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Journal for Educational Research Online
Journal für Bildungsforschung Online
Volume 8 (2016), No. 2, 212–232

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Abstract

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Keywords

Metacognition; Metacognitive strategy knowledge; Learning environment; Multilevel modeling

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Wahrgenommene Unterrichtsmerkmale und metakognitives Strategiewissen in der Oberstufe des Gymnasiums

Zusammenfassung

Bisherige Studien haben gezeigt, dass sich das metakognitive Strategiewissen (MSK) durch explizite Instruktionen und indirekten Massnahmen erfolgreich im Unterricht fördern lässt. Bisher gibt es jedoch kaum Untersuchungen, die die Bedeutung des schulisch-instruktionalen Kontextes des gymnasialen Oberstufenunterrichts für das MSK erforscht haben. Das Ziel dieser Studie ist es, zu untersuchen, inwiefern Zusammenhänge zwischen den wahrgenommenen Lernumgebungsmerkmalen des regulären gymnasialen Unterrichts und dem MSK der Schülerinnen und Schüler bestehen. Für diese Längsschnittstudie wurde eine repräsentative Kohorte von Schülerinnen und Schülern (N_{t1} = 1272/N_{t2} = 1126) der 10. und 11. Klassenstufe zu Beginn und am Ende des Schuljahres befragt. Anhand von Mehrebenenanalysen konnten sowohl Zusammenhänge auf der Individual- als auch auf der Klassenebene identifiziert werden. Auf der Individualebene zeigten sich positive Zusammenhänge zwischen der wahrgenommenen sozialen Integration, dem Autonomieerleben und dem MSK. Eine Lernumgebung, die sich durch selbstreflexive Elemente (z. B. Möglichkeiten zur Selbstkontrolle, Nachdenken über das Lernen) charakterisieren lässt, korreliert negativ mit dem MSK der Schülerinnen und Schüler. Die Ergebnisse weisen zudem darauf hin, dass auch auf der Klassenebene ein negativer Zusammenhang zwischen einem selbstreflexiven Unterricht und dem MSK der Schülerinnen und Schüler vorhanden ist. Die wahrgenommene Unterstützung durch die Lehrperson hatte sowohl auf der Individual- als auch auf der Klassenebene keinen Zusammenhang mit dem MSK. Theoretische und praktische Implikationen dieser Befunde werden diskutiert.

Schlagworte

Metakognition; Metakognitives Strategiewissen; Lernumgebung; Mehrebenenanalyse

1. Important role of metacognition in school

Metacognition plays an important role in students' school success and academic development. Students' effective learning is strongly linked to their metacognition, which enables students to choose effective strategies for accessing new knowledge, know how to proceed on challenging learning tasks, judge the quality of their own learning, and overcome learning difficulties (Zimmerman & Moylan, 2009). Therefore, the fostering of metacognition should play an important role in the educational context. Previous research has shown that the development of metacognitive strategy knowledge (MSK) begins at a very early age and continues over the entire life span (Alexander, Fabricius, Fleming, Zwahr, & Brown, 2003; Schneider, Kron-Sperl, & Hünnerkopf, 2009). Research has indicated that MSK of adolescents develops mainly through constant learning experiences and education and not so much due to improvement with age (Schneider, 2015). In line with this, studies found that teachers who focused on metacognitive instruction enabled students to gain greater insights into MSK for succeeding at academic challenges (Bransford, Brown, & Cocking, 2003; Hartmann, 2001). For one, MSK can be promoted directly through specific training programs or explicit instruction. Researcher-designed instructional interventions and training programs were found to be effective in several studies and meta-analyses (Dignath & Büttner, 2008; Hattie, Biggs, & Purdie, 1996). For another, teachers can promote MSK indirectly through the design of the learning environment (De Corte, Verschaffel, & Masui, 2004; Kistner et al., 2010). However, there is a lack of studies examining the effect of different characteristics of a learning environment in a regular classroom context at the upper secondary school level. Therefore, the aim of this study is to analyze the relationships between perceived learning environments and students' MSK.

1.1 Metacognitive strategy knowledge and its development

Metacognition is broadly understood as thinking about one's own thinking; it refers to knowledge about and regulation of cognitive functions (Flavell, Miller, & Miller, 2002). This study focuses on the knowledge component of metacognition. Metacognitive knowledge is knowledge that is acquired through experience and stored in long-term memory (for an overview see Tarricone, 2011). At least two knowledge components can be distinguished: Declarative metacognitive knowledge encompasses knowledge about *what* measures can be taken to solve a task, and procedural metacognitive knowledge can be described as knowledge about *how* strategies work and have to be applied (Schneider, 2015). This study focuses on metacognitive strategy knowledge (MSK). This concept is based on Flavell's (1979) work on declarative metamemory, which refers to people's verbalizable, stable, and consciously accessible knowledge of their own processing skills. It is knowledge about higher-order thinking strategies that affects the information and memory process (Pintrich, 2002). MSK involves knowledge about the specific demands of different tasks and what task characteristics call for the use of specific strategies. Moreover, MSK encompasses knowledge about the usefulness and characteristics of strategies (Flavell, 1979). This knowledge enables students to know *why* and *when* strategies are effective for processing information (Schraw & Moshman, 1995). The connection of the task and strategy dimension of MSK is realized in task performance, when students are challenged by demanding tasks and have to select and use effective strategies to successfully solve those tasks. In sum, MSK includes knowledge about effective methods of learning and enables learners to choose useful strategies in view of the demands of a task.

There is broad agreement in the literature that a rudimentary understanding of declarative metamemory develops in early childhood (Schneider, 2015). Because school can offer meaningful learning experiences, empirical evidence indicates that there is a development of MSK from kindergarten to the end of lower secondary school (Artelt, Neuenhaus, Lingel, & Schneider, 2012; Schneider et al., 2009). Only few studies investigated the development of MSK from early to late adulthood (e.g., Brown, Bransford, Ferrara, & Campione, 1983). It seems that MSK becomes relatively stable in adult learners; however, it may not be fully developed even in adulthood (Brown, 1987). Moreover, even late adolescents and adults occasionally fail to monitor their strategy use, because their MSK is inaccurate (McCabe, 2011). In this context, it was found that MSK does not necessarily develop with increasing schooling, when instruction does not require strategic engagement and students miss out on metacognitive learning experiences (Mok, Fan, & Pang, 2007; Sperling, Howard, Miller, & Murphy, 2002). In addition to the school context, there are further important factors for the development of MSK, such as extracurricular experiences, social aspects, and individual strategic activities (Hasselhorn & Labuhn, 2010; Karlen, Maag Merki, & Ramseier, 2014). These different prerequisites lead to interindividual differences in the development of metacognitive competencies.

1.2 Learning environments to promote metacognitive strategy knowledge

Many researchers have highlighted the importance of the educational context for the development of MSK (e.g., Desoete & Veenman, 2006), and several attempts have been made to connect the fostering of metacognition to educational settings (Leat & Lin, 2003; Schraw, Crippen, & Hartley, 2006; Veenman, Hout-Wolters, & Afflerbach, 2006). Researchers have stressed that teachers should not only provide students with new subject knowledge but also develop students' MSK by giving students feedback on their learning, providing explicit strategy instruction, promoting collaborative learning settings, and encouraging students to evaluate their learning behavior (McCormick, Dimmitt, & Sullivan, 2013; Paris & Paris, 2001; Zimmerman & Moylan, 2009). Teachers can promote MSK directly and explicitly through strategy instruction (Moos & Ringdal, 2012; Zohar, 2012). However, direct instruction of MSK requires that teachers have a highly pedagogical understanding of metacognition, and it is very demanding (van Velzen, 2012; Wilson & Bai, 2010).

Another way that teachers can foster MSK is to create learning environments that require students to use their MSK. Based on theoretical and empirical work, researchers have provided several guiding principles for designing learning environments that promote students' MSK (De Corte et al., 2004; Kistner et al., 2010; Veenman et al., 2006). In these learning environments, students are active, are challenged with complex tasks that require the activation of MSK and use of strategies, have enough time for independent learning, have opportunities for self-assessment, and receive support in monitoring and evaluating their learning (Bransford et al., 2003; Zohar & Dori, 2012). Autonomy that allows students to be self-active and take responsibility for their own learning processes is an important characteristic of such learning environments (Paris & Paris, 2001). In an early study, Turner (1995) found that when students could learn autonomously, they used more strategies and persisted longer when facing difficulties. Borkowski and Muthukrishna (1995) found that when students had the opportunity to be responsible for their own learning, they showed more active metacognition. However, studies have also shown that autonomous sequences for students have to be well organized and supported by teachers to have positive effects on learning (e.g., Kunter, Baumert, & Köller, 2007). For example, Leutwyler and Maag Merki (2009) found that self-activities without specific support by teachers had no effect on students' use of strategies.

In line with this, another guiding principle for teachers in designing learning environments is to offer support while students are engaging in metacognitive activities. Azevedo and Hadwin (2005) emphasized that when students experience metacognitive engagement, they may need support and coaching by teachers; otherwise, they might be overstrained. Teachers should therefore help students individually to increase their awareness and control of their learning behavior (Wolters & Pintrich, 1998). In this regard, an empirical study found that students showed higher metacognitive activities (i.e., use of MSK) in classes where teachers or peers provided support during self-learning phases (Perry & VandeKamp, 2000). In a more recent study, Houtveen and van de Grift (2007) showed that students made greater progress in MSK when teachers explicitly taught them the use of metacognitive reading strategies, with *gradual release of responsibility* to the students. Supportive teachers can positively influence students' metacognitive engagement (Zohar & Dori, 2012). However, it is important that teachers' support enables students to become more confident in strategic behavior and in applying MSK.

As the learning climate plays an important role for engagement in learning, researchers have highlighted the positive effects of social aspects (i.e., social integration, social interaction) on the development of competencies (Ryan & Patrick, 2001). For example, Leutwyler and Maag Merki (2009) found that perceived social integration (a student's feeling of belonging at school) influenced students' engagement and persistence in learning. Thus, the climate dimension may have an indirect effect on students' MSK by having a positive effect on their strategic engagement (Rheinberg, Vollmeyer, & Rollett, 2005). Further, studies showed that social interactions among students during co-regulative learning promoted students' acquisition of knowledge and metacognitive competencies (Hadwin, Järvelä, & Miller, 2011; Kramarski & Mevarech, 2003). One possible reason for the findings is that learning environments that allow students to successfully collaborate demand high metacognitive regulation and control activities (i.e., control and coordination of the group's learning, decisions on what strategies to use) that require MSK (De Backer, Keer, & Valcke, 2011). Moreover, peer interaction and social discourse can cause students to provide elaborations and explanations of their learning behavior, and accompanied and continuous reflection becomes supported by peers, which in turn can promote MSK (Kuhn & Dean, 2004; Schraw & Moshman, 1995).

A further key element in promoting MSK is to give students the opportunity for *self-reflective* activities. For example, when students have to self-monitor their levels of understanding and their effort, have to review their strategic behavior and their feelings and accomplishments, and have to evaluate their actions against other standards of performance or self-set learning goals (De Corte et al., 2004). Monitoring, evaluating, and reflecting are described as key processes of metacognitive activities. Those processes require students to use their metacognitive competencies and may at that same time promote their MSK (Masui & De Corte, 2005). Hence, on the one hand, self-reflective activities depend on internal (student) factors such as metacognitive competencies that help students to become more aware of their learning progress and to gain control over their strategic behavior. On the other hand, self-reflective activities also depend on external factors, such as the curricula, classroom activities, and tasks presented to students (Paris & Paris, 2001). However, studies showed that teachers rarely create learning environments that might promote MSK (Leutwyler & Maag Merki, 2009; Moely, Santulli, & Obach, 1995; Pauli, Reusser, & Grob, 2007). Teachers do not routinely include characteristics of such learning environments in their regular instruction (Kistner et al., 2010).

1.3 Students' perception of the learning environment

Different approaches can be used to investigate the relationship between learning environment and students' outcome. A promising and successful approach uses data from self-report measures that provide useful information on student ratings of characteristics of the learning environment for regular school instruction (e.g., Lüdtke, Robitzsch, Trautwein, & Kunter, 2009). Students can be considered expert at reporting perceived characteristics of learning environment and the quality of teaching (Clausen, 2002). Several empirical studies confirmed the reliability and validity of these measures and stressed the potential effect on individual outcomes (e.g., Kunter et al., 2007). However, this has yet not been investigated for MSK. Further, the approach makes it possible to distinguish between individual students' perceived experiences in instruction and general features of the learning environment on the class level. On the individual level, the individual students' perception of the learning environment refers to the phenomenology of the students and hence to differences between students. On the class level, the aggregated students' perception yields a shared perception of the learning environment and refers to differences between classes. The aggregated student ratings are seen as valid characteristics of the learning environment that apply to all students within one class.

1.4 Research question and hypothesis

In sum, only few studies have analyzed the relationship between perceived characteristics of learning environment and students' MSK. Specifically, there is a lack of studies simultaneously investigating the effects of different characteristics of learning environment in regular school instruction on the individual as well as on the class level. In this study, a multilevel modeling approach is used to integrate both the individual and the collective perception of the learning environments. With this statistical approach, variance within and between classes can be disentangled, so that both individual and shared perception of the learning environment can be accounted for simultaneously. The aim of this study is to examine the relationship between perceived characteristics of learning environment in the regular classroom context at the upper secondary school and students' MSK. This study is guided by following assumptions:

- perceived social integration,
- support,
- autonomy, and
- self-reflective activities are positively associated with students' MSK.

Based on studies that found that individual students' perceived experiences in school instruction (individual level) and the students' shared perception of the learning environment (class level) are relevant for student outcomes (e.g., Frenzel, Pekrun, & Goetz, 2007), we expect both levels to have a positive association with students' MSK.

2. Method

2.1 Participants and procedure

Students in Grades 10 and 11 were recruited from 73 classes at the upper secondary school level (ISCED Level 3A) across the Canton of Zurich, Switzerland. This school type is academically highly demanding and prepares students for direct university entrance in a period of three to four years. In Switzerland, only high-achieving students (approximately 20 % of cohort) in the lower secondary school level are permitted to enter this school type. Of questionnaires sent out, 2,433 evaluable questionnaires were returned, which is a response rate of 93 % at Time 1 (t1) and 86 % at Time 2 (t2). Two school classes were excluded, because they participated at only one of the two assessments. The final sample consisted of N = 1,272 students at t1 and N = 1,126 at t2. Corresponding to a representative cohort of students for this school type, 58.6 % of the students were female and 41.4 % male. The mean age of the students was M = 16.6 years (SD = 1.06). The two-wave longitudinal study was conducted at the beginning (t1) and at the end (t2) of the school year, with a nine-month interval. Students had to complete an online assessment that included a metacognitive strategy knowledge test and a standardized questionnaire with multiple-choice questions assessing different characteristics of the learning environment. The online assessment was administered class-wise during two regular hours of instruction. During administration of the questionnaire, at least one teacher supervised the class and ensured classroom discipline.

2.2 Measures

2.2.1 Metacognitive strategy knowledge test

In Swiss high schools that prepare students for university entrance, students have to write a longer essay as a requirement for their final certificate. The scenario-based MSK test used in this study refers to students' MSK in the context of tackling longer and complex essays at school. Scenario-based MSK tests of this kind are characterized by high reliability, validity, and economical use (Händel, Artelt, & Weinert, 2013; Maag Merki, Ramseier, & Karlen, 2013). The MSK test used in this study contains seven different learning scenarios, from choosing a topic for the essay to drawing conclusions for similar tasks. In each learning scenario, different strategies are presented that vary in their degree of effectiveness for the given scenario (see Figure 1). Students had to rate the usefulness of each strategy in relation to the requirements of the given scenario on a 6-point scale from 1 (not at all useful) to 6 (very useful).

Experts' ratings were used to determine the relation between two strategies (strategy alternative as superior or subordinate to another) and to build pair comparisons (for more details see Maag Merki et al., 2013). Students' estimated relation between two strategies (= pair of strategies) in comparison with the experts' rating was used to compute the MSK score. For every estimated item pair that corresponded to the experts' item pair, 1 point was given. For each incorrect answer, or non-correspondence with the experts' rating, 0 points were given. For each of the seven learning scenarios on the test, the average of all item pairs represented the scenario MSK score. The average of the values for these seven subscales formed the final MSK score. The values of the score ranged from 0 (= 0 % correspondence with the experts; low MSK) to 1 (= 100 % correspondence with the experts; high MSK). For both measurement time points, the internal consistency of the test was good (α_{t1}= .77, α_{t2} = .81).

Figure 1: One of the scenarios on the metacognitive strategy knowledge test

How useful do you consider following procedures when you have difficulty **gaining an overview of the topic**?		1 = not useful 6 = very useful					
		1	2	3	4	5	6
A	I read literature (such as books, online articles, journals) related to the topic and create a mind map.						
B	I talk with other persons (such as parents, friends) about my topic.						
C	I ask myself what I already know about the topic.						
D	I ask myself what we have already learned in school about the topic and what information is missing.						
E	I don't waste time on research; I prefer to start writing.						
F	I read related literature and set priorities about what I would like to do next.						
G	I think about my learning goals and on how I can reach them						

2.2.2 Perceived characteristics of the learning environment

A standardized questionnaire was used at t2 to assess different characteristics of the learning environment. Eight instruction subscales developed and validated by Maag Merki, Bieri, Forrer, and Grob (2004) were used (see Table 1 for an overview). The factors included are students' retrospectively reported regular classroom experiences. Preatorious (2014) found that characteristics of the learning environment are fairly stable over time, and several empirical studies demonstrated that students' retrospective self-reported ratings are a reliable and valid approach for assessing different characteristics of the learning environment (e.g., Kunter et al., 2007; Lüdtke et al., 2009).

As discussed in the literature, it is not appropriate to assume that the factor structure of the data is the same for both the individual level and class level (Lüdtke et al., 2009). It is necessary to establish proof of the structure for the two levels. An exploratory and confirmatory multilevel factor analysis was conducted using Mplus 7.1 to simultaneously investigate the factor structure for both levels. To handle missing data, the full information maximum likelihood (FIML) procedure was used. Goodness of fit for each model was assessed using the χ^2 value in relation to the degrees of freedom, comparative fit index (CFI), and standardized root mean square residual (SRMR) (Schermelleh-Engel, Moosbrugger, & Müller, 2003). Lüdtke et al. (2009) discuss two interclass correlations (ICC), ICC(1) and ICC(2), as indicators of the reliability of the aggregated students' ratings. ICC(1) refers to individual students' ratings and indicates the proportion of total variance attributed to the class level. ICC(2) indicates the reliability of the class-mean ratings.

The results of the exploratory factor analysis showed that the model with four identical factors on the individual level and on the class level fit the best between theoretical assumptions and data (χ^2/df = 0.273; CFI = 1.00; SRMR within/between = .001/.002). The confirmatory multilevel analysis also revealed adequate fit values for this model (χ^2/df = 2.600; CFI = .97; SRMR within/between = .022/.036). Table 1 shows that the internal consistencies and the interclass correlations for the individual (ICC(1)) and the aggregate level (ICC(2)) can be described as appropriate. To summarize, the results of these analyses showed that it is appropriate to investigate the effect of the perceived learning environment on both levels on the basis of four global scales representing perceived social integration as a proxy for social climate, support as an indicator of teacher assistance in class and perceived competence support, autonomy as an indicator of the degree of self-activity and perceived autonomy support, and self-reflection as indicator of students' perceived monitoring and reflection upon their own learning activities and perceived elaboration of their learning processes.

Table 1: Learning environment scales, subscales, sample items, factor values for the subscales, reliability, and ICC(1) and ICC(2) values.

Learning environment dimension (scale)	Indicators (subscales)	Sample item (number of items)	Standardized factor values (individual/ class level)	α	ICC(1)	ICC(2)
Social integration	Perceived social integration[a]	In class, we have a good classroom climate (5)	.90/.80	.81	0.13	0.70
Support	Teacher assistance in class[b]	Our teachers do a lot to help us (5)	.72/.77	.81	0.12	0.68
	Perceived competence support[b]	In class, I am often praised for doing well (6)	.96/.99			
Autonomy	Self-activity[b]	In class, we students have regular opportunities to realize our own ideas (5)	.80/.89	.86	0.12	0.69
	Perceived autonomy support[b]	In class, I have the opportunity to explore new themes independently (4)	.95/1.00			
Self-reflection	Self-monitoring[b]	We students regularly grade each other's tests (4)	.68/.82	.85	0.21	0.81
	Reflection on work[b]	In class, we reflect on our learning methods and learning activities from time to time (5)	.91/.96			
	Elaboration[b]	In class, we often have opportunities to connect what we learn in one subject with what we have learned in other subjects (4)	.85/.94			

[a] The response scale ranged from 1 (never) to 4 (very frequently). [b] The response scale ranged from 1 (none or only a few of my teachers) to 4 (most or all my teachers).

2.3 Statistical analyses and methodological considerations

The multilevel analysis was conducted using the software program HLM 6. Due to the structure of the data, three levels were taken into account. On the first level (time level), the development of MSK over time was examined with an unconditioned model. This model was also calculated to obtain the within-class and between-class variance (ICC) for the dependent variable (MSK). On the individual level (second level), the model was extended by successive inclusion of predictors (individual students' perceptions of the learning environment). This allowed examination of the effects of individual differences on the starting level of MSK and on the development of MSK. When students' ratings are included at the individual level, an appropriate centering option has to be chosen. In the literature, there is no consensus as to whether the group mean or the grand mean should be used. According to Lüdtke et al. (2009), students' self-reported ratings of their perceived characteristics of the learning environment are generic group-level constructs that affect individual perceptions. If the grand-mean centering option is applied, the class-level effects would be controlled for the interindividual differences, and consequently an essential component of the aggregated ratings would be eliminated. Therefore, in this study the group-mean centering option is used. On the class level (third level), the aggregated class scores, i.e., the shared perception of the learning environment, for each class were included in the model as predictors.

3. Results

3.1 Descriptive statistics

Correlation analysis (see Table 2) revealed significant positive low-to-moderate correlations between all characteristics of learning environments. Correlations between MSK and the different characteristics of learning environments were heterogeneous but were generally on a low level (r = -.10 to r = .17). Whereas perceived social integration was positively correlated with MSK, perceived self-reflection and MSK were negatively correlated. Mean average of self-reported characteristics of the learning environment showed that students perceived a high level of social integration. Self-reflection played a minor role in instruction. Support and autonomy factors of the learning environment were perceived as moderate. Students showed on average a moderate-to-high level of MSK at both measurement points.

Table 2: Descriptive statistics for and correlation between perceived learning environments and MSK

	Descriptive statistics		Correlations				
	M	*SD*	1	2	3	4	5
1 Social integration	3.21[a]	.59	-				
2 Support	2.50[a]	.51	.36***	-			
3 Autonomy	2.50[a]	.49	.23***	.61***	-		
4 Self-reflection	2.10[a]	.58	.14***	.51***	.65***	-	
5 MSK t1	.57[b]	.11	.16**	.01	.04	-.10**	
6 MSK t2	.57[b]	.22	.17***	.03	.04	-.17***	.59***

[a] Min. = 1 and max. = 4. [b] Min. = 0 and max. = 1.

***$p < .001$, **$p < .01$.

3.2 Multilevel modeling

To analyze the impact of the perceived learning environment on MSK, a random intercept and slope model was run. In a first step, the baseline model was run to estimate the time effect and the individual-level and class-level variance values. The ICC was 85.4 % for the individual level and 14.6 % for the class level. From this it could be inferred that significant differences in the development of MSK can be attributed to individual as well as class differences, even though MSK as a whole did not change over time. Moreover, as Table 3 shows, the significant residual variance parameters indicated that differences on both levels and on the intercept of MSK and the slope MSK are relevant. At the class level the model explained 15.3 % of the difference regarding the intercept and 35.2 % of the differences in MSK change over time, respectively, over the period of one school year.

In a second step, predictor variables were introduced on the individual level (see Table 3). The individual students' perception of social integration is positively related to students' amount of MSK. Students who perceived higher social integration reached higher levels on the MSK test at t1 than students who perceived lower social integration. Further, the results showed a negative relationship between perceived self-reflective learning environments and students' MSK. Perceived autonomy had an effect on change in students' MSK over time. Students who reported having perceived higher autonomy showed higher progress in MSK over time than students who perceived having lower autonomy. No effect of perceived support was found.

Table 3: Multilevel regression of individual-level and class-level predictors on MSK

Model	1	2	3
Measurement (time) level	β[a]	β[a]	β[a]
Intercept	.572***	.572***	.572***
Time	-.003	-.003	-.004
Individual level			
Intercept			
Social integration		.142***	.066***
Support		.003	.013
Autonomy		.002	.010
Self-reflection		-.095*	-.052*
Time Slope			
Social integration		.001	.002
Support		.005	.002
Autonomy		.042*	.018*
Self-reflection		-.031⁺	-.017⁺
Class level			
Intercept			
Social integration			.006
Support			.050
Autonomy			.063
Self-reflection			-.206*
Time Slope			
Social integration			.040⁺
Support			.003
Autonomy			.034
Self-reflection			-.083**
Residual variance parameter			
Measurement (time, level 1)	.010[b]	.010[b]	.010[b]
Intercept (individual level)	.033***	.032***	.032***
Time Slope (individual level)	.031***	.030***	.030***
Intercept (class level)	.006***	.006***	.005***
Time Slope (class level)	.003***	.003***	.002***
Explained variance and ICC proportion			
Explained variance (ref. preceding model)			
Individual level (intercept)		.032	.002
Class level (intercept)		-.034	.153
Individual level (time slope)		.012	.002
Class level (time slope)		-.014	.352
ICC			
Individual level	.854	.854	.871
Class level	.146	.147	.134

[a] standardized regression coefficient; Dependent variable is metacognitive strategy knowledge (MSK).
[b] Fixed correction for attenuation value.

***$p < .001$; **$p < .01$; *$p < .05$; ⁺$p < .10$.

Finally, in a third step, predictor variables were additionally introduced on the class level. Model 3 allows investigation of both individual and collective perception of the learning environments simultaneously. Analogous to Model 2, at the individual level there was a positive correlation between the individual students' perceived social integration and the level of MSK at t1 (see Table 3), and there was a negative correlation between self-reflective aspects of learning environments and MSK. Students who perceived higher autonomy showed higher progress in MSK over time than students who perceived lower autonomy. Only few significant results were found for the class level. In classes in which self-reflection was an important part of instruction, students showed a lower amount of MSK at t1 than students in classes with fewer opportunities for self-reflection in regular school instruction. Moreover, there was also a negative correlation between self-reflective learning environments and the change in MSK over time, showing that students in classes with higher reflective activities had a decrease in MSK over time rather than an improvement in MSK.

4. Discussion

4.1 Summary and discussion of the results

The aim of this study was to analyze the relationship between perceived characteristics of the learning environment and students' MSK in the regular classroom instruction context. It was expected that student's individual perceived experience (the individual level) and the shared perception of the learning environment (the class level) have a positive effect on students' MSK. In this study, different relationships were found for students' individual perception and the classes' shared perception of the learning environment. This discrepancy between the two levels has been demonstrated in various other studies (i.e., Kunter et al., 2007), and it underlines the importance of including students' ratings at the individual level and the aggregated class level. In general, the results showed that characteristics of the learning environment contribute significantly on both the individual level and the class level to explaining part of the variance of students' MSK. The effect sizes of those factors vary (β = .018 to β = -.206) and are not very large. However, the effect sizes correspond to effect sizes described in other multilevel and longitudinal studies and can therefore be seen as relevant (e.g., Leutwyler & Maag Merki, 2009).

Within this study, it was possible to observe MSK over a period of nine months. During that time, there was on average no significant gain in students' MSK. A possible explanation could be that students do not see a need to invest in strategic behavior and metacognition, because there is no need for them to self-regulate their learning to be successful at school. Studies have shown that in some learning contexts, elaborated strategic behavior and the use of MSK are not relevant for successful learning (e.g., Stoeger, Steinbach, Obergriesser, & Matthes, 2014). For schools at the lower and upper secondary school level in Switzerland, some studies showed that teachers rarely create learning environments that might require metacognitive competencies (e.g., Leutwyler & Maag Merki, 2009; Pauli et al., 2007). In this regard, Leutwyler (2009) mentioned that the curricula at Swiss high schools may not support teachers in including metacognitive thinking in their lesson plans. Another possible explanation is that teachers lack sufficient knowledge about metacognition to be able to create such learning environments (Zohar, 2012). It is also possible that teachers might not have seen the importance of fostering students' MSK in this school type, because they overestimated their students' strategic skills. However, the results indicate that interindividual differences in students' MSK over time exist. MSK might have decreased in some of the students and stayed stable or increased in other students. With the data of this study, it is not possible to explain these interindividual changes of MSK over time. In the literature, extracurricular experiences and the extent and intensity of students' strategic activities are discussed as possible factors (Hasselhorn & Labuhn, 2010; Karlen et al., 2014).

Whereas there was a positive correlation between students' personal experiences of social integration and students' MSK at the individual level, no positive correlation between social integration and MSK was found at the class level. How can this positive correlation between individual students' perceived social integration and students' MSK be explained? Social aspects are important prerequisites for motivation and are seen as essential factors for engagement in school learning (Rheinberg et al., 2005). Through stronger engagement in learning students can make important strategic experiences that may support the acquisition of MSK (Zimmerman & Moylan, 2009). Another explanation could be that students who feel socially integrated more often collaborate with other students. In this context, researchers showed that peer interaction and social discourse can have a positive effect on students' metacognition (Kuhn & Dean, 2004; Schraw & Moshman, 1995). However, the non-effect on the class level points up that social interactions do not per se have a positively influence on increases in MSK. It might be important that social interactions also include specific interactions concerning metacognitive activities (i.e., talking about advantages and disadvantages of strategies, discussing learning approaches, taking about how a task can be solved.

Another outcome of this study was contrary to expectations: There was no association between teacher support and students' MSK at the individual level or the class level. One explanation for this could be that perceived teacher support was not related to the development of MSK or to strategic behavior in general. It might be more likely related to problems concerning school subject-specific matters. In line with this assumption, De Kock, Sleegers, and Voeten (2005) conducted interviews with teachers who reported that they focus more on content knowledge than on supporting students in thinking about their own learning. Moreover, Bolhuis and Voeten (2001) showed that teachers only exceptionally teach students how to learn. Although this study found no association between teachers' support and students' MSK, it would be wrong to conclude that teachers' support is not relevant for metacognitive engagement. Whereas some students of course do acquire MSK through their own experiences, many more students fail to do so without specific support (Peeters et al., 2014). To get a clearer picture of what kind of support is important to foster students' MSK, future studies should also assess the type of support given by teachers.

Learning environments that give students autonomy in learning were partially positively related to students' MSK. This study found a positive correlation at the individual level but no effect at the class level. A possible explanation for the result on the individual level might be that students who perceive that they have more autonomy in the classroom might feel a stronger need for metacognitive engagement than students who feel that they do not have autonomy. But why was there no effect at the class level? Kirschner, Sweller, and Clark (2006) indicated that providing more autonomy to students with low experiences in strategic behavior could be detrimental as opposed to providing clear coaching. Situations in which students have to deal with more autonomy and have to take action for their own learning processes demand high strategic skills. Therefore, metacognitive competencies might first have to be developed to a certain level for students to be able to benefit from greater autonomy in the classroom. Another explanation for the non-effect of perceived autonomy could be that the *type of autonomy* allowed in classroom instruction might play an important role in the development of students' MSK. For example, if students have more autonomy in the sense that they may decide what task to solve and with whom they would like to solve this task, it is more evident that there will be no impact on MSK. Future studies will have to examine those assumptions and investigate what type of autonomy is relevant for fostering students' MSK. The studies should take *quality aspects* of the autonomy dimension (i.e., type of autonomy, length, support) into account.

In contrast to expectations, the relationship between perceived self-reflective learning environment and MSK was negative. A self-reflective learning environment is characterized by students' reflection upon learning, self-monitoring, and elaboration of new knowledge with previous knowledge. One possible explanation for the negative association may be that these very complex demands overstrained some students. As the descriptive results indicate (see Table 2) activities of this kind are not often part of regular classroom instruction, and for that reason, students might be unfamiliar with them. In an earlier study with students at the same school type, Leutwyler and Maag Merki (2009) mentioned that this kind of instructional design is almost nonexistent (see also Kistner et al., 2010, for the lower secondary school level). Therefore, in a first step, students may have a feeling of uncertainty facing these new challenges, so that at best new MSK is not consolidated and at worst existing MSK gets called into question and decreases. This explanation may partially help elucidate this result. It remains an after-the-fact speculation. Further empirical investigation is required to get a deeper understanding of the negative correlation between self-reflective learning environments and students' MSK.

4.2 Limitation and outlook

This study has several limitations. When interpreting the results of this study, it has to be kept in mind that these results could be related to the way in which characteristics of the learning environment were assessed (Dignath-van Ewijk, Dickhäuser, & Büttner, 2013). Perceived characteristics of learning environment were measured retrospectively at t2. Even though some characteristics of the learning environment might, to a certain degree, be stable over time, changes in instruction cannot be excluded. Therefore, future studies should assess perceived learning environments at several measurement points to take changes in instruction into consideration. Characteristics of learning environment were only measured on a general level. Future studies might consider to ensure more strongly concordance between all measured factors by taking subject- or domain-specific matters into account. Furthermore, future studies might combine self-reported perceptions of different learning factors with further assessments (e.g., observation, video study) to develop a clearer understanding of the instructional activities in different learning arrangements. This could help to get an elaborate picture of what happens during school instruction hours (e.g., tasks, teacher-student interactions, student-student interactions) and could help to explain unexpected results.

In this study, it was not possible to identify the *net relationship* between perceived characteristics of the learning environment and MSK since potentially important covariates (i.e., students IQ, motivation) were missing. Therefore, future studies should examine whether similar effects can be found when controlling for individual and class-level covariates. In addition, the inclusion of further measures such as extracurricular experiences, students' strategic engagement and activities would help to explain interindividual changes in MSK. Finally, it has to be mentioned that the sample was restricted to upper secondary education and to schools with higher academic demands. Therefore, the results of this study cannot be generalized to the whole cohort of students at the upper secondary school level.

Despite these limitations, the results provide additional support for the significance of characteristics of the learning environment for MSK. First, the results indicate that self-reflection phases in regular classroom instruction might require stronger guidance and support by teachers, so that a negative association with MSK might be turned into a positive effect. Second, as there were positive correlations between perceived social integration and students' MSK and perceived autonomy and students' MSK, it might be important for teachers to take social and motivational aspects of learning into stronger consideration while planning lessons.

Acknowledgements

I would like to thank Erich Ramseier for his insightful feedback on earlier version of this paper and the fruitful discussion on the development of the metacognitive strategy knowledge test.

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