Disentangling the Associations of Academic Motivation with Self-Concept and Academic Achievement using the Bifactor Exploratory Structural Equation Modeling Framework

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Abstract

This study investigated the associations between academic motivation, self-concepts, and achievement in math and German using the bifactor exploratory structural equation modeling (bifactor-ESEM) framework. Data from two independent samples (N_1 = 1402, N_2 = 1154) of German elementary and secondary school students revealed that the bifactor-ESEM representation of academic motivation was the most optimal solution among all models (CFA, bifactor-CFA, ESEM, bifactor-ESEM). Measurement invariance was supported across domains and education levels for all models. Global self-determined motivation was strongly associated with both academic self-concept and academic achievement. The specific motivation factors also shared associations with these variables over and above those involving the global self-determined motivation factor. This study highlights the importance of distinguishing global and specific levels of academic motivation.

Keywords: self-determination theory (SDT); academic motivation; self-concept; academic achievement; bifactor exploratory structural equation modeling (bifactor-ESEM)

The Organization for Economic and Co-Operation and Development (OECD, 2016) identifies academic underachievement as one of the core issues that urgently needs to be tackled by educational institutions around the world. Academic achievement is often operationalized in the form of grade point average (GPA), a metric that is highly important given the role played by GPA in driving admission decisions in further educational programs. GPA has also been found to predict educational attainment, and earnings in adulthood (French et al., 2015). Likewise, academic self-concept has been identified as an important psychoeducational factor (Marsh & Hau, 2003) due to its key contributory role driving positive school attitudes (Green et al., 2012), course selection (Guo, Parker, et al., 2015), educational and career aspirations (Marsh et al., 2013), as well as GPA (Marsh & Martin, 2011). As a third member of this triad of critically important education variables, academic motivation has also been identified as a critical determinant of school performance (Gillet et al., 2017), academic self-efficacy (Guay et al., 2019), and well-being (Burton et al., 2006; see also Ryan & Deci, 2017 for an overview), in addition to its role in driving academic self-concept (e.g., Guay et al., 2019) and academic achievement (e.g., Guay et al., 2010).

However, academic motivation, as typically operationalized in self-determination theory (SDT; Ryan & Deci, 2017), which is the main theoretical framework for the present study, is also a complex multidimensional construct whose operationalization faces a variety of challenges (e.g., operational measurement, factor structure, etc.). These operational challenges, and the way in which they have been previously addressed, might explain some divergent results obtained in past research, and suggest that the results from studies relying on an improper operationalization of academic motivation might provide an inadequate foundation for educational interventions aiming to enhance students' academic performance and self-concept. The present study was designed to offer novel insights into the association between academic motivation, academic self-concept, and academic achievement pertaining to the math and verbal (i.e., German) domains among elementary and secondary school students. In doing so, we addressed the crucial operational challenge of clarifying the multidimensional structure of motivation by using the bifactor exploratory structural equation modeling (bifactor-ESEM) framework (Morin et al., 2016).

Our interest in math is rooted in the fact that knowledge in STEM (science, technology, engineering, and mathematics) areas is essential to the development and advancement of technology and countries in general, but many talented students opt out of these fields early on and turn away from STEM careers (Bøe et al., 2011; Isphording & Qendrai, 2019; Wang & Degol, 2013), suggesting that more research is needed to better understanding the psychological underpinnings of these processes. As for German, in order for students (in Germany at least) to become fully participating members of society, they need to possess basic linguistic skills and competencies (e.g., comprehend and express themselves both in oral and written forms of communication) in their native language (i.e., German in the present study). Language skills are also necessary for students to be able to pursue secondary or tertiary educational tracks (i.e., they need to have a certain mastery of their native language to study, for example, chemistry or physics). Furthermore, in the academic self-concept area, the math and verbal domains have long been established as forming two opposite poles when all school subjects are considered (Marsh, 2007). As such, our dual focus on math and German (or verbal) allows us to increase the likely generalizability of our results to a wide range of subjects.

Defining Academic Self-Concept and Academic Motivation

In the educational research literature, global self-concept is broadly referred to as students' generic perceptions of themselves across domains that are formed through their interactions and experiences with their environment, particularly through the evaluations of significant others (Shavelson et al., 1976). Since Shavelson et al.'s (1976) seminal publication, the self-concept is generally acknowledged to form a complex multifaceted construct organized hierarchically. The global self-concept is located at the top of this hierarchy, followed by generic self-perceptions limited to a single life domain (e.g., the social, physical, and academic self-concepts) at the next level, and more specific self-concepts located at the lower level. For instance, the generic academic self-concept, which refers to students' mental representations of their educational abilities (Marsh & Craven, 1997), can itself be subdivided into self-conceptions related to specific school subjects (Marsh, 1990), such as math, science, biology, main language, foreign languages, or history. This distinction led Marsh and Shavelson (1985) to introduce an intermediate level between generic academic self-concepts and subject-specific self-concepts that differentiates math-related self-concepts from verbal self-concepts, assumed to occupy two opposite poles of students' academic self-concepts. As a result of this distinction, Marsh (1990) suggested that educational research interested in students' academic self-concepts should try, whenever possible, to capture this distinction. As a result, the present study focuses on the math self-concept and the German (main language) self-concept.

Although academic motivation has sometimes been defined in a domain-general and domain-specific manner that matches how the academic self-concept is typically defined (Vallerand et al., 1989, 1992), self-determination theory (SDT; Ryan & Deci, 2017) proposes that an even more critical differentiation has to be made regarding the types of motivation involved in determining students' involvement in their academic activities. From this perspective, intrinsic motivation refers to the drive to perform an activity for the enjoyment and pleasure associated with it. In contrast, extrinsic motivation refers to engaging in an activity for instrumental reasons and can itself takes many different forms depending on the extent to which the perceived instrumentality of the activity is internally or externally driven. At the most desirable extreme (i.e., directly following intrinsic motivation), identified regulation refers to the drive to perform an activity perceived as having valuable and personally important characteristics. Further along comes introjected regulation, which refers to being motivated toward an activity by internal contingencies (e.g., guilt, self-worth, or pride). Next comes external regulation which denotes engagement in an activity that is externally driven by a desire to obtain rewards or to avoid punishment or social pressure. Finally, at the least desirable extreme is amotivation, which refers to the lack of desire and the absence of intention to engaging in the activity. SDT acknowledges the unique qualities associated with each of these specific types of motivation while also positioning them along a global self-determination continuum (Deci & Ryan, 1985; Ryan & Deci, 2017), ranging from intrinsic motivation, to identified regulation, to introjected regulation, to external regulation, and finally to amotivation. This continuum is often referred to as a global self-determination factor and represents students' global sense of self-directedness and volition (i.e., "I want to" do this activity), whereas the specificity uniquely associated with each specific regulation refers the reason for this desire (e.g., Howard et al., 2020a).

The Dimensionality of Academic Motivation

Following recent recommendations highlighting the need to account for this dual global (i.e., global levels of self-determination) and specific (i.e., the unique quality of each type of motivation) nature of human motivation (Howard et al., 2018, 2020a; Litalien et al., 2017) and to avoid measurement imprecision and biased estimates of associations with other constructs (Asparouhov et al., 2015; Mai et al., 2018; Morin et al., 2016), the present study relies on a bifactor-ESEM (Morin et al., 2016, 2020) representation of academic motivation. This framework is explicitly designed to account for two sources of construct-relevant psychometric multidimensionality present in complex multidimensional measures via a bifactor component and an ESEM component. The bifactor component accounts for multidimensionality that is due to the simultaneous existence of global (i.e., a G-factor underpinning all responses of all subscales and reflecting students' global levels of self-determination and thus referring to this global "I want to" desire to pursue an activity for a variety of reasons) and specific (i.e., S-factors representing the unique qualities, or reasons to pursue the activity, associated with each type of academic motivation left unexplained by the G-factor) constructs. This component is thus directly aligned with SDT theoretical representation of human motivation as an overarching continuum of self-determination encompassing various types of motivation, each retaining their own specific nature (Ryan & Deci, 2017). In psychological terms, when we consider academic motivation, the global factor reflects students' overall levels of volition towards their studies (i.e., "I want to study/learn"), whereas the specific factors reflect the specific reasons for this desire: pleasure (intrinsic), importance for oneself (identified), feelings of guilt, shame or self-worth (introjected), external pressures (external), or a lack of intentionality (amotivation). These specific factors can retain more, or less, specificity depending on the extent to which participants' scores on these dimensions are aligned, or not, with their scores on the global factor.

In contrast, the ESEM component accounts for multidimensionality that is due to the conceptually-related nature of the various motivation types, each operationalized by fallible indicators likely to share smaller associations (i.e., cross-loadings) with other types of motivation. The ESEM component accounts for this second form of multidimensionality by allowing all cross-loadings to be freely estimated but constrained to remain as small as possible (Morin et al., 2020). The importance of this component is reinforced by statistical research (Asparouhov et al., 2015; Mai et al., 2018) showing that more accurate estimates of latent constructs and of their relations with other constructs are obtained when cross-loadings (even as small as .100) are freely estimated.

Within SDT research, to the best of our knowledge, only two studies have specifically sought to examine the co-existing global (the self-determination continuum) and specific (the unique quality of each type of motivation) structure of academic (Litalien et al., 2017) and work (Howard et al., 2018) motivations using the bifactor-ESEM framework. These studies first supported the superiority of a bifactor-ESEM representation of motivation relative to that of alternative confirmatory factor analytic (CFA), ESEM, and bifactor-CFA models. More precisely, the results from these studies have thus demonstrated that the structure of academic and work motivation (as measured by the Academic Motivation Scale and the Multidimensional Work Motivation Scale, respectively) was best represented by a global self-determination factor co-existing with non-redundant specific factors. Both Litalien et al. (2017) and Howard et al. (2018) reported the presence of a G-factor that perfectly matched the SDT continuum hypothesis. More specifically, this self-determination G-factor was characterized by strong positive loadings from intrinsic motivation items, moderate positive loadings from identified regulation items, smaller positive loadings from introjected regulation items, null or negative loadings from the external regulation items, and stronger negative loadings from the amotivation items. Both studies also revealed statistically significant and positive item loadings on the S-factors which reflected the unique quality associated with each type of behavioral regulation once the G-factor was taken into account. Finally, of major relevance to the present study, both studies revealed that the G-factor (global levels of self-determination) was the main driver of associations with a variety of covariates (e.g., achievement, dropout intentions, and satisfaction with studies in Litalien et al., 2017, and commitment and need satisfaction in Howard et al., 2018), but that the S-factors also explained additional variance in outcome levels beyond that already explained by the G-factor.

Since then, Howard et al. (2018) results have been replicated among multiple samples of employees (work motivation: Fernet et al., 2020a, 2020b; Gillet et al., 2020b; Howard et al., 2021; Tóth-Király, Morin, Bőthe, et al., 2021). However, Litalien et al.'s (2017) results, initially obtained among samples of Canadian university students, have only been replicated twice among samples of Canadian secondary school students (Guay & Bureau, 2018; Guay et al., 2021). More importantly, none of these studies were specifically designed to assess the structure of academic or work motivation, but only relied on a bifactor-ESEM representation as a preliminary step designed to estimate factor scores later used in latent profile analyses. The only exception is related to Guay and Bureau's (2018) study, which was more specifically designed to test associations between motivation factors and academic achievement among Canadian secondary school students, but only considered a subset of all possible types of motivation. Thus, Litalien et al.'s (2017) results still have to be formally replicated among additional samples of secondary school students from different cultural backgrounds, as well as among samples of primary school students. Furthermore, associations between academic motivation and self-concept have yet to be examined while also considering the dual global/specific nature of motivation. The present study was designed to address these limitations.

Evidence of Associations Between Academic Motivation, Self-Concept, and Achievement

Our decision to consider academic self-concept and achievement as important correlates of academic motivation is rooted in the diathesis-stress model (Boggiano, 1998) which describes how perceived interpersonal styles influence intrinsic-extrinsic motivational processes and the manifestation of more positive or negative self-concepts. More specifically, this model proposes that students' perceptions of autonomy-support in their social environment facilitates the development of more intrinsic (as opposed to extrinsic) types of motivational orientations which, in turn, should themselves tend to be associated with more positive achievement-related outcomes such as academic self-concepts (Boggiano, 1998; Guay et al., 2001). Based on this model, we can expect that students who are more intrinsically motivated (i.e., find the subject inherently enjoyable and pleasurable), or self-determined, should also display an inner confidence (i.e., more positive self-beliefs) in their ability to do well in their academic pursuits. This might translate into students spending more time on a subject (e.g., math or German) and, as a result, they might become increasingly more competent in this subject. This particular model also aligns with SDT's basic psychological needs theory (Ryan & Deci, 2017) which focuses on three basic psychological needs: autonomy (i.e., students' sense of volition their actions), competence (i.e., students' sense of mastery and accomplishment), and social relatedness (i.e., students' sense of social belonging and connectedness). These needs have been shown to be universal, and their satisfaction has been found to be conductive of a variety of desirable outcomes within education such as higher levels of class attendance and interest toward studies (Gillet et al., 2020a), positive affect (Garn et al., 2019), or better adjustment in secondary school (Ratelle & Duchesne, 2014). This theory, similar to the diathesis-stress model, proposes a pathway in which need supportive environments are assumed to facilitate the development of more autonomous forms of motivation and of a more positive self-concept (Vansteenkiste & Ryan, 2013; Yu et al., 2018).

These propositions have been tentatively supported by previous research. In multiple studies (Guo, Marsh, Parker, et al., 2015; Guo, Nagengast, et al., 2016; Guo, Parker, et al., 2015), math self-concept was found to share positive associations with math intrinsic value (a construct that bears conceptual similarities to intrinsic motivation toward math). A similar model was tested by Guay et al. (2019), who reported that the quality of kindergarten teachers' relations with students predicted grade 1 intrinsic motivation toward reading, which, in turn, predicted grade 1 reading self-concept, which, in turn, predicted grade 1 achievement in reading. Using a longitudinal design, Walgermo et al. (2018) also reported that prior levels of literacy interest (a construct that also bears conceptual similarities to intrinsic motivation toward reading) positively predicted subsequent levels of reading self-concept. Finally, when simultaneously taking multiple types of motivation into account, Areepattamannil and Freeman (2008) reported that verbal self-concept was positively associated with intrinsic and identified regulation, not associated with introjected and external regulation, and negatively associated with amotivation among a sample of Canadian immigrant and non-immigrant high school students. In a more recent multi-domain investigation (including math, science, writing, and reading), Chanal and Guay (2015) reported that domain-specific self-concepts had strong and positive associations with matching levels of intrinsic and identified motivation in the same domain, small positive or non-significant associations with introjected regulation in the same domain, and small negative or non-significant associations with external regulation in the same domain.

Shifting our focus to the associations between academic motivation and achievement, previous studies have systematically demonstrated that academic performance tends to be positively and moderately related to more autonomous forms of motivation (i.e., intrinsic motivation, identified regulation, or even global levels of self-determination), weakly related or unrelated to controlled motivations (i.e., introjected and external regulation), and negatively related to amotivation, with intrinsic motivation emerging as the only consistent predictor of academic achievement (Taylor et al., 2014). Examining associations between academic motivation and achievement in three subjects (French, math, English) while also relying on the bifactor-ESEM framework, Guay and Bureau (2018) reported that, among Canadian high school students, global levels of academic self-determination were positively related to academic achievement for two out of three subjects. Apart from this global factor, specific levels of intrinsic motivation were positively, while specific levels of introjected and external regulation were negatively, related to students' levels of academic achievement. Interestingly, Litalien et al. (2017) reported that intrinsic motivation was positively, while specific levels of introjected and external regulation as well as amotivation were negatively, related to academic achievement in a sample of university students.

Overall, most studies exploring the relations between academic motivation, self-concept, and achievement have either focused on a single motivational factor, or have relied on an incomplete (i.e., excluding some important types of motivation) or suboptimal (ignoring the global/specific nature of academic motivation) representation of academic motivation (with the exception Litalien et al., 2017). These simplified motivational representations, however, are not able to directly assess the unique role of each specific factor beyond that of the global factor, which can only be achieved using proper multidimensional methods.

Aims and Hypotheses

The present study was designed to disentangle the associations between academic motivation, self-concept, and achievement while relying on models allowing for a proper disaggregation of global and specific levels of motivation. Based on the available theoretical and empirical information, we first hypothesized that the bifactor-ESEM solution would provide the most accurate representation of students' ratings of academic motivation. Second, we expected the global self-determination factor to be associated with a factor loading pattern corresponding to the SDT continuum hypothesis (Howard et al., 2018; Litalien et al., 2017). Third, we expected global levels of self-determination to be positively related to both academic self-concept and academic achievement in math and German. Fourth, we expected the more autonomous specific motivational factors (i.e., intrinsic and identified) to be positively related, and the more controlled motivational factors (i.e., introjected, external, and amotivation) to be negatively related, to the outcomes. Fifth, we expected all of these associations to generalize to the math and German domain, as well as to primary and secondary school students.

This study provides a contribution to the literature in multiple ways. First, given that a substantial proportion of variance in motivation has been shown to be specific to school subjects (Bong, 2001; Shen et al., 2008), we focused on two distinct subjects in math and German. This serves as an important contribution to the literature as SDT motivations are typically assessed in a variety of school subjects separately, and, with few exceptions (Chanal & Guay, 2015; Guay & Bureau, 2018), research rarely focuses simultaneously on more than one school subject. Second, we disaggregated the global and specific levels of motivation, which provides a more fine-grained look into the associations between academic motivation and outcomes. Third, we compared our results between two distinct samples of students from two distinct levels of education (elementary and secondary).

Method

Sample

The present study relies on two large independent samples of elementary and secondary school students enrolled in randomly selected schools located in the North of Germany[1]. The first sample consisted of 1402 students (n_{boys} = 707, n_{girls} = 685) who completed the questionnaires in relation to the math domain. These students attended grades 3 to 10 (grade 3: *n* = 110, grade 4: *n* = 710, grade 5: *n* = 40, grade 6: *n* = 37, grade 7: *n* = 155, grade 8: *n* = 135, grade 9: *n* = 116, grade 10: *n* = 99), in 91 classes from 22 schools. Most of these students came from elementary schools (elementary schools: *n* = 793, Gymnasium: *n* = 260, Gesamtschule/ Oberschule: *n* = 349). Students were aged between 8 and 17 years (*M* = 11.37, *SD* = 2.31). The second sample included 1154 students (n_{boys} = 591, n_{girls} = 561) who completed the questionnaires in relation to the German domain. These students attended grades 3 to 10 (grade 3: *n* = 21, grade 4: *n* = 575, grade 6: *n* = 25, grade 7: *n* = 125, grade 8: *n* = 127, grade 9: *n* = 97, grade 10: *n* = 184, grade 5 was not assessed) in 70 classes from 18 schools (elementary school: *n* = 596, Realschule: *n* = 178, Hauptschule: *n* = 91, Gesamtschule: *n* = 51, Gymnasium: *n* = 238). Students were aged between 8 to 18 years (*M* = 12.12, *SD* = 2.56).

Procedure

All students completed the questionnaires in quiet classroom settings during a regular 45-minute lesson. All participants completed the questionnaires in a single domain (math or German) to ensure that elementary students had enough time to appropriately complete all measures within one classroom period. In addition, in elementary schools, all items were read aloud by trained research assistants to facilitate understanding. All students were informed of the purpose of the study and were assured that their participation was voluntary and anonymous, that there were no right or wrong answers, that their response would be confidential, and that they could withdraw at any time without justification. Active parental consent was obtained prior to the study. The Ministry of Education of Lower Saxony approved this study. Data collection took place between December 2018 and March 2019.

Measures

Academic motivation. Students' academic motivation in math and German was measured with a slightly modified German version (Freund & Lohbeck, 2020) of the *Academic Motivation Scale* (AMS; Vallerand et al., 1992). Each item started with the stem 'I learn math/German...', followed by three items related to each type of motivation (e.g., external regulation: "because I will get into trouble if I don't learn math/German"; introjected regulation: "because I will feel bad about myself if I didn't learn math/German"; identified regulation: "because math/German is important for me"; intrinsic motivation: "because math/German is fun"). Amotivation was measured with three items but starting with a different

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[1] In the German school system, elementary school usually ends after grade 4 when teachers provide a recommendation for a secondary school track depending on students' achievement levels: The highest school track, called Gymnasium, ends with a qualification for university entrance. This school track is reserved for all students with above-average achievement levels. The intermediate school track, called Realschule, is reserved for all students with average achievement levels and ends with a qualification for vocational education. The lowest school track, called Hauptschule, in contrast, is reserved for all students with the lowest achievement levels. Students from this school track can only achieve a qualification for limited number of occupations. Finally, there are mixed school tracks, called Oberschule or Gesamtschule, where all students with average and low achievement levels are taught together and can graduate from high school as well.

stem suitable for younger children (i.e., “Now consider whether these sentences are also right for you. Do you learn less in math/German…”), followed by three items (e.g., “because you think math/German is not useful?”). All items were rated on a 4-point response scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*) and are reported in Appendix 1 of the online supplements.

Academic self-concepts. Students’ academic self-concepts in math and German were measured using five items from the math and German competence subscales (e.g., “Math/German is easy for me”) of the German short version of the *Self-Description Questionnaire* I (Arens et al., 2013). Items were rated on a 5-point response scale ranging from 1 (*completely false*) to 5 (*completely true*).

Academic achievement. Academic achievement in math and German were measured by asking students to self-report their grades from their last school report. Students receive a numerical grade for each subject which are then aggregated into a single score representing their overall academic achievement. For easier interpretation, both grades were recoded such that higher values indicated better achievement. Indeed, in the German school system, grades normally range from 1 (*excellent*) to 6 (*insufficient*).

Analyses

Model Estimation

All analyses were performed in Mplus 8.2 (Muthén & Muthén, 2018), using the robust weighted least squares estimator with mean- and variance-adjusted statistics (WLSMV). WLSMV estimation has been found to outperform maximum-likelihood estimation methods (ML, or robust ML) for ordered-categorical items including five or fewer response categories and following asymmetric response thresholds such as those used in the present study (Finney & DiStefano, 2013). Models were estimated using all participants, and the limited number of missing responses (math domain: 0.9 % to 2.6 %, German domain: 0.3 % to 1.6 %) was handled using the default algorithms implemented in Mplus for WLSMV estimation (Asparouhov & Muthén, 2010). Students’ nesting within classrooms was taken into account using Mplus design-based correction procedures (Asparouhov, 2005).

Measurement Models

To identify the optimal representation of responses to the AMS, four alternative measurement models were first contrasted for each domain (math or German) and level (elementary or secondary; where secondary combines Realschule, Hauptschule, Gesamtschule, and Gymnasium) combinations. For the purpose of these analyses, the resulting sample sizes are: Elementary and German (n = 596), elementary and math (n = 793), secondary and German (n = 558), secondary and math (n = 609). First, we estimated first-order confirmatory factor analytic (CFA) solutions in which items were specified to be associated only with their a priori factors, no cross-loadings were included, and factors were allowed to correlate. Second, we estimated first-order ESEM solutions in which factors were defined as in the first-order CFAs, but in which all cross-loadings were freely estimated but “targeted” to be as close to zero as possible through the application of an oblique target rotation procedure (Browne, 2001). Third, bifactor-CFA solutions were estimated in which items were specified as all being associated with a global factor (G-factor), as well as with their a priori subscale forming a specific factor (S-factors). According to typical bifactor specifications (Morin et al., 2016, 2020), all factors were specified as orthogonal. As in the CFA solution, no cross-loadings were integrated in this solution. Fourth, bifactor-ESEM solutions were estimated in which the G- and S-factor were defined as in bifactor-CFA, but where all cross-loadings were freely estimated among the S-factors, but “targeted” to be close to zero via an orthogonal target rotation (Reise, 2012). In contrast, self-concept was represented as a simple one-factor CFA solution.

Measurement Invariance

Following the identification of the optimal solution for each sample, we then proceeded to tests of measurement invariance of this solution across the four a priori established samples to verify the extent to which our results could be assumed to generalize across education levels and domains. These tests were performed in the following sequence (Millsap, 2011): (1) configural invariance, (2) weak invariance, (3) strong invariance, (4) strict invariance; (5) invariance of the latent variance-covariance matrix; and (6) latent means invariance.

Associations with Academic Self-Concept and Achievement

The most invariant measurement model retained for academic motivation and self-concept were combined into a single model designed to estimate associations (by way of a multiple regression link function) between academic motivation, self-concept, and achievement. In this model, the factor scores reflecting students' self-concept and the observed scores reflecting their achievement were both regressed on all latent motivation factors. These analyses were conducted in the same multi-group framework used in tests of measurement invariance to assess the extent to which the relations would generalize across education levels and domains. These tests were performed in the following sequence (Tóth-Király, Morin, Gillet, et al., In Press): (a) regressions freely estimated across all groups; (b) regression slopes constrained to equality across groups; (c) regression intercepts constrained to equality across all groups; and (d) regression residuals constrained to equality across all groups.

Model Evaluation

The adequacy of all models was assessed using sample-size-independent fit indices: The comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). Based on commonly used guidelines (Hu & Bentler, 1999; Marsh et al., 2005; Yu, 2002), values greater than .90 and .95 for the CFI and TLI were respectively taken to reflect adequate and excellent fit, whereas values smaller than .08 or .06 for the RMSEA were respectively taken to indicate acceptable and excellent fit. Nested models within tests of measurement invariance and regression similarity were compared via the examination of changes (Δ) in fit indices, where a decrease in CFI and TLI of .010 or higher or an increase in RMSEA of 0.015 or higher indicate a lack of invariance or a lack of similarity (Chen, 2007; Cheung & Rensvold, 2002). Finally, reliability was assessed using McDonald's (1970) omega coefficient of composite reliability (ω), which has also been proposed to be suitable for ESEM, bifactor-CFA, and bifactor-ESEM models (Morin et al., 2020).

Given the ease with which each of the alternative measurement models estimated to represent academic motivation are able to absorb unmodelled sources of multidimensionality (Asparouhov et al., 2015; Morin et al., 2016; Murray, & Johnson, 2013), the consideration of model fit is often not sufficient to clearly identify the optimal solution (Morin et al., 2016, 2020). For this reason, these alternative models were also examined following recommendations formulated by Morin and colleagues' (2016, 2020). Thus, we first contrasted the first-order CFA and ESEM solutions. In this comparison, ESEM should be preferred when the factors remain equally well-defined by the observation of similarly strong main loadings, when cross-loadings remain reasonable in magnitude, and when estimates of factor correlations are reduced in ESEM relative to CFA (Morin et al., 2016, 2020). The retained first-order solution was then contrasted with its bifactor counterpart. In this comparison, support for the bifactor solution would come from the observation of a well-defined G-factor together with at least a subset of well-defined S-factors (Morin et al., 2016, 2020).

Results

Measurement Models: Academic Motivation

The goodness-of-fit of the alternative academic motivation measurement models is reported in Table 1. Parameter estimates obtained from these solutions are reported in Tables S1 to S4 of the online supplements. In each sample, the first-order CFA, first-order ESEM, and bifactor-ESEM solutions were able to achieve an excellent level of fit to the data, whereas the bifactor-CFA solutions systematically failed to reach acceptability according to the RMSEA (and TLI in the Elementary-German sample). Across all solutions and samples, the bifactor-ESEM solution achieved the highest level of model fit, although its superiority to the alternative solutions was generally negligible. However, as noted by Morin et al., (2020), model selection should be guided by an examination of parameter estimates, especially when considering similarly fitting solutions.

ESEM versus CFA. Across all samples, the factors appeared to be equivalently well-defined in the first-order CFA (λ = .556 to .989, M_λ = .882, ω = .834 to .962) and first-order ESEM (λ = .445 to .990, M_λ = .845, ω = .835 to .957) solutions. However, the ESEM solution revealed the presence of multiple statistically significant cross-loadings which remained low enough so as to not undermine the definition of the factors, although many of them were high enough ($\geq$ .100) to be noticeable. These cross-loadings might suggest the presence of an unmodelled G-factor. Finally, factor correlations (see Table S5 of the online supplements) were also reduced in the first-order ESEM solution ($|r|$ = .002 to .843, $M_{|r|}$ = .312) relative to the first-order CFA solution ($|r|$ = .002 to .904, $M_{|r|}$ = .343). All of these comparisons thus seemed to support the value of adopting an ESEM representation of the data. This solution was thus retained to be contrasted with its bifactor counterpart.

ESEM versus bifactor-ESEM. Across all samples, parameter estimates from the bifactor-ESEM solution revealed an academic self-determination G-factor which was well-defined by most indicators ($|\lambda|$ = .003 to .936, M_λ = .463) and reliable (ω = .911 to .960). More importantly, loadings on this G-factor matched the idea that it served to depict participants' global levels of self-determination in a way that match SDT hypothetical continuum of motivation. More precisely, these loadings were strong and positive for intrinsic motivation (λ = .626 to .936, M_λ = .819), moderate and positive for identified motivation (λ = .298 to .562, M_λ = .447), small for introjected motivation (λ = -.131 to .236, M_λ = .093), moderately negative for external motivation (λ = -.052 to -.308, M_λ = .213), and strong and negative for amotivation (λ = -.517 to -.859, M_λ = .743). Beyond this G-factor, the S-factors also retained a reasonable amount of specificity and reliability: intrinsic (λ = .060 to .625, M_λ = .3946, ω = .553 to .905), identified (λ = .664 to .825, M_λ = .739, ω = .859 to .903), introjected (λ = .462 to .891, M_λ = .750, ω = .845 to .883), external (λ = .769 to .903, M_λ = .846, ω = .925 to .947), and amotivation (λ = .281 to .605, M_λ = .456, ω = .714 to .833). It is important to remember that bifactor factor loadings are typically lower than those in first-order solutions because the item-level covariance is partitioned into two sources of true score (i.e., reliable) variance (G- and S-factors) rather than a single one. Importantly, these relatively weaker S-factors can still be considered reliable as they are estimated using latent variables that are naturally corrected for measurement error.

Next, tests of measurement invariance were conducted on the retained bifactor-ESEM solution across the four samples. The results from these tests are reported in Table 2 (Models MIM1−MIM6). The negligible decrease in model fit (ΔCFI and ΔTLI $\leq$ .010 and ΔRMSEA $\leq$ .015) supported the configural, weak, strong, partial strict (freeing up 3 item uniquenesses), and latent variance-covariance invariance of this solution across samples. These results also suggested the presence of latent mean differences on some of the factors. Although interesting in their own right, these latent mean differences are unrelated to the core objectives of this study. For this reason, these latent mean differences are reported and described in Table S6 of the online supplements.

Results from the most invariant model (latent variance-covariance) are reported in Table 3. Across all samples, these results confirm our prior interpretations, revealing a relatively well-defined G-factor reflecting participants' global levels of self-determination ($|\lambda|$ = .056 to .892, $M_{|\lambda|}$= .507-.512; ω = .950-.956). Indeed, these loadings were strong and positive for intrinsic motivation (λ = .855 to .891, M_λ = .877), moderate and positive for identified motivation (λ = .403 to .475, M_λ = .436), small for introjected motivation (λ = -.133 to .056, M_λ = .085), moderately negative for external motivation (λ = -.272 to -.303, M_λ = .286), and strong and negative for amotivation (λ = -.825 to -.892, M_λ = .862). Apart from the G-factor, the intrinsic (λ = .302 to .383, M_λ = .334-.335; ω = .738-.756), identified (λ = .708 to .778, M_λ = .743-.766; ω = .868-.896), introjected (λ = .552 to .944, M_λ = .764; ω = .854), external (λ = .732 to .889, M_λ = .797-.817; ω = .916-.935), and amotivation (λ = .227 to .359, M_λ = .283; ω = .589) S-factors were also reasonably well-defined and reliable. This bifactor-ESEM solution was retained for further analyses.

Measurement Models: Self-Concept

The goodness-of-fit indices associated with the self-concept measurement models across the four samples (Models MSC1-MSC4) are reported in the bottom section of Table 1, parameter estimates from these models are reported in Table S7 of the online supplements, and results from tests of measurement invariance conducted on this one-factor solution are reported in the middle section of Table 2 (Models MIS1-MIS6p). These results generally support the adequacy of this one-factor model in all samples, as well as its configural, weak, strong, and strict invariance across samples. However, the results failed to support the invariance of the latent variance and mean of this factor across samples. A detailed examination of the parameter estimates associated with the various solutions as well as of the modification indices associated with the failed latent variance and mean invariance solutions suggested that this lack of invariance was limited to some samples. More precisely, partial invariance models were supported in which the variance of the self-concept factor was freed in the Secondary-German sample (displaying lower level of inter-individual variability), and in which the mean of the self-concept factor was freed in the Secondary samples (while remaining equal across the Secondary-German and Secondary-math samples). This latent mean difference thus showed that average academic self-concept levels tended to be lower among secondary students (M = -.502, S.E. = .069, $p < .01$) relative to elementary students. Parameter estimates from this last model of partial latent mean invariance are reported in Table 4 and revealed well-defined (λ = .564 to .951, M_λ = .816) and reliable (ω = .876 to .923) self-concept factors across samples.

Associations with Academic Self-Concept and Achievement

The optimal, and most invariant, motivation measurement model was used to assess associations between academic motivation and students' levels of self-concept and achievement (see Figure 1). The results from the tests designed to assess the similarity of these regressions across samples are reported in the bottom section of Table 2 (Models MR1−MR4) and support the complete equivalence of these associations across samples. Parameter estimates from the final model (MR4) are reported in Table 5 and show that global levels of self-determined motivation were positively, and specific levels of external motivation were negatively, related to self-concept. Similarly, academic achievement was positively related to global levels of self-determined motivation and specific levels of intrinsic motivation, but negatively related to specific levels of introjected and external motivation.

Given the nature of the cross-sectional design used in this study, we also estimated an alternative model (suggested by a reviewer) in which self-concept was specified as a predictor of academic motivation, which was itself specified as a predictor of academic achievement. Self-concept was also allowed to directly predict academic achievement. While this alternative model yielded fit indices similar to Model MR4 (χ^2 = 969.234, df = 582, p < .001, CFI = .993, TLI = .994, RMSEA = .032 [90% CIs .029, .036], it includes a variety of associations inconsistent with theory, suggesting that our main model might have been more accurate in terms of directionality.

Discussion

The Structure of Academic Motivation Ratings

This study sought to re-examine the associations between academic motivation, academic self-concept, and academic achievement in math and German by systematically investigating the multidimensionality of students' ratings of their academic motivation. Our results, in line with prior SDT studies (Howard et al., 2018; Litalien et al., 2017), provided support for the superiority of the bifactor-ESEM representation of academic motivation, thus reinforcing the need to rely on a methodological approach able to properly disaggregate students' global levels of self-determined motivation (i.e., students' global sense of volition and self-directedness) from the specific qualities inherent to each type of behavioral regulation. Interestingly, factor loadings observed on the global self-determination factor identified as part of this bifactor-ESEM model were found to fully match SDT's hypothesized continuum structure of motivation (strong positive loadings from intrinsic motivation items, moderate positive loadings from identified regulation items, null or negative loadings from introjected regulation items, moderate negative loadings from the external regulation items, and stronger negative loadings from the amotivation items), which, in turn, lends further support to this hypothesis (e.g., Howard et al., 2018; Litalien et al., 2017; Ryan & Deci, 2017). Additionally, all S-factors retained a meaningful level of specificity beyond the variance in item ratings already explained by the G-factor, although this specificity was slightly lower for the intrinsic and amotivation S-factors. Still, the S-factors also retained a satisfactory level of reliability. Finally, our results supported the robustness of these findings by demonstrating the measurement invariance of both academic motivation and self-concept measurement models as a function of students' education level and subject domain.

Associations Between Academic Motivation, Self-Concept, and Achievement

Our results first supported our expectations that the global self-determination factor would be positively related to self-concept and academic achievement. These associations were pronounced, suggesting that this global factor explained a relatively large portion of the variance in these outcomes. This finding is in line with prior studies relying on the bifactor-ESEM framework and showing that global levels of self-determination had the strongest relations with a variety of covariates such as dropout intentions, ill-being, or psychological need satisfaction (Howard et al., 2018; Litalien et al., 2017). This conclusion, highlighting the importance of a global factor, appears to hold across different operationalizations of motivation (e.g., Fernet et al., 2017; Koen et al., 2015), or different settings and cultural contexts (e.g., Gillet et al., 2016; Jowett et al., 2017). In addition, this result aligns with the diathesis-stress model (Boggiano, 1998) and suggests that students characterized by high levels of self-determined motivation (i.e., volition and self-directedness toward math and German) might be more likely to demonstrate high levels of persistence when learning about math and German, which could lead to more positive math and German self-concepts and better grades. Put differently, the more students are voluntarily driven toward math/German (i.e., global self-determination), the more likely it is that they will think of themselves as being good in math/German.

Results become more finer-grained when focusing on the specific motivation factors. These results showed that academic self-concept and achievement were differentially related to unique motivational qualities. More specifically, apart from being related to global levels of self-determination, self-concept was also negatively related to specific levels of external regulation. These results highlight the detrimental nature of a motivational orientation towards math and German that is anchored in external reasons (i.e., avoiding getting into trouble with parents). Students who experience external pressures to learn about math/German are less likely to put effort into their preparation for their classes or exams which, in turn, might translate into lower academic self-concepts.

With respect to academic achievement, beyond global levels of self-determination, this outcome was positively related to specific levels of intrinsic motivation. This result is consistent with other studies relying on a bifactor-ESEM representation of academic motivation (e.g., Guay & Bureau, 2018; Litalien et al., 2017) and shows that students driven by the pure enjoyment and pleasure associated with these school subjects might perform better because they find these subjects rewarding in and of themselves. Academic achievement was also negatively related to specific levels of introjected and external regulation. These two S-factors might represent elevated levels of internal and external contingencies and pressures that are associated with math and German, which, in turn, might come to undermine academic achievement. In fact, this latter finding is consistent with previous research reporting positive associations between controlled motivation and less optimal academic outcomes (Deci et al., 2013; Guay et al., 2008). Overall, while some previous studies (e.g., Ratelle et al., 2007; Vansteenkiste et al., 2009) argued that the quality of each type of motivation (i.e., the unique nature of each specific factor) is more important than the global degree of self-determination, the present results suggest that both are important and relevant with respect to self-concept and academic achievement, and that a multidimensional approach might be the most optimal for SDT-based academic motivation (Howard et al., 2020b).

Contrary to our hypothesis, more autonomous forms of academic motivation (more specifically intrinsic motivation) were not related to the academic self-concept, and amotivation was not related to students' academic self-concept or achievement, at least once the global self-determination factor was taken into account. These results, however, are not concerning due to the fact that the intrinsic motivation and amotivation items contributed more strongly to the definition of the global self-determination factor than the items associated with the other motivation subscales, thus only retaining a limited amount of specificity. In fact, intrinsic motivation has been shown as one of the main driving characteristics of global self-determination relative to the other motivation factors (Howard et al., 2018; Litalien et al., 2017). What the current study suggests is that, among elementary and secondary school students, items measuring amotivation might be equally important contributors to the definition of the global factor and might provide a clearer (negative) indication of students' global levels of self-determination than of the specific levels of amotivation. This might not be the case among undergraduate and graduate students (Litalien et al., 2017) or working adults (Howard et al., 2018) who might have a more differentiated and nuanced grasp of amotivation. Future studies should strive to assess the replicability of these findings, to better document the meaning and implications of these specific factors in the context of bifactor models, and to investigate more directly the mechanisms at play in these associations.

Practical Implications

Our results also have tentative practical implications for teachers, parents, and people working in education aiming to enhance students' academic self-concepts and academic achievement through motivational interventions. Schools can foster higher levels of self-determination in students by creating and maintaining an environment that satisfies their basic psychological needs for autonomy, competence, and relatedness (Reeve & Halusic, 2009; Ryan & Deci, 2017). Experimental work and intervention studies (e.g., Aelterman et al., 2014; Stroet et al., 2013) focusing on the effects of need-supportive conditions (incorporating autonomy-support, involvement, and structure) have already supported the efficacy of this approach. Practitioners should put more emphasis on the characteristics associated with the specific intrinsic motivation factor by highlighting the enjoyable and pleasurable aspects of math and German. The importance of incentives and other pressures should be minimized to reduce the effects of introjected and external regulations. As for curbing amotivation, practitioners could adopt a variety of strategies, such as self-persuasion techniques (Aronson, 1999) or goal framing (Hardre & Reeve, 2003), to help students find reasons to engage in school-related activities. These techniques can even be combined with previously tested motivation intervention strategies seeking to help students develop interest in academic subjects (e.g., Hulleman & Harackiewicz, 2009).

Limitations and Future Directions

The present study has some limitations. First, the samples of schools and students cannot be considered to be representative of the school and student population in Germany. As a consequence, the generalizability of these results, within and beyond this country, remains uncertain. Further research should seek to more systematically assess the generalizability of the present results (i.e., the bifactor-ESEM representation of academic motivation and its associations with academic self-concept and achievement) to other countries, cultural groups, school levels, and languages. Similarly, while focusing on two distinct subject domains is a strength of this study, future studies are also needed to test the generalizability of our findings to other school subjects. Second, while cross-sectional studies can provide valuable information as part of preliminary investigations serving as the foundation for longitudinal research (which we hope to achieve in this study), the cross-sectional nature of the present study makes it impossible to reach any clear conclusions related to the directionality of the observed associations. Thus, future longitudinal research is needed to verify whether these associations indeed follow the hypothesized causal pathway. Given that reciprocal longitudinal relations have already been established between academic self-concept and achievement (Marsh et al., 2018), future studies should investigate the same reciprocal model with the inclusion of academic motivation. Longitudinal research would also make it possible to more precisely study stability and change in longitudinal trajectories of motivation, self-concept, and achievement, and the time-structured associations between these three constructs. Furthermore, causality could be established by relying on laboratory or intervention studies in which students' motivation or self-concept could be manipulated. Third, this study relied on self-reported measures which could be influenced by various self-report biases. Future studies are encouraged to administer informant-reported measures to students' peers, teachers, or parents, and to consider collecting objective academic achievement records from school registries. However, it is important to keep in mind that high correlations have been reported between self-reported and actual school grades (Kuncel et al., 2005; Noftle & Robins, 2007) and that both tend to share very similar associations with other variables (Kuncel et al., 2005), suggesting that our findings in this regard can be expected to generalize to more objective indicators of academic achievement, although this proposition needs to be verified by future research. The amotivation factor used in the present study did not capture the multidimensional aspect of this construct by focusing on a lack of pleasure but omitting the lack of efforts (e.g., Legault et al., 2006). This lack of construct coverage could explain why this S-factor retained less specificity than the other S-factors and presented no statistically significant associations with academic self-concept or achievement. It would be interesting for future studies to incorporate amotivation items measuring effort beliefs, ability beliefs, and task characteristics (e.g., Cheon & Reeve, 2015; Legault et al., 2006). An important fourth limitation of this study is the omission of predictor variables pertaining to motivation. Future studies should thus strive to identify and test a wide range of predictors (e.g., satisfaction of basic psychological needs, perceived parent and teacher behaviors, personality characteristics). Similarly, a more diversified set of outcomes (e.g., school dropout, vocational choices, academic burnout, well-being) should also be considered in future studies.

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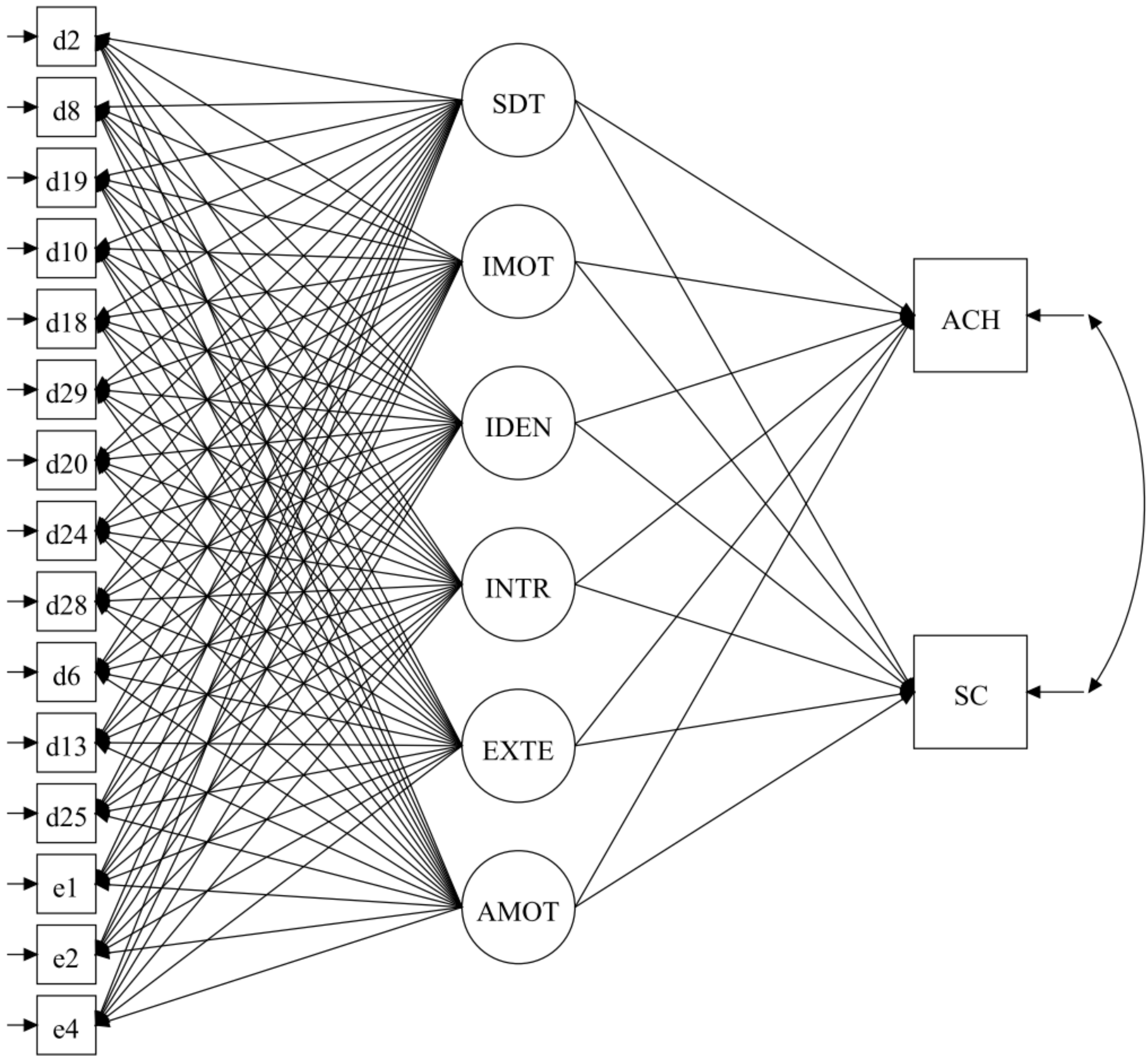

Figure 1.
Final Model Under Investigation

Note. SDT: Global self-determination factor; IMOT: specific intrinsic motivation; IDEN: specific identified regulation; INTR: specific introjected regulation; EXTE: specific extrinsic motivation; AMOT: specific amotivation; ACH = academic achievement, SC = academic self-concept. Academic motivation was represented with latent variables, academic achievement was represented with manifest variables, and self-concept was represented with factor scores saved from preliminary measurement models. Unidirectional arrows linking ovals and rectangles represent factor loadings and cross-loadings, unidirectional arrows linked to the items or the factors represent item uniquenesses or factor disturbances, respectively, while bidirectional arrows represent correlations and the other unidirectional arrows represent regressions.

Table 1

Goodness-of-Fit Results from the Measurement Models Estimated in the Present Study

Models	χ^2	df	CFI	TLI	RMSEA [90% CI]
Elementary-German (Motivation)					
MPG1. CFA	133.402*	80	.995	.994	.033 [.023, .043]
MPG2. ESEM	54.092	40	.999	.997	.024 [.000, .040]
MPG3. B-CFA	916.401*	75	.927	.898	.137 [.129, .145]
MPG4. B-ESEM	32.759	30	1.000	.999	.012 [.000, .034]
Elementary-Math (Motivation)					
MPM1. CFA	107.141*	80	.998	.997	.021 [.008, .030]
MPM2. ESEM	55.979*	40	.999	.997	.022 [.002, .035]
MPM3. B-CFA	696.224*	75	.950	.929	.102 [.095, .109]
MPM4. B-ESEM	39.735	30	.999	.997	.020 [.000, .036]
Secondary-German (Motivation)					
MSG1. CFA	145.039*	80	.993	.991	.038 [.028, .048]
MSG2. ESEM	48.053	40	.999	.998	.019 [.000, .036]
MSG3. B-CFA	541.498*	75	.949	.928	.106 [.097, .114]
MSG4. B-ESEM	31.089	30	1.000	1.000	.008 [.000, .033]
Secondary-Math (Motivation)					
MSM1. CFA	161.542*	80	.997	.995	.041 [.032, .050]
MSM2. ESEM	44.451	40	1.000	1.000	.014 [.000, .032]
MSM3. B-CFA	671.875*	75	.975	.965	.115 [.107, .123]
MSM4. B-ESEM	32.043	30	1.000	1.000	.011 [.000, .033]
Self-concept					
MSC1. Elementary-German	7.696	5	.993	.986	.090 [.000, .209]
MSC2. Elementary-Math	11.152*	5	.998	.997	.068 [.005, .123]
MSC3. Secondary-German	28.332*	5	.993	.986	.091 [.060, .126]
MSC4. Secondary-Math	32.633*	5	.996	.993	.095 [.066, .128]

Note. *p < .01; CFA: Confirmatory factor analyses; ESEM: exploratory structural equation model; B: bifactor; χ^2: WLSMV chi-square; *df*: Degrees of freedom; *CFI*: Comparative fit index; *TLI:* Tucker-Lewis index; *RMSEA*: Root mean square error of approximation; *90% CI*: RMSEA 90% confidence interval.

Table 2

Goodness-of-Fit Results from the Tests of Measurement Invariance and Regression Equivalence Estimated in the Present Study

Models	χ^2	df	CFI	TLI	RMSEA [90% CI]	$\Delta\chi^2$	Δdf	ΔCFI	ΔTLI	ΔRMSEA
Measurement Invariance (Motivation)										
MIM1. Configural	143.648	120	1.000	.999	.018 [.000, .028]	—	—	—	—	—
MIM2. Weak	326.699*	282	.999	.999	.016 [.005, .023]	195.088*	162	-.001	.000	-.002
MIM3. Strong	401.323*	354	.999	.999	.014 [.003, .021]	87.331	72	.000	.000	-.002
MIM4. Strict	659.178*	399	.996	.995	.032 [.028, .036]	292.908*	45	-.003	-.004	.018
MIM4p. Strict partial	605.944*	396	.996	.996	.029 [.024, .033]	226.430*	42	-.003	-.003	.015
MIM5. Variance-covariance	738.892*	459	.995	.996	.031 [.027, .035]	159.597*	63	-.001	.000	.002
MIM6. Latent means	1184.870*	477	.988	.989	.048 [.045, .052]	227.459*	18	-.007	-.007	.017
Measurement Invariance (Self-concept)										
MIS1. Configural	76.391*	20	.996	.992	.087 [.067, .108]	—	—	—	—	—
MIS2. Weak	76.910*	32	.997	.996	.061 [.044, .079]	20.522	12	+.001	+.004	−.026
MIS3. Strong	118.256*	59	.996	.997	.052 [.038, .065]	55.537*	27	−.001	+.001	−.009
MIS4. Strict	146.289*	74	.995	.997	.051 [.039, .063]	42.120*	15	−.001	.000	−.001
MIS5. Variance	231.044*	77	.990	.995	.073 [.062, .084]	38.449*	3	−.005	−.002	+.022
MIS5p. Partial variance	137.588*	76	.996	.998	.047 [.034, .059]	2.771	2	+.001	+.001	−.004
MIS6. Latent means	306.322*	79	.985	.992	.088 [.077, .098]	65.221*	3	−.011	−.006	+.041
MIS6p. Partial latent means	169.524*	78	.994	.997	.056 [.044, .068]	14.926*	2	−.002	−.001	+.009
Regression Models										
MR1. Freely estimated	830.623*	534	.995	.995	.029 [.026, .033]	—	—	—	—	—
MR2. Invariant regression slopes	908.665*	570	.994	.994	.030 [.027, .034]	96.147*	36	-.001	-.001	+.001
MR3. Invariant regression intercepts	919.888*	576	.994	.994	.031 [.027, .034]	22.426*	6	.000	.000	+.001
MR4. Invariant regression residuals	942.900*	582	.994	.994	.031 [.027, .035]	57.989*	6	.000	.000	.000

Note. **p* < .01; CFA: Confirmatory factor analyses; ESEM: exploratory structural equation model; B: bifactor; χ^2: WLSMV chi-square; df: Degrees of freedom; CFI: Comparative fit index; TLI: Tucker-Lewis index; RMSEA: Root mean square error of approximation; 90% CI: RMSEA 90% confidence interval; Δ: Change in model fit in relation to the comparison model.

Table 3

Final Parameter Estimates from the Most Invariant (Latent Variance-Covariance Invariance) Bifactor-ESEM Measurement Model (MIM5) for Motivation

	Elementary-German							Elementary-Math						
	G (λ)	IM (λ)	ID (λ)	IN (λ)	EX (λ)	AM (λ)	δ	G (λ)	IM (λ)	ID (λ)	IN (λ)	EX (λ)	AM (λ)	δ
Intrinsic (IM)														
D2	**.855****	**.383****	.000	.031	.065**	-.028*	.116	**.855****	**.383****	.000	.031	.065**	-.028*	.116
D8	**.891****	**.321****	-.011	.072**	.007	.019	.098	**.877****	**.316****	-.011	.071**	.007	.019	.127
D19	**.889****	**.302****	.036**	.059**	.036**	.002	.113	**.889****	**.302****	.036**	.059**	.036**	.002	.113
Identified (ID)														
D10	**.419****	.079**	**.708****	.050*	-.018	-.054	.311	**.419****	.079**	**.708****	.050*	-.018	-.054	.311
D18	**.403****	-.001	**.772****	.045	-.007	.019	.240	**.403****	-.001	**.772****	.045	-.007	.019	.240
D29	**.475****	-.032	**.749****	.085**	.018	.017	.204	**.475****	-.032	**.749****	.085**	.018	.017	.204
Introjected (IN)														
D20	**-.065***	.017	-.001	**.797****	.242**	.073	.297	**-.065***	.017	-.001	**.797****	.242**	.073	.297
D24	**.056**	-.122*	.110**	**.552****	.275**	.200**	.550	**.056**	-.122*	.110**	**.552****	.275**	.200**	.550
D28	**-.133****	.032	.026	**.944****	.191	-.020	.053	**-.133****	.032	.026	**.944****	.191	-.020	.053
External (EX)														
D6	**-.277****	-.057*	.016	.257**	**.829****	.034	.165	**-.277****	-.057*	.016	.257**	**.829****	.034	.165
D13	**-.272****	.084**	-.012	.288**	**.831****	.005	.145	**-.272****	.084**	-.012	.288**	**.831****	.005	.145
D25	**-.303****	.041	-.001	.397**	**.732****	-.022	.213	**-.303****	.041	-.001	.397**	**.732****	-.022	.213
Amotivation (AM)														
E1	**-.869****	.006	-.029**	.007	.025	**.359****	.114	**-.869****	.006	-.029**	.007	.025	**.359****	.114
E2	**-.892****	-.078**	.049**	.012	.005	**.227****	.145	**-.892****	-.078**	.049**	.012	.005	**.227****	.145
E4	**-.825****	.075**	.014	.005	.033	**.262****	.243	**-.825****	.075**	.014	.005	.033	**.262****	.243
	Secondary-German							Secondary-Math						
	G (λ)	IM (λ)	ID (λ)	IN (λ)	EX (λ)	AM (λ)	δ	G (λ)	IM (λ)	ID (λ)	IN (λ)	EX (λ)	AM (λ)	δ
Intrinsic (IM)														
D2	**.855****	**.383****	.000	.031	.065**	-.028*	.116	**.855****	**.383****	.000	.031	.065**	-.028*	.116
D8	**.891****	**.321****	-.011	.072**	.007	.019	.098	**.891****	**.321****	-.011	.072**	.007	.019	.098
D19	**.889****	**.302****	.036**	.059**	.036**	.002	.113	**.889****	**.302****	.036**	.059**	.036**	.002	.113
Identified (ID)														
D10	**.419****	.079**	**.708****	.050*	-.018	-.054	.311	**.460****	.087**	**.778****	.055*	-.019	-.060	.168
D18	**.403****	-.001	**.772****	.045	-.007	.019	.240	**.403****	-.001	**.772****	.045	-.007	.019	.240
D29	**.475****	-.032	**.749****	.085**	.018	.017	.204	**.475****	-.032	**.749****	.085**	.018	.017	.204
Introjected (IN)														
D20	**-.065***	.017	-.001	**.797****	.242**	.073	.297	**-.065***	.017	-.001	**.797****	.242**	.073	.297
D24	**.056**	-.122*	.110**	**.552****	.275**	.200**	.550	**.056**	-.122*	.110**	**.552****	.275**	.200**	.550
D28	**-.133****	.032	.026	**.944****	.191	-.020	.053	**-.133****	.032	.026	**.944****	.191	-.020	.053
External (EX)														
D6	**-.277***	-.057*	.016	.257**	**.829****	.034	.165	**-.277****	-.057*	.016	.257**	**.829****	.034	.165
D13	**-.272****	.084**	-.012	.288**	**.831****	.005	.145	**-.291****	.090	-.013	.308**	**.889****	.005	.022
D25	**-.303****	.041	-.001	.397**	**.732****	-.022	.213	**-.303****	.041	-.001	.397**	**.732****	-.022	.213
Amotivation (AM)														
E1	**-.869****	.006	-.029**	.007	.025	**.359****	.114	**-.869****	.006	-.029**	.007	.025	**.359****	.114
E2	**-.892****	-.078**	.049**	.012	.005	**.227****	.145	**-.892****	-.078**	.049**	.012	.005	**.227****	.145
E4	**-.825****	.075**	.014	.005	.033	**.262****	.243	**-.825****	.075**	.014	.005	.033	**.262****	.243

Note. **p* < .05; ***p* < .01; ESEM: exploratory structural equation modeling; D: Academic Motivation Scale items; E: Amotivation scale items; B: bifactor; G: global self-determination factor as part of a bifactor model; λ: Factor loading; δ: Item uniqueness; ω: model-based composite reliability; Target factor loadings are in bold.

Table 4

Parameter Estimates from the Most Invariant (Partial Latent Mean Invariance) Measurement Model (MIS6p) for Self-Concept

	Elementary-German		Elementary-Math		Secondary-German		Secondary-Math	
	λ	δ	λ	δ	λ	δ	λ	δ
Item 1	.937**	.122	.937**	.122	.893**	.205	.937**	.122
Item 2	.678**	.540	.678**	.540	.564**	.682	.678**	.540
Item 3	.951**	.095	.951**	.095	.916**	.160	.951**	.095
Item 4	.817**	.333	.817**	.333	.723**	.477	.817**	.333
Item 5	.793**	.371	.793**	.371	.694**	.518	.793**	.371
ω	.923		.923		.876		.923	

Note. **p* < .05; ***p* < .01; *λ*: Factor loading; *δ*: Item uniqueness; *ω*: model-based composite reliability.

Table 5

Parameter Estimates from the Final Latent Regression Model (MR4)

	Academic self-concept β (S.E.)	Academic achievement β (S.E.)
Global self-determined motivation	.586 (.053)**	.371 (.034)**
Specific intrinsic motivation	.267 (.142)	.188 (.090)*
Specific identified motivation	-.061 (.036)	-.053 (.028)
Specific introjected motivation	.035 (.029)	-.107 (.025)**
Specific external motivation	-.098 (.033)**	-.104 (.027)**
Specific amotivation	-.075 (.144)	-.022 (.089)
R^2	.436	.199

Note. *p* < .05; **p* < .01; *β*: standardized regression coefficient; *S.E.*: standard error; R^2: proportion of explained variance.

Online Supplements for:

Disentangling the Associations of Academic Motivation with Self-Concept and Academic Achievement using the Bifactor Exploratory Structural Equation Modeling Framework

Appendix 1
Items of the Academic Motivation Scale

	English translation	German original item content
Item stem	What are the reasons why you learn < academic subject >? I learn <…> because …	Was sind die die Gründe dafür, dass du < Schulfach > lernst? Ich lerne <…>, weil …
Intrinsic motivation (IMOT)		
2	I like <…>.	ich das Fach <…> mag.
8	<…> is fun.	mir <…> Spaß macht.
19	I enjoy <…>.	mir das Fach <…> sehr gut gefällt.
Identified motivation (IDEN)		
10	I need <…> for many things in my life.	ich <…> für viele Dinge im Leben brauche.
18	I have to be good at <…> for many things in my life.	ich <…> für viele Dinge im Leben gut können muss.
29	<…> can help me in my life.	mir <…> für viele Dinge im Leben helfen kann.
Introjected motivation (INTR)		
20	otherwise the others find me bad in <…>.	die anderen mich sonst vielleicht schlecht im Fach <…> finden.
24	otherwise I have a bad conscience.	ich sonst ein schlechtes Gewissen habe.
28	otherwise the others think bad of me.	die anderen sonst vielleicht schlecht über mich denken.
External motivation (EXTE)		
6	otherwise my parents scold me.	sonst meine Eltern schimpfen.
13	otherwise I get into troubles with my parents.	ich sonst Probleme mit meinen Eltern bekomme.
25	otherwise my parents are angry with me.	sonst meine Eltern wütend auf mich sind.
Item stem	Please think about whether these statements are also right for you. I choose to learn little for <…> because…	Überlege jetzt, ob diese Aussagen auch zu dir passen. Ich lerne wenig für <…>, weil …
Amotivation (AMOT)		
30	<…> is boring.	ich das Fach <…> langweilig finde.
31	<…> makes no fun.	das Fach <…> wenig Spaß macht.
33	I don’t feel like learning <…>.	ich oft keine Lust auf das Fach <…> habe.

Note. All items were evaluated on a 4-point response scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*).

Table S1

Parameter Estimates from the Motivation Measurement Models (MPG1-MPG4) in the Elementary-German Sample

	CFA		ESEM						B-CFA			B-ESEM						
	FO (λ)	δ	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ	G (λ)	S (λ)	δ	G (λ)	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ
IMOT																		
D2	.908**	.175	**.756****	.027	-.014	.022	-.155**	.189	**.825****	.355**	.193	**.859****	**.388****	.000	.032	.064	-.062*	.102
D8	.952**	.094	**.969****	.012	.060	-.085*	.018	.049	**.850****	.477**	.050	**.936****	**.172**	-.033	.097**	.004	.047	.082
D19	.928**	.139	**.760****	.038	-.029	.034	-.165**	.157	**.847****	.350**	.161	**.928****	**.060**	-.037	.045	.066	.023	.127
ω	.950		.940							.776			.553					
IDEN																		
D10	.839**	.296	.024	**.829****	.028	-.029	.017	.296	**.508****	.668**	.295	**.505****	.035	**.664****	.077	-.026	-.013	.295
D18	.885**	.216	.039	**.893****	.001	.000	.042	.204	**.529****	.716**	.207	**.532****	.046	**.713****	.062	-.005	.006	.202
D29	.903**	.184	-.078	**.888****	.001	.001	-.100	.188	**.553****	.708**	.193	**.562****	-.091	**.704****	.058	-.015	-.037	.176
ω	.908			.908						.863				.865				
INTR																		
D20	.914**	.165	-.175**	-.034	**.908****	.028	-.190**	.174	**-.186****	.870**	.208	**-.131***	.126**	.062	**.874****	.306	-.156**	.082
D24	.680**	.538	.109	.095	**.530****	.179**	.040	.542	**.012**	.670**	.551	**.099**	-.202**	.058	**.603****	.352	.129*	.442
D28	.889**	.209	.130	.005	**.960****	-.084	.175*	.128	**-.193****	.907**	.141	**-.078**	.052	.056	**.841****	.282	.104*	.190
ω	.871				.872					.869					.883			
EXTE																		
D6	.898**	.194	-.090	.033	-.057	**.924****	.026	.174	**-.326****	.839**	.190	**-.266****	-.158**	-.004	.220**	**.859**	.061	.114
D13	.923**	.147	.090	.030	-.012	**.925****	.126	.130	**-.250****	.904**	.121	**-.228****	.101**	.024	.275**	**.852**	.050	.134
D25	.912**	.168	-.030	-.103*	.144**	**.825****	-.124	.162	**-.270****	.853**	.199	**-.195****	.098*	-.061	.363**	**.808**	-.071	.160
ω	.936					.939				.930						.940		
AMOT																		
E1	.936**	.125	-.046	-.097**	.029	-.016	**.851****	.108	**-.913****	.195	.129	**-.853****	-.013	-.072**	.030	.006	**.402****	.105
E2	.923**	.149	-.293**	-.029	.074	-.040	**.637****	.174	**-.927****	.022	.139	**-.859****	-.066	-.002	.047	-.018	**.281****	.177
E4	.892**	.205	.009	-.005	-.049	.111**	**.896****	.161	**-.863****	.358	.126	**-.812****	.023	-.002	.009	.096	**.412****	.162
ω	.940						.928		.776	.456		.960					.730	

Note. *$p < .05$; **$p < .01$; CFA: confirmatory factor analysis; ESEM: exploratory structural equation modeling; D: Academic Motivation Scale items; E: Amotivation scale items; B: bifactor; G: global self-determination factor as part of a bifactor model; FO: first-order factors; S: specific factors as part of a bifactor model; λ: Factor loading; δ: Item uniqueness; ω: model-based composite reliability; IMOT: intrinsic motivation; IDEN: identified motivation; INTR: introjected motivation; EXTE: external motivation; AMOT: amotivation; Target factor loadings are in bold.

Table S2

Parameter Estimates from the Motivation Measurement Models (MPM1-MPM4) in the Elementary-Math Sample

	CFA		ESEM						B-CFA			B-ESEM						
	FO (λ)	δ	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ	G (λ)	S (λ)	δ	G (λ)	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ
IMOT																		
D2	.942**	.113	**.973****	-.023	-.058*	.029	.018	.099	**.827****	.460**	.104	**.676****	**.594****	.038	-.083**	.006	-.279**	.104
D8	.937**	.123	**.904****	-.005	.037	-.033	-.037	.122	**.831****	.429**	.125	**.626****	**.625****	.070*	-.012	-.028	-.315**	.112
D19	.945**	.108	**.861****	.049*	.000	-.007	-.063	.115	**.843****	.417**	.115	**.720****	**.535****	.086**	-.044	-.012	-.278**	.108
ω	.959		.957							.832			.905					
IDEN																		
D10	.811**	.343	.047	**.776****	.070	-.071	.006	.356	**.402****	.694**	.357	**.438****	.033	**.677****	.031	-.046	-.030	.345
D18	.807**	.349	.004	**.915****	-.043	-.019	.110	.231	**.341****	.802**	.240	**.298****	.050	**.825****	-.033	-.047	-.032	.224
D29	.904**	.183	-.043	**.819****	-.013	.068	-.153*	.246	**.474****	.719**	.258	**.429****	.066	**.734****	-.005	.034	-.146**	.250
ω	.879			.883						.852				.859				
INTR																		
D20	.874**	.235	-.038	-.049	**.915****	-.016	-.078	.194	**-.190****	.883**	.185	**.092***	-.111**	-.086*	**.872****	.304**	.093**	.111
D24	.639**	.592	.083	.078*	**.531****	.122**	.098	.608	**-.126****	.596**	.629	**-.053**	.047	.083*	**.539****	.299**	.050	.606
D28	.920**	.154	-.032	.008	**.914****	-.022	.022	.173	**-.252****	.866**	.186	**-.116****	-.011	.025	**.837****	.299**	.043	.194
ω	.858				.851					.846					.847			
EXTE																		
D6	.878**	.229	-.096	-.010	-.046	**.914****	-.070	.213	**-.265****	.842**	.221	**-.052**	-.141**	-.067	.194**	**.895****	.093*	.126
D13	.919**	.156	.042	-.028	.013	**.915****	.012	.148	**-.243****	.891**	.147	**-.172****	.045	-.025	.296**	**.839****	.026	.177
D25	.875**	.234	.055	.020	.076	**.813****	.071	.244	**-.249****	.828**	.252	**-.239****	.086	.046	.324**	**.786****	.005	.211
ω	.920					.920				.914						.925		
AMOT																		
E1	.886**	.214	-.094	-.041	.036	-.012	**.773****	.225	**-.896****	-.184	.163	**-.517****	-.369**	-.138**	.089**	.069*	**.605****	.199
E2	.930**	.134	-.082	.053*	-.067	.055	**.883****	.125	**-.941****	.126	.099	**-.612****	-.353**	-.041	.039	.089**	**.591****	.141
E4	.826**	.318	.065	-.063*	.046	-.029	**.863****	.298	**-.823****	.006	.323	**-.647****	-.151**	-.086*	.126**	.028	**.527****	.257
ω	.913						.907		.946	.146		.911					.833	

Note. **p* < .05; ***p* < .01; CFA: confirmatory factor analysis; ESEM: exploratory structural equation modeling; D: Academic Motivation Scale items; E: Amotivation scale items; B: bifactor; G: global self-determination factor as part of a bifactor model; FO: first-order factors; S: specific factors as part of a bifactor model; λ: Factor loading; δ: Item uniqueness; ω: model-based composite reliability; IMOT: intrinsic motivation; IDEN: identified motivation; INTR: introjected motivation; EXTE: external motivation; AMOT: amotivation; Target factor loadings are in bold.

Table S3

Parameter Estimates from the Motivation Measurement Models (MSG1-MSG4) in the Secondary-German Sample

	CFA		ESEM						B-CFA			B-ESEM						
	FO (λ)	δ	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ	G (λ)	S (λ)	δ	G (λ)	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ
IMOT																		
D2	.920**	.154	**.857****	-.024	-.007	.031	-.098*	.154	**.848****	.351**	.158	**.807****	**.453****	-.011	.042	.027	-.105**	.130
D8	.932**	.132	**.936****	-.004	-.007	-.002	-.003	.123	**.846****	.403**	.121	**.897****	**.318****	-.050	.021	.029	.093*	.082
D19	.949**	.099	**.898****	.062*	.060	-.063**	-.004	.095	**.874****	.363**	.104	**.857****	**.380****	.047	.088**	-.022	-.018	.110
ω	.953		.951							.765			.804					
IDEN																		
D10	.824**	.320	.006	**.788****	-.040	.030	-.065	.340	**.463****	.667**	.341	**.439****	.058	**.685****	.034	.021	-.069*	.329
D18	.884**	.218	-.033	**.919****	-.005	-.008	.006	.189	**.438****	.787**	.189	**.450****	-.028	**.774****	.065	.010	.007	.194
D29	.874**	.235	.040	**.857****	.045	-.016	.035	.241	**.450****	.743**	.246	**.480****	-.028	**.721****	.103**	.025	.053	.235
ω	.896			.895						.861				.862				
INTR																		
D20	.792**	.372	.137*	-.033	**.770****	.028	.120	.359	**.029**	.804**	.352	**-.012**	.231**	.072	**.834****	.235**	-.060	.187
D24	.637**	.594	.078	.135**	**.563****	.040	.010	.588	**.207****	.607**	.589	**.236****	-.099*	.116**	**.554****	.230**	.125*	.545
D28	.927**	.142	-.110	-.038	**.957****	.027	-.115*	.093	**.022**	.935**	.125	**.093**	-.094	.029	**.836****	.331**	.028	.172
ω	.834				.835					.838					.845			
EXTE																		
D6	.910**	.172	-.017	.009	-.053	**.925****	.028	.171	**-.221****	.888**	.163	**-.246****	.030	.026	.175**	**.857****	.014	.174
D13	.905**	.181	.008	.010	-.081*	**.988****	-.037	.120	**-.150****	.921**	.130	**-.190****	.059	.031	.164**	**.903****	-.033	.117
D25	.906**	.179	-.021	-.020	.215**	**.760****	.027	.195	**-.166****	.852**	.247	**-.153**	-.081*	-.012	.375**	**.806****	.110**	.167
ω	.933					.936				.929						.935		
AMOT																		
E1	.930**	.136	-.014	-.027	.036	-.026	**.921****	.120	**-.834****	.453**	.098	**-.802****	-.070*	-.032	.056	.054	**.501****	.094
E2	.912**	.168	-.168**	.027	.092**	-.048	**.790****	.179	**-.834****	.328**	.196	**-.831****	-.043	.049*	.108*	.028	**.338****	.179
E4	.812**	.340	.093*	-.023	-.137**	.091**	**.862****	.306	**-.728****	.357**	.342	**-.735****	.068	-.012	-.060	.096**	**.365****	.309
ω	.916						.916		.937	.671		.945					.714	

Note. *$p < .05$; **$p < .01$; CFA: confirmatory factor analysis; ESEM: exploratory structural equation modeling; D: Academic Motivation Scale items; E: Amotivation scale items; B: bifactor; G: global self-determination factor as part of a bifactor model; FO: first-order factors; S: specific factors as part of a bifactor model; λ: Factor loading; δ: Item uniqueness; ω: model-based composite reliability; IMOT: intrinsic motivation; IDEN: identified motivation; INTR: introjected motivation; EXTE: external motivation; AMOT: amotivation; Target factor loadings are in bold.

Table S4

Parameter Estimates from the Motivation Measurement Models (MSM1-MSM4) in the Secondary-Math Sample

	CFA		ESEM						B-CFA			B-ESEM						
	FO (λ)	δ	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ	G (λ)	S (λ)	δ	G (λ)	IMOT (λ)	IDEN (λ)	INTR (λ)	EXTE (λ)	AMOT (λ)	δ
IMOT																		
D2	.937**	.123	**.878****	.069**	-.027	.028	-.057	.106	**.830****	.450**	.108	**.847****	**.400****	.038	-.015	-.037	-.121**	.105
D8	.948**	.102	**.831****	.022	-.004	-.044	-.110**	.100	**.852****	.413**	.104	**.818****	**.434****	.018	-.019	-.096**	-.185**	.098
D19	.953**	.092	**.772****	.065**	.046	-.026	-.166**	.098	**.859****	.403**	.099	**.853****	**.368****	.047*	.035	-.076**	-.175**	.097
ω	.962		.953							.837			.828					
IDEN																		
D10	.923**	.147	.080	**.893****	-.049	-.003	.026	.162	**.447****	.797**	.165	**.450****	.029	**.792****	-.042	-.039	-.010	.166
D18	.843**	.290	-.019	**.875****	.044	-.069*	.042	.252	**.354****	.787**	.256	**.320****	.041	**.807****	.039	-.070*	-.041	.237
D29	.898**	.193	.026	**.872****	.011	.017	-.032	.201	**.423****	.786**	.204	**.456****	-.020	**.771****	.013	-.006	-.009	.197
ω	.918			.919						.900				.903				
INTR																		
D20	.808**	.347	.175**	-.041	**.850****	-.047	.126*	.289	**-.110**	.839**	.284	**-.036**	.207**	.001	**.891****	.203**	-.030	.120
D24	.556**	.690	-.117	.206**	**.445****	.176**	-.100	.665	**-.077**	.514**	.730	**.171***	-.267*	.118*	**.462****	.314**	.142	.553
D28	.992**	.017	-.088	-.052*	**.990****	-.018	-.065	.045	**-.245****	.932**	.070	**-.003**	-.073	-.055	**.856****	.323**	.037	.153
ω	.840				.839					.828					.855			
EXTE																		
D6	.902**	.186	-.147*	.054*	-.049	**.981****	-.169**	.134	**-.381****	.828**	.170	**-.232****	-.101*	.030	.184**	**.872****	.021	.141
D13	.972**	.055	.202**	-.061**	-.023	**.975****	.172**	.023	**-.462****	.866**	.036	**-.308****	.087*	-.062	.232**	**.901****	.090*	.020
D25	.895**	.199	-.043	-.048	.130**	**.765****	.047	.215	**-.470****	.743**	.228	**-.274****	-.097*	-.081*	.303**	**.769****	.146**	.204
ω	.946					.952				.932						.947		
AMOT																		
E1	.917**	.159	-.011	-.051**	-.017	.055	**.888****	.114	**-.917****	.335	.047	**-.747****	-.119**	-.091**	.036	.169**	**.528****	.112
E2	.965**	.068	-.293**	.025	.008	.029	**.684****	.112	**-.981****	-.080	.030	**-.790****	-.228**	-.008	.043	.137**	**.437****	.113
E4	.844**	.288	.000	.039*	.020	.007	**.881****	.241	**-.832****	.156	.284	**-.709****	-.064	.007	.066*	.128**	**.485****	.237
ω	.935						.928		.960	.475		.951					.820	

Note. *$p < .05$; **$p < .01$; CFA: confirmatory factor analysis; ESEM: exploratory structural equation modeling; D: Academic Motivation Scale items; E: Amotivation scale items; B: bifactor; G: global self-determination factor as part of a bifactor model; FO: first-order factors; S: specific factors as part of a bifactor model; λ: Factor loading; δ: Item uniqueness; ω: model-based composite reliability; IMOT: intrinsic motivation; IDEN: identified motivation; INTR: introjected motivation; EXTE: external motivation; AMOT: amotivation; Target factor loadings are in bold.

Table S5

Latent Factor Correlations from the First-order CFA (above the diagonal) and ESEM (below the diagonal) Solutions of Motvation Across the Four Subsamples

	Intrinsic	Identified	Introjected	External	Amotivation
Elementary-German					
Intrinsic	—	.578**	.025	-.185**	-.899**
Identified	.543**	—	.095	-.161**	-.586**
Introjected	.016	.062	—	.647**	.098
External	-.132*	-.132**	.618**	—	.285**
Amotivation	-.824**	-.533**	.097	.224**	—
Elementary-Math					
	Intrinsic	Identified	Introjected	External	Amotivation
Intrinsic	—	.454**	-.117**	-.172**	-.904**
Identified	.432**	—	-.034	-.128**	-.476**
Introjected	-.096*	-.029	—	.631**	.193**
External	-.150**	-.104*	.611**	—	.244**
Amotivation	-.883**	-.441**	.182**	.231**	—
Secondary-German					
	Intrinsic	Identified	Introjected	External	Amotivation
Intrinsic	—	.479**	.188**	-.166**	-.829**
Identified	.461**	—	.220**	-.061	-.463**
Introjected	.135*	.192**	—	.576**	-.042
External	-.153*	-.057	.501**	—	.279**
Amotivation	-.794**	-.448**	-.006	.268**	—
Secondary-Math					
	Intrinsic	Identified	Introjected	External	Amotivation
Intrinsic	—	.456**	-.011	-.369**	-.904**
Identified	.374**	—	.002	-.206**	-.435**
Introjected	-.004	.002	—	.544**	.104
External	-.317**	-.168**	.529**	—	.465**
Amotivation	-.821**	-.409**	.096	.414**	—

Note. * $p < .05$; ** $p < .01$; CFA: Confirmatory factor analysis; ESEM: Exploratory structural equation modeling.

Table S6

Latent Mean Comparisons Between the Samples

Latent variable	Elementary-German	Elementary-Math	Secondary-German	Secondary-Math
Global self-determined motivation	.000	.072 (.100)	-.515 (.117)**	-.366 (.105)**
Specific intrinsic motivation	.000	-.120 (.153)	-.358 (.186)	-.253 (.169)
Specific identified motivation	.000	.287 (.091)**	-.462 (.104)**	-.229 (.102)*
Specific introjected motivation	.000	.152 (.098)	-.219 (.100)*	-.264 (.102)**
Specific external motivation	.000	.218 (.090)*	.132 (.107)	.232 (.095)*
Specific amotivation	.000	.434 (.208)*	.721 (.228)**	.594 (.217)**
Global self-determined motivation		.000	-.591 (.103)**	-.459 (.090)**
Specific intrinsic motivation		.000	-.217 (.154)	-.069 (.152)
Specific identified motivation		.000	-.744 (.101)**	-.500 (.101)**
Specific introjected motivation		.000	-.384 (.103)**	-.413 (.101)**
Specific external motivation		.000	-.080 (.104)	.011 (.090)
Specific amotivation		.000	.301 (.185)	.092 (.185)
Global self-determined motivation			.000	.136 (.105)
Specific intrinsic motivation			.000	.131 (.161)
Specific identified motivation			.000	.242 (.110)*
Specific introjected motivation			.000	-.036 (.098)
Specific external motivation			.000	.094 (.096)
Specific amotivation			.000	-.172 (.169)

Note. * $p < .05$; ** $p < .01$; Latent means are fixed to zero in one referent group for identification purposes, and the latent means (and their significance) estimated in the other groups reflect deviations from the mean of this referent group expressed in standard deviation units.

Interpretations:

These differences reveal that global levels of self-determination were lower for secondary students than for elementary students. However, whereas they remained identical across domains for elementary students, these levels were slightly higher in Math than in German for secondary students. Like global levels of self-determination, specific levels of identified motivation were also lower for secondary students than for elementary students and was higher in Math, compared to German, domains. Specific levels of introjected motivation were generally lower among secondary students than among primary students. Specific levels of external regulation were higher in the Elementary-Math and Secondary-Math samples relative to the Elementary-German sample. Finally, specific levels of amotivation were lower in the Elementary-German sample relative to all other samples.

Table S7

Parameter Estimates from the Self-Concept Measurement Models Across Samples

	Elementary-German		Elementary-Math domain		Secondary-German		Secondary-Math	
	λ	δ	λ	δ	λ	δ	λ	δ
Item 1	.893**	.202	.901**	.189	.890**	.208	.943**	.111
Item 2	.722**	.479	.649**	.578	.567**	.678	.666**	.556
Item 3	.960**	.079	.937**	.122	.936**	.124	.958**	.081
Item 4	.795**	.367	.763**	.418	.743**	.448	.830**	.312
Item 5	.698**	.513	.802**	.356	.654**	.573	.820**	.327
ω	.910		.908		.876		.928	

Note. *$p < .05$; **$p < .01$; λ: Factor loading; δ: Item uniqueness; ω: model-based composite reliability.

Table S8

Correlations Between the Variables Used in the Present Study (Using a Bifactor Exploratory Structural Equation Modeling Representation of Academic Motivation)

	1	2	3	4	5	6	7	8
Elementary-German								
1. Global SDT	—							
2. Intrinsic	0	—						
3. Identified	0	0	—					
4. Introjected	0	0	0	—				
5. External	0	0	0	0	—			
6. Amotivation	0	0	0	0	0	—		
7. Self-concept	.601**	.224**	-.073**	.035	-.094**	-.043	—	
8. Grades	.394**	.134**	-.062*	-.110**	-.089**	.046	.728**	—
Elementary-Math								
1. Global SDT	—							
2. Intrinsic	0	—						
3. Identified	0	0	—					
4. Introjected	0	0	0	—				
5. External	0	0	0	0	—			
6. Amotivation	0	0	0	0	0	—		
7. Self-concept	.601**	.224**	-.073**	.035	-.094**	-.043	—	
8. Grades	.394**	.134**	-.062*	-.110**	-.089*	.046	.728**	—
Secondary-German								
1. Global SDT	—							
2. Intrinsic	0	—						
3. Identified	0	0	—					
4. Introjected	0	0	0	—				
5. External	0	0	0	0	—			
6. Amotivation	0	0	0	0	0	—		
7. Self-concept	.601**	.224**	-.073**	.035	-.094**	-.043	—	
8. Grades	.394**	.134**	-.062*	-.110**	-.089*	.046	.728**	—
Secondary-Math								
1. Global SDT	—							
2. Intrinsic	0	—						
3. Identified	0	0	—					
4. Introjected	0	0	0	—				
5. External	0	0	0	0	—			
6. Amotivation	0	0	0	0	0	—		
7. Self-concept	.601**	.224**	-.073**	.035	-.094**	-.043	—	
8. Grades	.394**	.134**	-.062*	-.110**	-.089*	.046	.728**	—

Note. *p < .05; **p < .01; SDT: self-determination. Self-concept was represented by factor scores (with M = 0 and SD = 1) saved from the partial mean invariant measurement model. Correlations between the variables were constrained to be equal across groups to ascertain that the associations between the variables are not impacted by random sampling error.