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Dimensional Comparisons in Students' Perceptions of the Learning Environment

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Abstract

This study aims to add empirical evidence to the generalized internal/external frames of reference (GI/E) model, according to which students' social and dimensional achievement comparisons might not only be related to students' self-concepts but also to perceptions of the learning environment. In a sample of $N = 4926$ German students, math and language achievements were measured along with two facets of students' perceptions of the learning environment, i.e., perceived instructional quality of math and language classes and perceived relations to math and language teachers. In the GI/E path model, achievement and perceptions of the learning environment were positively related within matching domains but negatively related or unrelated across non-matching domains. This pattern of relations indicates that social and dimensional achievement comparisons contribute to the formation of students' perceptions of the learning environment but the pattern of relations was stronger for math than for language achievement. Students' perceptions of instructional quality were more strongly related to achievement than perceptions of student-teacher relations. The findings were generalizable across same-aged elementary and secondary school students. The results are discussed regarding their implications for the proposed GI/E model and their importance for future research.

Keywords: I/E model, perceptions of learning environment, social comparisons, dimensional comparisons

Dimensional Comparisons in Students' Perceptions of the Learning Environment

Dimensional comparisons are a type of intra-individual comparison process according to which individuals compare attributes of the same person with each other (e.g., comparing one's own math achievement with one's own language achievement). Dimensional comparisons have gained prominence through the internal/external frames of reference (I/E) model (Marsh, 1986). Given that the I/E model has been restricted to the effect of dimensional comparisons on students' self-concepts, the present study aims to investigate the potential operation of dimensional comparison processes in the formation of students' perceptions of the learning environment. This study thus contributes to contemporary theoretical advances based on the traditional I/E model and the subsequently established dimensional comparison theory (DCT, Möller & Marsh, 2013) which itself led to the generalized internal/external frames of reference (GI/E) model (Möller, Helm, Müller-Kalthoff, Nagy, & Marsh, 2015).

1. The I/E Model

The I/E model (Marsh, 1986) was originally established to provide a theoretical explanation for the found near-zero correlation between math and language self-concepts. Students' self-concept is conceptualized as students' self-perceptions of their own achievement. As math and language achievements were found to be highly related, math and language self-concepts were also assumed to be substantially related but negligible correlations were consistently found instead. According to the I/E model, the near-zero correlation between math and language self-concepts is explained by the simultaneous operation of social and dimensional comparisons for self-concept formation. Using an external frame of reference, students conduct social comparisons by comparing their achievement in one domain with their classmates' achievements in the same domain. For example, if a student's language achievement is lower than his/her classmates' language achievement, his/her language self-concept is also likely to be lower. By using an internal frame of reference, students conduct dimensional comparisons and compare their achievement

in a given subject with their achievement in another subject. For example, if a student's language achievement is lower than his/her math achievement, his/her language self-concept will suffer but his/her math self-concept will benefit. The social comparison process is supposed to result in a positive correlation between math and language self-concepts while the dimensional comparison process is assumed to lead to a negative correlation. Hence, the simultaneous operation of both comparison processes in students' self-concept formation induces the observed negligible relation between math and language self-concepts. Besides the low correlation between math and language self-concepts, the I/E model makes assumptions regarding the pattern of relations between achievement and self-concepts of matching and non-matching domains (Figure 1a). Interpreted as a result of social comparison processes, the relations between achievement and self-concept of matching domains (e.g., math achievement and math self-concept; the horizontal paths in Figure 1a) are supposed to be substantial and positive. Conversely, dimensional comparison processes are expected to invoke negative relations between achievements and self-concepts of non-matching domains (e.g., math achievement and language self-concept; the cross-paths in Figure 1a).

The I/E model assumptions have been replicated in numerous studies and were found to be generalizable across gender, different age groups (Marsh, Abduljabbar et al., 2015), and different cultures or countries (Chui, 2008, 2012; Marsh & Hau, 2004). Furthermore, the I/E model assumptions were substantiated in cross-sectional (Marsh & Hau, 2004), longitudinal (Marsh & Köller, 2004; Möller, Retelsdorf, Köller, & Marsh, 2011; Niepel, Brunner, & Preckel, 2014) as well as experimental studies (Möller & Köller, 2001a, 2001b) and were found to be valid irrespective of the used self-concept and achievement measures (Marsh & Yeung, 2001). In a large meta-analysis, Möller, Pohlmann, Köller, and Marsh (2009) investigated 69 studies focusing on the relations between academic achievement and self-concepts. The average correlation between math and language achievements was strongly positive ($r = .67$) and much higher than the average correlation between math and language

self-concepts ($r = .10$). The four path coefficients illustrated the operation of social and dimensional comparison processes since the two horizontal paths relating math achievement and math self-concept ($\beta = .61$) and relating language achievement and language self-concept ($\beta = .49$) were substantial and positive, whereas the two cross-paths leading from language achievement to math self-concept ($\beta = -.27$) and math achievement to language self-concept ($\beta = -.21$) were negative.

2. The GI/E Model

The classic I/E model has shifted attention to and inspired research on the phenomenon of dimensional comparison processes (e.g., Eccles, 2009). It stimulated the recent establishment of DCT (Möller et al., 2015; Möller & Marsh, 2013) which takes a broader perspective on dimensional comparisons and points to their antecedents, psychological processes and consequences. In DCT, dimensional comparisons are more generally defined as taking place when a person compares his/her perceptions of aspects of a particular domain A with his/her perceptions of aspects of a particular domain B, bearing consequences for any kind of outcomes related to these domains. Thus, whereas the original I/E model is restricted to math and language achievements as independent variables and self-concepts as outcome variables, DCT opens its logic to a variety of other variables so that DCT leads to the development of the GI/E model (Möller et al., 2015; Figure 1b). Hence, using the original I/E model as a prototype, the GI/E model assumes dimensional comparisons to become evident by negative or near-zero cross-domain relations between any kinds of independent and outcome variables.

In order to provide empirical evidence of the GI/E model, recent studies have made initial attempts to extend the original I/E model to other outcome variables. In this context, a first set of studies retain students' self-concepts as outcome variables but expand the original juxtaposition of math and language self-concepts to a variety of domain-specific self-concepts such as students' self-concepts in science and different (native and foreign) languages (e.g.,

Jansen, Schroeders, Lüdtke, & Marsh, 2015; Marsh et al., 2014; Marsh, Lüdtke et al., 2015). In a more rigorous approach, other variables than self-concept are applied as outcome variables in order to illustrate that social and dimensional comparison processes entail broader cognitive, affective and motivational consequences. In this regard, the GI/E model assumptions were investigated with respect to self-regulated learning (Miller, 2000), emotions (Goetz, Frenzel, Hall, & Pekrun, 2008), intrinsic motivation (Marsh, Abduljabbar et al., 2015), and interest (Schurtz, Pfost, Nagengast, & Artelt, 2014).

So far, outcomes investigated in the context of the GI/E model have commonly addressed students' motivation in cognitive (e.g., self-concept, interest) and behavioral terms (e.g., self-regulation) but the scope of outcome variables which are subject to dimensional comparison processes might be even broader. To our knowledge, no study has yet examined the potential operation of dimensional achievement comparisons in the formation of students' perceptions of their learning environment. Therefore, this study aims to test whether the GI/E model is applicable to two central dimensions of students' perceptions of the learning environment, namely students' perceived teacher relations and students' perceived instructional quality.

3. Students' Perceptions of the Learning Environment

Students' perceived teacher relations are the first dimension of students' perceptions of the learning environment focused in this study. Positive student-teacher relations are characterized by students' experience of teachers providing academic and socio-emotional support to students, considering and meeting the students' needs, and pursuing an individually-orientated approach to the students (Birch & Ladd, 1998). Positive student-teacher relations have been consistently found to be related to a range of desirable student outcomes such as academic behavior (Furrer & Skinner, 2003; Hamre & Pianta, 2001; Hughes, Luo, Kwok, & Loyd, 2008), social behavior (Howes, Hamilton, & Matheson, 1994), or stress reactivity and well-being (Little & Kobak, 2003; Suldo et al., 2009). Of particular

relevance to the present study is the finding that positive student-teacher relations also share positive relations to students' achievement (e.g., Furrer & Skinner, 2003; Hamre & Pianta, 2001; Hughes & Kwok, 2007; Pianta, & Stuhlman, 2004; Spilt, Hughes, Wu, & Kwok, 2012).

Research on the association between student-teacher relations and achievement has mainly followed a domain-unspecific approach. Student-teacher relations have often not been measured related to a teacher for a specific subject but it has often remained unclear which teacher (e.g., students' math teacher or language teacher) is referred to (e.g., Birch & Ladd, 1997; Hughes, Cavell, & Willson, 2001). The application of such global measures, however, does not allow for an investigation of domain specificity in student-teacher relations, thus to study whether students display differential perceptions regarding their math and language teachers. Moreover, the relation between student-teacher relations and achievement has commonly been investigated by using global instead of domain-specific achievement indicators [students' average achievement drawn from math and language tests (e.g., Hughes & Kwok, 2007), or average grades (e.g., Furrer & Skinner, 2003)]. In this instance, it is not possible to examine whether dimensional achievement comparisons are at play in the formation of students' perceptions of student-teacher relations. In the latter case, students' achievement would be positively linked to students' perceived relation to the teacher of the matching domain (i.e., students who achieve well in math have a positive perception of the relation to their math teachers), but negatively related to students' perceived relation to the teacher of a non-matching domain (e.g., students who achieve well in math have a less positive or even negative perception of the relation to their language teacher).

Besides student-teacher relations, we consider students' perceived instructional quality as another facet of students' perceptions of the learning environment. Much research has focused on classroom management which is assumed to encompass different instructional aspects all ensuring students' time-on-task and classroom order (Evertson & Weinstein, 2006). Within this multidimensional conceptualization of classroom management, some

aspects target the clarity, structure, coherence and understandability, thus the quality of instruction (Seidel & Shavelson, 2007). Instructional quality has often been found to be positively associated with students' achievement (Hattie, 2009; Seidel & Shavelson, 2007). For instance, Seidel, Rimmel, and Prenzel (2005) demonstrated that coherence of physics lessons enhanced students' competence development in physics. Regarding math classes, cognitively activating instruction (i.e., providing students with math tasks demanding conceptual modeling, high levels of argumentation and translation processes, Kunter et al., 2013) as well as students' perceptions of rule clarity and teacher monitoring (Kunter & Baumert, 2006) have been shown to be positively related to students' math achievement, while students' perceptions of classroom chaos have been found to be negatively related to students' math achievement (Marsh et al., 2012).

Although a domain-specific approach has thus been pursued in research on the relation between students' achievement and perceived instructional quality, only within-domain relations have been considered (i.e., relations between perceived instructional quality and achievement addressing the same domain such as math or physics). In contrast, cross-domain relations have largely been neglected so far (i.e., relations between perceived instructional quality and achievement addressing non-matching domains). The examination of cross-domain relations could, however, provide insights into dimensional comparison processes potentially at play in students' perceptions of their classes' instructional quality which might lead to negative relations between math (language) achievement and students' perceptions of instructional quality in language (math) classes.

4. Generalizability across School Types

Specific characteristics of learning environments might vary between different academic settings such as elementary and secondary schools. Secondary schools place a stronger emphasis on achievement leading to a performance goal orientation in classrooms (Anderman, Maehr, & Midgley, 1999), to more distant student-teacher relations (Midgley,

Feldlaufer, & Eccles, 1989; see also Reddy, Rhodes, & Mulhall, 2003) and to less individualized and supportive instructions (Eccles et al., 1993). The higher importance placed on achievement in secondary schools might lead to a stronger connection between students' achievement and students' perceptions of the learning environment so that elementary and secondary school students might display differential relations between achievement and perceptions of the learning environment.

The present study includes students of the same age and grade level with one subsample attending elementary school and another group attending secondary school. This design is exceptional as studies commonly compare elementary and secondary school students who also differ in their age and grade level. This peculiarity is due to the fact that the present study draws on data gathered in the German federal state of Berlin. In the Berlin educational system, the majority of students change from elementary to secondary school after grade level 6 but a small number of students are eligible to transfer to secondary school already after grade level 4. The secondary schools offering an early transition after grade 4 belong to the high-ability (academic) track of the German secondary school system and are thus characterized by a high average level of student achievement. Furthermore, these schools have often developed specific profiles or programs (e.g., bilingual programs, physical education, music education) and are thus viewed as highly prestigious and high-achieving learning environments (Arens & Watermann, 2015; Baumert, Becker, Neumann, & Nikolova, 2009). In light of these differences between the learning environments experienced by same-aged elementary and secondary school students in Berlin, it is interesting to explore whether the students differ in their relations between achievement and perceptions of the learning environment including the use of social and dimensional comparison processes.

5. The Present Study

The present study aims to extend empirical evidence of the GI/E model to further outcome variables, namely to two key facets of students' perceptions of the learning

environment. In essence, we analyze whether social and dimensional comparisons of math and language achievement play a role in the formation of students' perceptions of student-teacher relations and instructional quality related to math and language classes. According to the central assumptions of the GI/E model, math and language achievements are assumed to be more highly correlated than students' perceptions of the learning environment related to math and language domains supporting the domain specificity of these perceptions. Due to social comparison processes, achievement is expected to be positively associated with students' perceptions of student-teacher relations and instructional quality in the same domain. A student with good math (language) achievement is presumed to display positive perceptions of his/her relation to his/her math (language) teacher and of the instructional quality of his/her math (language) classes. Following dimensional comparisons, we assume negative relations between achievement and both facets of students' perceptions of the learning environment of non-matching domains. Students with identical math achievement should perceive the relation to their math teacher and the instructional quality of math classes more negatively when demonstrating higher language achievement.

By integrating the two facets of students' perceptions of the learning environment – students' perceived student-teacher relations and instructional quality –, we are also able to examine whether these facets similarly or differentially follow the predictions of the GI/E model. It is conceivable that perceived instructional quality is more strongly associated with achievement and thus shows a clearer pattern of GI/E relations than student-teacher relations. Students might tend to attribute their achievement more strongly to the instructional quality of their classes whereas students' ratings of student-teacher relations might be largely affected by teachers' individual support to the students even in the case of students' low achievement (Stefanou, Perencevich, DiCintio, & Turner, 2004; Torsheim, Wold, & Samdal, 2000).

Finally, the present study explores whether the relations between achievement and the two facets of students' perceptions of the learning environment is generalizable across

students from different learning environments. For this purpose, this study considers an exceptional sample of same-aged students among whom one group attends elementary school whereas another group attends prestigious high-ability secondary schools.

6. Method

6.1 Sample

The data analyzed in this study were retrieved from the Survey of Reading and Mathematics Comprehension: Development from Grades 4 to 6 in Berlin (ELEMENT; Lehmann & Lenkeit, 2008), made available by the Research Data Centre at the Institute for Educational Quality Improvement (Berlin, Germany). Given that the German federal state of Berlin offers two pathways for the transition from elementary to secondary school (i.e., a commonly practiced transition between grade levels 6 and 7, and an early transition to the high-ability track of secondary schools after grade 4 for a minority of students, see above), the aim of the ELEMENT study was to examine and compare the development of cognitive (i.e., achievement) and non-cognitive outcomes (e.g., motivation) between the two groups of students across three measurement waves. The first measurement point took place at the end of grade 4 for students with a regular transition, but at the beginning of grade 5 for students with an early transition (thus, immediately after their transition to high-ability secondary schools). The second and third measurement points were realized at the end of grades 5 and 6 in both groups.

The present study focuses on the third measurement point of the ELEMENT study since the variables of interest were only assessed at this point. Hence, we considered a total sample of $N = 4926$ students ($N = 2474$ male, $N = 2452$ female) at the end of grade 6. A subsample of $N = 3169$ students followed the regular transition to secondary school and thus still attended elementary school. A subsample of $N = 1757$ students had experienced an early transition and thus had already attended high-ability (academic) track secondary schools for nearly two years (i.e., in grade levels 5 and 6).

6.2 Measures

6.2.1 Student perceptions. Using four items, the students were asked to rate their relations to their math teacher ($\alpha = .723$) and their language teacher ($\alpha = .739$). The items were worded in parallel and therefore only differed in whether they referred to the students' math or language teachers (e.g., "Our math/language teacher tries to attend to our wishes"). Second, the students were asked to judge the quality of instructions given in math and language classes. Concretely, four items (math instructional quality: $\alpha = .614$; language instructional quality: $\alpha = .716$) asked the students whether they thought that their math or language classes were well structured and focused on the learning content (e.g., "I can easily keep track in my math/language classes"). The language domain refers to German as a school subject with German as the language of instruction for the studied sample. All items were rated on a 4-point Likert-type scale (1=true, 2=almost true, 3=hardly true, 4=not true at all). Prior to conducting the analyses, items were uniformly coded so that higher values represent more positive levels of student-teacher relations and instructional quality.

6.2.2 Student achievement. Students' grades in math and language classes taken from their report cards served as achievement indicators. School grades in Germany range from 1 to 6 with 1 depicting the best and 6 presenting the lowest grade. For ease of interpretation, grades were reverse scored so that higher grades represent higher levels of achievement. Table S1 of the Online Supplements provides an overview of the descriptive statistics of all variables used in this study.

6.3 Statistical Analyses

All analyses were conducted within the framework of structural equation modeling (SEM; e.g., Kline, 2005) using Mplus 7.3 (Muthén & Muthén, 2014). All models were estimated by applying the robust maximum likelihood estimator (MLR) which has been shown to be robust against any form of violation of normality assumptions and accounts for the treatment of items responded on a Likert-type scale as continuous variables. Since the

items referring to students' perceptions of the learning environment had the same wordings but only differed in their reference to math or language, all models included correlated uniquenesses between these parallel-worded items to consider potential shared method variance (e.g., Marsh et al., 2013).

In order to account for the hierarchical nature of the data with students nested in classes (Raudenbush & Bryk, 2002), all analyses were conducted using the Mplus option "type = complex" with students' classes treated as clustering variables. Non-consideration of the hierarchical structure of the data might lead to inflated Type I errors due to the possible violation of the independence of observations as students attending the same class might be more similar to each other than students attending different classes. The Mplus option "type = complex" corrects for possible biased standard errors resulting from this clustering effect.

Missing values on school grades were estimated by multiple imputation by chained equations (MICE, e.g., White, Royston, & Wood, 2011). Five imputed data sets were created by applying a wide range of auxiliary variables including the grades the students had obtained at preceding measurement waves, class-average standardized reading achievement, students' academic motivation (e.g., interest), as well as socio-economic background variables. All analyses involving students' achievement were conducted with the Mplus option "type = imputation" which combines the parameters of each of the five imputed data sets. Missing data on the remaining items assessing students' perceptions of the learning environment (between 20.0% and 22.7%) were estimated by the Full Information Maximum Likelihood (FIML), a reliable procedure resulting in unbiased parameter estimates that is less work intensive than multiple imputation but similarly efficient (Enders, 2010; Graham, 2009).

A confirmatory factor analysis (CFA) model was first estimated in which two separate factors were assumed for both facets of students' self-perceptions of the learning environments related to math and language classes. Therefore, this model comprises four factors (i.e., separate factors for students' perceived relation to the math teacher, perceived

relation to the language teacher, perceived quality of math instruction, and perceived quality of language instruction) to test whether students differentiate between these facets.

Subsequently, achievement factors were included in this model by using students' school grades as single-item indicators. Based on this model, we tested the GI/E model assumptions using a latent regression model in which students' math and language achievements were assumed to be related to the two facets of students' perceptions of the learning environment in math and language domains.

In order to examine the generalizability of relations between achievement and students' perceptions of the learning environment across elementary and secondary school students, multi-group models were conducted in which students' school type (elementary vs. secondary school) was used as a grouping factor (Millsap, 2011). Using a model of configural invariance, we first tested whether the factor structure (i.e., the same number of factors defined by the same items) generalizes across both groups of students (Meredith, 1993). In a further step, the factor loadings were assumed to be invariant across both groups (weak measurement invariance; Meredith, 1993). Factor loading invariance is a prerequisite for all further invariance tests including tests of structural invariance which examine whether the relations between factors are the same or different across groups (Brown, 2006). In order to test the generalizability of the GI/E model assumptions across the two groups of students, we first stated a regression model in which the paths between achievement and students' perceptions of the learning environment were freely estimated in both groups before assuming the paths to be invariant across groups.

Since the robust chi-square statistic has been found to be to some extent unsuited to the assessment of model fit given its dependency on sample size (Marsh, Hau, & Grayson, 2005), we considered descriptive goodness-of-fit indices including the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA) (Marsh, Hau, & Wen, 2004). Regarding the CFI and TLI, values above .90 and .95

indicate adequate and good model fit, respectively (Hu & Bentler, 1999). For the RMSEA, values should be below .05 to represent a close fit whereas values between .05 and .08 indicate a reasonable fit (Browne & Cudeck, 1993).

The multi-group invariance models can be conceptualized as nested models that only differ in the model parameters which are set to be invariant across groups. The chi-square difference test compares the fit of nested models but has also been shown to be sensitive to sample size (Marsh et al., 2005). Therefore, it is recommended to examine changes in the descriptive goodness-of-fit indices for judging invariance. According to the guidelines proposed by Cheung and Rensvold (2002), invariance can be assumed as long as the CFI does not drop more than .01 between more and less restrictive models (also see Chen, 2007). Hence, cut-off values for the various goodness-of-fit indices have been established to evaluate the fit of latent models including nested models. However, these cut-off values should serve as guidelines rather than being treated as “golden rules”, and researchers are advised to substantiate their ultimate model evaluation by drawing on different types of information including the resulting parameter estimates, statistical conformity, and theoretical adequacy of the models (Marsh et al., 2004).

7. Results

7.1 Preliminary Analyses

Model 1 (see Table 1), the CFA model including separate factors for the different measures of students' perceptions of the learning environment for math and language classes, demonstrated an adequate model fit. All factors were well-defined due to substantial and significant factor loadings (students' perceived relation to the math teacher: .405 to .733; $M = .633$; students' perceived relation to the language teacher: .404 to .758; $M = .656$; perceived quality of math instruction: .420 to .724; $M = .569$; perceived quality of language instruction: .502 to .768; $M = .642$). Within the domains of math and language, both facets of students' perceptions of the learning environment were substantially albeit not perfectly related (within

math: $r = .649$; within language: $r = .728$) providing evidence that students' perceptions of student-teacher relations and instructional quality represent separate facets. In addition, the results supported the domain specificity of these perceptions in light of small correlations between the same facets relating to math and language classes (student-teacher relations: $r = .318$; instructional quality: $r = .349$; both $p < .001$; see Table S2 of the Online Supplements).

Model 2 additionally included factors for math and language achievements defined by students' school grades. An inspection of the standardized factor correlations (Table 2) reveals domain-specific relations with instructional quality being more highly related to students' achievement than student-teacher relations. Math achievement demonstrated relatively higher relations to students' perceived instructional quality in math classes ($r = .416$; $p < .001$) and relations to their math teachers ($r = .132$; $p < .001$) compared to instructional quality in language classes ($r = .105$; $p < .001$) and students' relations to their language teacher ($r = -.014$; *ns*). In parallel, language achievement demonstrated a higher relation to students' perceived instructional quality in language ($r = .275$; $p < .001$) than in math ($r = .220$; $p < .001$) classes although the difference was small. Language achievement revealed a relatively weak association to students' relations to their language teacher ($r = .090$; $p < .001$) and a higher but still weak association with students' perceived relation to their math teacher ($r = .105$; $p < .001$). These findings suggest some differences in the associations between achievement and students' perceptions of the learning environment between the math and language domains.

7.2 The GI/E Model

The path model for testing the GI/E model assumptions with students' perceptions of the learning environment as outcome variables (Model 3) is statistically equivalent to Model 2 resulting in the same fit, as the correlations between factors were only replaced by regression paths. The results (Figure 2) generally supported the GI/E model assumptions. Math and verbal achievements were found to be more highly correlated ($r = .606$, $p < .001$) than

students' perceptions of their relations to math and language teachers ($r = .321, p < .001$) and students' perceptions of instructional quality in math and language classes ($r = .350, p < .001$). These findings supported again the domain specificity of both facets of students' perceptions of the learning environment. Moreover, students' achievement was found to be positively related to students' perceptions of the learning environment in the same domain but negatively related to students' perceptions in the other domain. Hence, math achievement was positively related to students' perceived instructional quality in math classes ($\beta = .446; p < .001$) and to students' relations to their math teachers ($\beta = .109; p < .001$) but negatively related to perceptions of instructional quality in language classes ($\beta = -.097; p < .001$) and relations to the language teachers ($\beta = -.108; p < .001$). In parallel, language achievement was positively associated with students' perceived instructional quality in language classes ($\beta = .333; p < .001$) and relations to language teachers ($\beta = .155; p < .001$), but unrelated to students' perceived instructional quality in math classes ($\beta = -.051; ns$) and students' relations to their math teachers ($r = .039; ns$).

In a further model (Model 4), the relations of achievement to student-teacher relations and instructional quality were set to be of equal size within domains. Hence, the path leading from math (language) achievement to students' relations to their math (language) teachers was restricted to be of the same value as the path leading from math (language) achievement to quality of math (language) instruction. The fit of this model substantially declined compared to that of the unrestricted Model 3 since the decrease in the CFI value ($\Delta CFI = .022$) exceeded the recommended cut-off value of $\Delta CFI \leq .01$ (Cheung & Rensvold, 2002) and the resulting TLI value even indicated poor model fit. This finding implicates that the two facets of students' perceptions of the learning environment were differentially related to students' achievement with perceptions of instructional quality showing higher relations than perceptions of student-teacher relations.

7.3 Generalizability across Learning Environments

To test the generalizability of the GI/E path model across elementary and secondary school students, Models 5 and 6 examined measurement invariance across groups in a first step. The results supported the invariance of factor loadings (Model 6) as the decline in model fit was negligible relative to the model of configural invariance (Model 5). Based on the model of invariant factor loadings (Model 6), the path model for the relations between students' achievement and the two facets of students' perceptions of the learning environment (Model 3 for the total sample) was freely estimated in both groups (Model 7). Constraining the paths to equal size in both groups (Model 8) did not lead to a change in the CFI value indicating that the path model is generalizable across the two groups of students. Accordingly, sixth-grade students attending elementary school and sixth-grade students attending high-ability secondary schools were not found to differ regarding the relations between achievement and the two facets of students' perceptions of the learning environment in the domains of math and language. These associations were found to follow the GI/E model assumptions in both groups.

8. Discussion

Based on the classic I/E model and subsequently established DCT, research has recently proposed the GI/E model according to which dimensional comparison processes might influence other variables than students' academic self-concepts. The present study aims to enrich corresponding empirical evidence by looking at the associations between students' achievement and two facets of students' perceptions of the learning environment – student-teacher relations and instructional quality – in the domains of math and language. In general, the pattern of the GI/E model could be supported for both facets of students' perceptions of the learning environment. First, the correlation between students' perceived relations to their math and language teachers and the correlation between students' perceived instructional quality of math and language classes were lower than the correlation between math and language achievements. Second, achievement and perceptions of the learning environment

were found to be positively related within math and language domains but negatively related across domains. For instance, math achievement was found to be positively related to students' perceptions of the relations to their math teacher and to students' ratings of the instructional quality in math classes, but negatively related to students' perceptions of their relations to the language teacher and instructional quality in language classes.

Instructional quality was found to be more highly related to students' achievement within and across domains compared to student-teacher relations. This finding seems plausible since student-teacher relations might rather depend upon teacher characteristics and teacher support than on students' achievement (Stefanou et al., 2004; Torsheim et al., 2000). Even low-achieving students might perceive a positive relation to their teachers, particularly if the teachers demonstrate support and empathy to the students.

The resulting GI/E pattern was more pronounced for math achievement since the findings showed positive relations between math achievement and both facets of students' perceptions of the learning environment regarding math classes and negative relations between math achievement and both facets of students' perceptions of the learning environment regarding language classes. Language achievement was found to be positively related to both facets of students' perceptions of the learning environment regarding language classes corresponding to the GI/E model expectations but it was unrelated to students' perceptions of instructional quality in math classes and to students' perceptions of the relation to their math teachers. This finding might be explained by the general relevance of language achievement that goes beyond the corresponding school subject itself. Students' language achievement might rather also be relevant to students' accomplishments in other subjects including math (e.g., to adequately comprehend math tasks or to study textbooks in other subjects) so that the implications of dimensional comparisons of one's language achievement might be less pronounced. Since this is only one possible explanation, further research is

necessary to study differences and similarities regarding the strengths and consequences of dimensional achievement comparisons in math and language domains.

The findings of the present study substantially contribute to research on dimensional comparisons showing that these processes are not only involved in the formation of students' academic self-concept. Instead, dimensional comparison processes also seem to be evident in the formation of students' perceptions of the learning environment. The present study therefore suggests answers to the "With What Effect?" question conceptualized as an important issue in DCT, addressing potential effects of dimensional comparisons (Möller & Marsh, 2013).

The findings of our study were generalizable across students experiencing different learning environments as they could be replicated with sixth-grade elementary school students and with a sample of same-aged students attending prestigious high-ability secondary schools. Hence, irrespective of their experienced learning environment, students seem to apply dimensional achievement comparisons in the formation of their perceptions of the learning environment. The overall findings of the present study thus implicate dimensional comparison processes to be a universal phenomenon with consequences going beyond students' academic self-concepts and being applied by different student samples.

This study considers two facets of students' perceptions of the learning environment and demonstrated the separation between perceptions of instructional quality and perceived student-teacher relations. For future studies, it might be advisable to take into account different theoretical conceptualizations and empirical operationalizations of students' perceptions of the learning environment which differentially distinguish between and classify facets of students' perceptions of the learning environment, and include further facets such as teachers' diagnostic competence (Südkamp, Kaiser, & Möller, 2012), autonomy support (Reeve, Bolt, & Cai, 1999), or teacher enthusiasm (Kunter, Frenzel, Nagy, Baumert, & Pekrun, 2011). In this context, future research might also benefit from simultaneously

considering students' perceptions, teachers' perceptions, and observational data to consider different perspectives and ratings, that might agree or disagree, regarding different facets of the learning environment.

Further research is necessary to illuminate the processes underlying the found relations between students' achievement and perceptions of the learning environment. Students' academic self-concept might be supposed to mediate these relations. However, given its inconsistent relations to dimensions of students' perceptions of the learning environment (Arens, Morin, & Watermann, 2015; Marsh et al., 2012), self-concept might be only one possible candidate and alternative mediator variables should be considered such as students' attributions for success and failure (Weiner, 1985). Indeed, students' perceptions of accountability might be of high relevance to explain the present findings on relations between students' achievement and students' perceptions of the learning environment. For instance, a student who does well in math might hold the math teacher to account for the good math accomplishments which might lead to positive perceptions of the student's relations to the math teacher and to positive assessments of the teacher's given math instructions. In case of a student's relatively low level of language achievement, he/she might tend to at least partially attribute the poor performance to the language teacher's inadequate teaching (i.e., low perceptions of instructional quality) and insufficient support (i.e., a perceived negative relation to the language teacher).

More generally, this study stimulates further research on the GI/E model that might lead to further insights into the use and consequences of dimensional comparison processes. In this context, future research should examine even more outcome variables which might be influenced by dimensional comparison processes. On the other hand, an even more sophisticated and necessary approach would be to look at the independent variables. The classic I/E model has considered achievement [either in terms of school grades or standardized achievement test scores (Möller et al., 2009)] as the subject of social and

dimensional comparison processes. Existing extensions of the original I/E model that go beyond self-concept as an outcome variable (Goetz et al., 2008; Miller, 2000; Schurtz et al., 2014) including this study have still used achievement as the independent variable. Hence, future attempts should be made to investigate which variables besides achievement might also be subject to social and dimensional comparison processes (i.e., the question of what is compared, see the “With What” question in Möller & Marsh, 2013). In this context, diary studies (Möller & Husemann, 2006) revealed some first insights that individuals also tend to apply dimensional comparison processes to personality characteristics and physical attractiveness. In an experimental study, Möller and Savyon (2003) manipulated intelligence as the independent variable by success or failure feedback on anagram tasks. People in the failure condition rated themselves as being more honest than did students who received positive feedback indicating dimensional comparisons in the relation between intelligence and honesty. Finally, to get complete sophisticated evidence of the GI/E model, the consideration of various independent and outcome variables should be complemented by different study designs including longitudinal studies to examine possible reciprocal relations between the variables (Möller et al., 2011), and experimental studies to make causal inferences.

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Table 1

Goodness-of-fit Indices

	χ^2	df	CFI	TLI	RMSEA	Model Description
Model 1	897.110	90	.941	.922	.047	4-factor CFA model (separate factors for student-teacher relations and instructional quality related to math and language domains)
Model 2	1238.335	114	.931	.908	.045	6-factor CFA model (separate factors for student-teacher relations and instructional quality in math and language domains, math achievement, and language achievement)
Model 3	1238.335	114	.931	.908	.045	Path model
Model 4	1612.242	118	.909	.882	.051	Paths model with invariant paths
Model 5	1384.026	228	.934	.912	.045	6-factor CFA model: Configural invariance across school tracks
Model 6	1388.637	240	.935	.917	.044	6-factor CFA model: Loading invariance across school tracks
Model 7	1388.636	240	.935	.917	.044	Multi-group path model: Freely estimated paths
Model 8	1388.484	248	.935	.920	.043	Multi-group path model: Invariant paths

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; CFA = confirmatory factor analyses. All models integrated correlated uniquenesses between parallel-worded items and were conducted with the MLR estimator. All χ^2 values are significant ($p < .001$).

Table 2
Standardized Factor Correlations of Model 2

	Student-teacher Relation Math	Student-teacher Relation Language	Instructional Quality Math	Instructional Quality Language	Math Achievement
Student-teacher Relation Language	.318*				
Instructional Quality Math	.633*	.238*			
Instructional Quality Language	.281*	.719*	.337*		
Math Achievement	.132*	-.014	.416*	.105*	
Language Achievement	.105*	.090*	.220*	.275*	.606*

Note. * $p < .001$.

Figure 1a
The traditional I/E model according to Marsh (1986)

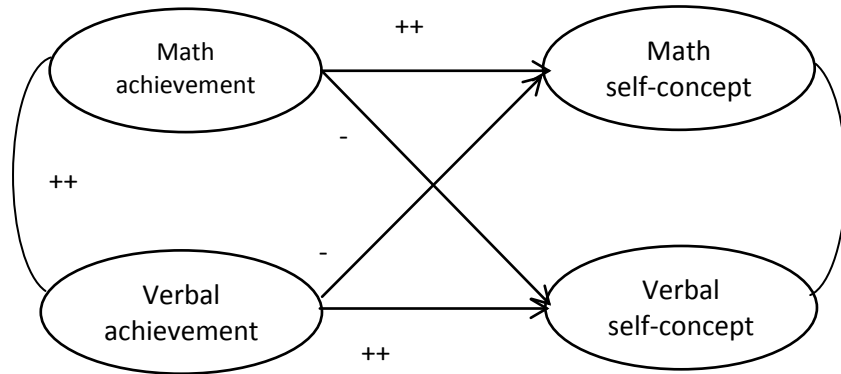
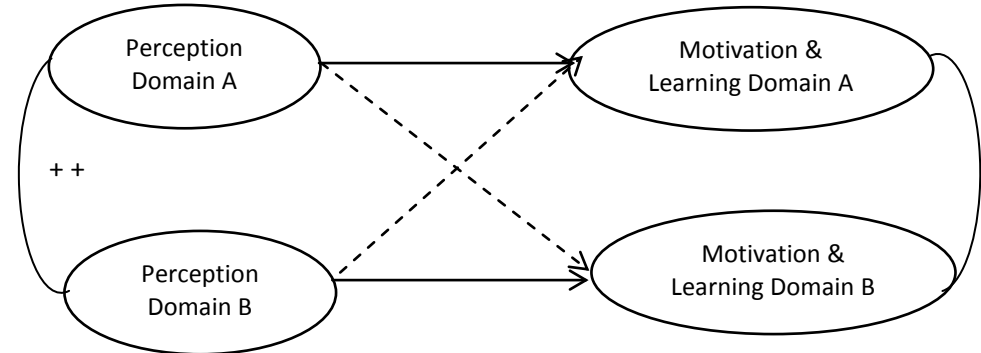


Figure 1b
The generalized I/E model according to Möller et al. (2015)



—————> Effects of social comparisons

-----> Effects of dimensional comparisons

**Online Supplements for
“Dimensional Comparisons in Students’ Perceptions of the Learning Environment”**

Table S1

Descriptive Statistics and Reliability Estimates of the Variables

	<i>M</i>	<i>SD</i>	α	Skew	Kurtosis
Student-teacher Relationship Math	3.132	0.672	.723	-0.783	0.272
Student-teacher Relationship Language	3.114	0.696	.739	-0.722	0.144
Instructional Quality Math	3.260	0.558	.614	-0.932	1.322
Instructional Quality Language	3.213	0.620	.716	-0.875	0.975

Note. *M* = Mean, *SD* = Standard deviation, α = Coefficient alpha reliability estimate.

Table S2

Standardized Factor Correlations of Model 1 of the Main Manuscript

	Student-teacher Relationship Math	Student-teacher Relationship Language	Instructional Quality Math
Student-teacher Relationship Language	.318		
Instructional Quality Math	.649	.254	
Instructional Quality Language	.286	.728	.349

Note. For all correlations * $p < .001$.