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Two kinds of meaningful multimedia learning: Is cognitive activity alone as good as combined behavioral and cognitive activity?

Irene T. Skuballa[a,*], Anke Dammert[b], Alexander Renkl[b]

[a] Science Division, Department of Psychology, New York University Abu Dhabi, United Arab Emirates
[b] Department of Psychology, University of Freiburg, Germany

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ABSTRACT

Learners should become cognitively active to profit from multimedia representations. However, whether novices' cognitive engagement should be augmented by behavioral engagement during multimedia learning is controversial. We find support for both stances in the literature: high cognitive engagement and high cognitive-plus-behavioral engagement. We investigated the effectiveness of two types of prompts corresponding to these stances. Study 1 (44 8th-graders) tested a group with think prompts versus a group with think-and-do prompts, whereas Study 2 (94 8th-graders) aimed to additionally investigate whether prompts per se revealed an effect. Although prompts prolonged learning time, think prompts promoted knowledge acquisition. Our findings show that learners who engaged in cognitive activity outperformed those who were prompted for cognitive and behavioral engagement. Pure cognitive engagement benefited retention, transfer, and the retrieval of information focused by prompts. We discuss reasons why behavioral engagement can be detrimental.

1. Introduction

Many students read text books with a marker in their hand ready to highlight information in the hope they will remember that information later on. The question arises whether this can be considered meaningful learning, and what are better alternatives to processing information from multimedia materials. Based on the theory of cognitive multimedia learning (CTML), multimedia refers to the presentation of material delivered as complementary texts and pictures (Mayer, 2009). Textual information can be presented as printed or auditory words, and pictures can be presented in a static or dynamic manner. Meaningful learning with multimedia refers to the result of the active and constructive cognitive processing of textual and pictorial information to achieve comprehension of the content, which translates into high levels of retention and transfer (Mayer, 2005a). The CTML describes learning as the active construction of a mental model representing the main ideas and important relationships within the learning content (Mayer, 2005a). This model is based on three main assumptions that describe learning with multimedia: humans process visual and auditory information through different channels (Paivio, 1986), the processing of information in working memory is restricted to a limited amount of information at one time (Chandler & Sweller, 1991; Sweller, Ayres, & Kalyuga, 2011), and learners must engage in active information processes (Wittrock, 1989). To specify the last assumption, successful active processing requires learners to: (1) select relevant words from text representations and pictures from illustrations through sensory memory in order to create a word and image base, (2) organize words into a coherent verbal model and pictures into a coherent pictorial model in working memory, and (3) connect the new incoming information to prior knowledge from long-term memory through integration processes (Mayer, 2005a, 2009; Wittrock, 1989). Cognitive engagement is a prerequisite for meaningful learning which can but does not have to be augmented by behavioral engagement.

General active processing can be characterized by behavioral and cognitive engagement each represented by a separate dimension varying in intensity from low to high. A combination of behavioral and cognitive activity can be illustrated in a 2 × 2 cross tabulation with four quadrants (Fig. 1). According to the CTML, two scenarios are expected to encourage learning: pure cognitive engagement and cognitive engagement-plus-behavioral activity (Mayer, 2005b, 2009). As long as cognitive activity is high, the level of behavioral activity can vary because both combinations, that is, high cognitive activity combined with low behavioral activity and high cognitive activity combined with high behavioral activity, are expected to foster meaningful learning. Instructions that promote such engagement can be considered effective. In sum, two stances predict meaningful learning: first, when the learner is engaged in a high-level cognitive activity without behavioral activity (stance 1), and second, when the learner is engaged in a high-level

* Corresponding author. NYU Abu Dhabi, Saadiyat Campus, Computational Research Building (A2), P.O. Box 129188, Abu Dhabi, United Arab Emirates.
E-mail addresses: its101@nyu.edu (I.T. Skuballa), anke.dammert@googlemail.com (A. Dammert), renkl@psychologie.uni-freiburg.de (A. Renkl).

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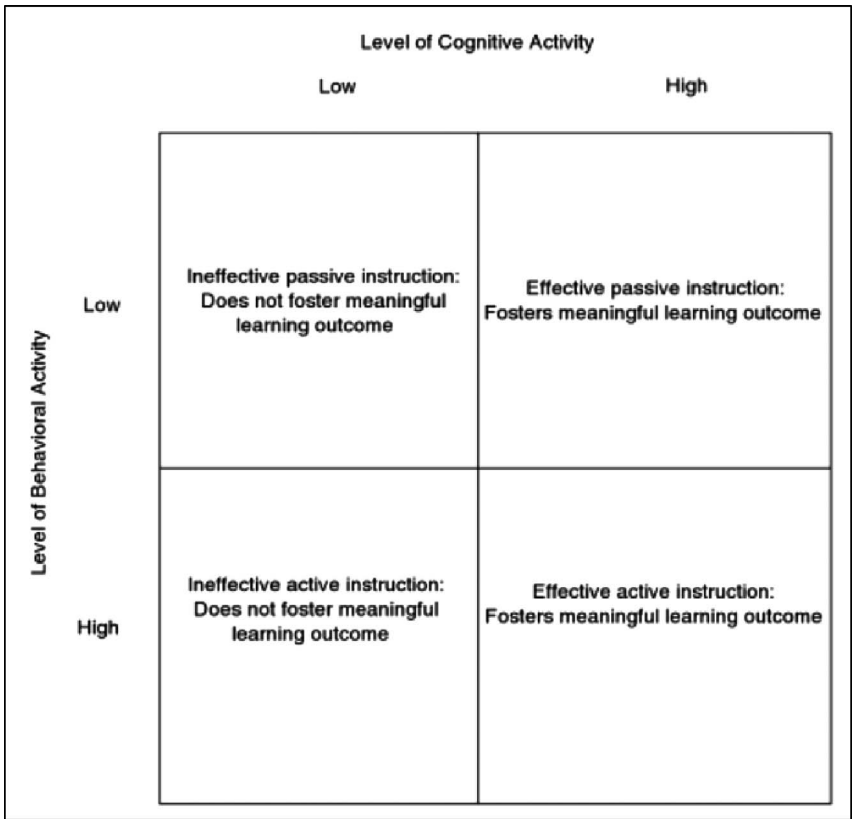

Fig. 1. Two kinds of meaningful learning (Mayer, 2009, p. 23).

cognitive activity with behavioral activity (stance 2).

Pure self-explanations, for instance, where learners create their own explanations to concepts in the learning material, can be considered high in cognitive activity and low in behavioral activity (Mayer, 2009; Roy & Chi, 2005). They require deep mental processing and offer an example of the first stance. Hands-on activities, on the other hand, such as typing answers in a cloze text, finding matching information by drag and drop, or highlighting information, are considered behavioral activities (Bodemer, Ploetzner, Feuerlein, & Spada, 2004; Mayer, 2005a; Ploetzner, Lowe, & Schlag, 2013). These can be low in cognitive engagement when students do not try to make sense of the learning material, or high in cognitive encouragement when students actively process the materials and integrate information from different sources to externalize the correct answer (Mayer, 2009). The latter corresponds to the second stance. We investigated both stances expected to foster multimedia learning. We compared the effects of prompts to engage in cognitive-plus-behavioral processes, that is, self-explaining and highlighting, versus prompts to engage in cognitive processes only, that is, self-explanation. Study 1 aimed to test whether there was any difference between both stances using these specific prompts in a paper-pencil learning environment, whereas Study 2 aimed to corroborate those findings and examine the additional benefit of prompts per se in a computer-based learning environment.

In the following, we provide support from the literature for both stances. We then introduce highlighting as a form of behavioral engagement and elaborate why novices should be prompted about key concepts in self-explanations. Against this backdrop, we introduce our studies to investigate both kinds of meaningful multimedia learning.

1.1. Meaningful learning through cognitive engagement

Contradicting Mayer's approach, some researchers do not assume that both kinds of meaningful learning are equally effective; pure cognitive engagement without any behavioral activities is expected to promote learning best. For example, prompted self-explanations are an effective instructional learning strategy that results in profound and deep mental model construction (Chi & Wylie, 2014). They are defined as a cognitive activity generating explanations to oneself in order to make sense of the learning content (Chi, 2009; Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Pashler et al., 2007). Self-explanations enable learners to identify their gaps in prior knowledge and overcome such discrepancies by adjustments to their flawed mental models (Chi, 2000).

Renkl and Atkinson (2007) argue clearly in favor of the first stance's perspective, namely active cognitive information processing only. They contrast two perspectives on learning (also Renkl & Atkinson, 2007; Renkl, 2009, 2011). The perspective of active doing is grounded in situated learning, where the learner's cognition is bound to activities experienced in concrete situations (Greeno, 2006). As a prerequisite to successful knowledge acquisition, learners must engage in observable, overt activities by, for example, participating in a discourse or problem-solving process. This perspective might reflect Mayer's second stance. However, Renkl and Atkinson (2007) clearly prefer the first stance that matches the perspective of active information processing, which focuses on mental engagement with the learning content, and is assumed to promote knowledge acquisition at its best, thus it should be given priority. This perspective equates with the upper-right quadrant of Mayer's model, described by low behavioral and high cognitive activity (cf. Fig. 1). In a nutshell, behavioral activity is not required at all. According to this perspective, knowledge acquisition is a constructive process realized initially in the mind. The actual learning process takes place in working memory, where new information is associated with existing knowledge from long-term memory (elaboration) as reflected in integration processes of the CTML (Mayer, 2005a). Further support for a purely cognitive stance is provided by Ploetzner et al. (2013) who propose characterizing cognitive techniques for learning systematically from textual and pictorial representations. Externalizing mental processes such as highlighting or marking have no additional value and,