefs over time. The Wald chi-square test will be used to test if significant growth parameters differ across genders (Wang & Wang, 2019).

3. Results

3.1. Growth trajectories of self-concept and interest

The analysis started with exploring the functional form of growth in students' self-concept and interest in each domain. LGMs including a linear growth factor were compared with models including both a linear and quadratic growth factor. We found that for mathematics self-concept and interest, the models that included both a linear and a quadratic growth factor fitted the data better, and the means of the quadratic slopes were significant. Regarding self-concept and interest in L1, neither the means nor the variances of the quadratic slope factors were significant, and the models including only a linear growth factor fitted the data better. Consequently, a model that included both a linear and a quadratic growth factor was chosen for self-concept and interest in mathematics, whereas a model that included only a linear growth factor was chosen for self-concept and interest in L1 (see Table 2 for estimates).

After confirming the best fitting LGM for each construct, all constructs were combined into the same model. The combined LGM also fitted the data well, χ^2 (63) = 118.866, $p < 0.001$, CFI = 0.989, TLI = 0.979, RMSEA = 0.038, SRMR = 0.034, and the best log likelihood value was replicated, but the model produced a warning involving the quadratic growth factors in mathematics self-concept and interest, implying that the latent variable covariance matrix (i.e., the variance–covariance matrix) was not positive definite. To address this issue, the variances of the quadratic growth factors in mathematics self-concept and interest were fixed to zero, as there was no significant variance in these growth factors based on the initial models. This model also fitted the data well, χ^2 (82) = 150.827, $p < 0.001$, CFI = 0.986, TLI = 0.980, RMSEA = 0.037, SRMR = 0.042.

3.2. Trajectory profiles of self-concept and interest

Next (RQ1), growth mixture models were applied to examine whether distinct latent trajectory groups of students could be identified

Table 1
Confirmatory factor analysis.

Measure	Time point	N	χ^2	df	CFI	TLI	RMSEA	SRMR	p
Math self-concept and interest	1	581	12.480	8	.998	.996	.031	.016	.131
	2	554	18.109	8	.995	.991	.048	.018	.020
	3	454	17.007	8	.995	.991	.050	.018	.030
	4	447	11.015	8	.999	.997	.029	.011	.201
Language self-concept and interest	1	579	29.118	8	.987	.975	.068	.020	.000
	2	554	21.676	8	.993	.987	.056	.018	.006
	3	455	20.341	8	.990	.982	.058	.022	.009
	4	445	22.503	8	.990	.982	.064	.022	.004

Table 2
The goodness of fit statistics and parameter estimates for different growth models.

Measure	Model	χ^2	*df*	CFI	TLI	RMSEA	SRMR	*p*	Intercept		Linear slope		Quadratic slope	
									Mean	Variance	Mean	Variance	Mean	Variance
Math self-concept	Linear	57.508	5	.922	.907	.131	.096	.000	3.61*	0.67*	−0.06*	0.02*		
	Linear & quadratic	5.626	1	.993	.959	.087	.015	.017	3.66*	0.70*	−0.22*	0.07	0.04*	0.00
Math interest	Linear	16.349	5	.989	.987	.061	.035	.006	2.74*	1.07*	0.01	0.03*		
	Linear & quadratic	0.001	1	1.00	1.00	.000	.000	.980	2.79*	1.04*	−0.12*	0.02	0.03*	0.00
L1 self-concept	Linear	28.620	5	.973	.968	.088	.079	.000	3.72*	0.56*	−0.03*	0.01*		
	Linear & quadratic	19.583	1	.979	.873	.174	.031	.000	3.73*	0.46*	−0.03	−0.01	0.00	0.00
L1 interest	Linear	39.115	5	.961	.953	.106	.049	.001	3.01*	0.94*	0.02*	0.03*		
	Linear & quadratic	35.755	1	.960	.762	.238	.042	.000	3.01*	0.89*	0.03	0.03	0.02	0.00

Note. *$p < 0.05$.

based on their development of self-concept and interest in mathematics and L1 from seventh to ninth grade. Up to four profiles were tested, but the results revealed that a one-class solution described the data best. Although the entropy values indicated good classification accuracy for models with additional classes, the BIC continued to increase, indicating that the one-class model described the data best. The VLMR likelihood ratio test supported this conclusion, as models with several classes did not show to be preferable over the initial one-class model. Fit indices are presented in Table 3 and growth trajectories of the one-class solution are depicted in Fig. 1 (calculated based on latent intercept and slope means).

The growth trajectories revealed that significant declines (linear slopes) occurred in both math and L1 self-concept from seventh to ninth grade, although the quadratic trend of math self-concept was positive, indicating that the negative trend subsided towards the end of lower secondary school. The initial levels of math and L1 interest (i.e., intercepts) were significantly lower compared to the initial levels of self-concept, in both domains. Interestingly, the trajectories of math and L1 interest differed: while there was a significant decline in math interest, followed by a positive quadratic trend, L1 interest slightly increased from seventh to ninth grade among students.

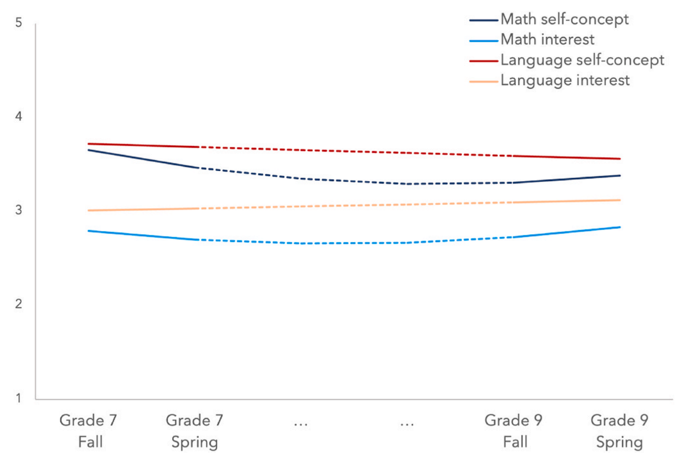

Fig. 1. Growth trajectories of self-concept and interest in mathematics and language (L1).
Note. The dotted lines represent model-based estimates (not empirical).

3.2.1. Gendered trajectories of self-concept and interest

Since a one profile solution described the data best in the initial GMMs, we continued with a multigroup latent growth model to compare boys' and girls' trajectories and cross-domain relations between self-concept and interest in mathematics and L1. The multiple group LGM fitted the data well, χ^2 (164) = 210.678, $p = 0.008$, CFI = 0.991, TLI = 0.986, RMSEA = 0.030, SRMR = 0.052. The Wald test revealed that girls' initial levels of mathematics self-concept ($x^2 = 44.518$, $p < 0.01$) and interest ($x^2 = 15.345$, $p < 0.01$) were significantly lower than for boys, but there were no significant differences in the slopes of either self-concept or interest in math. In L1, a significant difference was found in the slope of self-concept ($x^2 = 6.376$, $p < 0.05$), as girls' L1 self-concept remained relatively stable, whereas it followed a steeper decline among boys. Girls' initial level of L1 interest was also significantly higher than boys' ($x^2 = 9.399$, $p < 0.05$). The gendered trajectories are visualized in Fig. 2.

In a second step, grades in math and L1 were included as covariates in the model, set to predict all latent intercept and linear slope factors. This was done to control for students' initial performance while examining the cross-domain relations between motivational beliefs in math and L1. This model also fitted the data well, χ^2 (196) = 255.734, $p = 0.003$, CFI = 0.990, TLI = 0.984, RMSEA = 0.032, SRMR = 0.050, and it did not substantially change the motivational trajectories (see Figure A1 in the Appendix). The significant estimates of the final model, showing the cross-domain relations, are depicted in Fig. 3 for boys and Fig. 4 for girls.

When examining cross-domain correlations, negative associations were found between math and L1 self-concept for both boys and girls: seventh-grade mathematics self-concept (i.e., intercept) was negatively related to their L1 self-concept development (i.e., linear slope), and vice versa. For boys, their initial level of math interest was also negatively related to their L1 interest development, whereas for girls, the opposite relation was found: higher initial interest in L1 in seventh grade was related to more negative development in math interest across lower secondary school.

Table 3
Fit indices for different developmental profile solutions.

Number of classes	Entropy	BIC	SABIC	p_{VLMR}	*N*
1	–	18188.307	17966.071		612
2	0.692	18212.796	17955.638	0.3521	98, 514
3	0.705	18218.130	17926.050	0.1471	200, 333, 79
4	0.735	18247.024	17920.020	0.6462	233, 1, 73, 305

4. Discussion

The aim of this study was to examine both inter- and intraindividual differences in students' trajectories of self-concept and interest in mathematics and language (L1) during lower secondary education. Contrary to our expectations (RQ1) our main findings suggest that although significant variance seemed to occur in the overall levels of self-concept and interest among students, their growth rates were relatively homogenous, showing that the majority of students experienced some decline in their motivational beliefs after entering lower secondary education. However, when we looked at motivational development separately by gender (RQ2), we found a pronounced differentiation in girls' domain specific self-concept and interest development that was not evident among boys, while negative cross-domain relations were

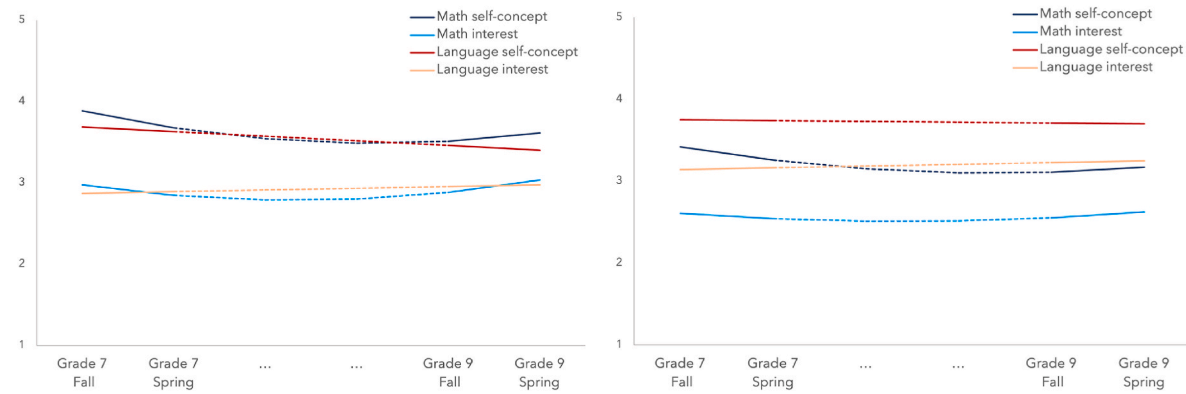

Fig. 2. Gendered developmental trajectories of self-concept and interest in mathematics and language (L1).
Note. Boys' motivational trajectories are on the left and girls' to the right. The dotted lines represent model-based estimates (not empirical).

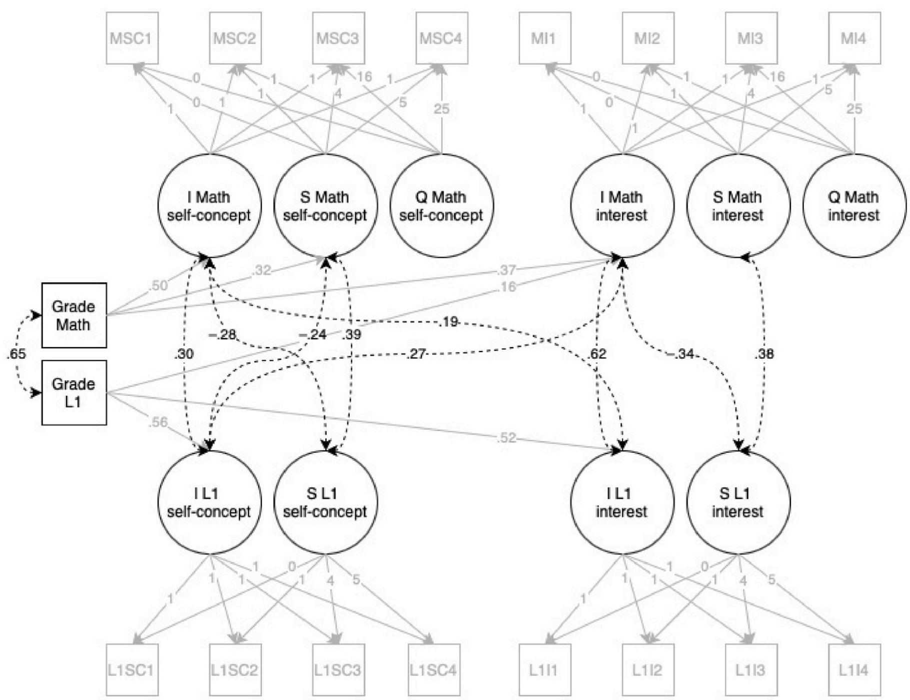

Fig. 3. Significant cross-domain relations between self-concept and interest in mathematics and language (L1) among boys.
Note. MSC = Math self-concept; MI = Math interest; L1SC = Language self-concept; L1I = Language interest; I = Intercept; S = Linear slope; Q = Quadratic slope. Dotted lines represent significant ($p < 0.05$) correlations. Gray straight lines represent significant regression pathways.

detected among both genders. We discuss our main findings in more detail below.

4.1. *Inter- and intraindividual differences in students' mathematics and language motivation*

Based on dimensional comparison theory (Möller & Marsh, 2013; Wan et al., 2023; Wigfield et al., 2020) and empirical findings (Gaspard et al., 2020; Guo et al., 2018), we expected that intraindividual differences in students' motivational beliefs across domains would be detected among students (i.e., different trajectories of math and L1 motivation within students, H1a). Although no significant differences were found in the initial levels of self-concept in math and L1 in seventh grade, their development across lower secondary education slightly differed, partly supporting our expectations (H1a). While declines were found in both domains, L1 self-concept remained relatively stable, whereas math self-concept followed a U-shaped trend, starting with a more pronounced decline that was leveled out towards ninth grade. This pattern shares some similarities with the largest profile identified by Gaspard et al. (2020), as they found 72% of students belonging to a profile with relatively stable L1 self-concept, and a more pronounced decline in the math domain. Intraindividual differentiations across math and L1 interests were also identified: L1 interest increased across Grades 7–9, whereas math interest declined. Thus, our findings generally support the idea of intraindividual differentiation across domains, particularly regarding students' interests. One explanation for the more pronounced negative trend in math motivation (as compared to L1) could be that the content in secondary-school math changes to become rather abstract, making it difficult for students to see the utility value of it, and become interested in it. If students experience the change in math content to be too demanding, they might start to devalue math to protect their ability perceptions and use dimensional comparison processes to focus on their relative strengths instead. Regarding interindividual differences, contrary to what we expected (H1b), a one-profile solution

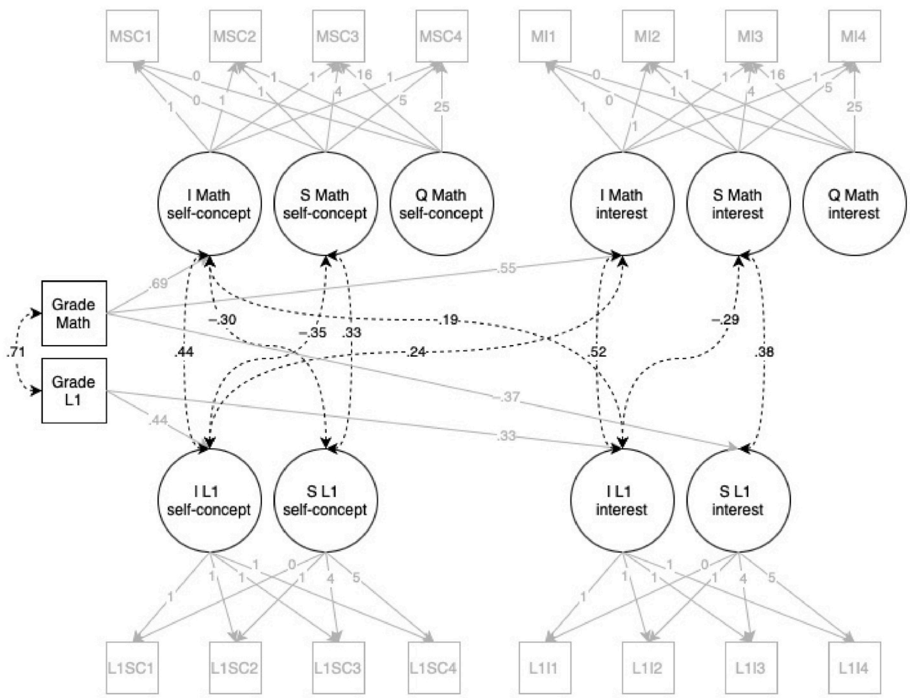

Fig. 4. Significant cross-domain relations between self-concept and interest in mathematics and language (L1) among girls.
Note. MSC = Math self-concept; MI = Math interest; L1SC = Language self-concept; L1I = Language interest; I = Intercept; S = Linear slope; Q = Quadratic slope. Dotted lines represent significant ($p < 0.05$) correlations. Gray straight lines represent significant regression pathways.

described the data best, suggesting that adolescents' development of self-concept and interest in math and L1 are relatively homogenous across lower-secondary education. Thus, it seems that the majority of students experience a negative trend in their motivational beliefs at the beginning of lower secondary education, which could reasonably reflect some mismatch between the needs of the students and changes in the educational environment on a general level (Eccles & Roeser, 2009). Finnish students entering seventh grade are not only entering puberty and going through related changes, but also, transitioning from having one class teacher to several subject teachers, into a larger school building, and experiencing changes in peer-groups and increased academic demands. Thus, from a stage-environment fit perspective (Eccles & Roeser, 2009), it is not surprising to see negative trends in their motivation after an educational transition. However, the negative development in math leveled out at the end of secondary education, suggesting that the trends were relatively temporary, and that students adjust to the secondary school environment when, simultaneously, the turmoil related to puberty eases off for many.

A closer look at the latent intercept- and slope factors revealed that variation among students was mainly found in the overall levels of self-concept and interest (i.e., intercepts), and barely in the growth rates (i.e., slopes). This suggests that while students likely differ in their levels of math and L1 self-concept and interest as they enter lower secondary education, the majority follow similar developmental trends. As the aim of GMM is to determine distinct developmental profiles by including both linear and quadratic slope factors as profile indicators (in this case, 4 latent intercepts and 6 latent growth factors), it is possible that overall mean-level differences in students' self-concepts and interests remain undetected, due the lack of variance in the growth factors.

As Gaspard et al. (2020) tracked students over a much longer time period (Grades 1–12), including two major educational transitions, they allowed for more pronounced changes to occur. Our findings, on the other hand, align with previous studies investigating stability and change in students' motivational beliefs across shorter time periods (e.g., Grades 7–9, through latent transition analysis), as these have found high stability in students' expectancy- and value beliefs (Lazarides, Viljaranta, Aunola, Pesu, & Nurmi, 2016). In the Finnish lower secondary school environment, students also have relatively limited options to advance in specific domains (e.g., choose advanced math classes), and it has been suggested that dimensional comparisons are triggered when students must choose between different courses at school (Wigfield et al., 2020). Therefore, it is possible that differentiated trajectories start to emerge later on when students are faced with more choices regarding the content of their studies (e.g., in upper secondary education: Guo et al., 2018).

It is also worth noting that the overall levels of interest within each domain were significantly lower than of self-concept, for the whole sample. Yet, the trajectories of math self-concept and interest were highly similar, whereas L1 self-concept and interest, surprisingly, followed opposite trends. Self-concept and interest are generally highly correlated constructs, but self-concept is known to be highly related to students' achievements, whereas interest has been found to be more predictive of students' aspirations and educational choices (Eccles & Wigfield, 2020). Thus, declines in self-concept may be rooted in increasing academic demands and pressure to achieve during this time, coupled with increased social comparison during adolescence. Students' interests, on the other hand, may not be as affected by these challenges, and increases in L1 interest may instead reflect students' starting to realize the importance and usefulness of good L1 skills for their educational goals, as they are getting closer to making important decisions about further education.

4.2. Gendered motivational trajectories

Regarding gender differences, in line with previous findings (Guo et al., 2018; Guo, Marsh, et al., 2015; Jacobs et al., 2002; Marsh et al., 2005) and our expectations (H2a, H2b), boys reported higher levels of math motivation, and lower levels of L1 interest as compared to girls already at the beginning of seventh grade. Thus, taken together, most gender differences in students' motivational beliefs appear to emerge already during the elementary/primary school years (Fredricks & Eccles, 2002; Jacobs et al., 2002), possibly stemming from gendered socialization expectations from parents, teachers, peers, and media (Eccles, 2009). Guo et al. (2018) also found gender differences in the growth trajectories in both math and Finnish among Finnish upper secondary school students. However, we found little evidence of increased gender gaps during early adolescence in the present study, as no differences in math development were detected among our sample. We did, however, similarly to the findings by Jacobs et al. (2002), find that the gender gap in L1 self-concept grew increasingly wider over the lower secondary school years.

There was also a clear distinction in the overall levels of girls' motivational beliefs across domains, favoring the L1 domain, and this differentiation was also visible in the growth rates. This differed from the boys, as their levels of math and L1 motivation remained on the same level across the lower secondary school years. Yet, while studying the cross-domain relations, it seemed that both boys and girls use dimensional comparisons to specialize in a specific domain, possibly to protect their positive self-perceptions by focusing on domains of relative strength. For boys, however, higher math interest was related to more negative development in L1 interest, whereas the opposite relation was found for girls.

Reliance on dimensional comparisons might be harmful in some cases. For example, it is possible that a girl with equally high performance in both math and L1, still identifies as a "reading person" because they feel relatively stronger in reading, whereas a similar process might be true for boys in math. Considering that students' interests and value-beliefs are significant predictors of their educational and occupational aspirations (Widlund et al., 2020), more so than self-concept, these findings would explain the current occupational situation in many countries, including Finland, where girls are significantly underrepresented in many STEM-related fields. In Finland, gender differences are usually not detected in mathematics performance, but girls commonly perform better in reading (OECD, 2019). In our sample, while we controlled for performance in the measurement model, girls outperformed boys in both domains, but the gender gap in L1 performance was larger. This, coupled with gendered stereotypes implying that math is more of a "male subject" whereas L1 may be viewed as a "female subject", may explain why many girls performing well in both subjects identify more strongly with the L1 domain. Consequently they may start to value it more while they simultaneously disengage from math, while a similar but opposite process occurs for boys. This, on the other hand, might lead to girls opting out of pursuing math-related educational and career alternatives.

4.3. Practical implications

The findings of this study have some implications for both practice and future interventions. Considering that significant variance was detected in the initial levels of self-concept and interest in both domains, but not in their growth rates suggests that future interventions should be targeted early in the school years. This might be particularly important for girls, as pronounced differentiation was found in their domain-specific motivational beliefs already at the beginning of seventh grade. In general, previous intervention studies have found that targeting students' utility value might be particularly helpful in increasing their motivation within a domain; for example, by making the content more personally meaningful for students, and relating and explaining the usefulness of it for everyday tasks (Rosenzweig, Wigfield, & Eccles, 2022). Studies have also suggested that girls seem to be particularly engaged by activities they perceive as socially meaningful and important (Watt et al., 2012), which should be acknowledged when targeting girls' motivation in math, as this is considered a rather skill-based and abstract subject.

However, as this study found strong support for dimensional comparison theory (Möller & Marsh, 2013), this is something that should be acknowledged when planning targeted interventions to, for example, support students' math motivation. Based on our findings, increasing students' interest in one domain (e.g., math), might, at the same time, lower their interest in the L1 domain. Gaspard et al. (2016), indeed, found this effect while targeting students' value beliefs in math in an intervention study: while they successfully boosted students' math-related task values, students' L1 values simultaneously decreased (Gaspard et al., 2016). Thus, it would be important for parents and teachers to be aware of, not only gendered stereotypes and how these might affect students' motivational beliefs (and consequently, their educational and occupational choices), but also the dimensional comparison processes that might occur among students. One way to prevent harmful differentiations in students' motivational beliefs across domains could perhaps be to better connect different domains in educational settings, considering that school subjects are often taught separately. Students may not always be aware that they are, in fact, combining many different skills (e.g., reading comprehension and arithmetic skills) while performing various tasks (e.g., problem solving) during school lessons. Thus, teachers could more explicitly point out the similarities between, for example, math and L1, and their combined usefulness for several tasks and occupations.

4.4. Limitations and further research

Although this study was one of the first to investigate inter- and intraindividual differences in students' joint trajectories of math and reading self-concept and interest, it also excluded other relevant EVT constructs that have been found to be predictive of students' educational and occupational choices. It would be important for future studies to, for example, include negative aspects of task values (e.g., cost). Cost may be an important indicator for explaining why some students lower their aspirations or opt out of pursuing academic goals, despite being otherwise highly interested (Gaspard et al., 2018;Widlund et al., 2024).

Second, our findings should not be generalized across all school subjects, as we only included two academic domains. However, choosing math and L1 seems relevant considering that they are viewed as key academic domains, and previous studies have found the strongest negative cross-domain effects between such dissimilar domains (Gaspard et al., 2018). Nevertheless, cross-domain growth processes of other domains should be included in future studies, as these may provide more information about potentially positive relations between closely related domains (e.g., math and science).

Also, in this study, we did not include any outcomes (e.g., educational aspirations or choices) in our mixture model, and we did not have longitudinal information of students' performance, which are relevant to the developmental processes of students' motivational beliefs and central parts of the EVT framework. However, we believe that demonstrating inter and intraindividual differences in the development of students' motivational beliefs, while also controlling for initial performance, is an important contribution to the field. The inclusion of additional variables would significantly increase the amount of estimated parameters and the complexity of the GMM. This in turn could lead to statistically improper solutions and likely convergence problems. Due to the complexity and heavy computation of GMM, previous studies adapting this approach to study individual differences in students' cross-domain motivational trajectories (Gaspard et al., 2020; Guo et al., 2018) have relied on factor scores saved from preliminary measurement models. However, the use of factor scores to extract distinct developmental profiles makes it impossible to study, for example, the correlations between intercepts and growth rates across domains, which was an important contribution of the present study.

Also, based on the findings, future studies should track students over a longer period (e.g., over educational transitions) to, for example, better capture when the differences in students' dimensional comparison processes occur. Based on our findings, it is challenging to conclude whether dimensional comparison processes contribute to the gender differences in students' domain-specific motivational beliefs – or whether the identified cross-domain relations among girls are a result of them having differentiated motivational beliefs across domains in the first place. Therefore, it would also be important to track students from earlier grades to better capture when the differentiation of girls' math and L1 motivations are starting to take place. Also, specifically while focusing on gender differences, it would be important to also consider the societal context and educational environment, and for example, the role of gender representation among teachers for students' motivational beliefs (Doornkamp, Groeneveld, Groeneveld, Van der Pol, & Mesman, 2022).

5. Conclusion

This study contributed to the field as exceptionally few have studied individual differences in students' growth trajectories of self-concept and interests, and this study being among the first to investigate how gendered motivational beliefs are related to growth rates across domains. One of the main findings was that students' motivational development in math and L1 was relatively homogenous and, for the most part, slightly negative across grades 7–9. This implies that the majority of students experience some challenges while simultaneously entering both early adolescence and lower secondary education, highlighting the importance of supporting students' motivation and well-being during this critical time period when several co-occurring changes take place, and while they are making important decisions about their future.

When gender and performance was accounted for, we also found that there was a clear differentiation in girls' motivational beliefs across domains, favoring the L1 domain, which was not detected among boys. However, both genders were engaged in dimensional comparison processes. Coupled with prevailing gender stereotypes, this may be harmful in some cases. It could, for example, unnecessarily hinder some from engaging in and aspiring for math-related educational and career alternatives, despite having high performance in math. This is something that should be considered in schools while supporting students' motivation and goal-setting, and, while planning future interventions to support students' motivational beliefs.

CRediT authorship contribution statement

Anna Widlund: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. **Markku Niemivirta:** Conceptualization, Formal analysis, Methodology, Writing – review & editing. **Heta Tuominen:** Conceptualization, Methodology, Writing – review & editing. **Johan Korhonen:** Conceptualization, Formal analysis, Methodology, Project administration, Writing – review & editing.

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Appendix

Table A1
Correlations Between All Study Variables

	T1 MSC	T2 MSC	T3 MSC	T4 MSC	T1 MI	T2 MI	T3 MI	T4 MI	T1 L1SC	T2 L1SC	T3 L1SC	T4 L1SC	T1 L1I	T2 L1I	T3 L1I	T4 L1I
T1 MSC	–	.79*	.65*	.63*	.64*	.76*	.40*	.61*	.42*	.35*	.28*	.23*	.27*	.21*	.14*	.09
T2 MSC	.71*	–	.71*	.66*	.61*	.95*	.46*	.64*	.39*	.35*	.27*	.23*	.34*	.26*	.18*	.07
T3 MSC	.60*	.67*	–	.84*	.50*	.71*	.67*	.83*	.28*	.25*	.26*	.24*	.16*	.18*	.11	.03
T4 MSC	.50*	.67*	.79*	–	.48*	.67*	.70*	.97*	.21*	.22*	.19*	.21*	.13	.18*	.05	.03
T1 MI	.58*	.50*	.52*	.39*	–	.71*	.51*	.53*	.31*	.31*	.28*	.22*	.46*	.40*	.31*	.26*
T2 MI	.66*	.93*	.68*	.68*	.63*	–	.53*	.66*	.38*	.35*	.28*	.23*	.38*	.31*	.22*	.12
T3 MI	.39*	.53*	.74*	.60*	.62*	.63*	–	.68*	.22*	.22*	.22*	.19*	.25*	.33*	.27*	.15*
T4 MI	.48*	.66*	.79*	.96*	.45*	.69*	.70*	–	.22*	.22*	.19*	.22*	.16*	.23*	.11	.10
T1 L1SC	.26*	.21*	.15*	.06	.24*	.21*	.18*	.06	–	.77*	.64*	.53*	.54*	.43*	.43*	.31*
T2 L1SC	.20*	.28*	.19*	.17*	.27*	.30*	.28*	.20*	.58*	–	.63*	.50*	.49*	.57*	.46*	.28*
T3 L1SC	.18*	.27*	.27*	.16*	.20*	.28*	.29*	.19*	.48*	.68*	–	.73*	.47*	.50*	.63*	.50*
T4 L1SC	.10	.20*	.22*	.22*	.13	.21*	.22*	.26*	.39*	.58*	.66*	–	.40*	.41*	.48*	.60*
T1 L1I	.19*	.24*	.25*	.17*	.47*	.32*	.45*	.21*	.62*	.46*	.38*	.33*	–	.69*	.58*	.50*
T2 L1I	.17*	.27*	.20*	.27*	.39*	.35*	.39*	.31*	.48*	.63*	.49*	.44*	.69*	–	.63*	.53*
T3 L1I	.12	.23*	.22*	.24*	.29*	.31*	.41*	.28*	.37*	.52*	.68*	.53*	.50*	.63*	–	.68*
T4 L1I	.06	.17*	.18*	.20*	.21*	.21*	.29*	.25*	.29*	.43*	.54*	.71*	.42*	.55*	.72*	–
$M(SD)_{boys}$	3.90 (0.80)	3.64 (0.95)	3.59 (0.95)	3.68 (1.02)	2.97 (1.19)	3.41 (1.00)	2.91 (1.22)	3.54 (1.09)	3.65 (0.86)	3.68 (0.90)	3.43 (0.92)	3.53 (0.91)	2.84 (1.11)	2.96 (1.12)	2.88 (1.12)	3.08 (1.16)
$M(SD)_{girls}$	3.43 (0.90)	3.23 (1.05)	3.18 (1.03)	3.24 (1.04)	2.61 (1.14)	3.05 (1.10)	2.60 (1.10)	3.13 (1.07)	3.74 (0.90)	3.79 (0.87)	3.66 (0.96)	3.74 (0.87)	3.09 (1.15)	3.28 (1.12)	3.15 (1.06)	3.33 (1.08)
Chronbach's α	.90	.93	.93	.95	.93	.93	.93	.94	.88	.91	.93	.94	.93	.94	.92	.94

Note. * = $p < 0.05$. Correlations for boys are presented on the left side of the diagonal and for girls to the right. MSC = Math self-concept; MI = Math interest; L1SC = Language self-concept; L1I = Language interest.

Table A2
T-test Results Comparing Boys and Girls in Performance in Math and Language (L1)

Grade	Gender	*M* (*SD*)	df	*t*	*p*	Cohen's D
Grade 7 Language	Boys	7.59 (1.01)	539	−8.365	<.001	0.71
	Girls	8.31 (1.00)				
Grade 7 Math	Boys	7.62 (1.26)	539	−2.518	.012	0.22
	Girls	7.89 (1.26)				
Grade 9 Language	Boys	7.54 (1.19)	545	−8.927	<.001	0.76

(continued on next page)

Table A2 (*continued*)

Grade	Gender	*M* (*SD*)	df	*t*	*p*	Cohen's D
	Girls	8.41 (1.07)				
Grade 9 Math	Boys	7.47 (1.46)	541	−3.806	<.001	0.33
	Girls	7.93 (1.37)				

Table A3
The Goodness of Fit Statistics for Alternative Models Testing Longitudinal CFA

Model	χ^2	*df*	CFI	TLI	RMSEA	SRMR	ΔCFA	ΔRMSEA	*p*
Configural invariance	1627.571	960	.971	.966	.034	.027			.000
Factorial invariance	1664.727	984	.971	.967	.034	.029	.000	.000	.000
Scalar invariance	1735.523	1008	.969	.965	.034	.030	.002	.000	.000

Table A4
The Goodness of Fit Statistics for Alternative Models Testing Multiple Group CFA between Genders

Model		χ^2	*df*	CFI	TLI	RMSEA	SRMR	ΔCFA	ΔRMSEA	*p*
T1										
	Configural invariance	202.748	96	.976	.968	.062	.033			.000
	Factorial invariance	208.747	104	.977	.971	.059	.038	.001	.003	.000
	Scalar invariance	222.017	112	.976	.971	.058	.039	.001	.001	.000
T2										
	Configural invariance	185.224	96	.981	.974	.058	.028			.000
	Factorial invariance	191.884	104	.981	.976	.055	.030	.000	.003	.000
	Scalar invariance	215.411	112	.978	.974	.058	.033	.003	.003	
T3										
	Configural invariance	140.812	96	.988	.984	.045	.031			.002
	Factorial invariance	152.373	104	.987	.984	.045	.039	.001	.000	.001
	Scalar invariance	164.346	112	.986	.984	.045	.039	.001	.000	.001
T4										
	Configural invariance	154.012	96	.987	.982	.052	.031			.000
	Factorial invariance	168.647	104	.985	.981	.053	.041	.002	.001	.000
	Scalar invariance	185.656	112	.983	.980	.054	.043	.002	.001	.000

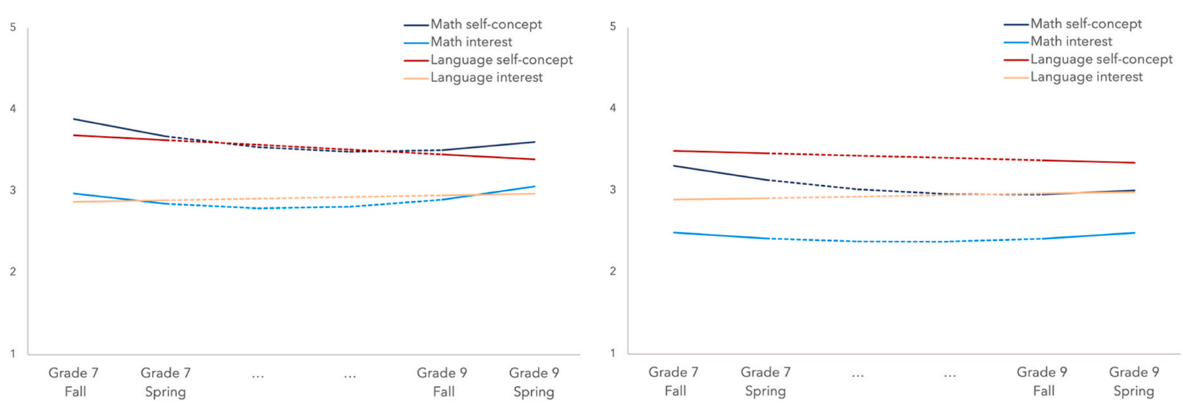

Fig. A1. Gendered trajectories of self-concept and interest and mathematics and Language while controlling for achievement.
Note. Boys' motivational trajectories are on the left and girls' to the right. The dotted lines represent model-based estimates (not empirical).

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Anna Widlund, Åbo Akademi University: developmental dynamics between students' academic well-being, motivation, and learning.

Markku Niemivirta, University of Eastern Finland: developmental and situational dynamics between students' motivation, task engagement, subjective well-being, and learning.

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