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Cognitively demanding learning materials with texts and instructional pictures: teachers' diagnostic skills, pedagogical beliefs and motivation

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Abstract Learning materials incorporating written texts as well as instructional pictures are the basis for learning in many subjects. However, text–picture integration makes high cognitive demands of learners, and it seems plausible that the development of this competence is influenced by teachers' instructional skills. The present studies investigated first the differential role of learning materials integrating text with pictures in geography and biology classes compared to German language arts instruction, and the accuracy of teachers' diagnostic judgments concerning materials and student competencies from teachers who majored in different subjects. Second, we examined whether teachers with different majors systematically differ in their pedagogical beliefs and motivation to use text–picture materials, and if these differences predict both the quantity as well as the quality of instruction using both text and pictures. We present teacher questionnaires and test data from two independent studies, including $N=108$ teachers with biology/geography or German major with in total over 1,000 students from grades 5 through 8 of all school tracks in study I, and $N=107$ teachers with their students in study II. Descriptive statistics, t tests, and SEM are reported. The results indicate that teachers currently do not sufficiently manage to judge these learning materials, and that for the most part, variation between teachers was not systematically attributable to their subject major. At the same time, the differences observed between teachers in pedagogical beliefs and motivation had important

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consequences for both the quantity and quality of instruction using both text and pictures. Implications are discussed in regard to further research and educational practice.

Keywords Text–picture integration · Reading · Judgment accuracy · Teacher beliefs · Teacher motivation · Teacher education

Introduction

Instructional pictures such as flow charts, diagrams, and graphs are an integral part of technology-enhanced as well as paper-based learning in most school subjects. The major function of instructional pictures in secondary education is to convey additional information not provided by the text. Experimental studies have shown that this additional information is beneficial for text comprehension and memory (Mayer 2001; Schnotz and Kulhavy 1994; Willows and Houghton 1987). However, to fully understand the instructional pictures, students not only have to process text and picture information separately but also have to integrate the two sources of information which poses high cognitive challenges (Mayer 2002).

Current models of multimedia learning assume that comprehension and learning are highly dependent on the constraints of the human cognitive system. These constraints refer to the sensory registers, which are highly temporally limited, and to working memory, which is limited in capacity as well as temporally limited; cf. Baddeley 1986). In contrast, long-term memory is assumed to have a practically unlimited capacity. The assumption of a highly limited working memory has implications for teaching and learning and this is at the core of Cognitive Load Theory (CLT; Sweller et al. 1998). According to CLT, instructional design should be adapted to the constraints of the human cognitive architecture. Research has indeed shown that this text–picture integration makes high cognitive demands of students and that many need instructional support to interpret instructional pictures (Leinhardt et al. 1991; Shah and Hoeffner 2002; see also for example Plass et al. 2003 about the influence of verbal and spatial skills). Nevertheless, text–picture integration is not systematically taught in teacher education programs in Germany.

When preparing and teaching lessons that involve instructional pictures, teachers have to gauge both the difficulty and demands of the text–picture materials and students' competencies. Well-developed diagnostic skills enable them to adapt their instruction to the needs of the students in the class (Hoge and Coladarci 1989; Rogalla and Vogt 2008). Teachers' beliefs and motivation are further factors influencing their instructional behavior and, in turn, students' learning involvement and success (Darling-Hammond 2000; for text–picture integration, see Schroeder et al. 2011). Because text–picture integration is not systematically taught in teacher education programs and because the role of instructional pictures differs across school subjects, teachers of different subjects can be expected to vary in their diagnostic skills, beliefs, and motivation concerning text–picture integration.

Text–picture integration

In secondary education, the major function of instructional pictures is to convey additional information not provided by the text. The pictures can be realistic or schematized and exhibit various degrees of abstraction (e.g., photographs, tables, and graphical representations) (Carney and Levin 2002; Schroeder et al. 2011). The complex processes of reading a text poses additional cognitive challenges when pictures have to be elaborated at the same time

(Mandl and Levin 1989; Schnotz 2005). To achieve full comprehension, students need to extract information from both sources—text and picture—and to integrate this information with their prior knowledge (Ainsworth 2006; Mayer 2002). It has been argued that verbal and pictorial information is encoded via separate channels, each with limited capacity (e.g., Paivio 1986; see also Chandler and Sweller 1991; Mayer 2001, 2002). The integration process involves surface-structure mapping between word and picture elements (e.g., using color codes or arrows) as well as deep-level mapping through establishing simple or complex relations between the content-containing units of both sources of information (Schnotz and Bannert 2003).

Research has identified several difficulties that students face when interpreting the pictures used in instructional texts (Gobbo 1993; Leinhardt et al. 1991; Mayer 1993; Shah and Hoeffner 2002). For example, many students have problems identifying numeric values in a table, have misconceptions about the interpretation of pictures, and make typical errors such as slope/height confusion when reading graphs. Additionally, the subjective ease of picture encoding gives students the metacognitive illusion of having fully understood the instructional pictures. As a result, they focus on the textual information, with negative consequences for learning.

It is therefore crucial that teachers are aware of the cognitive challenges of these materials and provide the necessary instructional support for text–picture integration, for example, by teaching their students about pictorial rules and representational conventions (see Peeck 1994). Understanding the characteristics of the text–picture learning material enables teachers to manipulate instruction, for example following Mayer's (2001) principles of multimedia learning. Moreover, they need to motivate their students to invest additional effort in processing text and picture information at the same time. Research has shown that forms of direct instruction—i.e., specific, controllable instructional strategies and guidelines requiring the learner to respond with concrete actions—are most effective in fostering text–picture integration (Mautone and Mayer 2007; Peeck 1994; but see Bartholomé and Bromme 2009). Teachers' diagnostic skills, beliefs, and motivation concerning text–picture integration can be expected to be especially important for students' learning in the first years of secondary education, when students are still rather unfamiliar with schematic pictures.

Teachers' diagnostic skills, beliefs, and motivation

Teachers' competencies, such as their diagnostic skills, beliefs, and motivation, are assumed to influence their classroom practice and, in turn, students' learning (Darling-Hammond 2000). Extensive research exists investigating the linking of various aspects of teachers' competencies to elements of classroom instruction known to be effective for students learning such as cognitive activation, classroom management and constructive support (e.g., for motivation, Brophy and Good 1986; Kunter et al. 2008; for diagnostic sills, Anders et al. 2011; Hoge and Coladarci 1989; for beliefs, Dubberke et al. 2008; Woolfolk Hoy et al. 2006).

In terms of text–picture integration in particular, it has been shown that teachers' beliefs directly affect students' engagement to learn from texts with instructional pictures: results of a recent study by Schroeder et al. (2011) showed that teachers who believed that students should be taught clear strategies on how to learn from texts with instructional pictures gave more engaging lessons. In contrast, teachers who believed that students should learn to interpret these materials independently gave less engaging instruction. A multilevel mediation model showed the effects of teachers' beliefs on students' engagement to be mediated by their instructional behaviors. Students reported higher engagement when they

were taught by teachers who showed better classroom management skills, spent more time discussing texts containing instructional pictures, and gave more adaptive explanations (for more details, see Schroeder et al. 2011).

Based on the research literature in the field of teacher motivation—mostly teachers' motivation to teach—similar effects of teachers' motivation on student engagement can be assumed (Brophy and Good 1986; Kunter et al. 2008). Teachers' diagnostic skills—their ability to accurately judge students' characteristics and/or characteristics of learning materials for example in regard to difficulty, cognitive demands or motivational potential—inform the planning, delivery, and evaluation of classroom instruction (Hoge and Coladarci 1989; Rogalla and Vogt 2008). When lessons involve instructional pictures, teachers need to gauge the cognitive demands of the learning materials as well as students' competencies. Evaluating text–picture learning materials is especially challenging—teachers have to assess the cognitive load of both the text and the picture information as well as the complexity of integrating the two. It is therefore relevant to ask whether teachers are able to accurately gauge the difficulty of specific tasks, the percentage of students capable of solving them, and the overall performance of specific students. Recent empirical findings suggest that teachers' judgments in the area of text–picture integration are not very accurate (McElvany et al. 2009).

Unfortunately, many teachers are unaware that their students may have difficulties in processing instructional pictures. Fostering the ability to interpret these pictures is not recognized as an instructional goal in its own right and teachers are not usually trained in ways of enhancing students' text–picture integration skills (Houghton and Willows 1987). Furthermore, the importance of instructional pictures differs from one subject to the next. For example, biology learning materials generally contain numerous graphs and diagrams, whereas educational materials for German as a native language tend not to use instructional pictures. Thus, it would be important to know if teachers from different subjects with varying importance of these materials systematically differ in the competencies regarding text–picture integration, which might also be reflected in their classroom practice.

Text–picture materials are a core element of learning material, and some students struggle bringing both sources of information, text, and picture, together in order to reach a complete understanding of the learning content. Thus, among the different aspects of instructional quality, the extent to which teachers invest effort in making sure that all students achieve a thorough understanding of text–picture material, teachers' engagement seems a core aspect to investigate. However, no previous research has investigated whether teachers of different subjects differ in their diagnostic skills, pedagogical beliefs, or motivation concerning text–picture integration in the classroom. Moreover, it is unclear whether these differences impact the teachers' instructional behavior.

The present research: aims and predictions

The present research brings together different theoretical approaches—theories on text–picture integration, cognitive load theory, as well as theories on teacher competencies and effects in instruction—as theoretical background for two consecutive studies. We present data from two independent studies addressing four research aims. In study I, we first tested the hypothesis I that learning materials integrating text with pictures play a greater role in geography and biology classes than in German language arts instruction. Moreover, we investigated whether teachers who majored in geography or biology in their pre-service university training differ systematically in the accuracy of their diagnostic judgments concerning text–picture materials and student competencies from teachers who majored in

German language arts. We predicted that geography/biology teachers would exhibit higher judgment accuracy because they should have a greater expertise in the area of text–picture integration due to their pre-service training and additionally are more familiar with using instructional pictures in their classes (hypothesis II).

In study II, we investigated whether teachers differ in their pedagogical beliefs and motivation to use text–picture materials in their lessons. This research question was prompted by previous research on the impact of teachers' competencies on instructional quality and student learning. We hypothesized that geography/biology teachers would have more favorable beliefs and motivation regarding the use of instructional pictures in their classes (hypothesis III). We expected the widespread use of these materials in textbooks and other learning materials in geography and biology to make these teachers more aware of the relevance of text–picture integration, its effects on cognitive load while learning, and of the need to give their students sufficient practice in this important skill. At the same time, being aware of the usefulness of the materials might lead to a higher motivation. Finally, we investigated the core hypothesis that differences in how teachers of different subjects approach text–picture integration predict both the quantity (frequency of use of texts with integrated pictures) and quality (teachers' engagement) of instruction using both text and pictures (hypothesis IV).

Method study I

Sample

In study I, 48 schools of all tracks were drawn randomly from the total population of all secondary schools in Rhineland-Palatinate, Germany. A grade 5, 6, 7, or 8 class was then drawn randomly within each school, and that class's biology, geography, and German teachers were invited to participate in the study. Those who taught two subjects to a class were instructed to complete the study questionnaire containing the measures (see next section; further details also in McElvany et al. 2009, 2010) only for their main subject, with the exception of questions relating to homework assignments. An overview of the sample is provided in the left column of Table 1.

In total, 1,060 students from grades 5 through 8 participated with more than 20 students per class participating on average. All students in each participating class completed a test booklet that provided data on their text–picture integration skills. The test booklets comprised eight half-page, non-continuous texts with an instructional picture along with six multiple-choice questions for each material assessing students' comprehension of the material. The topics of the examples were subject-independent (production of chocolate; house trash). They resembled very much any typical school book for the subjects biology and geography as the examples were created after an evaluation of nearly all school books

Table 1 Overview of teachers participating in studies I and II

	Study I	Study II
Geography/biology	66	67
German	42	40
Total number	108	107
Average age in years (M (SD))	44.4 (11.4)	44.1 (10.8)
Percentage female	65.1	63.2

in these subjects for these grades available in Germany. Students' answers were evaluated using the Rasch model, represented one competence dimension, and average scores increased across grades as hypothesized.

Measures

Use of text–picture learning materials Teachers were asked to specify the percentage of their lessons in one school year that involved texts with integrated pictures, as well as the percentage of homework assignments that required students to work both with text and pictures.

Diagnostic skills A questionnaire containing examples from the test of students' text–picture integration competence that had been previously administered to each teacher's class (see above) was used to measure teachers' diagnostic skills.

The following measures of diagnostic skills were implemented, covering both student competency and task difficulty aspects, and are standard measures in the current research in this area (for details on diagnostic skills components and measurements see McElvany et al. 2009):

- *Absolute judgment accuracy—individual task (% of class solving the task):* difference between the teacher's estimate of the percentage of students in his/her class able to solve a specific task and the actual percentage (average of absolute differences across all six tasks per teacher and overall average).
- *Absolute judgment accuracy—overall test (number of tasks solved by class):* difference between the teacher's estimate of the number of tasks (maximum 48) solved by their students and the actual number (average of all absolute differences).

While the first two measures are concerned with absolute judgments, the following two measures assess the ability for relative judgements, which are relevant in classroom practice as well.

- *Diagnostic sensitivity—task difficulty (r):* correlation of the teacher's estimated difficulty ranking of the six tasks with the actual difficulty ranking (average of all individual teacher's correlations using Fisher's Z transformation).
- *Diagnostic sensitivity—student competencies (r):* correlation of the teacher's estimated ranking of seven (randomly drawn) of his/her students according to their ability to integrate information from texts and pictures with the actual performance ranking (average of all individual teacher's correlations using Fisher's Z transformation).

Procedure

The teacher questionnaires were sent to a school representative who distributed them to the teachers of the selected class. Teachers took approximately 45 min to complete the questionnaires. Students were assessed by trained research assistants in regular lesson time. Student booklets included tests of the ability to integrate information from pictures and texts, tests of general cognitive abilities, measures of student involvement and teachers' instructional behavior, and several questions tapping socio-demographic and general data. All questionnaire and tests were paper–pencil–instruments.

Results

Use of text–picture learning materials

To investigate hypothesis I, descriptive statistics were examined and *t* tests for independent or respectively dependent groups were conducted to check statistical significance of observed differences. As expected, the results indicated that texts with integrated pictures are used more frequently in geography/biology lessons (66.8% of lessons; SD=22.9) than in German lessons (27.6%; SD=21.4; $t(125)=-9.701$; $p<.001$). The same pattern emerged for homework assignments: 46.5% (SD=25.6%) of geography/biology homework assignments involved texts with integrated pictures, compared with 16.9% (SD=15.6%; $t(117.78)=-7.888$; $p<.001$) of German homework assignments.

For homework assignments, we can also take an intrapersonal perspective and compare the answers of teachers ($N=21$) who teach both biology/geography and German and provided answers for both subjects. This analysis confirms the previous results: teachers of both subjects gave their students more geography/biology homework (47.6%) than German homework (18.7%; $t(20)=-5.121$; $p<.001$) involving texts with instructional pictures. In sum, the teacher data concerning frequency of material use in classroom as well as homework assignments support our hypothesis that the relevance of text–picture materials and instruction differs across subjects.

Teachers' diagnostic skills

In regard to hypothesis II, we compared the diagnostic skills of teachers who had majored in geography/biology with those who had majored in German by performing separate *t* tests for each of the four aspects of diagnostic competence investigated. All measures present differences (absolute judgments) or correlations (relative judgments) between teacher-estimated and actual outcomes (see "Measures"). Measures based on correlations (diagnostic sensitivity) were linearized by means of Fisher's Z transformation prior to the *t* test analysis. Additional analysis comparing the two subsample on other potentially relevant aspects by *t* tests or respectively chi square test revealed no differences between the groups concerning teachers' age, teaching experience, grade taught, and academic track of pre-service training.

The final pattern of results (see Table 2) is very clear cut: none of the comparisons reached statistical significance. However, the effect sizes suggest that the judgments of a class's absolute overall test performance provided by teachers who majored in German

Table 2 Comparison of teachers' diagnostic skills by university major

	Subject					
	German	Geography/biology	*t*	*df*	*p*	*d*
Absolute judgment accuracy—individual task (%)	0.16 (0.14)	0.17 (0.12)	−0.150	101	>0.05	0.03
Absolute judgment accuracy—overall test (tasks)	5.48 (4.32)	7.34 (6.39)	−1.478	98	>0.05	0.34
Diagnostic sensitivity, task difficulty (*r*)	0.47 (.29)	0.50 (.32)	−0.573	103	>0.05	0.10
Diagnostic sensitivity, student competencies (*r*)	0.36 (.51)	0.29 (.47)	0.608	95	>0.05	−0.13

were somewhat more accurate than those provided by teachers who majored in geography/ biology.

Method study II

Sample

Sample selection in study II was parallel to study I, with the exception that only grades 5 and 6 classes and their teachers were included. An overview of the sample is provided in the right column of Table 1. On the student level, N=1,051 students from 48 classes participated.

Measures

Teachers' characteristics: teachers' beliefs and motivation Teachers responded to a questionnaire constructed specifically for the present study. Some items were derived from an existing questionnaire assessing teacher characteristics in the domain of mathematics and were adapted in their wording to tap teacher characteristics in the domain of text–picture integration (McElvany et al. 2010; see the COACTIV study: Kunter et al. 2007). In the analyses reported here, we focus on six scales assessing teachers' pedagogical beliefs and motivation concerning text–picture integration. Teachers rated their agreement with the statements on a 4-point scale anchored at 1 (*do not agree at all*) and 4 (*agree completely*).

First, the *utility of pictures* scale assessed the degree to which the teachers considered pictures to be useful for instruction in general and their own teaching in particular. Second, the *importance of promotion* scale measured teachers' beliefs about how important it is for all teachers in a school to promote students' text–picture integration skills. Third, the *importance of practice* scale tapped teachers' beliefs about the importance of giving students explicit practice in processing instructional pictures. Fourth, the *strategy use* scale measured teachers' endorsement of the belief that their students should learn clear strategies, schemes, and routines for interpreting new and complex pictures. Fifth, the *self-efficacy* scale assessed the degree to which teachers considered themselves competent in teaching students to integrate text and pictures. Sixth, the *intrinsic motivation* scale measured teachers' personal enjoyment of learning materials combining texts and pictures. Table 3 provides sample items, descriptive statistics for the total sample and by university major, inter-correlations, and reliabilities for all scales used to measure teacher characteristics.

Instructional quantity and quality Two scales measured aspects of text–picture integration in classroom instruction. First, the four items of the *instruction quantity* scale measured the frequency of use of text–picture instruction in the classroom (example item: "We discuss a text and a related picture."). Responses were given on a rating scale from 1=*never* to 6= *very often*. The reliability was good (Cronbach's α=.82). Second, the four items of the *teacher engagement* scale assessed the extent to which teachers invest effort in making sure that all students achieve a thorough understanding of text–picture material (example item: "When pictures are integrated in a text, I make sure that all students really understand the pictures and how they relate to the content of the text."). The reliability was good (Cronbach's α=.86).

Table 3 Beliefs and motivation concerning text–picture integration: comparison of teachers who majored in geography/biology or German

No.	Construct (number of items)	Example item	Total sample							University major						
			N	M (SD)	Inter-correlations					M (SD)		Cronbach's α		$t_{(df)}$	*p*	*d*
					2	3	4	5	6	Geography/ biology	German	Geography/ biology	German			
1	Belief—utility (4)	It is generally useful to combine pictures with texts in instruction to help students grasp the content	106	3.66 (0.40)	0.39***	0.33***	0.18	0.43***	0.42***	3.71 (0.37)	3.52 (0.46)	0.81	0.76	$-2.07_{(92)}$	<0.05	0.44
2	Belief—importance of promotion (4)	The ability to read texts with integrated pictures is so important for learning in all subjects that all teachers should promote students' skills in this area	106	3.17 (0.52)	1	0.44***	0.27***	0.13	0.22**	3.20 (0.51)	3.03 (0.55)	0.76	0.75	$-1.49_{(91)}$	>0.05	0.32
3	Belie—importance of practice (4)	It is important to give students practice in reading and understanding pictures of varying levels of complexity that are integrated in texts	105	3.45 (0.48)		1	0.53***	0.23**	0.25**	3.43 (0.44)	3.45 (0.56)	0.75	0.89	$0.95_{(51.71)}$	>0.05	−0.02
4	Belief—learning theory—strategy use (4)	Students become good readers of texts if they keep practicing certain strategies for dealing with texts and pictures	106	3.14 (0.53)			1	0.03	0.08	3.14 (0.52)	3.05 (0.58)	0.82	0.84	$-0.76_{(91)}$	>0.05	0.16

Table 3 (continued)

No.	Construct (number of items)	Example item	Total sample							University major						
			N	M (SD)	Inter-correlations					M (SD)		Cronbach's α		$t_{(df)}$	*p*	*d*
					2	3	4	5	6	Geography/ biology	German	Geography/ biology	German			
5	Self-efficacy—instruction (4)	I am confident that I can succeed in teaching my students learning content that requires them to process texts and pictures at the same time	104	3.34 (0.40)				1	0.43***	3.38 (0.40)	3.27 (0.41)	0.75	0.64	$-1.29_{(90)}$	>0.05	0.28
6	Intrinsic motivation (3)	I enjoy working with pictures integrated in school textbooks or other learning materials	105	3.39 (0.48)					1	3.43 (0.47)	3.29 (0.52)	0.83	0.90	$-1.37_{(90)}$	>0.05	0.30

Procedure

The procedure was the same as in study I.

Results

Teachers' beliefs and motivation

Study II first examined whether teachers who majored in geography/biology differed in their pedagogical beliefs and motivation concerning text–picture integration from those who majored in German language arts. Table 3 presents the means for both groups of teachers and the results of *t* tests for independent groups performed on each of the six beliefs and motivation scales separately in order to check statistical significance of the observed differences in means. The two groups differed in several respects (hypothesis III): teachers who majored in geography or biology expressed stronger beliefs that instructional pictures are useful for instruction and their own teaching. The size of this effect was moderate (Cohen 1988). Other effects of substantial size ($d \approx .30$) failed to reach statistical significance: this was the case for the means of teachers who majored in geography or biology expressing (1) stronger beliefs that text–picture integration should be generally promoted by all teachers and (2) more motivation to work with instructional pictures in their lessons. Moreover, this holds true for the higher mean of teachers who majored in geography or biology regarding self-efficacy to work with materials containing instructional pictures. Overall, aside from the teachers who majored in geography or biology displaying more positive beliefs concerning the usefulness of these learning materials than German teachers, there are indications of generally more positive beliefs and motivation about the benefits of using texts including instructional pictures. But as the additionally observed differences failed to reach statistical significance, the results have to be carefully interpreted.

Predicting instructional quantity and quality

In a last step, we examined whether teachers' beliefs and motivation predict the quality and quantity of their instructional behavior concerning text–picture integration in a prediction model (hypothesis IV). The structure equation model was specified in the program Mplus. It assumed that a teacher's main subject (0=German vs. 1=geography or biology) affects their beliefs and motivation as a distal variable (see Fig. 1). We excluded the *importance of promotion* scale from the analysis because it had no significant prediction coefficient in the model. Further, the model was specified for teachers' beliefs and motivation to predict the quantity (frequency of use of texts with integrated pictures; M=4.15, SD=0.77) and the quality (teacher engagement; M=3.23, SD=0.48) of instruction involving text–picture integration. Inter-correlations of all teacher belief and motivation scales were allowed, and all constructs were included as manifest variables. Statistically not significant paths remained in the final model specification. In order to use all available information, the FIML option was used to handle missing data.

Figure 1 depicts all statistically significant paths in the model ($p<.05$). Again, the model revealed differences between teachers of different majors: Teachers who majored in geography or biology expressed stronger beliefs in the utility of instructional pictures, were more motivated to use them, and more self-efficacious. Moreover, and most importantly, the differences in teachers' beliefs and motivation affected their instructional behavior.

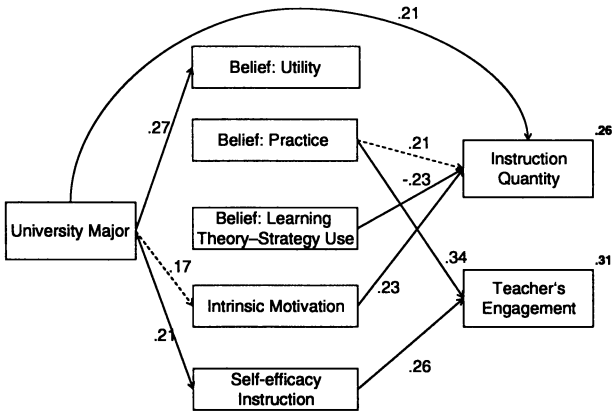

Fig. 1 Effects of university major and teachers' beliefs and motivation on the quantity and quality of instruction involving text–picture integration. Inter-correlations between teachers' beliefs were also included in the model but are not shown in the figure. *Dashed arrows* indicate marginally significant effects ($p<0.10$)

First, teachers were more likely to use texts with instructional pictures in their instruction if they believed that students should be given the opportunity to practice using these pictures in the classroom and that they should be taught explicit strategies for picture interpretation, or if they were more motivated to use instructional pictures in their lessons. In contrast, teachers' instructional quality was predicted primarily by the belief that pictures should be practiced in class and their self-efficacy beliefs.

In sum, there were two indirect effects of the university major on teachers' instructional behavior, mediated by their motivation and self-efficacy to use instructional pictures in their classes. Teachers' beliefs about giving students the opportunity to practice working with instructional pictures and teaching explicit strategies also predicted their instructional behavior, but these predictions were independent of the university major. Overall, the amount of variance explained by teachers' subject background, beliefs, and motivation was substantial, ranging from 26% to 31%.

General discussion

We investigated whether teacher characteristics in the important domain of text–picture integration—specifically, diagnostic skills, beliefs, motivation—varied with their subject background and if differences predicted instructional quantity and quality. Results of these first studies in this research area indicated that the percentage of lessons or homework tasks using texts with integrated pictures was significantly higher in geography and biology than in German instruction. Nevertheless, the teacher's subject background seemed to be of rather limited importance for the diagnostic skills under investigation in this study. An exception was the effect size of the differences in diagnostic accuracy concerning students' overall test performance: the judgments provided by teachers who majored in German were somewhat more accurate than those of the teachers who majored in geography or biology. Given the importance of text–picture materials in the classrooms, these results shed light on the challenge for pre-service teacher training to increase teachers' diagnostic skills across all three investigated majors.

However, subject background was relevant for other teacher characteristics, especially the belief that pictures are useful for instruction and their own teaching. Which subject the teachers studied at university also appears to be related to the importance they attribute to all teachers in a school promoting students' text–picture integration skills, to their self-

efficacy beliefs, and to their intrinsic motivation to use these materials in the classroom. One possible reason why some differences between the two teacher groups failed to reach statistical significance might be that both groups, biology/geography majors vs. German majors, were still quite heterogeneous groups in themselves, including teachers teaching in different grades and school types among others.

In contrast, teachers' instructional theory regarding strategy use for text–picture materials was largely not related to their university training. Additionally, there was evidence that differences in related teacher characteristics have important implications for both the quantity and the quality of teachers' instruction involving text–picture integration. Generally, all results pointed in the direction specified by our hypotheses. However, there was an unexpected negative relation between strategy use and instructional quantity. One explanation for this finding might be that teaching students explicit strategies for dealing with instructional pictures is likely to be more time consuming. As a consequence, teachers who believe that students should learn explicit strategies for picture interpretation use pictures more carefully: they use them less often in their classes and, when they do, they invest more time in teaching how they should be interpreted. To conclude, the relationships identified between teachers' characteristics and the quality and quantity of instruction provide important information: Pre-service teacher training should systematically focus on the teaching with text–picture materials and needs to elaborate effective approaches to develop favorable teachers' skills and motivation in this area.

Obviously, some limitations have to be acknowledged and considered for further research: The sample size, especially for the prediction model, is quite small and larger samples would be appreciated. This would also allow for more refined differentiations of different groups of teachers. Further research should also investigate other aspects of instructional quality and students' perspective on instructional practice. This would also help to overcome the limitation of teachers' self-report measures as used in this study. Follow-up studies should use additional measures such as (video-based) classroom observation and the analysis of classroom discourse to assess teachers' instructional strategies (instructional quality) and amount of time devoted to text–picture integration (instructional quantity). Additionally, research is necessary on design, implementation and evaluation of training measures for pre-service teachers to learn more about developing lessons with the appropriate cognitive load for students with a range of capabilities and information tolerances.

The result give an important indication that CLT might be enriched by taking the teachers' perspective more into account: teachers' beliefs and motivation concerning learning materials, which entail various degrees of cognitive load, matter for their instructional quantity and quality. In the same time teachers differ in their competencies in this area. Furthermore, the results pointed to the core issue, that teachers currently do not sufficiently manage to judge these kinds of learning materials accurately in regard to their difficulty for students. This could indicate that teachers do not have the knowledge base to judge the cognitive load of text–picture materials correctly. In order to allow optimal planning and realization of instruction suitable for the ability level of the learners, it seems an important contribution to future teacher education would be knowledge about CLT. Concurrently, research concerning its implementation and effects is warranted.

Overall, the results highlight the importance of university training for teachers' beliefs, even after many years of classroom practice. Teachers who majored in biology or geography considered instructional pictures to be more useful for their instruction and were more motivated to use them in their classes. In contrast, the effect sizes of differences indicated that teachers who majored in German language arts were less motivated and less efficacious in using instructional pictures in their classes, with negative prediction results not only of the quantity

but also of the quality of instruction involving text with integrated pictures. This finding is problematic considering that language arts teachers are traditionally considered responsible for developing students' reading competencies—including integrated text–picture comprehension—whereas teachers of other subjects usually take students' reading competencies as a given. There is clearly an urgent need for pre- and in-service teacher education to develop the understanding of text–picture integration among teachers in all subject areas.

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Development, prerequisites and training of reading literacy and motivation. Teachers' professional competences (e.g., diagnostic skills). Students with immigrant background

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Current themes of research:

Learning and instruction. Teacher expertise. Large-scale assessments. Development of educational systems. Cognitive and motivational development in childhood and adolescence.

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Include current themes of research

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Current themes of research:

Knowledge acquisition from texts and pictures. Computer-based learning. Situational and individual determinants of learning with media. Teaching and learning in universities.

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Current themes of research:

Knowledge acquisition from texts and pictures. Learning with media. Test development.

Most relevant publications:

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