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formal und inhaltlich überarbeitete Version der Originalveröffentlichung in:
formally and content revised edition of the original source in:
British journal of educational psychology 86 (2016) 4, S. 526-545, 10.1111/bjep.12121

This is the peer reviewed version of the following article: Rieser, Svenja / Naumann, Alexander / Decristan, Jasmin / Fauth, Benjamin / Klieme, Eckhard / Büttner, Gerhard (2016): The connection between teaching and learning: Linking teaching quality and metacognitive strategy use in primary school. British Journal of Educational Psychology 86(4), pp. 526-545, which has been published in final form at https://doi.org/10.1111/bjep.12121. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Self-Archiving.

The Connection between Teaching and Learning: Linking Teaching Quality and Reported Metacognitive Strategy Use in Primary School

Abstract

Background:

In order for teaching to be successful, students need to be actively involved in learning. However, research on teaching effectiveness often neglects students' learning activities. Although it is assumed that effective teaching promotes the use of beneficial learning activities, empirical evidence for this connection is still limited.

Aims:

This study investigates the connection between effective teaching and reported learning activities. We hypothesize specific relations between a three dimensional model of teaching quality (i.e., cognitive activation, supportive climate, and classroom management) and students' reported use of metacognitive strategies. Students' intrinsic motivation is considered as a mediator and a moderator of this connection.

Sample:

N = 1,052 students from 53 German primary school classes and their science teachers participated.

Methods:

Data were collected through classroom or video observation and questionnaires over a period of approximately two months. Multi-level analysis was utilised to test our hypotheses.

Results:

Each dimension of teaching quality positively predicted students' reported use of metacognitive strategies. For supportive climate this connection was mediated by students' intrinsic motivation. Cognitive activation negatively predicted the slopes between students' reported metacognitive strategy use and motivation.

Conclusions:

The results support the notion that effective teaching is connected to learning activities and stressed the importance of students' learning motivation. Results from the cross-level-interaction could indicate that especially less motivated students' reported metacognitive strategy use might be supported by cognitively activating teaching.

Much research has identified characteristics of effective teaching (e.g., Hattie, 2009). Yet, as Vermunt and Verloop (1999) state: “Teaching does not automatically lead to learning. The learning activities students engage in largely determine the quality of the learning outcomes they attain“(p. 258). Thus, practices of effective teaching need to be related to effective learning activities to yield achievement gains (Vermunt & Verloop, 1999; Winne, 1987). Even though this idea is now well-known and widely accepted, only little empirical research has been conducted to strengthen it. The present study tries to connect research on effective teaching and students’ learning activities by exemplarily linking a three dimensional model of teaching quality with students’ reported use of metacognitive strategies.

Reported use of metacognitive strategies in the classroom context

Research on students’ learning activities is often conducted in the context of self-regulated learning. Self-regulated learners are expected to use a variety of different learning strategies. Most prominently among them are cognitive, motivational and metacognitive strategies (e.g., Boekaerts, 1999; Pintrich, 2004; Zimmerman, 2000). Metacognitive strategies are cognitions which are used to plan, monitor and evaluate the learning process (Veenman, Hout-Wolters, & Afflerbach, 2006; Zimmerman, 2011) thus coordinating and regulating cognitive and motivational processes. Therefore metacognitive strategies play an essential part in efficient and successful learning and were chosen to be the focus of this study.

However, not all students use metacognitive strategies to regulate their learning at all times. It is assumed, that the use of metacognitive strategies is related to personal conditions and characteristics of the learning environment that either foster or hinder it (e.g., Boekaerts, 1997; Winne, 2001).

In school, teachers play a major role in the creation of learning environments that support students’ use of metacognitive strategies. Otto (2010) differentiates two ways in which learning environments created by teachers can support students’ use of metacognitive strategies: either through direct instruction or by providing favourable learning conditions.

Direct instruction of metacognitive strategies means that metacognitive strategies themselves become the content of the lesson. The teacher and the students discuss when, how and why to use a specific metacognitive strategy and practice its application. Thus, students reflect their learning process and deliberately try to improve it (e.g., Baas, Castelijns, Vermeulen, Martens, & Segers, 2014; Dignath, Büttner, & Langfeldt, 2008; Kistner et al., 2010; Kostons & van der Werf, 2014; Veenman, 2011b). This kind of support is especially helpful if students have little experience in using metacognitive strategies.

When providing favourable learning conditions, teachers do not explicitly aim at teaching students new metacognitive strategies but rather create conditions that allow and support the use of metacognitive strategies which the students have already acquired. These conditions comprise learning tasks and materials but also other students or the teacher (Otto, 2010). Research on learning conditions found that students report to use metacognitive strategies more frequently while working on complex tasks that required them to coordinate several steps to succeed. Teachers are also able to support their students' reported use of metacognitive strategies by encouraging peer discussions and providing constructive feedback that focuses on personal progress. Thereby students are given additional opportunities to reflect about and improve their learning. Lessons that supported students' reported use of metacognitive strategies were well-structured with clear rules and routines thus providing students with a reliable environment in which they learn autonomously (e.g., de Corte, Verschaffel, & Masui, 2004; Donche, De Maeyer, Coertjen, van Daal, & van Petegem, 2013;Hospel & Galand, 2016; Perry, Philips, & Dowler, 2004).

The role of motivation for the reported use of metacognitive strategies

However, whether students make use of the learning environment offered to them strongly depends on personal conditions, especially their motivation to learn. The term “motivation to learn” refers to the interaction of students learning related goals, values and beliefs (Eccles & Wigfield, 2002; Murphy & Alexander, 2000). Students with a strong motivation to learn can be expected to pay increased attention to their learning progress, by planning, monitoring and evaluating their learning. It is likely that those students also invest the extra effort which the use of metacognitive strategies requires in order to achieve a better understanding (Zimmerman, 2011). Research that connects different motivational constructs with reports of metacognitive strategy use supports these assumptions. Positive connections with students' reported use of metacognitive strategies were identified for students who were interested in the topic (McWhaw & Abram, 2011), attached high personal value to a task (Berger & Karabenick, 2010) or had a learning goal orientation (Coutinho & Neuman, 2008; Mouratidis, Vansteenkist, Michou, & Lens, 2013; Vrugt & Oort, 2008). Several studies also found that students with high self-efficacy beliefs reported to use metacognitive strategies more frequently (e.g., Artelt, Baumert, & Julius-McElvany, 2003; Berger & Karabenick, 2010; Moos, 2014).

When considering previous research, it appears that students with a strong motivation to learn report to use metacognitive strategies more often. Furthermore, teachers can support the reported use of metacognitive strategies through the learning environment they create. The learning environment created by teachers is also the focus of research on effective teaching. A comprehensive model of effective teaching is provided by Klieme, Pauli, and Reusser (2009).

The three dimensional model of teaching quality

In their model of teaching quality, Klieme, Pauli, and Reusser (2009) differentiate between three dimensions: cognitive activation, supportive climate and classroom management (for a similar model see Pianta and Hamre, 2009). Cognitive activation describes teaching practices that enhance students' engagement with the learning content. In cognitively activating lessons, teachers confront their students with complex tasks, explore their ideas and thinking processes, encourage class wide discussions and activate prior knowledge (Lipowsky et al., 2009; Pianta & Hamre, 2009). Previous research has shown that students experiencing a high level of cognitive activation also show higher achievement gains (Baumert et al., 2010; Fauth, Decristan, Rieser, Klieme, & Büttner, 2014b; Mashburn et al., 2008).

Supportive climate strongly builds on results from self-determination theory (Deci & Ryan, 1990; Ryan & Deci, 2002) and is expected to strengthen autonomous motivation (Klieme et al., 2009). Autonomous motivation comprises different forms of extrinsic motivation (identification, integration) and intrinsic motivation. Autonomously motivated students feel that they determine their action without any external control. They experience themselves as competent, self-determined and socially related (Ryan & Deci, 2000b). Teachers can support students' autonomous motivation by providing individual assistance and constructive feedback, and also show caring in their interactions with students (e.g., Kiemer, Gröschner, Pehmer, & Seidel, 2015; Reeve & Jang, 2006). Several empirical results back this assumption (Assor, Kaplan, & Roth, 2002; Fauth, Decristan, Rieser, Klieme, & Büttner 2014a; Reyes, Brackett, Rivers, White, & Salovey, 2012).

Effective classroom managers establish clear rules and routines, intervene quickly when lessons are disrupted, and thoroughly plan and structure their lessons. Therefore, lessons run more smoothly so that more time can be spent on actually dealing with the content (Emmer & Stough, 2001; Kounin, 1970; Marzano & Marzano, 2003). It has been shown that an effective classroom management fosters students' achievement (Fauth et al., 2014b; Lipowsky et al., 2009) and thereby allows them to experience themselves as competent. Furthermore, by providing a well-structured lesson, effective classroom managers offer their students a safe context for competent and autonomous action. According to research on self-determination theory this should strengthen autonomous motivation (Reeve, 2006). Empirical support for this connection between classroom management and students' motivation to learn has been provided in several studies (e.g., Arens, Morin, & Watermann, 2015; Fauth et al., 2014a; Kunter, Baumert, & Köller, 2007; Roth, Assor, Kanat-Maymon & Kaplan, 2007).

The three dimensional model of teaching quality claims to support multiple goals of classroom teaching. Yet, there has been little research connecting this model with outcome measures other than student achievement or motivation. Therefore, the aim of our study is to bridge the gap between theories of effective teaching and research on learning processes by systematically connecting the three dimensional model of teaching quality with reported metacognitive strategy use.

Teaching quality and the reported use of metacognitive strategies

Therefore, we work out specific relations between reports of metacognitive strategy use and each dimension of teaching quality while taking students' motivation into account.

For supportive climate, we expect a connection to students' reported use of metacognitive strategies that is fully mediated by students' motivation to learn. Supportive climate mainly aims at strengthening autonomous motivation by creating feelings of competence, self-determination and relatedness (Klieme et al., 2009; Ryan & Deci, 2002). This enhanced motivation should in turn result in more frequent reports of metacognitive strategy use (e.g., Coutinho & Neuman, 2008; McWhaw & Abram, 2001; Moos, 2014) as these will help the students to achieve their learning goals.

Effective classroom management may contribute to students' reported use of metacognitive strategies in two ways. First, a well-managed classroom can promote students' reported use of metacognitive strategies by providing enhancing routines (de Corte et al., 2004; Eshel & Kohavi, 2003; Perry et al., 2004). A teacher might, for example, include collaborative planning in each lesson. Thereby students learn to routinely plan before working on a task. Second, classroom management can support autonomous motivation (Arens, et al., 2015; Fauth et al. 2014a; Kunter et al., 2007; Reeve, 2006). Motivated students can be expected to report metacognitive strategy use more frequently (e.g., Coutinho & Neuman, 2008; McWhaw & Abram, 2001; Moos, 2014). Therefore, if teachers manage their classrooms efficiently, they promote students' reported use of metacognitive strategies directly by providing routines that support it as well as by facilitating their motivation. Results by Mouratidis et al. (2013) support this mediated connection by showing that competence need satisfaction partly mediated the connection between classroom structure and students' reported use of learning strategies, including metacognitive strategies.

Cognitive activation comprises direct instruction of metacognitive strategies (i.e., reflection about thinking and learning, Dignath et al., 2008; Veenman, 2011b) as well as characteristics of a favourable learning environment (e.g., de Corte et al., 2004; Perry et al., 2004). Therefore, if teachers conduct cognitively activating lessons, their students should report to employ metacognitive strategies more frequently. When taking into account the positive connection between students' motivation to learn and reported metacognitive strategy use, two conflicting assumptions can be made: First, it can be assumed that especially those students who are highly motivated to learn, take up the opportunities created in a favourable learning environment by employing metacognitive strategies. In that case, cognitive activation strengthens the connection between students' motivation and their reported metacognitive strategy use. This assumption is supported by Lipowsky et al. (2009) who examined a similar relationship between cognitive activation, interest, and students' achievement in secondary school (see also Gilbert et al., 2014). Alternatively, it can be assumed that less motivated students profit from cognitive activation which contains the explicit instruction of metacognitive strategies. These less motivated students might not seize the opportunities offered by a favourable learning environment on their own accord. If explicitly instructed to do so, they can be expected to use metacognitive strategies more often. In this case, the connection between students' motivation and reported metacognitive strategy use will be less pronounced in classes with a high degree of cognitive activation. This assumption is matches research by Hamre and Pianta (2005) arguing that especially children at risk of school failure profit from cognitively activating lessons. As empirical evidence for the impact of cognitive activation on the connection between students' motivation and reported metacognitive strategy use is still lacking, it cannot yet be decided which of the two conflicting assumptions should be adopted.

Based on these considerations, we deduce three hypotheses and one research question from the theoretical and empirical background:

1. Each of the three dimensions of teaching quality positively predicts students' reported use of metacognitive strategies.
2. The connection between supportive climate and reported metacognitive strategy use is mediated by students' motivation to learn.
3. The connection between classroom management and reported metacognitive strategy use is mediated by students' motivation to learn.
4. How does cognitive activation impact the connection between students' motivation to learn and their reported metacognitive strategy use?

Method

This study is part of a larger intervention study in primary school science education (Decristan, Hondrich, Büttner et al., 2015). Overall, 1052 German primary school students from 53 third grade classrooms in 39 primary schools participated. The students were aged between 7.2 and 10.9 years (M = 8.8 years, SD = 0.5) and approximately half of them were female. Their science teachers were asked to conduct a standardized unit on floating and sinking (4.5 x 90 minutes) to provide a comparable context in all classrooms. Data collection comprised student questionnaires and video or classroom observations. Questionnaires were administered immediately before and after the teaching unit. The video or classroom observations took place during a specified lesson of the teaching unit (see Figure 1).

Insert Figure 1 about here

Measures

Teaching quality: To assess the dimensions of teaching quality we used video and classroom observations. In order not to overstrain the observers' attention during the classroom observations each dimension of teaching quality was represented by one high inference rating item. All items were adapted for use in primary school from Rakoczy and Pauli (2006) and documented in an elaborate manual (Fauth et al., 2014b). Cognitive activation comprised the reflection of students' learning process and understanding (e.g., the teacher asks students how they reached a specific conclusion). Supportive climate evaluated the teachers' encouragement and caring behaviour towards their students (e.g., the teacher shows interest in students' opinions). Classroom management focused on the implementation of routines and rules (e.g., transitions between activities are short and well organised). Observers completed 40 hours of training. Of the participating classes, 36 agreed to be video-recorded. For the other 17 classes live observations were conducted. To check interrater agreement all video- and 50% of the classroom observations were conducted by two independent observers. After watching the whole lesson, observers gave their rating on each of the three items on a four-point scale, where a rating of 1 stood for low teaching quality and a rating of 4 represented high quality teaching. If observers did not fully agree in their judgements their mean rating was used in the analysis. As can be seen in Table 1 interrater reliability for all items was good (ICC > .70). Indicators of the validity of the rating are provided by Fauth et al. (2014b), who identified connections with student interest and achievement.

Insert Table 1 about here

Reported metacognitive strategy use: To establish the effect of classroom variables such as teaching quality on metacognitive strategy use, we needed data on metacognitive strategy use during the teaching unit from a large sample of students. Thus some regularly advised methods (e.g., thinking-aloud, or observational methods) could not be used. Therefore, we resorted to using students' self-reports on metacognitive strategy use. As we acknowledge that students' reports of their metacognitive strategy use do not necessarily correspond with their actual use (e.g., Samuelstuen & Bråten, 2007; Schellings & Hout-Wolters, 2011; Veenman, 2011a), we will refer to this measure as "reported metacognitive strategy use". Students reported on their use of metacognitive strategies before and after the unit on floating and sinking. The questionnaires contained 10 items referring to students planning, monitoring and evaluation of their learning process. All items were adapted from Otto (2007), Spörer (2009) or Wernke (2009) and were answered on a four-point Likert scale (1 = I don't agree, 4 = I fully agree). To improve validity we acted on the advice offered in the literature on self-report measures: All items should refer to a specific learning situation (Wernke, 2009). At the assessment before the teaching unit students reported on their metacognitive strategy use in previous science classes (e.g., "In science class, I make sure to stay focused on the task.") while at the second measurement they reported on reported metacognitive strategy use during the unit on floating and sinking (e.g., "In the lessons on floating and sinking…"). Additionally, we conducted thorough cognitive pretesting (Karabenick et al., 2007) to assure that our items were understandable for the intended age group (Samuelstuen & Bråten, 2007; Schellings, 2011). A translated version of the items and further support for the validity of our data is provided by Rieser, Fauth, Decristan, Klieme, and Büttner (2013). As can be seen in Table 2, reliability at both assessments was good ($\alpha > .70$). As the ICC indicates, students' reported use of metacognitive strategies varied substantially between classes.

Motivation: As a measure of students' motivation to learn during the teaching unit, a questionnaire assessing intrinsic motivation was administered at the second measurement point. The questionnaire consisted of six items (e.g., "I worked hard in science class because the topic was fascinating.") which the students answered on a four point Likert scale (1 = I don't agree, 4 = I fully agree). Intrinsic motivation was chosen, as it is considered to be the purest form of autonomous motivation. When intrinsically motivated, students learn because they experience learning itself as positive or are interested in the content (Deci & Ryan, 2008). All items were adapted from Blumberg, Hardy, and Möller (2008) and Bos et al. (2005). Reliability of the scale was good (Table 2). There was a substantial amount of variance in intrinsic motivation between classes.

Science competence: As metacognitive strategies need to be adapted to new domains, it has been shown that prior knowledge is a powerful predictor for students' use of metacognitive strategies (Moos & Azevedo, 2009; Pintrich & Zusho, 2002; Veenman & Spaans, 2005; Wyatt et al., 1993). Therefore students' science competence we assessed before the teaching unit as an indicator for students' prior domain knowledge. The test score was included as a covariate in all our analyses. The test was adapted from the TIMSS 2007 science test (Martin, Mullis, & Foy, 2008) and comprised 12 items. Reliability of the test was satisfactory (EAP/PV = .70).

Insert Table 2 about here

Data analysis

Due to the clustered data structure with students nested within classes, we conducted multilevel-analysis for all hypotheses, specifying doubly-manifest models (Lüdtke, Marsh, Robitzsch, & Trautwein, 2011). To test the first hypothesis, an intercepts-as-outcomes model with individual-level covariates was used (Raudenbush & Bryk, 2010). Each rating of teaching quality was introduced as a classroom-level predictor for students' reported use of metacognitive strategies (*post*).

To check our second and third hypotheses we used multilevel-mediation-models (see Figure 2). Before specifying the mediation-models we tested whether there were significant connections between the independent, the dependent and the mediating variable, thereby following the recommendation by Baron and Kenny (1986). As we assessed classroom management and supportive climate by classroom observations, they did not show any variance between students within the same classroom (individual-level). For that reason, we could not use the data to explain differences in intrinsic motivation between individual students. However, as it is assumed that classroom management and supportive climate have a positive effect on each student's intrinsic motivation within a class; it can also be expected to raise the average intrinsic motivation of all students from that class. Therefore, we followed the recommendation by Zhang, Zyphur, and Preacher (2009) and specified the mediation on the classroom-level. Again students' reported metacognitive strategy use (*post*) was used as the dependent variable while either the ratings of supportive climate or classroom management functioned as the independent variable. The class-average rating of intrinsic motivation during the teaching unit was introduced as a mediator for this connection on the classroom-level (Zhang et al., 2009).

These models run the risk of being compromised by a common method bias as the mediator and the outcome were assessed simultaneously (Podsakoff, MacKenzie, & Podsakoff, 2003). To avoid this problem we randomly split the students from each class into two groups. For the mediation-analysis, the class-average intrinsic motivation was computed from the ratings of the first half, while the other half's reported metacognitive strategy use (*post*) was used as the dependent variable. Thus, both constructs were rated by different students without shrinking our sample size on the classroom-level. Descriptive data for the reduced sample can be found in the annotations to Table 1. As classes were split at random, the disregarded responses may be treated as missing completely at random.

To answer our research question concerning the impact of cognitive activation on the connection between students' motivation and reported metacognitive strategy use (*post*), we used an intercepts-and-slopes-as-outcomes-model (Raudenbush & Bryk, 2010). On the individual-level we introduced students' intrinsic motivation as a group-mean centred predictor for reported metacognitive strategy use (*post*). On the classroom-level, we used cognitive activation to predict the students' reported metacognitive strategy use as well as the slopes between intrinsic motivation and reported metacognitive strategy use.

To check whether intrinsic motivation and reported metacognitive strategy use were confounded on the individual-level, we conducted confirmatory factor analysis. The results indicated that only the two-factor model which distinguished between reported metacognitive strategy use and students' intrinsic motivation fitted the data (see table 3). Thus, both constructs could empirically be separated and the full dataset was used.

Prior to analysis, all values were standardized ($M = 0$; $SD = 1$). The analyses were run in MPlus7 (Muthén & Muthén, 1998-2011). In all analyses classroom variables were centred at the grand-mean. On the individual-level we controlled for students' reported metacognitive strategy use (*pre*) and their science competence which were centred at the grand-mean (Enders & Tofighi, 2007). We estimated the indirect effects in the mediation-models by using the model indirect command in MPlus7. Significance of the indirect effects was tested by using the delta method (MacKinnon, 2008).

The average amount of missing data per scale was 8% (range 7% to 13%). Cases with missing data on the manifest predictor variables were not included in the analyses. No data was missing on the classroom variables as these data were collected by classroom observations or by calculating the class-average rating.

Results

Table 2 presents the descriptive results for the student questionnaire scales. On average, students rated their reported use of metacognitive strategies (*pre* and *post*) and their intrinsic motivation as high. Intrinsic motivation and reported metacognitive strategy use (*post*) showed a high intercorrelation on the individual-level as well as on the classroom-level.

Table 1 presents the descriptive data for the high inference ratings of the three dimensions of teaching quality. On average, observers assigned medium to high ratings for teaching quality.

Hypothesis 1:

Supporting our first hypothesis, each of the three dimensions of teaching quality was shown to be a positive predictor for students' reported use of metacognitive strategies (see Table 4, models 2–4).

Insert Table 4 about here

Hypothesis 2:

The necessary preconditions (cf. Baron & Kenny, 1986) to test our second hypothesis were met by our data. We found significant associations between the class-average intrinsic motivation and students' reported metacognitive strategy use (β = .27; *SE* = .06; *p* < .001, one-tailed) or supportive climate (β = .34; *SE* = .13; *p* = .007, one-tailed) respectively. The results of the multilevel mediation-model can be found in Figure 2.

Insert Figure 2 about here

The results supported our hypothesis: The class-average intrinsic motivation mediated the connection between supportive climate and reported metacognitive strategy use. As the direct path between supportive climate and reported metacognitive strategy use did not remain statistically significant after introducing the indirect path, the connection was fully mediated by intrinsic motivation.

Hypothesis 3:

The procedure for testing our third hypothesis was analogous to the procedure for our second hypothesis. Classroom management was not significantly related to the class-average intrinsic motivation ($\beta = .16$; $SE = .14$; $p = .123$, one-tailed). Thus, our data did not support the hypothesized mediation.

Research question 4:

Our research question referred to the impact of cognitive activation on the connection between intrinsic motivation and reported metacognitive strategy use. As model 1 (Table 5) shows, the residual slope variance for the connection between intrinsic motivation and reported metacognitive strategy use was rather small but significant.

Insert Table 5 about here

Cognitive activation negatively predicted the slopes between students' intrinsic motivation and reported use of metacognitive strategies. This indicates that the connection between intrinsic motivation and reported metacognitive strategy use was less distinct in classrooms with a high degree of cognitive activation (Table 5, model 2). To be able to interpret this result, we tested whether the effect of cognitive activation on students' reported metacognitive strategy use was the same for less (reporting intrinsic motivation below the class-median) and highly motivated students (reporting intrinsic motivation at or above the class-median). As Table 6 shows, cognitive activation only predicted students' reported use of metacognitive strategies in less motivated students. This means that less motivated students' reported metacognitive strategy use is higher in cognitively more activating classrooms while the degree of cognitive activation does not relate to reported metacognitive strategy use respecting highly motivated students.

Insert table 6 about here

Discussion

Before discussing our results, some limitations should be noted. Due to the large sample size that was necessary to conduct the analysis, we used self-reports of metacognitive strategy use of rather young students. Third grade students are just beginning to use metacognitive strategies for learning (e.g., Annevirta & Vauras, 2001; Bryce & Whitebread, 2012). This threatens the validity of the measure. However, due to our careful endeavours to improve validity described earlier we are confident that our measure might at least approximate actual use of metacognitive strategies.

Most of the data we used was longitudinal, thus substantiating the assumed directions of the effects we explored. However, the connection between intrinsic motivation and reported metacognitive strategy use (*post*) is based on cross-sectional data thus allowing no conclusions about causal direction (MacCallum, Wegener, Uchino, and Fabrigar, 1993). To our knowledge, there is relatively little empirical evidence for any of the possible directions of the connection between these constructs. A recent study using cross-lagged analysis conducted by Berger and Karabenick (2014) supports our assumption. Further, when reviewing research on teaching quality it appears plausible that supportive climate or classroom management foster motivation directly while there is little evidence for a direct connection with reported metacognitive strategy use.

The aim of this study was to identify connections between characteristics of effective teaching and students' reported learning activities. For that purpose, we established theoretical and empirical links between the three dimensions of teaching quality and students' reported use of metacognitive strategies. As expected, each dimension of teaching quality was positively related to students' reported use of metacognitive strategies (Hypothesis 1). This result supports our assumption that high quality teaching might encourage students to use metacognitive strategies more frequently. On a more general level, this also supports the theoretical assumption that characteristics of teaching are connected to students' learning activities (Vermunt & Verloop, 1999; Winne, 1987).

However, the connection between teaching and learning appears to be dependent on student characteristics: The connection between reported metacognitive strategy use and supportive climate was fully mediated by the class-average intrinsic motivation to learn. Supportive climate mainly aims at strengthening students' autonomous motivation (Klieme et al., 2009; Ryan & Deci, 2002) and does not include attributes that are related to indirect or direct approaches to foster strategy use (Otto, 2010). Thus, the connection between a supportive climate and reported metacognitive strategy use is solely based on the positive connection of both constructs with students' motivation to learn.

Contrary to our expectation, we did not find a connection between classroom management and the class-average intrinsic motivation. A possible explanation might be that an efficient classroom management strengthens more extrinsic forms of autonomous motivation (e.g., identification or integration) but is unconnected to students' inherent enjoyment of learning itself or the topic which characterises intrinsic motivation.

Regarding our research question we discovered that cognitive activation negatively predicted the slopes between intrinsic motivation and reported metacognitive strategy use. Theoretically, this negative interaction could be interpreted in two ways: First it might mean that less motivated students report more use of metacognitive strategies when experiencing a high degree of cognitive activation. Second, it could mean that highly motivated students report less use of metacognitive strategies in cognitively activating classrooms. To investigate this issue further, we tested the connection between cognitive activation and reported metacognitive strategy use for highly and less motivated students. The results support the first interpretation that less motivated students profit from cognitively activating lessons (Gilbert et al., 2014). In our study, cognitive activation was mainly operationalized as teachers' exploration of students' ideas and thinking. This aspect of cognitive activation strongly resembles aspects of explicit instruction of metacognitive strategies (Baas et al, 2014; Dignath et al., 2008). This might have led the less motivated students to (report to) use metacognitive strategies more frequently than they would have done on their own accord.

Against expectation, we found a negative relation between students' science competence and their reported use of metacognitive strategies. Our expectation was based on results from research that was conducted with adults who were real experts in their domain (e.g., university professors, Wyatt et al., 1993). Even if third grade students reached a high score on our measure of science competence, their knowledge is far inferior to that of real experts. Their limited experience might not suffice to adapt metacognitive strategies efficiently to a new topic and thus result in the unexpected negative connection.

Although some of the empirical links we identified were rather small, our results expand the current knowledge about the processes involved in effective teaching. Thereby we followed Winne's (1987) demand to grant students' learning activities a greater role in research on teaching. We were able to show that effective teaching is connected to students' reported use of metacognitive strategies. Additionally, our results emphasize the central role of student characteristics: Supportive climate seems to strengthen favourable characteristics like intrinsic motivation and thus increase students' reported use of metacognitive strategies. Cognitive activation appears to have a compensatory effect on less motivated students. They reported a higher level of metacognitive strategy use in cognitively activating classrooms. However, cognitive activation as we operationalized it appeared to be unconnected with reported metacognitive strategy use in highly motivated students.

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Table 1

Summary of the Descriptive Data and Intercorrelations between the High-Inference Rating Items of Teaching Quality

Item	*N*	*M*	*SD*	*ICC*	Cognitive activation	Supportive climate	Classroom management
Cognitive activation	53	2.73	0.95	.81	-	.38**	.60**
Supportive climate	53	3.07	0.73	.72		-	.55**
Classroom management	53	3.37	0.78	.81			-

** $p < .01$.

Table 2

Summary of Descriptive Data for and Correlations between the Student Measures of Reported Metacognitive Strategy Use (pre and post) and Intrinsic Motivation (post)

Instruments	Number of Items	*N*	*M*	*SD*	α	*ICC*	*ICC 2*	Reported metacognitive strategy use (*pre*)	Reported metacognitive strategy use (*post*)	Intrinsic motivation
Reported metacognitive strategy use (*pre*)	10	937	3.48	.48	.82	.08	.58	-	.31**	.27**
Reported metacognitive strategy use (*post*)	10	970	3.34	.67	.91	.11	.66	.32*	-	.72**
Intrinsic motivation	6	973	3.45	.72	.91	.11	.66	.36**	.88**	-

Note. Intercorrelations on the individual-level are presented in the upper right hand corner; intercorrelations on the classroom-level are presented in the lower left hand corner. Descriptive data for reported metacognitive strategy use in the split sample used in the mediation-models were *M* = 3.32

(*SD* = .71); *ICC 1* = .16 and *ICC 2* = .62. . Descriptive data for intrinsic motivation were *M* = 3.47 (*SD* = .71); *ICC 1* = .08 and *ICC 2* = .43. The correlation between both measures on the classroom-level was *r* = .55***.

* $p < .05$, ** $p < .01$

Table 3

Fit indices of confirmatory factor analyses.

Index	One-factor model	Two-factor model
χ^2 (df)	1361.158 (104)	531.891 (103)
p(χ^2)	< .001	< .001
CFI	0.86	0.95
TLI	0.84	0.95
RMSEA	0.11	0.07
SRMR	0.06	0.03
AIC	32200.548	31373.282
BIC	32282.506	31456.947
Wald test		χ^2 = 500.022 (df = 1) p < .001

Note. In the one-factor model all items belonging to the scales intrinsic motivation and reported metacognitive strategy use (*post*) were modelled to load on the same factor. In the two-factor model the items of each scale formed an individual factor.

Table 4

Results of the Intercepts-as-Outcomes-Model Predicting Reported Metacognitive Strategy Use (post) from the Ratings of Teaching Quality

	Model 1	Model 2	Model 3	Model 4
Individual-level				
Reported metacognitive strategy use (*pre*)	.29*** (.04)	.30*** (.04)	.29*** (.04)	.30*** (.05)
Science competence	-.07* (.04)	-.08* (.04)	-.08* (.04)	-.08* (.04)
Classroom-level				
Cognitive activation		.12** (.05)		
Supportive climate			.13** (.05)	
Classroom management				.13** (.05)
R^2 (individual-level)	.102***	.106***	.104***	.106***
R^2 (classroom-level)	-	.143	.182	.181

Note. Standardized regression weights, standard errors are in parentheses.

* $p < .05$, ** $p < .01$, *** $p < .001$; one-tailed test.

Table 5

Intercepts-and-Slopes-as-Outcomes-Model Predicting Students' Reported Use of Metacognitive Strategies (post) through the Rating of Cognitive Activation and its Interaction with Students' Intrinsic Motivation

	Model 1	Model 2
Individual-level		
Reported metacognitive strategy use (*pre*)	.14*** (.03)	.15*** (.03)
Science competence	-.04* (.02)	-.04* (.02)
Intrinsic motivation	.65*** (.04)	.65*** (.04)
Classroom-level		
Cognitive activation (on intercept)		.12** (.05)
Cognitive activation (on slope)		-.09** (.04)
Residual slope variance	.031** (.01)	.025** (.01)

Note. Standardized regression weights, standard errors are in parentheses.

* $p < .05$, ** $p < .01$, *** $p < .001$; one-tailed test.

Table 6

Intercepts-as-Outcomes-Models Testing the Connection between Cognitive Activation and Students' Reported Use of Metacognitive Strategies in Highly and Less Motivated Students

	Highly motivated students (n = 567)	Less motivated students (n = 406)
Individual-level		
Reported metacognitive strategy use (*pre*)	.15*** (.06)	0.30*** (.06)
Science competence	-.06 (.05)	-.07 (.06)
Classroom-level		
Cognitive activation	.08 (.22)	.50*** (.13)
R^2 (individual-level)	0.027	.101**
R^2 (classroom-level)	0.007	.245

Note. Standardized regression weights, standard errors are in parentheses. Highly and less motivated students were defined by their reported intrinsic motivation relative to the class-median intrinsic motivation. Students reporting class-median intrinsic motivation were added to the group of highly motivated students. As the sample was split at the class-median for each class, sample size at the classroom-level remained at 53 classes.

* $p < .05$, ** $p < .01$, *** $p < .001$; one-tailed test.

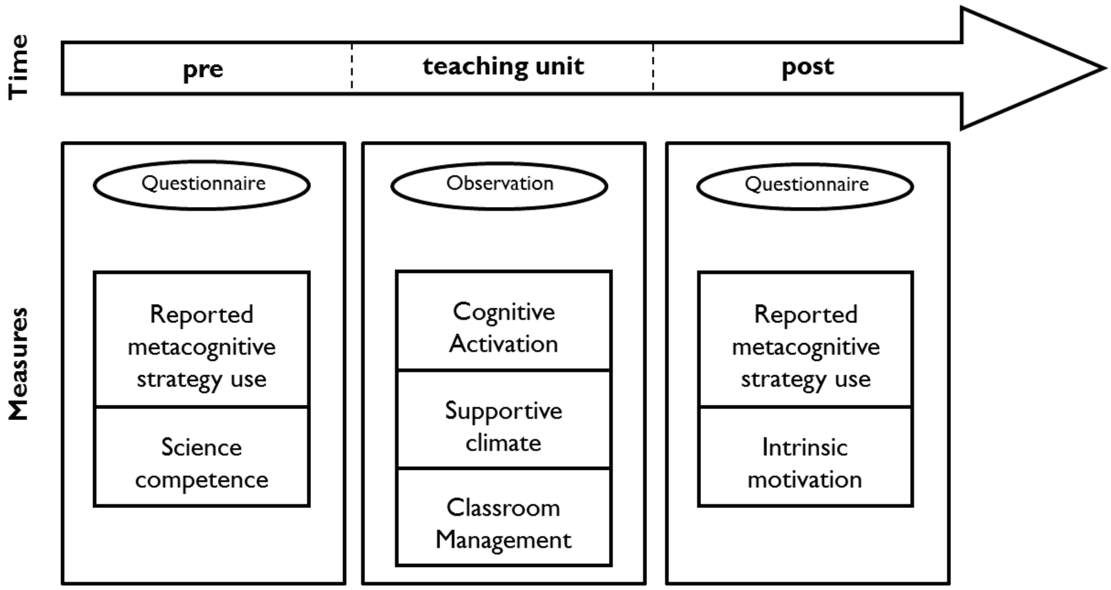

Figure 1. Design of our study representing the different measurement points (time) and the measures assessed at each measurement point. At pre- and post-test student questionnaires were used. During the teaching unit classroom or video observations took place to assess the three dimensions of teaching quality.

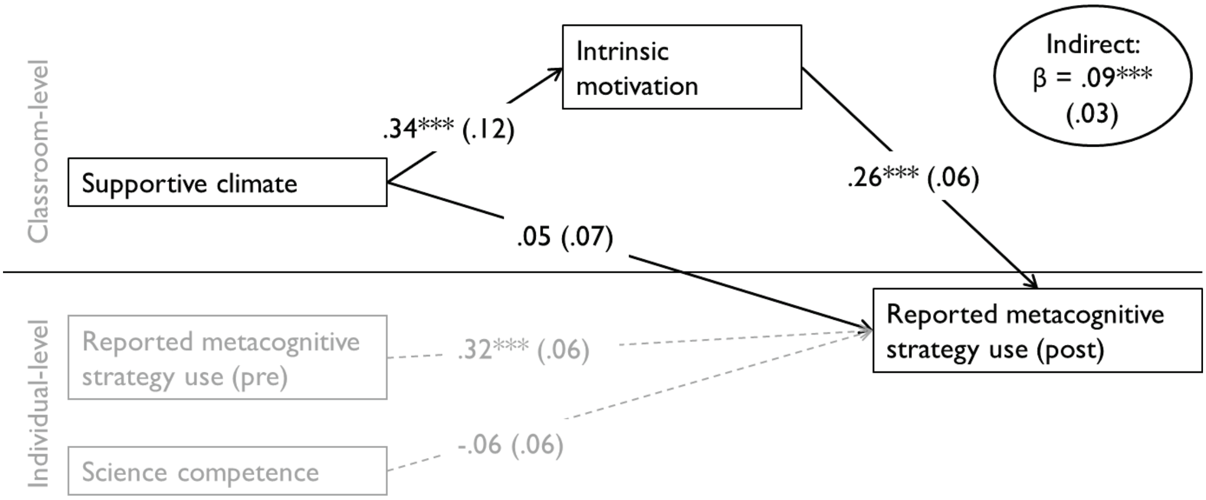

*Figure 2***.** Results of the multilevel-mediation-model testing whether the connection between supportive climate and reported metacognitive strategy use (*post*) is mediated by students' intrinsic motivation. Standardized regression weights, standard errors are in parentheses. Covariates are presented in light grey. To avoid a common method bias, class-average intrinsic motivation was computed using half the students' ratings from each classroom. The other half's report on metacognitive strategy use (*post*) was introduced into the analysis. R^2 (Individual-level) = .124**; R^2 (Classroom-level, reported metacognitive strategy use) =.467*, R^2 (Classroom-level, motivation) = .112.

* $p < .05$. ** $p < .01$. *** $p < .001$; one-tailed test.