Pictorial illustrations in intelligent tutoring systems: Do they distract or elicit interest and engagement?

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Abstract: Do pictorial illustrations distract from learning and, thus, decrease learning outcomes, as suggested by Cognitive Load Theory and Cognitive Theory of Multimedia Learning? Or can pictorial illustrations trigger interest and thereby enhance the willingness to learn as suggested by interest theories? Although these approaches seem to contradict each other, we assume that they are compatible: Pictorial illustrations may hamper short-term learning but raise interest and engagement so that in the medium run learning may be enhanced. In order to test our "integrative" hypothesis, we explored the potential of different types of pictorial illustrations to trigger situational interest in the context of geometry learning. Results showed an effect of pictorial illustrations on the interestingness of geometry problems. In addition, interest in further learning with the computer-based learning environment was higher with pictorial illustrations than without. On the other hand, interest in deepening geometry knowledge was reduced when illustrations were added.

Introduction

Most (German) mathematical textbooks are full of pictorial illustrations. Does this make sense given that such pictorial illustrations may be "*seductive details*" that impede learning (Harp & Mayer, 1997, 1998)? Or do they actually enhance interest and, thereby, the willingness to engage in learning? Weidenmann (1991) suggests that pictorial illustrations have different supporting functions such as activation, construction, or focusing special aspects of the learning materials. In addition, Anglin, Towers, and Levie (1996) suggest in their review that pictorial illustrations–beside their compensatory, cognitive, and attentional functions–also have an affective function in learning.

Contrary to these assumptions on the beneficial functions of pictorial illustrations, *Cognitive Load Theory* (Sweller, 2005)–which assumes that many difficulties in learning are due to unnecessary (i.e., extraneous) working memory load–postulates a number of potential negative effects of pictorial illustrations (Sweller, van Merrienboër & Paas, 1998): Redundancy effect (i.e., when different sources such as pictures and text provide the same information and, thus, induce unnecessary processing demands), split-attention effect (i.e., extraneous load due to difficulties in mapping text and pictures), and extraneous load due to irrelevant illustrations that do not contain essential information. Similarly, *Cognitive Theory of Multimedia Learning* (Mayer, 2005) predicts that words, illustrations, or sounds which are not relevant to the central learning goals should be omitted (e.g., Harp & Mayer, 1997, 1998). In addition to the redundancy effect (Mayer, Heiser & Lonn, 2001; Moreno & Mayer, 2002) and split-attention effect (Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, Spires, & Lester, 2001) Mayer and Moreno (2003) refer to the coherence effect (e.g., unnecessary load through interesting but extraneous material). In conclusion, learning materials should be as concise as possible (Mayer & Moreno, 2003). Both theories suggest eliminating any redundant or decorative elements. Accordingly, computer-based multimedia environments should not contain redundant or decorative pictorial illustrations.

In the last years, however, even cognitive load researchers increasingly call for the consideration of motivational and emotional aspects (e.g., Zander, Brünken, 2009; Paas, Tuovinen, van Merrienboër & Darabi, 2005; van Merrienboër & Ayres, 2005). Against this background, the construct of *interest* seems especially relevant (Tulis, 2009; Krapp, 1999, 2000; Krapp, Hidi & Renninger, 1992). It comprises a value-related and emotion-related component (Schiefele, Krapp, Wild & Winteler, 1992). Hidi (2000) distinguishes between two different, but linked types of interest, *individual* and *situational interest*. Individual interest is defined as a relatively stable predisposition, whereas situational interest arises as a reaction to environmental input, for example, visual and auditory (Krapp, 1999). Research has shown that (situational) interest eases comprehension (Hidi, 2001) and learning (Ainley, Hidi & Berndorff, 2002; Hidi, 2001; Schiefele, 1998). Explanations for such effects include deeper processing, and a higher degree of cognitive organization (Ryan, Connell & Plant, 1990). Interest is also positively related to persistence (Ainley, Hidi, 2002; Ainley, et. al., 2002), activation (Schiefele, 1990), and elaboration (Krapp, 1999; Schiefele, 1996, Ryan et al., 1990). Furthermore, it is essential for engagement in learning (Anderman, Noar, Zimmerman, & Donohew, 2004). Examples of factors that trigger and maintain situational interest are novelty, concreteness, and visual imagery (Hidi, 2001). Most results on situational and individual interest were found in the context of learning from text. *Concreteness, a personally relevant context, ease of comprehension*, and *unexpected information* (see Anderson, Shirey, Wilson & Fielding, 1987; Hidi & Baird, 1986, 1988) are, for example, factors that trigger and maintain situational interest in text learning. One way to adapt these aspects to computer-based multimedia environment is the use of concrete, meaningful and relevant context oriented pictorial illustrations.

Although the different theoretical perspectives on potential effects of pictorial illustrations seem to contradict each other, we assumed that they are compatible: Pictorial illustration may hinder short-term learning outcomes but can raise interest and engagement so that in the medium term learning is enhanced. As a first step in testing our "integrative" hypothesis, we conducted a study to explore the following aspects: First, we were interested whether pictorial illustrations can actually increase situational interest. Second, we wanted to identify sets of pictorial illustrations that do or that do not enhance situational interest in the domain of geometry. These pictorial illustrations will subsequently be used to test the integrative hypothesis in the context of learning with intelligent tutoring environments (here: Cognitive Tutors; Koedinger & Corbett, 2006). Up to now, most of the interest research has been conducted in the context of learning from text (Anderson, Shirey, Wilson & Fielding, 1987; Hidi & Baird, 1986, 1988). Our third goal was to test whether and how the four factors mentioned above would affect situational interest for the case of pictorial illustrations in the context of tutoring environments. A last goal was to identify potential relationships between picture-induced interest and the willingness to work with a picture-enriched computer-based learning environment as well as the willingness to deepen geometry knowledge.

Method

Participants and Design

Participants were 87 students (52 female, 35 male) from grade 8 of a German secondary school (age: $M = 13.9$ years; $SD = 0.6$). In a within-subjects design, students evaluated screenshots showing geometry problems with and without pictorial illustrations. In order to be able to evaluate a larger number of pictorial illustrations, we used a multi-matrix-design with eight questionnaires. Within each questionnaire one half of the screenshots corresponded to another half of the screenshots of another questionnaire.

More specifically, the main part of the questionnaire consisted of fifteen screenshots of a computer-based learning environment on the topic intersecting lines (mathematical principles: angle addition, vertical angles, linear pair, and complementary angle). Each screenshot showed a word problem and a corresponding line drawing. The problems varied in the number of sub-problems (one to three). Eleven of the fifteen drawings included pictorial illustrations that–from an instructional designer's point of view–were mainly decorative (i.e., without explicit instructional functions such as providing information or activating relevant schemas). The remaining four drawings did not include a pictorial illustration. However, each of these four drawings corresponded to one of the drawings that included a pictorial illustration.

Materials

The screenshots were taken from a Cognitive Tutor Geometry (Koedinger & Corbett, 2006). The Cognitive Tutor is an Intelligent Tutoring System based on cognitive theory (Anderson, Corbett, Koedinger & Pelletier, 1995). Cognitive Tutors promote learning by tutored problem solving. They provide step-by-step feedback adapted to the actual knowledge level of students. Cognitive Tutors are successfully applied in a diverse set of domains such as mathematics, genetics, and computer programming (for an overview, see Anderson et. al., 1995; Koedinger & Corbett, 2006).

All pictorial illustrations were drawn from a pool of 44 illustrations. They showed real-life situations (e.g., sitting in front of computer, gables, and compasses). In the first part of the questionnaire, each page contained a screenshot of a geometry problem from the Cognitive Tutor lesson either with or without pictorial illustration (see Figures 1 and 2). Students had to rate the interestingness (adapted from Schiefele, 1990) of the screenshots on two different subscales (nine point Likert scales). The first subscale referred to the emotion-related component of interestingness, the second subscale to the value-related component (see Figures 1 and 2). The emotion-related component was assessed by the three items *Excitement*, *Entertainment*, and *Boredom,* the value-related component by the items *Usefulness*, *Worthless,* and *Unimportance* (similar items were used by Schiefele, 1990). Furthermore, for each screenshot the students rated (on nine point Likert scales) the previously mentioned four potential factors for interest (*concreteness, ease of comprehension*, *unexpected information*, and *personally relevant context*; see bottom part of figure 1 and 2).

Further questions (to be rated on five point Likert scales) referred to willingness for further learning with the computer-based learning environment (enriched with pictorial illustrations), willingness to deepen geometry knowledge, individual topic interest related to the content of the pictorial illustrations, to computer knowledge and mathematics knowledge and demographic characteristics.

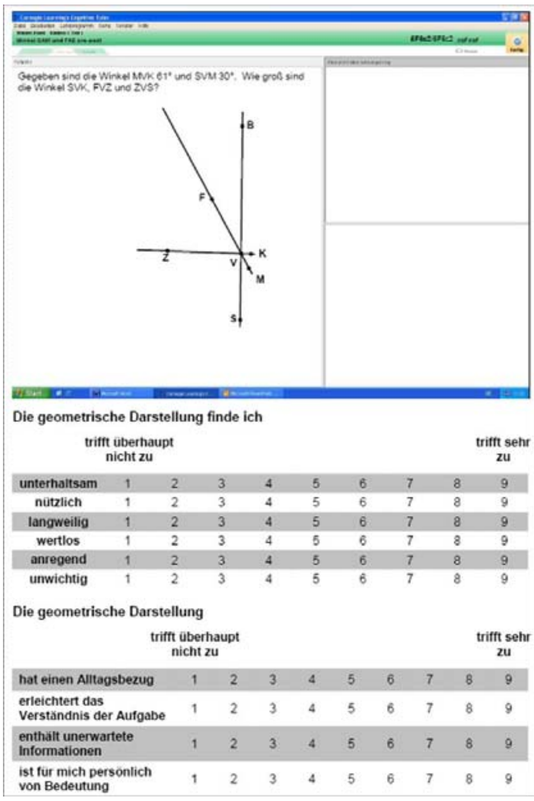

Figure 1. Page without pictorial illustration.

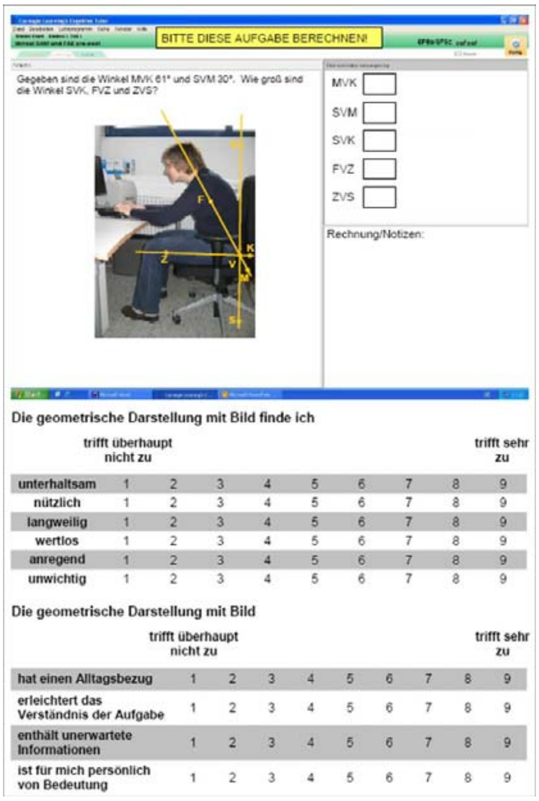

Figure 2. Page with pictorial illustration.

Procedure

The study was performed in group sessions. The sessions lasted about 28 minutes (Range: 16 - 46 minutes). First, all students were introduced to the topic of intersecting lines by the experimenter. Then, they received an example of how to evaluate the screenshots. In order to provide a context as much similar as possible to actually working with the computer-based learning environment, the students then worked on four geometry problems (two with line drawings, two with line drawings enriched with pictorial illustrations). Afterwards the students rated the interestingness of the screenshots and they were asked to rate different potential reasons for their interest. Finally, all participants answered a set of additional questions (e.g., demographic characteristics).

Results

Our first research question referred to a potential effect of pictorial illustrations on situational interest. A paired *t*-test (two-tailed) revealed a significant difference between screenshots (i.e., geometry problems) with and without pictorial illustrations, $t(85) = 4.02$, $p < .001$, $d = .55$. Figure 3 shows that this effect can largely be attributed to the emotion-related component of interest, $t(85) = 6.68$, $p < .001$, $d = .88$, as there were no differences in the value-related component, $t(85) = 0.85$, *n.s*, $d = .11$. Therefore, in all further analyses we concentrated on the emotion-related component (if not stated otherwise).

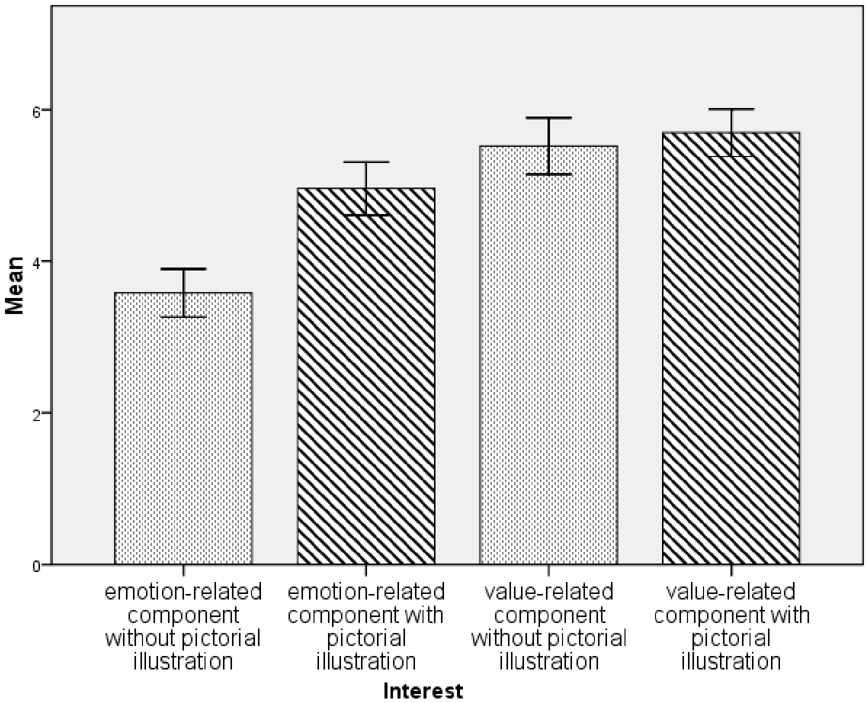

Figure 3. Effect of pictorial illustrations on interest (emotion-related and value-related)

Our second goal was to distinguish between the most interesting and the least interesting pictorial illustrations. We compared the effect sizes between the most interesting pictorial illustrations (upper quarter) and the least interesting pictorial illustrations (lower quarter). This comparison yielded an effect size of $d = .56$ for the ninth most interesting pictorial illustration compared to the ninth least interesting one. Pictorial illustrations rated as "interesting" could be characterized as *dynamic* (e.g., showing activities such as sailing, volleyball, or riding). The most interesting picture, for example, showed a sailboat sailing close to the wind. Pictorial illustrations rated as "non-interesting" could be characterized as *static* (e.g., showing artifacts such as compasses, maps, or traffic signs). One of the least interesting pictures, for example, was a canvas. Therefore, it can be speculated that dynamic attributes are perceived as more entertaining, less boring and more exciting.

Our third goal was to assess whether and how factors that were found to increase interest in texts (i.e., concreteness, personally relevant context, ease of comprehension, and unexpected information) could be related to interest in tutoring environments that are enriched with pictorial illustrations. Table 1 shows that in the present study each of these four factors correlated significantly with both the emotion-related component and the value-related component of interest. This result supports the notion that these factors that are related to interest as induced by texts also have a psychological validity for interest as induced by pictorial illustrations (in tutoring environments).

Table 1: Correlations between reasons for interest and interest in drawings with and without pictorial illustrations ($N = 87$)

	Perceived concreteness	Perceived personally relevant context	Perceived ease of comprehension	Perceived unexpected information
Emotion-related	.46***	.53***	.55***	.42***
Value-related	.44***	.45***	.63***	.29***

***$p < .001$.

Against the background of this strong pattern of correlations, we were interested whether and how these reasons would differ in situations (i.e., geometry problems) in which pictorial illustrations were available or not. Paired *t*-tests (two-tailed) showed that concreteness was rated higher in situations with pictorial illustrations than in situations without, $t(85) = 12.24$, $p < .001$, $d = -1.76$. Similarly, the perceived personally relevant context was rated higher in situations with pictorial illustrations $t(85) = -2.28$, $p < .05$, $d= -0.21$. There were, however, no significant differences for ratings of the ease of comprehension ($t(85) = 0.91$, *n.s.*, $d = .00$) or unexpected information, $t(85) = -1.98$, *n.s.*, $d = -0.20$.

In summary, this pattern of results indicates that decorative pictorial illustrations increased the perceived personal relevance and perceived concreteness of the learning material, but they did not increase the perceived ease of comprehension. This latter finding further indicates that the pictorial illustrations might not have activated relevant schemas as suggested, for example, by Schwartz and Collins (2008).

Finally, we were interested in whether pictorial illustrations can enhance further learning and engagement. For this purpose, we investigated the relationships between interest in situations with and without pictorial illustration and both the willingness to deepen geometry knowledge as well as in further learning with the illustration-enriched computer based learning environment. As can be seen in Table 2, the willingness to deepen geometry knowledge and the willingness for further learning with the computer-based environment were positively related to interest ratings (irrespective of the availability of pictorial illustration).

Table 2: Correlations between interest (with/without pictorial illustrations) and the willingness to learn with the computer-based learning environment and to deepen geometry knowledge (in Parentheses: partial correlations controlling for individual interest in geometry).

	Willingness to learn with the computer-based learning environment	Willingness to deepen geometry knowledge
Interest (n = 84)		
Without pictorial illustration	.24* (.15)	.45*** (.36)**
With pict illustration	.54*** (.47)***	.22* (.04)

*p < .05. **p < .01. ***p < .001

Comparisons of the correlation coefficients between mathematical problems with and without pictorial illustrations, however, showed that the correlations between interest and the willingness to learn with the computer-based learning environment was rated significantly higher when a pictorial illustration was available than when it was not, $t(84) = 2.58$, $p < .05$. This was not the case for the correlations of interest and the willingness to deepen geometry knowledge, $t(84) = 1.89$, *n.s.*

As it can be assumed that students who are generally interested in geometry might not need pictorial illustration to further increase their interest, we controlled the individual interest in learning geometry. The difference of the partial correlations (see Table 2, in parentheses) between interest and the willingness for further learning with the environment remained significant, $t(84) = 2.35$, $p < .05$. In addition, the partial correlation between interest and the willingness to deepen geometry knowledge became significant, $t(84) = 2.24$, $p < .05$.

Thus, interest as induced by pictorial illustrations seemed to be strongly positively related to students' perceptions of the learning environment more than to their willingness to deepen geometry knowledge. On the other hand, interest as induced by the mathematical problems per se (i.e., when no pictorial illustration was available) was strongly related to the willingness to deepen geometry knowledge; there was no such relationship for interest when a pictorial illustration was available. In other words, students who like pictorial illustrations might prefer to work with a computer-based learning environment but they are not necessarily interested in deepening geometry knowledge.

Discussion

The main purpose of the present study was to identify pictorial illustrations with the potential to enhance interest. A secondary purpose was to test whether factors that were found to increase interest as suggested by text research (e.g., text attributes such as concreteness) might also enhance interest in the context of illustrated tutoring environments. A final purpose was to explore the relationships between interest and the students' willingness to engage in further learning.

The results showed that pictorial illustration increased the emotion-related component of interest, but not the value-related component. This suggests that the illustrations were mainly perceived as decorative but not as informative. Furthermore, our findings also suggest that interest-evoking attributes as identified in text research can be transferred to interest research with pictorial illustrations (in the context of tutoring environments), at least in part: The pictorial illustrations did not–according to the learners' perception–enhance comprehension or provide unexpected information. However, they were perceived as making the geometry problems more concrete and to provide a personally relevant context. These results are first indications that pictorial illustrations do not give a semantic context and, therefore, activate certain schemas which support learning (Schwartz & Collins, 2008). Further steps to investigate not only the perceived ease of comprehension, but real comprehension (in terms of conceptual and procedural knowledge) will be taken in a subsequent study.

Interestingly, the more the students perceived the pictorial illustrations as interesting the higher was their willingness to learn with a picture-enriched computer-based learning environment. Contrary, interest in pictorial illustrations was unrelated to the willingness to deepen geometry knowledge (especially when the individual geometry interest was held constant). The willingness to deepen geometry knowledge was rather related to interest in mathematical problems without pictorial illustrations. It can be speculated that students might have realized the "decorative" aspect of the pictorial illustrations, and thus, perceived them as irrelevant for further engagement in learning geometry. In conclusion, interesting pictures might primarily influence how much students engage in further working in a learning environment, but not necessarily how much they engage in concentrating on the learning content. In these respects, the present findings quite well reflect the contradictive positions between interest research and cognitive research. As suggested by interest research, pictorial illustrations can enhance interest and the willingness to learn. At the same time, however, students can perceive pictorial illustrations as irrelevant for deepening geometry knowledge, as suggested by the cognitive research.

A restriction of this study was that we did not measure learning outcomes. Moreover, the students did not work in a real computer-based learning environment (e.g., a Cognitive Tutor). Therefore, our conclusions are based on self-assessed measurements. An interesting question with respect to learning outcomes arises from the finding that interest elicited by decorative pictures seemed to foster the willingness for further working with a picture-enriched computer program but not to deepen geometry knowledge. If the learners would actually show certain persistence in working with an illustrated computer program, but without intentions to deepen the geometry knowledge, would this nevertheless deepen their understanding? A follow-up experiment (in preparation) will address this question. In addition, it will explicitly test our integrative hypothesis stating that pictorial illustration may hinder short-term learning but may raise interest and engagement so that in the medium term learning is enhanced. In order to test this assumption, we will compare three experimental groups (students from the 8th grade) working in a Cognitive Tutor Geometry (topic of intersecting lines): one group with interesting pictorial illustration, one with non-interesting pictorial illustrations (control of picture effects), and one group without any pictorial illustrations. While working with the computer-based learning environment the students will rate the interestingness of the pictorial illustrations after each geometry problem. Before and after the learning phase a geometry knowledge test (conceptual and procedural knowledge) will be administered. In addition, data on interest and mood experiences will be collected. During the two weeks between the immediate posttest and a delayed posttest the students will have the opportunity to deepen their geometry knowledge by studying a small geometry booklet (at home). The delayed posttest will be very similar to the first posttest but will additionally include problems from the booklet. We assume that in the immediate posttest learners will be best off without pictorial illustrations. For the delayed posttest, we expect, however, that interesting pictorial illustrations will lead to superior learning.

References

Ainley, M., & Hidi, S. (2002). Dynamic measures for studying interest and learning. In P.R. Pintrich & M.L. Maehr (Eds.). *Advances in motivation and achievement: New directions in measures and methods.* (Vol 12, 43-76) Amsterdam: JAI.

Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*(3), 545-561.

Anderman, E. M., Noar, S., Zimmerman, R., & Donohew, L. (2004). The need for sensation as a prerequisite for motivation to engage in academic tasks. In M.L. Maehr & P.R. Pintrich (Eds.)., *Advances in motivation and achievement, Volume 13: Motivating students, improving schools: The legacy of Carol Midgley*, (pp. 1-26). Greenwich, CT: JAI Press.

Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *The Journal of the Learning Sciences, 4*, 167–207.

Anderson, R. C., Shirey, L. L., Wilson, P. T., & Fielding, L. G. (1987). Interestingness of children's reading material. In Snow, R. E., and Farr, M. J. (eds.), *Aptitude, Learning and Instruction*: *Vol. III, Cognitive and Affective Process Analyses*, Erlbaum, Hillsdale, NJ.

Anglin, G. J., Towers, R. L., & Levie, W. H. (1996). Visual message design and learning: The role of static and dynamic illustrations. In D. H. Jonassen (Ed.), *Educational communications and technology.* (pp.755-794).New York: Simon & Schuster Macmillian.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology, 90*(3), 414-434.

Hidi, S. (2000). An interest researcher's perspective: The effects of extrinsic and intrinsic factors on motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and Extrinsic Motivation* (pp. 309-339).

Hidi, S. (2001). Interest, reading, and learning: Theoretical and practical considerations. *Educational Psychology Review, 13*(3), 191-209.

Hidi, S., & Baird, W. (1986). Interestingness—A neglected variable in discourse processing. *Cogn. Sci.* 10: 179–194.
Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository texts. *Reading Res. Q.* 23: 465–483.
Koedinger, K. R., & Corbett, A. T. (2006). Cognitive tutors: Technology bringing learning sciences to the classroom. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp.61-77). New York, NY: Cambridge University Press.
Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education, 14*, 23-40.
Krapp, A. (2000). Interest and human development during adolescence: An educational psychological approach. In J. Heckhausen (Ed.), *Motivational Psychology of Human Development* (pp. 109-128). Amsterdam: Elsevier.
Krapp, A., Hidi, S., & Renninger, K. A. (1992). Interest, learning and development. In K. A. Renninger, S. Hidi & A. Krapp (Eds.), *The Role of Interest in Learning and Development* (pp. 3-25). Hillsdale, NJ: Erlbaum.
Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31-48). New York, NY: Cambridge University Press.
Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology, 93*, 390-397.
Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90*, 312-320.
Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*, 43-52.
Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology, 91*, 358-368.
Moreno, R., & Mayer, R. E. (2002). Verbal redundancy in multimedia learning: When reading helps listening. *Journal of Educational Psychology, 94*, 156-163.
Moreno, R., Mayer, R. E., Spires, H. A., & Lester, J. C. (2001). The case for social agency in computer-based multimedia learning: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19*, 177-214.
Paas, F., Tuovinen, J. E., Van Merrienboër, J. J. G., & Darabi, A. A. (2005). A motivational perspective on the relation between mental effort and performance: Optimizing learning involvement in instruction. *Educational Technology Research and Development, 53*(3), 25-34.
Ryan, R. M., Connell, J. P., & Plant, R. W. (1990). Emotions in nondirected text learning. *Learning and Individual Differences, 2*, 1-17.
Schiefele, U. (1990). Thematisches Interesse, Variablen des Leseprozesses und Textverstehen. [topic interest, variables of reading processes and text comprehension]. *Zeitschrift für experimentelle und angewandte Psychologie, XXXVII(2)*[Journal of experimental and applied psychology], 304-332.
Schiefele, U. (1996). Topic interest, text representation, and quality of experience. *Contemporary Educational Psychology, 21*, 3-18.
Schiefele, U. (1998). Individual interest and learning, what we know and what we don't know. In Hoffman, L., Krapp, A., Renninger, K., and Baumert, J. (eds.), *Interest and Learning: Proceedings of the Seeon Conference on Interest and Gender*, IPN, Kiel, Germany, pp. 91–104.
Schiefele, U., Krapp, A., Wild, K.-P., & Winteler, A. (1992). Eine neue Version des "Fragebogens zum Studieninteresse" (FSI) [New version of "study interest questionnaire"]. Gelbe Reihe-Arbeiten zur Empirischen Pädagogik und Pädagogischen Psychologie (21) [Yellow Issue-Works of empirical education and educational psychology], 1-26.
Schwartz, N. H., Collins, C. (2008). Arguing a position from text: The influence of graphic themes on schema activation. In J. Zumbach, N. Schwartz, T. Seufert, & L. Kester (Eds.), Beyond knowledge: The legacy of competence. Meaningful computer-based learning environments (pp. 117-119). Berlin: Springer.
Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 19-30).
Sweller, J., van Merrienboër, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review 10* (3), 251-296.
Tulis, M. (2009). Interest, enjoyment and pride after success and failure in mathematics. Fostering Communities of Learners. Paper presented at the 13th Biennial Conference for Research on Learning and Instruction. Amsterdam (NL), August 2009.
Van Merrienboër, J. J. G., & Ayres, P. (2005). Research on cognitive load theory and its design implications for e-learning. *Educational Technology Research and Development, 53*(3), 5-13.
Weidenmann, B. (1991). *Lernen mit Bildmedien.* [Learning with visual media]. Weinheim, Basel: Beltz Verlag.

Zander, S., & Brünken, R. (2009). Do intrinsic and extrinsic aspect of motivation affect cognitive load in different ways? Fostering Communities of Learners. 13th Biennial Conference for Research on Learning and Instruction, 477. Paper presented at the 13th Biennial Conference for Research on Learning and Instruction. Amsterdam (NL), August 2009.

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