17 The Self-Explanation Principle in Multimedia Learning

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Abstract

Multimedia learning environments combine multiple sources of information (e.g., text, diagrams, and simulations) to help students master cognitively challenging domains. However, in order to benefit from these environments, students need to make connections among the sources of information. One strategy for encouraging students to think deeply about and cognitively engage with the learning material is prompted self-explanation. Self-explanation is a constructive or generative learning activity that facilitates deep and robust learning by encouraging students to make inferences using the learning materials, identify previously held misconceptions, and repair mental models. In this chapter, we present a framework for categorizing the many forms of prompted self-explanation and highlight ways that self-explanation has been successfully incorporated into multimedia learning environments to improve student learning. In addition, we discuss specific forms of self-explanation that may be particularly well suited for multimedia learning environments. We end with a discussion of implications for cognitive theory and instructional design and ideas for future work.

Introduction

Making Sense of Multimedia Lessons

Multimedia learning environments present combinations of text, illustrations (such as diagrams, figures, and photographs), narration, and animation and are typically computer-based. Generally, it has been found that learning from multimedia resources is better than learning from a single medium (Clark & Mayer, 2011; Mayer & Moreno, 2002; Najjar, 1996), assuming that the materials are well designed (Mayer, Heiser, & Lonn, 2001). Multimedia resources aid learning because different modes of presentation provide different affordances and highlight different aspects of the material. For example, diagrams excel at presenting spatial information, and animations provide dynamic and temporal information that is difficult to infer from text alone. Thus, not only do multimedia environments provide complementary information, but through multimodal presentations they take advantage of learners' capacity to encode both verbal and nonverbal information (cf. Paivio, 1991).

However, to maximally benefit from multimedia resources, learners must actively identify relationships between the information as well as integrate the information into a single, coherent representation. The need for integration is shown by an eye-tracking study in which college students learned about pulley systems from text and diagrams (Hegarty & Just, 1993). The results showed that successful learners interspersed inspecting the diagram with reading the text rather than studying the text and diagrams independently. This allowed the learners to integrate information from both sources and to form a complete mental model of how pulley systems operate. However, mere exposure to multimedia materials does not guarantee learning that is superior to that acquired through a single medium; learners must construct a coherent representation that integrates information across sources (Kozma, 1994; Schnotz & Bannert, 2003). In a study in which students learned about weather patterns by watching simulations, Lowe (2003) concluded that, in the absence of support, learners focused on the perceptually salient aspects of the simulation and not the deeper, domain-relevant information. Another study showed that when studying from texts and diagrams, most students do not naturally integrate the information. Instead, college students typically begin by reading the complete text and then shifting attention to the graphics. Moreover, they tend to spend considerably more time studying the text than the visualizations (Schmidt-Weigand, Kohnert, & Glowalla, 2010), but their time may be better spent studying the visualizations. She and Chen (2009) found, by monitoring middle school students' eye fixations while learning about mitosis and meiosis from multimedia learning materials, that students who fixated longer on the graphics demonstrated a better understanding of the materials. Thus, it seems that frequent back-and-forth integration is better than placing greater emphasis on the text and shifting to the diagram or visualization only at the end of the passage.

In short, learning in multimedia environments is potentially very effective, but only if learners engage in the cognitively demanding task of integrating across knowledge sources. Moreno and Mayer (2007) suggest that students should be encouraged to reflect during learning in order to integrate and organize new information. One constructive and reflective learning activity that may be particularly suitable for integrating materials is prompted self-explanation. In fact, Butcher (2006) demonstrated that students who self-explained in a multimedia environment (text and diagrams) generated more inferences and learned more than those who self-explained in a text-only environment. Moreover, analysis showed that students who self-explained simple diagrams with text were more likely to include integration utterances in their explanations than students studying from text alone. In this chapter, we provide a brief review of the self-explanation principle and introduce a framework for categorizing the number of ways in which self-explanation has been operationalized. We then apply this framework to a number of studies combining multimedia learning and the self-explanation effect. We end with a description of the limitations of current work and suggestions for future studies.

Self-Explaining, a Constructive Learning Activity

In the nearly 25 years since Chi et al.'s (1989) seminal work on self-explanation, much research has demonstrated the effectiveness and generality of self-explanation as an instructional learning strategy. Self-explanation has been shown to be effective in a number of domains, including computer programming (Bielaczyc, Pirolli, & Brown, 1995; Recker & Pirolli, 1995), biology (Ainsworth & Loizou, 2003; Butcher, 2006; Chi, Leeuw, Chiu, & Lavancher, 1994), fractions (Rau, Aleven, & Rummel, 2009), number conservation (Siegler, 2002), probability (Berthold, Eysink, & Renkl, 2009), word problems (Nathan, Mertz, & Ryan, 1994), equation solving (Rittle-Johnson, 2006), physics (Conati & VanLehn, 2000), medicine (Chamberland et al., 2011), and reading comprehension (McNamara & O'Reilly, 2007). This demonstrated success led to its inclusion as one of seven recommended instructional strategies in the 2007 Institute for Educational Science practice guide (see recommendation 7 in Pashler et al., 2007) and one of 25 principles of learning by the Association for Psychological Science (see principle 17 in Graesser, Halpern, & Hakel, 2007).

Self-explanation is a constructive or generative learning activity that facilitates deep and robust learning and, like other cognitive skills, improves over time. According to Chi (2000), self-explanation aids learners through a process by which students generate inferences and then map these inferences to their existing mental models. Self-explanation supports students in recognizing discrepancies when they arise and making appropriate adjustments to their mental models. According to the Cascade model (VanLehn, Jones, & Chi, 1992) when students self-explain, they identify and fill gaps in their knowledge. This process enables better declarative knowledge of the domain and provides multiple strategies by which students can solve subsequent problems.

When first introduced, the self-explanation effect stood out because it revealed a surprising finding: namely, encouraging students to become cognitively engaged with the learning material, even with no expert present to teach, correct errors, or explain misconceptions, leads to improved learning compared with passively reading the text. In retrospect, this finding may seem quite intuitive; however, the prevalent notion at the time was that students needed to be taught, coached, or guided in the learning process. In fact, self-explaining alone is superior to self-explaining coupled with instructional explanations. Using a 2 × 2 design, Schworm and Renkl (2006) compared self-explanation with no self-explanation crossed with the presence or absence of instructional explanations. In this study, students provided self-explanations by typing, and the instructional explanations were available on demand (students could click a button to receive an explanation). The results showed that the participants who were prompted to self-explain but did not receive instructional explanations performed the best. Those who received neither self-explanation prompts nor instructional explanations performed the worst on an immediate post-test, while the participants who were prompted to self-explain and received instructional explanations performed better than participants in the no-prompts/no-explanation group but worse than those who were prompted to self-explain without receiving explanations. Thus, self-explaining alone was superior and more effective for learning than self-explaining paired with direct instruction.

Recently, researchers have begun to investigate whether boundary conditions exist for self-explanation and under what specific conditions the instructional strategy supports learning. In Chi's (2000; Chi et al., 1989) original conception, self-explaining was defined as making inferences or providing justifications when such information was not provided in a text passage or in worked-out solution steps. This suggests that for domains in which there are no logical inferences and/or justifications, self-explaining should be of limited value for learning. This prediction was confirmed in the domain of second-language grammar learning as well as in an artificial categorization domain. In a series of studies, Wylie, Koedinger, and Mitamura (2009, 2010) compared prompted menu-based self-explanation with a no-self-explanation, practice-only condition designed to teach English language learners the English article system (e.g., determining when to say *a* dog vs. *the* dog). In the menu-based self-explanation condition, students selected the grammar rule that explained why a given English article was used (e.g., "Use *the* when the noun has already been mentioned"). In the practice-only condition, students selected the correct article to complete the sentence (e.g., "I just bought this car last month, but today ___ car wouldn't start"). The results showed that students in both groups achieved significant pre-test to post-test learning gains, but there were no differences with respect to learning. Furthermore, students in the practice-only group completed the instruction in 28% less time than it took students to complete the self-explanation instruction (Wylie et al., 2010). Since these grammatical procedural rules lack logical justifications, self-explaining does not add any benefit.

Similarly, others have found limitations to the benefits of self-explanation when applied to domains that contain frequent exceptions, such as learning artificial categories. Williams et al. (2013) suggest that prompting students to self-explain while learning categories with exceptions takes more time and may result in overgeneralizations that are difficult to change. In a lab study, participants were randomly assigned to learn to identify objects either in reliable categories (no exceptions included during the learning phase) or unreliable categories (two exceptions included in the learning phase). For example, in one study, participants were taught to categorize or label whether people rarely or frequently donate to charities on the basis of age and personality patterns. In the reliable condition, all training examples followed the pattern. In the unreliable condition, unbeknownst to participants, the learning materials contained two exceptions (out of 10 examples total). As an additional factor, study condition was crossed with learning prompts: think-aloud or open-ended self-explanation. The results showed that for reliable categories, participants who were prompted to self-explain learned categories more quickly than those who were prompted to think aloud. However, for unreliable categories, prompting learners to self-explain seemed to hinder learning. Only half of participants who were prompted to self-explain the unreliable category were able to achieve mastery and successfully learn the category, compared with 75% of participants who were instructed to think aloud while learning the unreliable category. These findings suggest that in domains containing rules that cannot be logically deduced or for which broad generalizations are not helpful, self-explanation is an unnecessary or perhaps even detrimental learning strategy.

Furthermore, the effects of self-explanation may interact with the type of instruction that students receive. Matthews and Rittle-Johnson (2009) gave students conceptual instruction on mathematical equivalence problems (e.g., 3 + 9 + 8 = 9 + __) and compared an open-ended self-explanation condition with a no-self-explanation control condition. In the self-explanation condition, students explained both correct and incorrect solutions after receiving conceptual instruction. Conceptual knowledge is that which refers to general domain principles rather than specific procedures. In the case of equivalence problems, conceptual knowledge includes teaching students what the equal sign means but does not include teaching them specific procedures for completing the problems. In the control condition, students received the same conceptual instruction but with no explicit prompts to self-explain. The results showed no difference in learning gains or retention rates between students in the self-explanation condition compared with those in the no-self-explanation control group. The authors propose two hypotheses to explain why conceptual instruction alone was sufficient in this case. The first hypothesis is that the conceptual knowledge instruction did not leave students with gaps in their understanding; therefore, prompting students to self-explain, a task believed to target and remove these gaps, did not provide any additional learning benefit. The second hypothesis is that conceptual instruction implicitly encourages students to self-explain, so even those in the no-self-explanation control group may have spontaneously self-explained the material, thereby equating the two conditions. This study highlights another possible limiting factor: if instructional material sufficiently covers the domain or implicitly encourages students to self-explain, explicit prompts provide no additional benefit.

While the success of self-explanation has been widespread, it is important to note that there are boundary conditions for when it is applicable and beneficial to learning. It is also important to note that there are a number of ways in which self-explanation has been operationalized. While self-explanation may be a particularly effective strategy in multimedia learning because it can aid in the process of integrating words (e.g., written or spoken text) and images (e.g., pictures, videos, or simulations), it is important to understand the specific types of self-explanation and the affordances that each provides.

Forms of Self-Explanation

As summarized in Table 17.1, recent studies have instantiated the self-explanation principle in a variety of ways and across a number of different media and instructional resources. One way to organize the forms is to view them as falling along a continuum, as shown in Figure 17.1. At one end are open-ended self-explanation prompts that encourage students to make connections between prior knowledge and the newly presented information but do not place any limits or expectations on the type of explanation that is generated. This open-ended form was used in the original self-explanation studies (Chi et al., 1989, 1994). In the first work to establish a causal link between self-explanation and increased learning, students were prompted to self-explain out loud after each sentence they read (Chi et al., 1994). Specifically, they were asked to explain what the sentence meant and were encouraged to make connections between prior knowledge and the provided material. Students who were prompted to self-explain were more likely to develop a correct model of the human circulatory system than students who were not prompted to self-explain and instead read the text twice (to control for time-on-task).

Open-ended self-explanation prompts have been used in computer-based and multimedia systems where, instead of verbalizing, students type their explanations (Figure 17.2). In one study, de Koning et al. (2011) asked participants in the self-explanation (reflection) condition to explain out loud while viewing either a cued or an uncued animation of the circulatory system. In the cued version, spotlight cues highlighted important areas of the animation, thereby reducing cognitive load by reducing the amount of space students had to search. The results showed that students viewing the cued version who were prompted to self-explain generated significantly more inferences than students in any of the other three groups (cue/no self-explanation; no cue/self-explanation; no cue/no self-explanation), and students

Table 17.1. *Overview of studies by self-explanation form and instructional context*

	Open-ended	Focused	Scaffolded	Resource-based	Menu-based	Text	Single image	Multiple images	Solved problems	Worked examples	Game/simulation
Aleven and Koedinger (2002)				X					X		
Atkinson et al. (2003)					X					X	
Berthold et al. (2009)	X		X							X	
Butcher and Aleven (2008)				X			X		X		
Chi et al. (1994)	X					X					
de Koning et al. (2011)	X					X		X			
Gadgil et al. (2012)	X	X						X			
Hsu and Tsai (2011)					X						X
Johnson and Mayer (2010)	X				X						X
Kwon et al. (2011)		X			X					X	
van der Meij and de Jong (2011)	X	X						X			

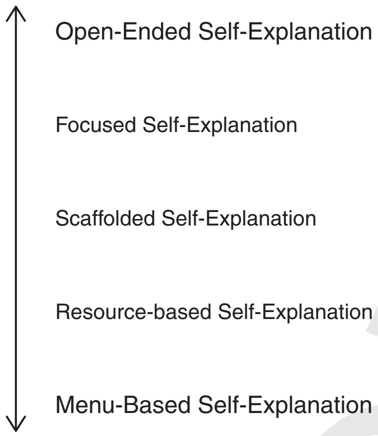

Figure 17.1. *Continuum of different forms of self-explanation.*

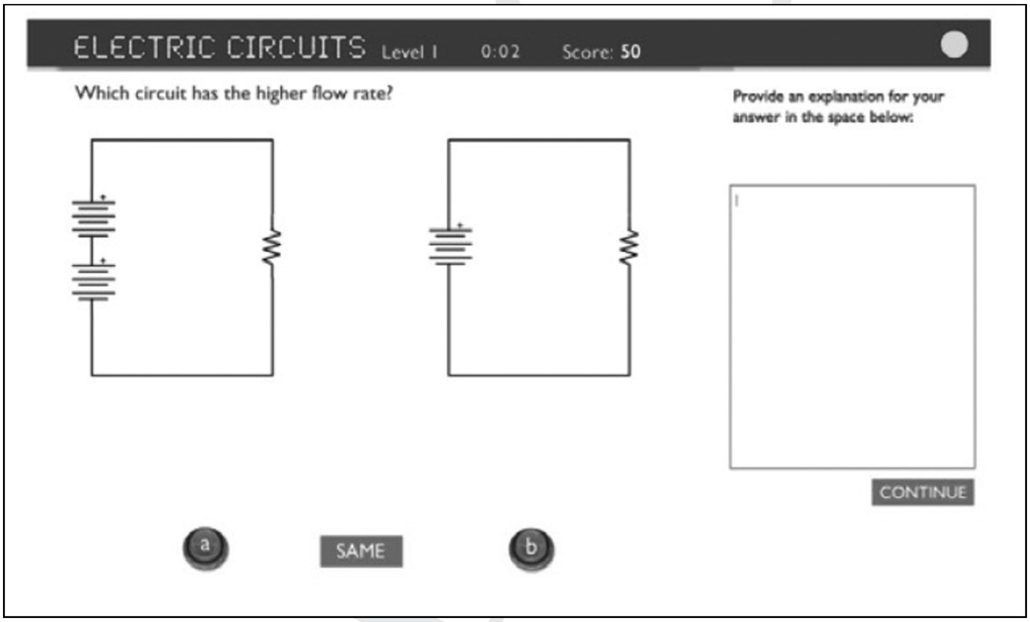

Figure 17.2. *Example of an open-ended self-explanation prompt (from Johnson and Mayer, 2010). After selecting an answer, students enter a free-response explanation in the textbox.*

who self-explained with cues generated fewer incorrect self-explanations than students who self-explained the animation that was not cued. In this study, cues served as a second information source, and thus these results support the idea that multiple sources (animations and cues) are greater than a single information source (animation alone) and that open-ended self-explanation

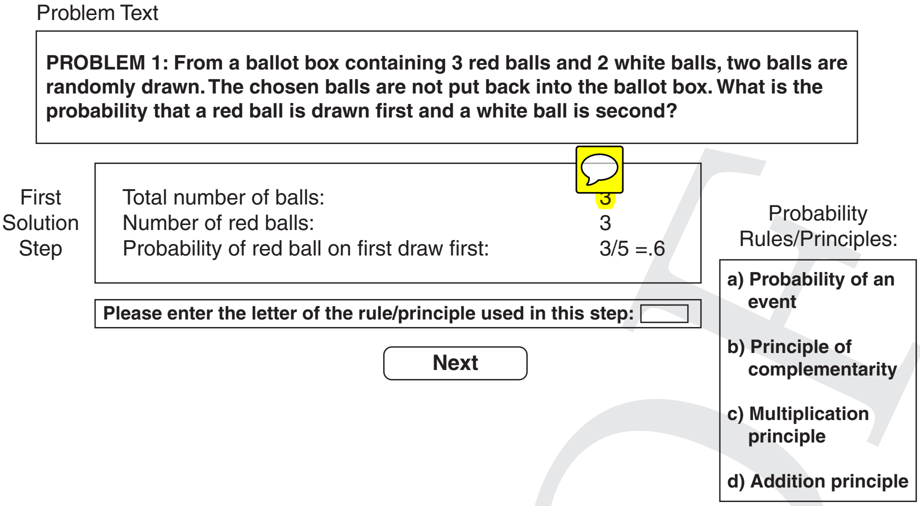

Figure 17.3. *Example of a menu-based prompted self-explanation (from Atkinson et al., 2003). After answering the problem, students select the probability rule or principle that best explains the step.*

can be used successfully to help students integrate information. The advantages of the open-ended method are that students are free to explain their own mental model and are not influenced by preconceived ideas about what may be challenging or where knowledge gaps may exist. In addition, it may be a more natural way to explain, since students' thoughts and ideas are not restricted, and students are free to make connections where they see fit.

At the other end of the spectrum are menu-based explanation prompts that facilitate deep thinking about the material by asking students to select explanations from a provided menu. This form has recently been used in computer-based learning environments in an effort to reduce the number of incorrect self-explanations and to provide feedback to students on their explanation choices (Atkinson, Renkl, & Merrill, 2003; Wylie, Koedinger, & Mitamura, 2009). For example, Atkinson et al. (2003) prompted students to self-explain by selecting a probability principle for a multiple-choice list (Figure 17.3). The results showed that students who were prompted to self-explain performed better on both near and far transfer tasks than students who were not prompted to self-explain, indicating that the self-explanation effect holds when students explain by selecting rules or principles from menus.

Similarly, Hsu and Tsai (2011) found an advantage for menu-based explanation prompts in an educational game. The created two versions of a game designed to teach students the relationships between light and shadows. In the self-explanation version, after students made a mistake, they were prompted to select the cause or explanation of their mistake via a multiple-choice menu. In the no-self-explanation version, no prompts were displayed. The findings showed that only students who were prompted to self-explain showed pre- to post-test learning gains, suggesting that prompting students to explain via menus can be an effective educational strategy for multimedia environments.

While open-ended and menu-based approaches mark the two extremes, there are a number of ways of prompting students to self-explain that fall in the middle: focused, scaffolded, and resource-based prompts. Focused prompts are similar to open-ended prompts in that they are generative and do not restrict the student's reply, but focused prompts provide more explicit instruction regarding what the content of the self-explanation should include. For example, Gadgil, Nokes-Malach, and Chi (2012) used focused self-explanation prompts when they asked students to compare and contrast two models of the cardiac system. This is a form of focused self-explanation because instead of being asked simply to explain the material, as is done with open-ended prompts, students were specifically asked to compare and contrast the two models. Van der Meij and de Jong's (2011) directive prompts are another example of focused self-explanation, since those prompts specifically encouraged students to identify relationships between multiple representations (e.g., between a graphical representation and a numeric representation). While open-ended self-explanation prompts simply ask students to explain new material, focused self-explanation prompts direct student explanations in a specific way.

An even more focused approach to prompting students to self-explain is the use of self-explanation scaffolds (Berthold et al., 2009). Scaffolded or assisted self-explanation prompts utilize a cloze or fill-in-the-blank approach, with students filling in missing parts to complete the explanation or justification (Figure 17.4). This approach is hypothesized to be especially beneficial for novice learners who might lack sufficient prior knowledge to generate open-ended self-explanations on their own.

Finally, using a form of self-explanation that resembles the menu-based approach, Aleven and Koedinger (2002) investigated the effects of adding resource-based self-explanation prompts to a geometry tutor. In their system, students explain or justify each problem-solving step either by typing the name of a geometry principle or selecting it from a provided glossary. While similar to the menu-based approach because students can use the provided glossary as a reference to look up explanations and thus turn the explanation step into a recognition rather than recall problem, the large size of the glossary compared with a few provided explanations in a menu-based system differentiates these two approaches. Results from the Aleven and Koedinger study showed that students in both the resource-based explanation and control (no self-explanation) groups showed significant pre- to post-test learning gains, with students who were prompted to self-explain showing greater

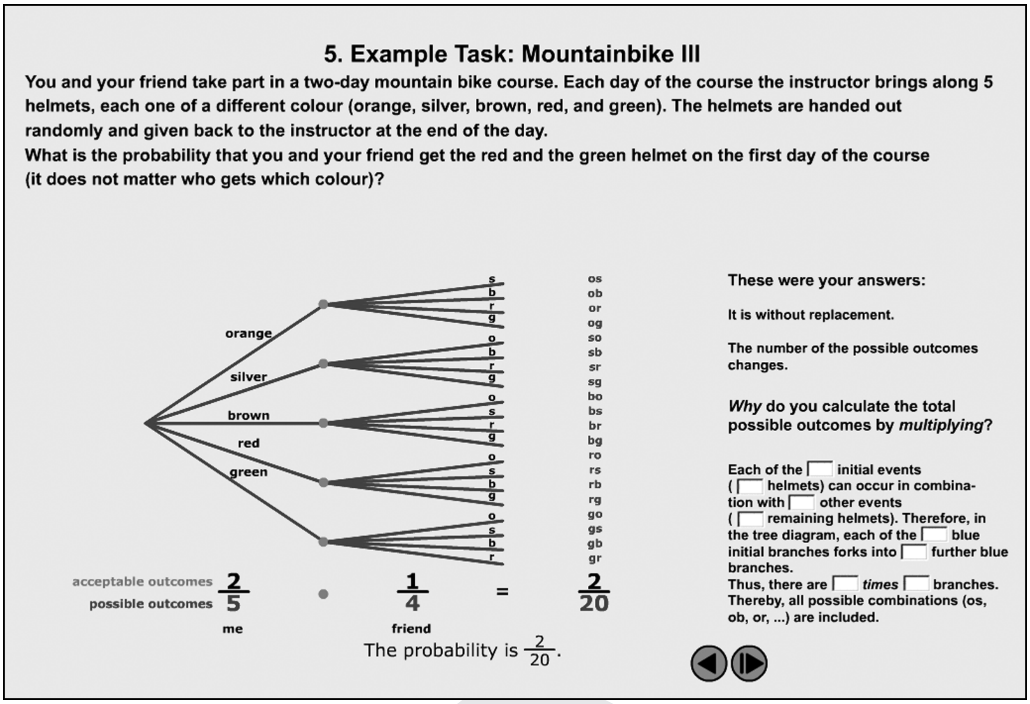

Figure 17.4. *Example of a scaffolded prompted self-explanation (from Berthold, Eysink, & Renkl, 2009). Students complete the problem and then fill in the blanks of the scaffolded explanation prompt.*

learning gains on transfer measures than those in the no-self-explanation group.

While self-explanations can take a number of forms, their common feature is that by prompting students to self-explain, they encourage students to think deeply and to cognitively engage with the learning materials by making connections to prior knowledge and refining mental models. When self-explanation was originally conceived as a strategy for students learning new, text-based materials, it made sense to ask students to self-explain in an open-ended manner; however, as the strategy is applied to other instructional contexts, like multimedia environments, it is important to know which form of self-explanation should be used. In the next section, we apply the previously presented framework to a number of existing studies. Taken together, the studies show that specifically for multimedia learning environments in which multiple information sources are present, open-ended self-explanation prompts are relatively less helpful than those that provide more focused direction. Results from prior studies show that providing a more specific manner of explaining through the use of focused, scaffolded, or resource-based prompts leads to deeper learning than free-form, open-ended explanations.

Table 17.2. *Review of studies that incorporate more than one form of self-explanation*

	Open-ended	Focused	Scaffolded	Resource-based	Menu-based	Instructional context
Berthold et. al (2009)	−		+			Worked examples
Butcher and Aleven (2008)				=/=		Problem solving
Gadgil et al. (2012)	−	+				Multiple representations
Johnson and Mayer (2010)	−				+	Gamelike environment
Kwon et al. (2011)		+			−	Problem solving
van der Meij and de Jong (2011)	−	+				Multiple representations

Note: Conditions marked with + indicate significant learning advantages over conditions marked with –. Conditions marked with = indicate no significant differences.

Comparing Multiple Forms of Self-Explanation in Multimedia

As shown in Table 17.2, the majority of studies comparing multiple forms of self-explanation in multimedia have compared the traditional form (open-ended) with a more directed approach. For example, van der Meij and de Jong (2011) built two versions of a simulation-based learning environment that incorporated multiple representations. In one version, students self-explained by responding to a general prompt asking them to explain or justify their answer (open-ended self-explanation). In the second version, the explanation instructions were more explicit and students were asked to explain how the two given representations were related (focused self-explanation). The results showed increased performance under both conditions, but students in the focused self-explanation group showed greater learning gains. These findings support the hypothesis that for multimedia learning contexts, a more focused self-explanation prompt is better than a general open-ended prompt.

A study by Gadgil, et al. (2012) also can be reinterpreted and viewed as a study comparing traditional open-ended self-explanation with a more focused approach. In their study, while learning about the cardiac cycle, students either were asked to self-explain a correct diagram (open-ended self-explanation) or were asked to self-explain two diagrams. One of the diagrams contained the correct model and the other depicted a model containing misconceptions that the student held. In the focused self-explanation condition, students were explicitly asked to make connections between the two information sources and were encouraged to compare and contrast the two models. Again, the results showed that both forms of self-explanation led to increased learning gains, but the focused self-explanation prompts led to greater gains than the open-ended approach. This study suggests that when multiple sources of information are presented, encouraging students to self-explain in a more focused manner is beneficial.

In a study comparing open-ended with menu-based self-explanation within the context of a multimedia gamelike environment, Johnson and Mayer (2010) conducted two experiments investigating different forms of self-explanation. In the first, they compared a self-explanation condition, in which participants selected the explanation from a given menu (menu-based), with a no-self-explanation control. The results showed that menu-based self-explanation resulted in greater transfer performance than playing the game without explanation prompts. A second, follow-up study revealed no learning differences between an open-ended self-explanation condition that required students to generate an explanation on their own and a no-explanation control condition. The authors argue that generating explanations from scratch disrupts the game flow, thereby reducing the learning potential. Another explanation, according to our framework, is that the open-ended responses fail to focus the student sufficiently, especially in games in which a great deal o information is presented, whereas menu-based explanations help students make connections by supporting them in the explanation process. When learning from a complex environment, students need support to maximally benefit from self-explanation.

Finally, working within the probability domain, Berthold and colleagues (2009) compared scaffolded and open-ended self-explanation with a no-self-explanation control. The results showed that both open-ended and scaffolded self-explanation prompts led to better conceptual and procedural understanding than the control condition, and in line with our hypothesis, scaffolded self-explanations prompts were especially beneficial in helping students integrate multiple representations. This pattern of results suggests that, at least for multimedia environments in which multiple sources of information are provided, a more focused form of self-explanation is better than the traditional open-ended approach. We hypothesize that when students are explicitly asked to make connections between the sources of information while self-explaining, they are better able to integrate the information and form a more complete mental model.

Work by Butcher and Aleven (2008) further supports this hypothesis by comparing two resource-based self-explanation conditions in a multimedia computer-based geometry tutor. The tutor included both a diagram depicting the problem and a table in which students could enter values (e.g., the measure of a specific arc of a circle). In one condition, students solved for the required value and explained each step by selecting a geometry rule to justify their answer. In the second condition, in addition to selecting the geometry rule to explain or justify their answer, students had to identify the part of the diagram to which the rule applied. While the authors hypothesized that the diagram condition would lead to greater learning, the results showed no additional benefits of asking students to make explicit connections to the diagram. However, these results are in line with those predicted by our framework, since both conditions employed the same form of self-explanation prompt.

Implications for Instructional Design and Cognitive Theory

The success of using prompted self-explanation in multimedia environments suggests that encouraging students to self-explain is a valuable strategy, specifically when self-explanations are directed and explicitly encourage students to make connections between the sources of information. However, as we have noted, boundary conditions exist and there are limits to the generalizability of self-explanation as an effective strategy. In deciding whether to incorporate self-explanation into future instructional systems, it is important to determine if the outcomes of self-explanation align with the pedagogical goals. For example, self-explanation is best used to help students develop robust mental models of challenging conceptual domains (e.g., biology and physics) and may not be as well suited to simpler procedural domains for which rules or patterns cannot be logically deduced or explained (e.g., second-language grammar).

While all forms of self-explanation encourage students to think deeply about the material and may lead to improved learning over no-self-explanation controls, it is essential to look at both the educational objectives and the form in which self-explanation is implemented before making broad claims about the generality and applicability of self-explanation. A framework for interpreting the various forms of self-explanation is ICAP (Chi, 2009; Chi & Wylie, submitted), which categorizes different types of engagement activities (interactive, constructive, active, and passive) and hypothesizes that as engagement increases so does learning (I > C > A > P). The framework categorizes instructional activities on the basis of overt student behaviors. For example, a passive activity entails the simple reception of information (e.g., listening to a lecture, reading a textbook, or watching a video), while an active activity involves, at minimum, some sort of selection procedure (e.g., underlining or highlighting a text). A constructive activity is one in which students are expected to go beyond the provided material and generate new content (e.g., building a concept map or writing an essay), and an interactive activity is one in which two or more students work together to complete a constructive activity (e.g., peer tutoring). The hypothesis states that as lessons become more cognitively engaging (moving from passive to interactive), student learning should increase.

ICAP can also be used to categorize the many forms of self-explanation. In the most cognitively basic, passive form, self-explanations drop the "self" and are simply instructional explanations provided to students. Active self-explanations are those that are menu-based, resource-based, or scaffolded since they require a student to select the correct response. Constructive self-explanations can be either open-ended or focused since both require students to generate an explanation on their own, and interactive self-explanations involve pairs or small groups of students working together to generate or critique each other's answers. As reviewed in Fonseca and Chi (2011), self-explanations implemented in interactive modes tend to lead to better learning than the constructive modes, which are better than the active modes, which in turn are better than the passive modes. Several studies have shown constructive, open-ended self-explanation prompts to be better for learning than a number of passive explanation-based environments where students repeat sentences (O'Reilly, Symons, & MacLatchy-Gaudet, 1998), reread instructional text (Chi et al., 1994; Griffin, Wiley, & Thiede, 2008), or observe others' solutions (Pine & Messer, 2000). Similarly, a study by Kwon, Kumalasari, and Howland (2011) supports the framework and demonstrated that constructive, open-ended explanations lead to increased learning compared with active, menu-based explanations.

Limitations of Current Research

According to the ICAP framework, the most stringent test of an instructional strategy is to compare it with another strategy at the same level of cognitive engagement. For example, constructive, open-ended self-explanation prompts should be compared with other constructive tasks (e.g., building a concept map or comparing and contrasting). In a review, Fonseca and Chi (2011) point out that relatively few studies of this nature exist. One recent example is the Gadgil et al. (2012) study that compared two forms of constructive self-explanation. Other examples compare self-explanation with generating summaries (King, 1992), explaining to others (Roscoe & Chi, 2008), or explaining solutions generated by experts (Calin-Jageman & Ratner, 2005; Siegler, 1995) or misconceptions of others (Pillow, Mash, Aloian, & Hill, 2002). In order to rigorously test the benefits of the self-explanation effect, more studies, especially within multimedia learning environments, should compare instructional strategies that fall within the same level of cognitive engagement.

Implications for Future Research

An exciting goal of future work is to leverage the computational power of multimedia and computer-based systems in order to develop adaptive self-explanation prompts. An early example of this is work done by Yeh, Chen, Hung, and Hwang (2010) in which they compared two types of self-explanation prompts, prediction-based and reasoning-based. They hypothesized an interaction between explanation form and prior knowledge; namely, students with low prior knowledge would benefit more from a reasoning-based prompt, and students with high prior knowledge would benefit more from a prediction-based prompt. The results supported their hypothesis, as well as the idea that students may benefit from self-explanation prompts that vary with respect to focus (prediction vs. reason), form (menu-based vs. open-ended), or presentation based on individual differences. In another example, a menu-based self-explanation tutor was augmented and made adaptive in that it prompted students to self-explain only when estimates for a given rule or knowledge component were low. The results showed significant learning gains on procedural, declarative, and retention measures. However, only the declarative knowledge gains were significantly higher than those under the control no-self-explanation condition (Wylie, Sheng, Mitamura, & Koedinger, 2011). Combined, these results suggest that there is a promising future for adaptive self-explanation tutors, and future work should examine more sophisticated forms of adaptability.

Conclusions

Prompted self-explanation is a proven strategy to help students learn both conceptual and procedural domains. In this chapter, we presented a framework that identified a continuum ranging from open-ended to menu-based explanation styles, highlighting examples of each within the context of multimedia learning, and presented a number of studies whose results support the hypothesis that self-explanation prompts that provide more focus or direction are particularly beneficial for multimedia learning environments, because they foster integration across multiple sources of information and help students develop a single, coherent representation.

Glossary Terms

Self-explaining: A constructive or generative learning activity that facilitates deep and robust learning through reflecting, generating inferences, and repairing mental models. The generated inferences and related knowledge is a self-explanation.

Open-ended self-explanation prompt: A form of self-explanation prompt that encourages students to make connections between prior knowledge and the newly presented information but does not place limits or guidance on the type of explanation that is generated.

Menu-based self-explanation prompt: A form of self-explanation prompt in which students self-explain by selecting an explanation from a provided menu.

Focused self-explanation prompt: A form of self-explanation prompt that is similar to an open-ended prompt in that it is generative and does not restrict the student's reply, but focused prompts provide more explicit instruction regarding what the content of the self-explanation should include (e.g., compare and contrast).

Scaffolded self-explanation prompt: A form of self-explanation prompt that utilizes a cloze or fill-in-the-blank approach, with students filling in missing parts to complete the explanation or justification.

Resource-based self-explanation prompt: A form of self-explanation prompt that is similar to a menu-based self-explanation but instead of selecting an explanation from a menu, students have access to resources (e.g., a glossary) from which they can base their explanation.

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