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The role of decorative pictures in learning

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Abstract Three experiments with students from 7th and 8th grade were performed to investigate the effects of decorative pictures in learning as compared to instructional pictures. Pictures were considered as instructional, when they were primarily informative, and as decorative, when they were primarily aesthetically appealing. The experiments investigated, whether and to what extent decorative pictures affect the learner's distribution of attention, whether they have an effect on the affective and motivational state and whether they affect the learning outcomes. The first experiment indicated with eye-tracking methodology that decorative pictures receive only a bit initial attention as part of the learner's initial orientation and are largely ignored afterwards, which suggests that they have only a minor distracting effect if any. The second experiment showed that despite the small amount of attention they receive, decorative pictures seem to induce better mood, alertness and calmness with learners. The third experiment indicated that decorative pictures did not intensify students' situational interest, but reduced perceived difficulty of the learning material. Regarding outcomes of learning, decorative pictures were altogether neither harmful nor beneficial for learning. However, they moderated the beneficial effect of instructional pictures—in essence: the multimedia effect. The moderating effect was especially pronounced when learners had lower prior knowledge. The findings are discussed from the perspective of cognitive, affective and motivational psychology. Perspectives of further research are pointed out.

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Introduction

For centuries, writtenlearning materials have included text and pictures. Combining texts with pictures is generally assumed to have a positive effect on learning. Abundant research has demonstrated that students learn generally better from text and pictures than from text alone (Levie and Lentz 1982; Levin et al. 1987). Mayer and his colleagues have demonstrated that explanatory illustrations do not only improve retention, but also comprehension of complex subject matter, which finally turns into better problem solving skills, provided that text and pictures are coherent and presented spatially or temporally close to each other (Mayer 1997, 2009; Moreno and Mayer 1999). Mayer has coined the term 'multi-media effect' to summarize this kind of effect.

Most of the research mentioned so far dealt with instructional pictures (Schnotz and Kulhavy 1994). These pictures show the appearance of an object (such as the look of a dinosaur) or the functioning of a technical device (such as a bicycle pump) or cause-effect relations within natural phenomena (such as the formation of lightnings) (cf. Mayer 2009; Peeck 1994). The corresponding graphics can be realistic (based on physical resemblance), abstract (based on underlying logical structures), or analogical (based on functional analogies) (cf. Alesandrini 1987). However, a dip into textbooks for schools shows that learning materials include not only instructional pictures, but also decorative pictures (Pozzer and Roth 2003), which are intended to give relief to the learning situation and to make the material aesthetically pleasing. Historically, the use of pictures for teaching and learning was a core idea of Comenius (1658) in his 'Visible World in Pictures'. Children's curiosity, comprehension and joy of learning were supposed to be fostered by a rich collection of both instructional and decorative images. Teachers and developers of learning material put emphasis also nowadays on fostering learners' attention and on generating a comfortable atmosphere with the aid of decorative pictures. Photographs and illustrations, for example, are often considered as a means to motivate readers by making documents more attractive and interesting (Male 2007; Rubens 2000) and by stimulating aesthetic visual perception (Chiaverina et al. 1997). These beliefs are strong and widespread. However, there is little research so far whether and to what extent decorative pictures really have an effect on learning.

Instructional pictures and decorative pictures are distinguished according to their main function: providing information versus enabling aesthetic experience (Takahashi 1995). The two functions do not exclude each other. Instead, they can be thought of as two orthogonal dimensions, which serve as co-ordinates of a two-dimensional space. Depending on their co-ordinates, pictures can include more or less information about the subject matter to be learned, and they can have more or less aesthetic appeal. Sometimes, a picture is both informative and aesthetically pleasing (cf. Tufte 1990; Wainer 1997). Sometimes, a picture is both uninformative and unpleasant. In real life, however, there is on the one hand a large amount of pictures that include much information about the learning content without being very aesthetically pleasing. On the other hand, there is a large amount of pictures that are aesthetically pleasing, but with little information about the learning content. The term 'instructional pictures' will be used in the following for the first type (i.e. pictures with a primarily informational function), whereas the term 'decorative pictures' will be used for the second type (i.e. pictures with a primarily aesthetic function).

From a cognitive perspective, instructional pictures are supposed to increase learnability in the light of the multimedia effect, as they envision relevant information and provide direct support for the construction of mental models (Mayer 2009; Schnotz 2005; Schnotz and Bannert 2003). For decorative pictures, however, such a positive effect seems to be questionable, because these pictures include by definition only few learning-relevant information. One could therefore suspect that the more attention is attracted by these pictures, the more they will distract the individual from learning (cf. Harp and Mayer 1998; Sanchez and Wiley 2006). However, pictures could have not only cognitive, but also affective or motivational effects on learning (cf. Carney and Levin 2002; Levie and Lentz 1982). Although decorative pictures do presumably not contribute much to the process of learning from a cognitive perspective, they seem to be good candidates for affective or motivational effects on learning.

What refers to the *affective* side, appealing pictures could satisfy needs for beauty and induce a positive mood during learning via aesthetic stimulation (see Hekkert 2006; Leder et al. 2004; Takahashi 1995). Some authors suggest that a positive mood would positively influence cognitive processing, as it is associated with holistic information processing and can therefore support successful processing of complex tasks (Abele 1992; Schwarz 1990). Other authors assume that a positive mood will reduce the available working memory capacity for analytic cognitive processing and can therefore be detrimental to learning (Easterbrook 1959; Ellis and Ashbrook 1988).

What refers to the *motivational* side, a pleasant mood stimulated by decorative pictures might enhance the individual's readiness to continue the process of learning. Decorative pictures could also directly enhance learners' motivation by stimulating situational interest (Anderson et al. 1987; Harp and Mayer 1997; Hidi and Baird 1988; Schraw et al. 2001). Increased interest could enhance the willingness and persistence of learning, foster more intensive and concentrated learning, and activate cognitive strategies that lead to deeper elaboration (Schraw and Lehman 2001; Schiefele and Krapp 1996; Vollmeyer and Rheinberg 2006).

According to these considerations, decorative pictures could have negative consequences due to distraction of attention as well as positive consequences due to their potential affective and motivational effects on the individual. Such positive affective and motivational effects are frequently mentioned in the literature, but only little empirical research has been performed yet to confirm the validity of these assumptions.

Research questions and hypotheses

In view of the above-mentioned considerations, three questions arise with regard to the role of decorative pictures in written learning material:

1 Do decorative pictures affect the learner's distribution of attention?
2 Do decorative pictures have an effect on the learner's affective state?
3 Do decorative pictures have an effect on the learner's motivational state and on learning outcomes?

We will report in the following three studies which aimed at answering these questions. The focus in these studies was on the effects of decorative pictures. The effects of instructional pictures were used as a baseline for evaluating the decorative picture effects.

Regarding the first question, our hypotheses were:

(H1.1) According to their lower informational content, decorative pictures capture less attention than instructional pictures
(H1.2) For the same reason, decorative pictures stimulate less text-picture integration than instructional pictures

Regarding the second question, our hypotheses were:

(H2.1) Decorative pictures tend to create a positive mood due to the satisfaction of aesthetical needs
(H2.2) Decorative pictures tend to increase learner's alertness due to aesthetic stimulation
(H2.3) Decorative pictures tend to increase learner's calmness due to aesthetic experience

One can suspect that a positive mood has also motivational and volitional effects on the learner, because it might increase the learner's readiness to start learning and to continue his/her learning activities instead of quitting them. Furthermore, one can assume that higher alertness and higher calmness contribute to a more concentrated cognitive processing, that is, a more intensive learning.

Regarding the third question, our hypotheses were:

(H3.1) Due to a more positive mood, decorative pictures tend to increase interest in the learning material
(H3.2) Due to a more positive mood, decorative pictures tend to reduce the perceived difficulty of the learning material
(H3.3) Due to positive motivational and volitional effects and due to more concentrated cognitive processing, decorative pictures lead to better learning results

Study I

Our first study aimed at answering the question whether and to what extent decorative pictures as compared to instructional pictures affect the learner's distribution of attention. We expected that decorative pictures would attract less attention (H1.1) and trigger less text-picture integration (H1.2) than instructional pictures.

Method

Learning material

We used a 1,130 words expository text from the domain of physics about ray optics, entitled 'Light and Shadow', which was combined either with decorative pictures or instructional pictures or decorative *and* instructional pictures. The text was developed by science education experts on the basis of common German schoolbooks. The text was subdivided into nine sections of no more than one page text length. The following paragraph shows an example out of the nine text sections:

(1) Silhouettes and shaded areas
Shadows are cast when light hits an opaque object. Thus, light cannot directly enter the space behind the object and is absent there. This non-illuminated space behind

an opaque object is called ***shadow volume****. A* ***shadow*** *(or a* ***silhouette****) is the contour of the shadow volume becoming visible on a surface (such as a wall or a screen). The form of a the shadow volume and the contour of a shadow (silhouette) are determined by the shape of the opaque object (and the shape of the light source). For example, a round opaque object casts a round silhouette. The form of a shadow space and contour can be determined by geometrical means. For this purpose one employs the so-called* ***marginal rays****. Marginal rays are light rays that just go past the object and thus mark the border between illuminated (light) and non-illuminated space (shadow).*

For each text section, a decorative picture and a thematically appropriate instructional picture were chosen from various schoolbooks. Text section (1), for example, was associated with the decorative picture shown in Fig. 1 and the instructional picture shown in Fig. 2. The decorative pictures were aesthetically appealing photographs representing a natural phenomenon described in the text. The instructional pictures were diagrams illustrating important ideas and relationships among concepts described in the text. The decorative and the instructional pictures had been evaluated in a previous pilot study by 12 experts from science education and from text-picture comprehension research regarding their aesthetic appeal and informational content. All experts invariably judged the aesthetic appeal of the decorative pictures higher than the appeal of the instructional ones, and they judged the informational content of instructional pictures higher than the content of decorative ones.

Picture size varied between 30 and 40 cm^2. Regarding placement of instructional pictures (i.e. the spatial relations between pictures and the text segment), one could generally follow the contiguity principle (Mayer 2009) by placing the picture as closely as possible to the conceptual reference points in the text in order to enhance cross-referential

Fig. 1 Example of a decorative picture

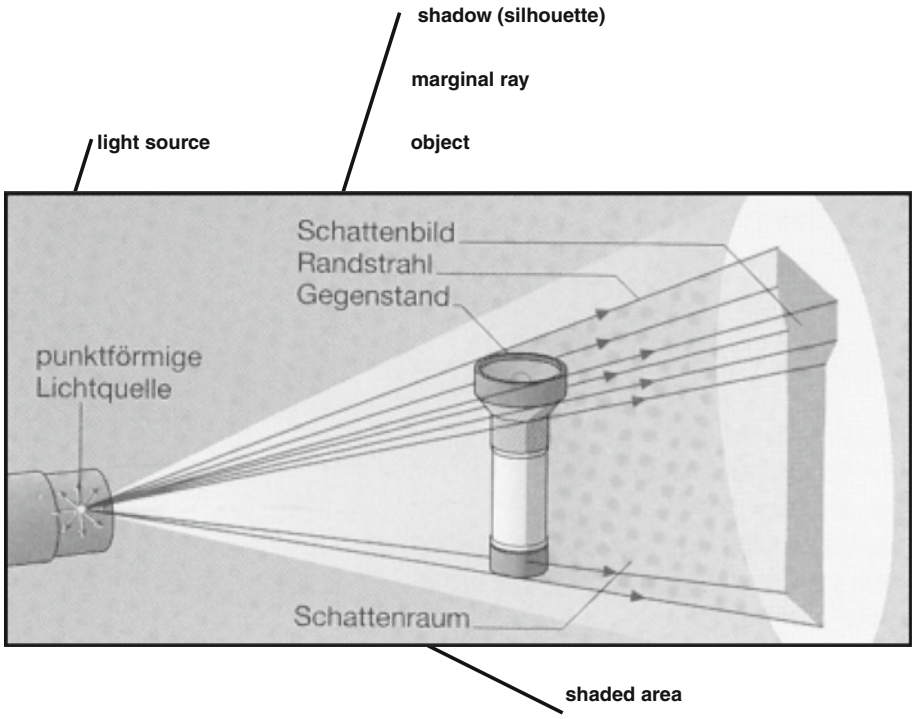

Fig. 2 Example of an instructional picture

connections between text and picture. However, this is not always as easy as it seems to be, because there can be various points of reference in the text. Regarding placement of decorative pictures, the contiguity principle does not apply because there are nearly no (if any) conceptual reference points in the text. However, as decorative pictures are expected to induce affective reactions, it seems reasonable to place these pictures at the beginning rather than the end of the text segment. In order to control for sequencing, we decided to place both the decorative and the instructional picture at the beginning of the corresponding text segment. For the decorative picture, this is common practice in textbooks and science journalism. This sequencing is also in line with findings of Kulhavy et al. (1994), who have pointed out that picture before text is better than text before picture. Because picture and text were on the same page for each text segment, there was also no noteworthy violation of the contiguity principle. When the experimental procedure required to present text with both decorative and instructional pictures, the decorative picture was placed before the instructional one.

Participants

30 students from a secondary school in Germany (so-called 'Gymnasium') participated in the study. 15 were 7th graders and 15 were 8th graders; 16 were females, 14 were males. Students' mean age was 13.00 years (SD = 1.05). We choose grade 7 and 8 to ensure sufficient variation in prior knowledge. In the federal state of Rhineland–Palatinate of Germany, where the study was conducted, students receive physics instruction from 8th grade on, including some geometrical optics. Hence, students at grade 8 had already some

prior knowledge about the learning domain, whereas students at grade 7 could be considered as complete novices. In this way, any effects of prior knowledge should become obvious and, for the same token, prior knowledge independent effects would demonstrate generalizability. Students were recruited at school. They were invited to our university lab to participate in the study. Each students received 10 Euros and a small piece of chocolate for his/her participation.

Procedure

Participants were randomly assigned to one of three experimental conditions (ten students per condition): Text with decorative pictures, text with instructional pictures, and text with decorative *and* instructional pictures. The learning material was presented on a computer screen. Each of the nine text sections (with decorative picture or instructional picture or decorative *and* instructional picture) was displayed on a separate screen page. Students were tested individually. They were seated so that their eyes were approximately 80 cm away from the monitor. Participants had been informed beforehand that they should read, understand, and learn some learning material and that their eye movements would be recorded with a head mounted eye-tracker system.

As eye movements are generally considered as a useful indicator for an individual's present attention and—according to the eye-mind assumption—for cognitive processing (Just and Carpenter 1980; Rayner 1992), we recorded the participants' eye movements during learning with an infrared video-based tracking system (EYELINK-II from SR Research). The system consisted of three miniature cameras mounted on a headband. Two high-speed cameras with built-in infrared illuminators allowed for binocular eye tracking. The third optical high speed camera monitored head movements so that the point of gaze could be accurately tracked even when subjects moved their heads. The best eye to record was automatically selected during the calibration procedure. Calibration was accepted when the maximal error in gaze position was smaller than 1.5° and average error was smaller than 1.0°. The cameras sampled pupil locations at the rate of 250 Hz.

After a short calibration procedure, the students were instructed to read at their normal rate and to comprehend what they were reading as well as they could. They were able to switch back and forth between different screen pages and had as much time as they needed to learn the content. While reading the learning material, their eye movements were recorded.

Scoring

Gaze duration per picture and per text were used as indicators of attention for each participant. Gaze duration is the accumulated time of fixation, including re-fixations, on the corresponding area of the display (decorative picture, instructional picture, or text). Furthermore, we counted the number of switches between text and picture fixations (and vice versa) as an indicator of text-picture integration (Hegarty and Just 1993). Fixation durations of less than 80 ms were excluded from the analyses because readers are not presumed to extract any vital information during such short fixations (Rayner and Pollatsek 1987).

In order to analyze the temporal pattern of how students allocate their attention across time when reading a page, we subdivided for each page (i.e. for each of the nine segments of the learning material) the time of the *first* visit into five 20 %-segments. In this way, we determined how much attention each student spent on the text and on the picture(s) during the first, the second, the third, the fourth and the fifth 20 % time-segment on each page.

Results

Table 1 shows the means and standard deviations of the gaze durations (accumulated fixation times) of decorative pictures and of instructional pictures and of the number of switches between text and pictures for the 20 students who had read text with only decorative pictures or text with only instructional pictures (which allows a between subjects analysis) and for the ten students who had read text with decorative and instructional pictures (which allows a within subjects analysis).

A 2 × 2 ANOVA of gaze durations with the between-factors *type of picture* (decorative/instruction) and *grade* (7th/8th) was performed for 20 students, half of them having read text with only decorative pictures and the other half text with only instructional pictures. The analysis revealed a significant main effect for *type of picture* ($F(1, 16) = 17.31, p < 0.001, \eta^2 = 0.52$): Decorative pictures received less visual attention than instructional ones. The other effects (*grade* and the interaction *type of picture x grade)* were not significant. Furthermore, a 2(×2) ANOVA of gaze durations with the between factor *grade* (7th/8th) and the within-factor *type of picture* (decorative/instruction) was performed for the ten students, who had read text with both decorative and instructional pictures. This analysis revealed also a significant main effect for *type of picture* ($F(1, 8) = 32.50, p < 0.001, \eta^2 = 0.80$) as, again, decorative pictures received less visual attention than instructional ones. The other effects were not significant.

A 2 × 2 ANOVA of number of switches between text and pictures with the between-factors *type of picture* (decorative/instruction) and *grade* (7th/8th) of 20 students who had seen text with decorative pictures or text with instructional pictures revealed a significant main effect for *type of pictures* ($F(1, 16) = 5.63, p < 0.05, \eta^2 = 0.26$): There were less switches between text and decorative picture than between text and instructional pictures. The other effects were not significant. A 2(×2) ANOVA of number of switches between text and pictures with the between factor-*grade* (7th/8th) and the within-factor *type of picture* (decorative/instruction) and revealed also a significant main effect for *type of picture* ($F(1, 8) = 31.47, p < 0.01, \eta^2 = 0.80$). Again, there were less switches between text and decorative pictures than between text and instructional pictures. The other effects were not significant.

Based on the temporal patterns of the students' allocation of attention to the text and the picture(s) within the 1st, 2nd, 3rd, 4th and 5th 20 %-interval of the *first visit* reading times of each page, we calculated the mean temporal pattern of attention allocation by averaging

Table 1 Means and standard deviations (in parentheses) of eye movement parameters (gaze durations of pictures and number of switches between text and picture) of students who had seen either text with decorative pictures or text with instructional pictures (between subjects analysis) and of students who had seen text with both decorative and instructional pictures (within subjects analysis)

	Decorative instructional 7th grade		Decorative instructional 8th grade	
	M (SD)	*M* (SD)	*M* (SD)	*M* (SD)
Between-subjects analysis	n = 5	n = 5	n = 5	n = 5
Gaze duration	23.6 (19.1)	119.4 (51.6)	33.1 (15.4)	69.4 (42.2)
Number of switches	47 (24.9)	98 (31.2)	54 (32.3)	68 (35.3)
Within-subjects analysis	n = 5		n = 5	
Gaze duration	20.7 (10.1)	111.2 (46.7)	17.5 (7.5)	102. (43.9)
Number of switches	16 (7.2)	65 (22.9)	22 (6.7)	97 (41.2)

across all pages and all participants per experimental condition. Figure 3 shows the patterns of text with only decorative pictures. Figure 4 shows the patterns of text with only instructional pictures. Figure 5 shows the patterns of the text with both decorative and instructional pictures. As can be seen from Figs. 3 and 5, decorative pictures were only looked at in the beginning of reading a page and were largely ignored afterwards. On the contrary, as can be seen from Figs. 4 and 5, instructional pictures were not only observed two or three times as long as decorative pictures in the beginning of reading a page, but were also looked at throughout the whole reading of the page. Contrary to decorative pictures, attention to instructional pictures increased again within the last 20 % of reading time per page.

Discussion

The results of Study I were in line with our hypotheses. Decorative pictures capture less attention and stimulate less text-picture integration than instructional pictures. They receive only some initial attention, obviously as part of the learner's initial orientation about the page, but are largely ignored afterwards. Instructional pictures, on the contrary, attract considerably more attention than decorative ones not only during the beginning phase of reading, but throughout the whole reading process.

According to our results, decorative pictures should have only small (if any) distracting effects on learning. They should not be harmful for learning, because they receive only a small amount of attention. Instructional pictures, on the contrary, receive much more attention and, accordingly, seem to play a much more important role in cognitive processing. We assume that instructional pictures have a visual organizer function in the first phase of reading, as they skeletonize the mental model which has then to be elaborated during the following reading. After an initial phase of instructional picture-enhanced mental model construction, the text takes the lead for further elaboration of the mental

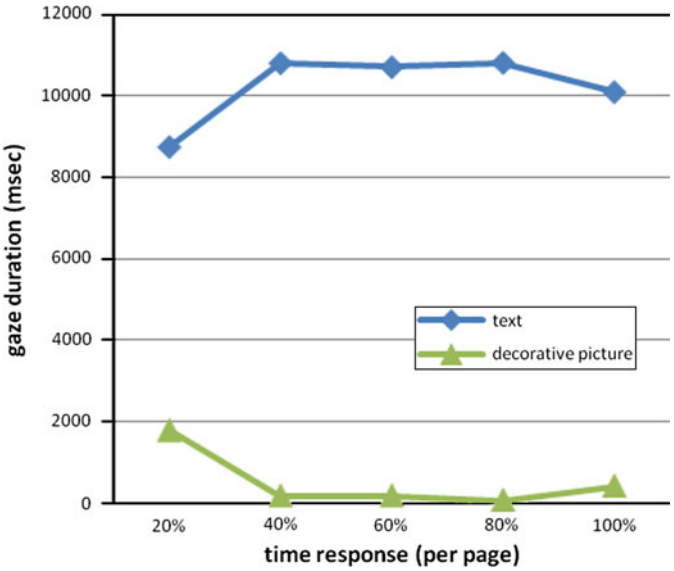

Fig. 3 Average gaze durations for text and picture across time of first visit readings (averaged across all pages) when text was combined with only decorative pictures

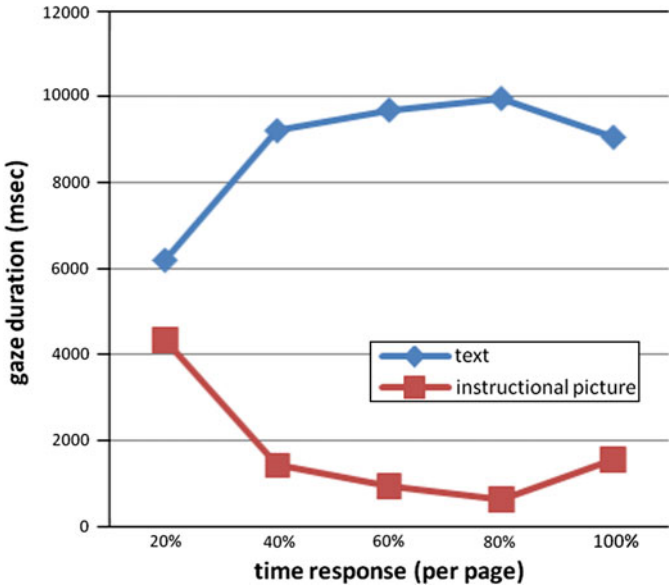

Fig. 4 Average gaze durations for text and picture across time of first visit readings (averaged across all pages) when text was combined with only instructional pictures

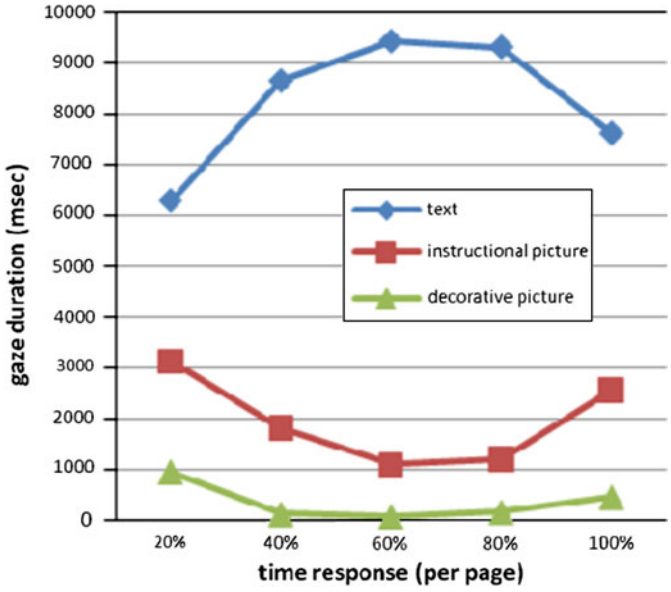

Fig. 5 Average gaze durations for text, decorative picture and instructional picture across time of first visit readings (averaged across all pages) when text was combined with decorative and instructional pictures

model. The corresponding decrease of attention to instructional pictures and the increase of attention to the text can be seen in Fig. 4 as well as in Fig. 5. At the beginning of learning, instructional pictures capture relatively high initial attention in order to support the

learner's initial mental model construction; afterwards, they receive less attention than before, because the learner concentrates on reading the text. The final increase of attention in the case of instructional pictures is possibly the result of a final semantic page wrap-up. We speculate that the individual will at this point recall the previously read text information and verify this information by re-considering the picture. As expected, these results were not influenced by grade, which means that the findings can be generalized to some extent across age groups.

Study II

If decorative pictures do not attract much attention (and accordingly do not have much impact on cognitive processing) it does not imply that decorative pictures have no influence on the learner at all. If they have an affective impact on the learner, it is possibly not necessary to look at them for a longer time. Our second study aimed therefore at answering the question whether decorative pictures have indeed an affective impact on learners as compared to instructional pictures. We had hypothesized that decorative pictures create a more positive mood due to the satisfaction of aesthetical needs (H2.1) and that, due to aesthetic stimulation and experience, decorative pictures tend to increase the learner's alertness (H2.2) and calmness (H2.3).

Method

Learning material

We used the same expository text about ray optics and the same decorative and instructional pictures as in Study I. However, pictures were not integrated into the text across the nine sections. Instead, the text was presented first, followed by the decorative and instructional pictures in random order. The text and the pictures were presented as print material.

Participants

57 students from the 7th and 8th grade of a German high school (Gymnasium) participated in the study. 29 were females, 28 were males. Their mean age was 13.04 years (SD = .87). Students participated at school in the context of their regular lessons. They received a small piece of chocolate for their participation.

Procedure

Participants were tested in groups. First, they had to read the text. They were instructed to read at their normal rage and to comprehend what they were reading as well as they could. This text reading followed two purposes: Students should feel as if they were in a real learning situation and they should become familiar with the semantic context of the pictures. Second, after text reading, the nine decorative and the nine instructional pictures were presented in random order to the students. After viewing each picture, the students' mood was measured with the Multidimensional Mood Inventory of Steyer (1997).

The Multidimensional Mood Inventory consists of three bi-polar scales: *mood* (good/bad), *alertness* (awake/sleepy), and *calmness* (calm/restless). According to Steyer et al. (1997), the three dimensions are not totally independent, but can be clearly differentiated according to inter-correlations and factor loadings. The items were simple adjectives such as 'good', 'alert', and 'calm'. The participants were asked to describe their mood after every picture on a 5-point rating scale (1 = lowest score, 5 = highest score) for the three adjectives. Students had as much time as they needed for evaluating the pictures' impression on them.

Scoring

A mean score of each of the 3 scales (mood, alertness, and calmness) was calculated for each student across all 9 decorative pictures. Similarly, a mean score of each scale was calculated for each student across all 9 instructional pictures. For decorative pictures, internal consistencies (Cronbach's α) of the nine items scales were .80 for mood, .81 for alertness, and .81 for calmness. For instructional pictures, the corresponding internal consistencies were .93 for mood, .91 for alertness, and .89 for calmness.

Results

Table 2 shows the means and standard deviations of the students' affective reactions to the decorative and the instructional pictures. A (2×) 2 ANOVA of *mood* as dependent variable with the within-factor *type of picture* (decorative/instructional) and the between-factor *grade* (7th/8th) revealed a highly significant effect of *type of picture* ($F(1,55) = 131.25$; $p < 0.001$; $\eta^2 = 0.71$), but no significant effect of grade ($F(1,55) = 0.09$; ns). The (2×) 2 ANOVA of *alertness* with *type of picture* and *grade* showed also a highly significant effect of *type of picture* ($F(1,55) = 34.46$; $p < 0.001$; $\eta^2 = 0.39$), but no significant effect of grade ($F(1,55) = 0.10$; ns). Similarly, the (2×) 2 ANOVA of *calmness* with *type of picture* and *grade* revealed a highly significant effect of *type of picture* ($F(1,55) = 50.11$; $p < 0.001$; $\eta^2 = 0.48$), but no significant effect of grade ($F(1,55) = 0.14$; ns). None of the interactions was significant within the three analyses).

Discussion

The results of Study II clearly support hypotheses H2.1, H2.2 and H2.3. Decorative pictures have obviously an effect on the learner's affective state. More specifically, they seem to induce better mood, higher alertness and more calmness of the learner as compared to instructional pictures. The fact that effects were not influenced by grade implies that they can be generalized across age groups.

Table 2 Means and standard deviations of students' affective states in terms of mood, alertness and calmness as reactions to decorative pictures and to instructional pictures in Study II

	Decorative pictures ($n = 57$)		Instructional pictures ($n = 57$)	
Scale MMI	M	SD	*M*	SD
Mood	4.04	0.48	2.64	0.91
Alertness	3.64	0.58	2.86	0.99
Calmness	3.86	0.54	2.96	0.94

Note. *ScaleMMI* scales of the multidimensional mood inventory

We cannot exclude the possibility that a picture does not only influence one (immediately associated) affect measure, but has also a mediated effect on the affect measures of the following pictures. However, this is not a fundamental problem, because due to the random-order presentation of decorative and instructional pictures, a spillover of mood from one picture to another would at most blur the existing differences between the different types of pictures without a systematic bias.

Study III

We had hypothesized that decorative pictures increase interest in the learning material (H3.1), that students consider learning material with decorative pictures less difficult (H3.2) and that—due to increased interest in the learning material and due to more concentrated cognitive processing—decorative pictures lead to better learning results (H3.3). It should be noted that similar effects can also be expected for instructional pictures, though for different reasons. As instructional pictures visualize the learning content, they could also increase situational interest in the learning material. As they provide relatively direct admittance to mental model construction, they could also cause students to consider the learning material less difficult. Finally, as students learn better with text and pictures than with text alone (Mayer 2009), instructional pictures should also lead to better learning results.

Method

Experimental material

The learning material of Study I was also used in Study II, but was presented on paper. Four versions were created: The first version consisted of text and decorative pictures, the second one of text and instructional pictures, the third one of text, decorative pictures *and* instructional pictures, and the fourth version consisted of only text without pictures.

To assess participants' *prior knowledge*, we constructed nine open questions related to the core themes of the nine text segments. For example, one item was '*What is a shadow image?*'. We developed a coding schema for evaluation of the students' answers. The coding schema allowed to assign 0–3 points for each item (0 points = no answer or incorrect answer, 1 point = partly correct answer, 2 points = correct answer with no use of technical terms, 3 points = correct answer including the use of technical terms). Every answer was rated by two independent raters. Inter-rater reliability was determined by Cohen's κ and revealed values between $\kappa = 0.62$ and $\kappa = 0.99$ indicating a good to very good agreement (Fleiss and Cohen 1973). We aggregated the scores over all nine items for each student. A maximum 27 points could be achieved as a total score. Students' empirical test scores varied between four and 22 points ($M = 10.53$, SD = 5.40).

Participants' *intelligence* was measured with the Berlin Intelligence Structure Test for adolescents (Jaeger et al. 2006). This test is based on the Berlin Intelligence Structure Model, which offers the possibility to assess different skills related to different kinds of content (verbal, figural, and numerical). Due to time restrictions, we decided to use four scales for verbal and figural content. In order to assess students' *interest in the learning material*, we used the Interest-Scale from the Questionnaire of Current Motivation (Rheinberg et al. 2001). According to this scale, five different statements (items) have to be evaluated on a 7-point rating scale ranging from 1 *(does not apply)* to 7 *(doesfully apply).*

An example statement is '*I would read these kinds of texts also in my leisure time'*. Internal consistency was $\alpha = 0.87$. The *perceived difficulty* of the learning material was assessed with the items '*Overall I found the text difficult to understand*' and '*Compared to other schoolbook texts, the text was difficult to understand.*' Both statements had to be evaluated on a 4-point rating scale ranging from 1 (*does not apply)* to 4 (*doesfully apply)* (Trafimow et al. 2002). The correlation between the two items was very high ($r = 0.60$, $p < 0.001$).

In order to measure *learning performance*, we constructed 18 multiple choice items, which required deep understanding of the learning material. Each question was followed by five possible answers. The following item gives an example:

(2) *Why do we see the moon in different phases, contrary to the sun?*

(a) *Because the moon is smaller than the sun*
(b) *Because the sun shines on its own, whereas the moon has to be illuminated*
(c) *Because the moon rotates around the earth, whereas the sun does not*
(d) *Because the moon is closer to the earth than the sun*
(e) *Because the earth rotates around the sun, whereas the moon does not*

The items were pre-tested with a sample of 55 students from 7th and 8th grade. Only items with an average difficulty ($0.20 \leq p \leq 0.80$) and an item-total correlation higher than $r = 0.10$ were included in the scale. The finally selected 12 items had an internal consistency (Cronbach's α) of 0.70 in the pilot sample and 0.68 in the current sample. This reliability seems satisfactory as each item deals with different text parts and learners possibly understand one part of the text better than another.

Participants

194 students from the 7th and 8th grade of a German high school (Gymnasium) participated in the study. Four classes were from 7th and four classes were from 8th grade. 103 were females, 91 were males. Students' mean age was 13.25 years (SD = 0.69). Participants were randomly assigned to one of four experimental conditions. 50 students were assigned to text with decorative pictures, 50 to text with instructional pictures, 45 to text with decorative *and* instructional pictures, and 49 were assigned to text without pictures. Participants received a small piece of chocolate for their participation.

Procedure

The study was conducted in group sessions under natural conditions in the context of regular schooling and required three lessons à 45 min. In the first lesson, participants worked on the intelligence test and the prior knowledge test. In the second and the third lesson, students were given (aside from the $2 \times 45 = 90$ min. constraint) practically unlimited time to work with the learning material. They were instructed to read the text at their normal rate and to comprehend what they were reading. When students had finished reading the learning material they were asked to give the instructor a sign and hand the learning material over. The instructor wrote down the learning time which was rounded to the nearest 15 s. After the learning period, participants were asked to answer the questionnaires about interest in the learning material and about the perceived task difficulty. Finally, they received the items of the learning performance test. Time to fill in the learning performance test was not restricted. The test took about 20 min on the average.

Scoring

As a prior knowledge score, we aggregated for each student the item scores across all 9 open questions of the prior knowledge test. For intelligence, we calculated for each student the average score across all four BIS scales. As indicator of interest in the learning material, we computed the average score of the five corresponding items for each participant. For the perceived difficulty of the learning material, we determined for each student the average score of the two items. Finally, as indicator of learning performance, we determined for each participant the sum of correctly answered test items.

Results

Table 3 shows the means and standard deviations of the students' prior knowledge, intelligence, interest in the learning material, perceived difficulty of the learning material, learning performance and learning time in the four experimental groups. Prior knowledge and intelligence as fundamental learning prerequisites correlated with 0.55 ($p < 0.001$) and 0.56 ($p < 0.001$) with learning performance. The groups with decorative pictures had higher prior knowledge than the groups without decorative pictures ($t(192) = 2.18$; $p = 0.03$), but there was no difference in terms of intelligence ($t(192) = 0.84$; ns). For the groups with and without instructional pictures, there were neither significant differences for prior knowledge ($t(192) = 0.75$; ns) nor for intelligence ($t(192) = 0.51$; ns). Therefore, we decided to use only prior knowledge as a covariate for further analysis.

An ANCOVA of the students' interest in the learning material with the between factors *decorative pictures* (yes/no) and *instructional pictures* (yes/no) using *prior knowledge* as covariate resulted in a marginally significant effect of *prior knowledge* ($F(1,185) = 2.98$; $p = 0.086$; $\eta^2 = 0.016$), a significant effect of *instructional pictures* ($F(1,185) = 3.54$; $p1 = 0.031$; $\eta^2 = .019$) and a marginally significant interaction *instructional pictures x prior knowledge* ($F(1,185) = 3.81$; $p = 0.053$; $\eta^2 = 0.020$). No significant main or interaction effect was found related to decorative pictures. Accordingly, students with instructional pictures showed higher interest in the learning material than students without

Table 3 Means and standard deviations (in parentheses)of prior knowledge, intelligence, interest in the learning material, perceived difficulty of the learning material, learning performance and learning time of students with text and decorative plus instructional pictures, students with text and only decorative pictures, students with text and only instructional pictures, and students with only text (no pictures)

	Decorative and instructional *M* (SD) *n*	Decorative only *M* (SD) *n*	Instructional only *M* (SD) *n*	No picture *M* (SD) *n*
Prior knowledge	8.29 (4.92) 45	7.72 (4.30) 50	6.86 (4.40) 50	6.39 (3.81) 49
Intelligence	102.38 (6.79) 44	101.49 (6.50) 49	101.17 (7.27) 49	100.96 (7.15) 47
Interest in learning material	3.63 (1.11) 45	3.54 (1.49) 50	3.34 (1.35) 50	3.25 (1.44) 48
Perceived difficulty of learning material	1.64 (0.52) 45	1.80 (0.74) 49	1.75 (0.69) 50	2.00 (0.79) 49
Learning performance	7.47 (2.67) 45	6.28 (2.42) 50	6.82 (2.63) 50	6.27 (2.48) 49
Learning time in seconds	919.91 (330.26) 45	982.30 (334.76) 50	972.86 (295.56) 50	987.60 (341.20) 48

instructional pictures. The interaction *instructional pictures x prior knowledge* showed that this effect was especially pronounced when learners had lower prior knowledge. Decorative pictures, on the contrary, did not affect students' interest in the learning material.

An ANCOVA of the students' perceived difficulty of the learning material with the between factors *decorative pictures* (yes/no) and *instructional pictures* (yes/no) using *prior knowledge* as covariate resulted in a significant effect of *decorative pictures* ($F(1,185) = 4.16$; $p = 0.022$; $\eta^2 = .022$) and a marginally significant interaction *decorative pictures x prior knowledge* ($F(1,185) = 3.45$; $p = 0.061$; $\eta^2 = 0.019$). No significant main or interaction effect was found related to instructional pictures. Accordingly, decorative pictures reduced perceived difficulty of the learning material. The interaction *decorative pictures x prior knowledge* indicated that this effect was especially pronounced when learners had lower prior knowledge. Instructional pictures, on the contrary, did not affect perceived difficulty of the learning material.

An ANCOVA of the students' learning performance with the between factors *decorative pictures* (yes/no) and *instructional pictures* (yes/no) using *prior knowledge* as covariate resulted in a significant effect of *instructional pictures* ($F(1,185) = 4.60$; $p1 = 0.017$; $\eta^2 = 0.024$), a significant interaction *decorative x instructional pictures* ($F(1,185) = 5.22$; $p = 0.023$; $\eta^2 = 0.027$) and a marginally significant interaction *decorative x instructional pictures x prior knowledge* ($F(1,185) = 3.79$; $p = 0.053$; $\eta^2 = 0.020$). No significant effects ($F(1,185) < 1.00$) were found for *decorative pictures*, the interaction *decorative x prior knowledge* and the interaction *instructional pictures x prior knowledge*. Students with instructional pictures showed higher learning performance than students without instructional pictures. Decorative pictures, on the contrary, had neither a harmful nor a beneficial overall effect on students' learning performance. However, the interaction *decorative x instructional picture* showed that decorative pictures had a moderating function with regard to the effect of instructional pictures. When combined with decorative pictures, the instructional pictures were more beneficial for learning than without decorative pictures. The marginally significant interaction *decorative x instructional pictures x prior knowledge* further indicated that this combinatory effect of decorative and instructional pictures was especially pronounced, when learners had lower prior knowledge. An ANCOVA of the students' learning time with the between factors *decorative pictures* (yes/no) and *instructional pictures* (yes/no) using *prior knowledge* as covariate did not show any significant effects except for prior knowledge ($F(1,185) = 6.23$; $p = 0.013$; $\eta^2 = 0.033$).

Discussion

As for instructional pictures, the study revealed a positive effect on students' interest, but contrary to our expectations no effect on the perceived difficulty of the learning material. The increase of interest could be related to the perceived usefulness of instructional pictures as an easily accessible source of information, especially for students with lower prior knowledge. However, instructional pictures about ray optics were possibly not easy to understand and therefore did not reduce learners' difficulty ratings. As expected, students with instructional pictures showed higher learning performance according to the multimedia effect (Mayer 2009) than students without instructional pictures.

Contrary to our expectations (H3.1), decorative pictures did not enhance students' interest in the learning material. However as expected (H3.2), students perceived the learning material with decorative pictures as less difficult than the material without decorative pictures, especially when they had lower prior knowledge. The effect could be

caused by interrelations of positive mood induced by decorative pictures and higher confidence of students that would make the learning material look less difficult. These interrelations need of course clarification by further research.

Decorative pictures turned out to be neither harmful nor beneficial for learning, which did not support our hypothesis H3.3. However, decorative pictures moderated the beneficial effect of instructional pictures on learning. When combined with decorative pictures, instructional pictures were more beneficial for learning than without decorative pictures. It seems that the cognitive impact of instructional pictures combined with the affective impact of decorative pictures makes learning more successful. Students with lower prior knowledge have special benefits from this combination. Perhaps, these students have more worries about their abilities to master the learning material than students with higher prior knowledge. If decorative pictures induce higher alertness and higher calmness with these students, they would allow them more concentrated cognitive processing and, thus, better learning results. Further research is needed to clarify these interrelations.

We did not find significant differences in learning time between the different experimental groups. This might be to some extent due to our experimental situation, which was too close to regular schooling. In such a situation, learning times of students are not independent: When one student finishes the learning task, his/her peer students are more likely to finish working on the task too. Motivational and volitional effects need probably sufficient space for self-regulated learning, which allows the individual to decide relatively independently from other students whether he/she will continue or quit learning. Motivational and volitional effects might also need more learning sessions, if the effects are small and need to be accumulated in order to become visible.

General discussion

Abundant research has demonstrated that students learn better from text with contiguously presented instructional pictures than from text alone (Levie and Lentz 1982; Levin et al. 1987; Mayer 2009; Moreno and Mayer 1999). However, little research has been done yet on the impact of decorative pictures on learning (Pozzer and Roth 2003; Takahashi 1995). The studies presented in this article aimed at contributing to clarifying this issue. More specifically, they investigated, whether decorative pictures affect learners' distribution of attention, whether they have an impact on learners' affective states, and whether they influence learners' motivational states and learning outcomes.

As decorative pictures include only little learning-relevant information, they cannot contribute much to mental model construction directly. Instead, they could be at risk of distracting the individual's attention and therefore act as an impediment for learning (cf. Harp and Mayer 1998; Sanchez and Wiley 2006). According to our first study, however, decorative pictures do not have an essential distracting effect. They seem to capture only very little attention—much less than instructional pictures—when starting reading a new page as part of the learner's initial orientation about the material, but are largely ignored afterwards. Thus, as decorative pictures attract only a small amount of attention, they should not be harmful for learning.

However, the lack of learning-relevant information and the small amount of attention received from learners does not imply that decorative pictures do not have an effect on learning at all. They can very well have an impact on the learners affects even when they are only briefly looked at. Appealing pictures can satisfy needs for beauty and trigger aesthetic stimulation (Takahashi 1995), which in turn might influence the learner's

emotional state (Leder et al. 2004). According to our second study, decorative pictures seem to induce better mood, alertness and calmness of the learner, which is taken by itself a good reason for considering carefully how and when to insert decorative pictures into learning materials (Hekkert 2006). Our second study did not allow making inferences about more distant effects of such affective influences. However, one can speculate that an improved affective state does also have motivational effects, first, because a better mood might increase the individual's readiness to learn and, second, because higher alertness and calmness could enhance more concentrated cognitive processing.

Our third study aimed at investigating these effects of decorative pictures on motivation and learning outcomes. We had expected that both decorative and instructional pictures would stimulate situational interest of the individual and reduce perceived difficulty of the learning material, which in turn should increase the willingness and persistence of learning and finally lead to better learning results (Abele 1992; Anderson et al. 1987; Harp and Mayer 1997; Hidi and Baird 1988; Schiefele and Krapp 1996; Schraw et al. 2001; Schraw and Lehman 2001; Schwarz 1990; Vollmeyer and Rheinberg 2006). The situational interest assumption was confirmed for the instructional pictures, but not for the decorative ones, whereas the perceived difficulty assumption was confirmed for the decorative pictures, but not for the instructional ones. On the one hand, students with instructional pictures had more interest in the learning material than those without, especially when they had lower prior knowledge, whereas no such effect was found for decorative pictures. On the other hand, students with decorative pictures perceived the learning material less difficult than those without, especially when they had lower prior knowledge, whereas no such effect was found for instructional pictures.

As instructional pictures visualize the learning content, they are a promising information source for mental model construction. This might have enhanced also interest in the learning material especially for learners with lower prior knowledge, whereas decorative pictures do not provide such learning-relevant information. Although decorative pictures might have induced better mood, alertness and calmness, they did obviously not affect situational interest. However, we have to take also the possibility into account that a self-report questionnaire is not sufficiently sensitive for the research question at hand. For example, an item such as '*I would read such texts in my free time*' might eventually not be able to grasp subtle differences in interest evoked by including different kinds of pictures in the material. It might be better to use other variables as indicators for interest in future studies. If students can choose between texts with and without pictures, for example, they may prefer text with pictures to those without pictures.

Regarding the effect of decorative pictures on perceived difficulty, we had assumed that a positive mood of students induced by decorative pictures would induce higher confidence and, thus, make the learning material look less difficult. Our findings seem to support this hypothesis. However, we have to take also the possibility into account that decorative pictures will trigger specific preconceptions by giving students the illusion that material which contains decorative pictures is not that difficult (cf. Salomon 1984). Further research is needed to clarify this issue. We suspect that instructional pictures did not reduce perceived-difficulty of the material, because they were complex enough to be considered as demanding as the text.

Not surprisingly, students with instructional pictures showed higher learning performance than students without such pictures, which is in line with the multimedia effect (Carney and Levin 2002; Mayer 2009). Decorative pictures, on the contrary, turned out to be neither harmful nor beneficial for learning. In view of the fact that so many instructional materials include decorative pictures, the *lack* of a *negative* effect could already be

interpreted as a *positive* message. However, the lack of a positive effect could also be due to the specifics of our research design. Learning took place in a natural classroom setting. In such a situation, students' learning times are probably mutually interdependent: When more and more peers finish their learning tasks, the remaining students are likely to hurry up and finish their learning task too. Motivational effects of pictures on learning outcomes are more likely to be found in settings which allow more individualized learning. Individuals should be able to decide independently from others, whether, how much and how long they are willing to engage in learning. Furthermore, it is possible that more learning sessions are required to allow for an accumulation of small motivational effects.

Although decorative pictures did not have a main effect on learning, they moderated the beneficial effect of instructional pictures on learning. When combined with decorative pictures, instructional pictures with text were more beneficial for learning than without decorative pictures. This effect was especially pronounced when students had lower prior knowledge. We can only speculate at this point about the reasons of this moderator effect. If we suppose that students frequently worry about their about their abilities to master the learning material, triggering higher alertness and calmness through decorative pictures might allow them to process information in a more concentrated manner than without these pictures. Thus, the beneficial effect of instructional pictures would be fortified. It seems reasonable to assume that low prior knowledge students have more worries than more advanced students, which would explain why the moderating effect of decorative pictures is especially pronounced when prior knowledge is low. However, further research is needed to clarify this issue. As a preliminary conclusion from our findings, one can assume that the *combined* cognitive effect of instructional pictures and affective impact of decorative pictures makes learning especially successful.

Further research on the effects of decorative pictures on learning should include not only experimental studies, but also field studies to evaluate the transferability of findings from research labs into the educational field. In the studies presented above, only a small proportion of the curriculum (ray optics in physic) was addressed, only learners from a narrow age group (7th and 8th graders) and a specific level of education (Gymnasium) participated, and only a specific type of decorative pictures (aesthetic photographs) was used in the material. These factors would need a systematic variation as well as a search for specific interaction effect in order to achieve a more comprehensive view of this area. In light of the widespread use of decorative pictures in learning material, such research would be of high interest both from a theoretical and a practical point of view.

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