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Do Focused Self-Explanation Prompts Overcome Seductive Details? A Multimedia Study

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ABSTRACT

Research on the seductive details effect on reading expository texts in multimedia learning environments has grown over the past few decades. However, less is known when seductive details are encountered in learning through worked-examples to solve problems. Thus, it is necessary to examine the seductive details effect when solving problems in a worked-example-based multimedia learning environment and the effect of focused self-explanation on seductive details. In the present experiment, the participants ($N = 80$) were randomly assigned to one of four different conditions and learned a multimedia lesson about electrical circuits on the computer: (a) seductive details, (b) seductive details and self-explanation prompts, (c) no seductive details, or (d) no seductive details but self-explanation prompts. Results showed that seductive details hindered learning because of increased extraneous cognitive load, and that focused self-explanation overcame the negative deleterious effect of seductive details through decreased extraneous cognitive load, and therefore improved learning. The theoretical and practical implications are discussed and future research directions are presented.

Keywords

Seductive details, Self-explanation, Multimedia learning, Worked examples

Introduction

Seductive details are materials that are interesting and entertaining but are irrelevant to the main ideas or learning objectives of a lesson (Harp & Mayer, 1997; Harp & Mayer, 1998). Rey (2012) systematically reviewed the seductive details effect literature and stated that overloading the working memory is one of the possible causes of the seductive details effect. Seductive details can be considered, by definition, as a source of extraneous cognitive load in that they are not relevant for learning and can be altered by instructional interventions (Beckmann, 2010; Park, Moreno, Seufert, & Brunken, 2011; Sweller, van Merrienboer, & Pass, 1998). Seductive details have been believed to trigger students' situational interest through the natures of novelty and interestingness, which has been well documented recently (e.g., Magner, Schwonke, Aleven, Popescu, & Renkl, 2014). However, by tempting students to spend their limited working memory resources in processing extraneous information, seductive details are damaging to the construction of a coherent mental representation (Park, Flowerday, & Brunken, 2015). Other than overloading the working memory, seductive details may hamper learning due to attention distraction (Lehman et al., 2007), coherence disruption (Mayer & Jackson, 2005), or schema interference (Harp & Mayer, 1998).

Solution to the seductive details effect

Technology has developed rapidly in education and offered a broad selection of multimedia tools for presenting complex learning information (e.g., Flikr, Youtube). In spite of their easy accessibility and wide acceptability by learners, a main concern is that seductive details defined as interesting but irrelevant messages are hidden in these visually rich presentations. In the light of few information-picking choices learners could have when facing technology-based learning materials, to find a way to remedy the negative impact brought about by seductive details is of high importance. Unfortunately, regardless of abundant research asserting that seductive details are deleterious because they engender extraneous overload, results are yet inconclusive and hence no definite pragmatic solution has been found. Although a straightforward solution to the extraneous overload problem, suggested by researchers, is to eliminate words and pictures that are irrelevant to the instructional goal or at least insert these messages sparingly (Mayer & Fiorella, 2014; Mayer, Heiser, & Lonn, 2001; Rey, 2012), seductive details are expected everywhere in today's learning environment particularly in computer-based presentations and thus simply excluding seductive details may not be feasible in many situations. Since seductive details are concerned with extraneous cognitive load, effective pedagogical approaches need to be developed to alleviate the load. Therefore, further research explicitly examining the role of different cognitive strategies (e.g., note-taking, making predictions, making inferences) in overcoming the seductive details effect can help the learner to deal with the complexity of multimedia learning environments.

A solution: Self-explanation

Up to date, the majority of research on seductive details has utilized expository texts as the instructional material. For instance, the topics used by previous studies include the process of lightning (e.g., Harp & Mayer, 1998; Lehman et al., 2007; Peshkam, Mensink, Putnam, & Rapp, 2011), what causes ice ages (Sanchez & Wiley, 2006), how a cold virus infects the human body (Mayer, Griffith, Jurkowitz, & Rothman, 2008), and the synthesis of ATP (Park et al., 2011; Park, Flowerday, & Brünken, 2015). In contrast, there are surprisingly few studies that focused on problem-solving domains (e.g., Towler et al., 2008). Problem-solving is a crucial component of learning competencies and is a complex process that requires domain-specific knowledge, structural knowledge, and metacognition (Bulu & Pedersen, 2012). Hence, this paucity presents an opportunity for research explicitly examining the seductive details effect in the process of solving problems. In the present study, the learning environment was designed through worked examples because they are regarded as supporting the initial acquisition of cognitive skills (Renkl, 2014) by applying the principle to problem solving. Furthermore, Renkl (2005) stated that providing worked examples is an effective method for problem-solving.

Although there is a common recognition of the importance of worked examples in skill acquisition, learning from worked examples does not guarantee favorable learning outcomes (Schworm & Renkl, 2006). Learners' self-explanation activities are critical in fully exploiting the potential of instruction based on worked examples (Renkl, 2011). It is argued that the extent to which learners benefit from worked examples depends on how well they explain the provided solutions to themselves (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Renkl, Stark, Gruber, & Mandl, 1998).

Self-explanation refers to a reflective activity explaining to oneself the meanings of learning materials (Chi et al., 1989). Also, self-explanation can be considered as a product besides an activity. Ainsworth and Burcham (2007) pointed out that a self-explanation is additional knowledge generated by learners beyond the information they are given to study. Consider learners reading explanatory texts on ice ages for an example. The texts tell learners "CO_2 prevents long-wave radiation from escaping from the Earth into space." The learner may ask "Why CO_2 is able to prevent such radiation" and then self-explain "It could be that CO_2 in the atmosphere is like a big sponge absorbing radiation."

According to Chi (2000), self-explanation helps learners actively construct understanding in two ways: generating appropriate inferences and revising knowledge, which have been acknowledged by much research (e.g., Ainsworth & Burcham, 2007; Kwon, Kumalasari, & Howland, 2011), and recognized as two fundamental reflection mechanisms that can help learners engage in deeper sense-making activities, thus developing a deeper understanding of material (Rau, Aleven, & Rummel, 2015). In most cases, text is not expected to be a complete covering every detail, self-explanation can compensate for the inadequacy or ambiguity of the text by means of generating inferences. In addition, self-explanation can enable learners to realize a gap and compare their flawed mental models to those presented in the text, which can finally help them to revise their current models accordingly and resolve the dissonance.

Other than the benefits aforementioned, self-explanation may enhance learning by reducing extraneous cognitive load. Although engaging in the process of prompting open self-explanations may force learners to spend a great deal of extra time and effort in attending to task-extraneous aspects (e.g., where to start self-explaining; how deep a self-explanation should go), which usually require more working memory resources, certain forms of instructional assistance added to self-explanation are able to prevent working memory being overloaded. For example, providing a partial explanation could reduce extraneous cognitive load by reducing the size of the problem space (Kwon, Kumalasari, & Howland, 2011; Van Merrienboer & Sweller, 2005). Menu-based self-explanation prompts force essential and generative processing, while minimizing extraneous processing and maintaining motivation (Johnson & Mayer, 2010).

Therefore, in the manner of engaging in constructing inferences and assessing the gap, self-explanation may be able to moderate the diverting, disrupting, or distracting effect of seductive details. As McEldoon, Durkin, and Rittle-Johnson (2013) stated, self-explanation can benefit learning by focusing attention on relevant, underlying principles. In other words, learners are better able to distinguish between main concepts and secondary ideas during the self-explaining process and thus seductive details are processed at a minimum level or even sifted out. On the other hand, in learning through worked examples, prompts to self-explain specific solutions can reduce the element interactivity not essential to the task (Sweller, 2010), which may in turn compensate for the extraneous cognitive load caused by seductive details.

The present study

The experiment aimed to investigate the roles of focused self-explanation in learning from worked-out examples when seductive details are either included or excluded. Another focus of the study concerns the interactional relationship between self-explanation and seductive details on both extraneous cognitive load and transfer performance. The experiment was implemented in a computer-based multimedia learning environment and the learning material presented on computers was chosen from the field of physics focusing specifically on electrical engineering.

The study addressed four research questions: (a) are there any differences among the four different conditions in triggered situational interest, (b) are there any differences among the four groups in extraneous cognitive load, (c) are there any differences among the four groups in learning performance, and (d) are there any mediation effects of different conditions on learning performance through extraneous cognitive load?

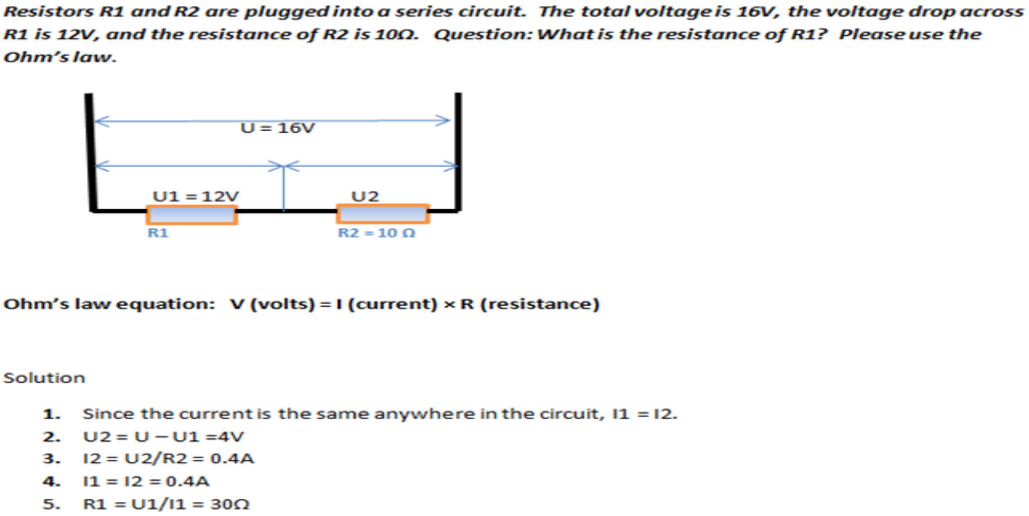
Methods

Participants and design

Our sample consisted of 80 students in grade 10 (47 females, 33 males, average age = 16.6 years ranging from 15 to 18 years, *SD* = .82) from a middle school in China. Most of the participants had not studied electrical circuits systematically and intensively but had learned some basic facts (e.g., the difference between a series circuit and a parallel circuit). They were randomly assigned to one cell of a 2 × 2 between-subjects factorial design. The first factor was the presence or absence of seductive details. The second was the presence or absence of self-explanation prompts. Thus, there were 20 students in the seductive-details plus prompting condition (SP), 20 in the seductive-details only condition (SN), 20 in the no-seductive-details plus prompting condition (NP), and 20 in the no-seductive-details only condition: control condition (C).

Materials

In a computer-based learning environment, the multimedia instruction used in this study pertained to series and parallel circuits, particularly applying Ohm's law in such circuits (e.g., determine the voltage if the current and resistance are known). The entire learning material was presented on 3 screens, the first one with a brief description of electrical circuits and Ohm's law and its equations, the second one with a worked example related to a series circuit, and the third one with a worked example related to a parallel circuit. Specifically, the second screen contained a problem formulation, an equation, and solution steps (see Figure 1).



Resistors R1 and R2 are plugged into a series circuit. The total voltage is 16V, the voltage drop across R1 is 12V, and the resistance of R2 is 10Ω. Question: What is the resistance of R1? Please use the Ohm's law.

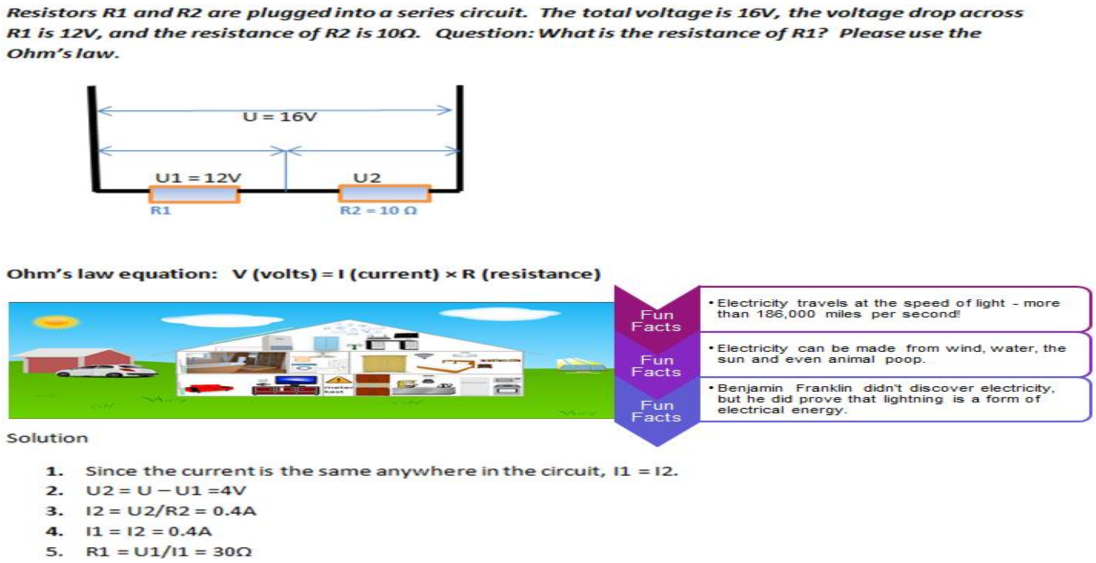
Ohm's law equation: V (volts) = I (current) × R (resistance)

Solution

1. Since the current is the same anywhere in the circuit, I1 = I2.
2. U2 = U – U1 =4V
3. I2 = U2/R2 = 0.4A
4. I1 = I2 = 0.4A
5. R1 = U1/I1 = 30Ω

Figure 1. Screenshot of the learning environment of learning a worked example

In the seductive-details conditions, interesting information presented in both image and text was inserted after the problem formulation (see Figure 2). The information was selected from online resources dealing with the topic of circuits but not relevant to the instructional goal. In the prompting conditions, each solution step was followed by a self-explanation prompt (see Figure 3) with the purpose of encouraging the learners to self-explain the logic behind each solution step. The self-explanation prompts presented to the participants were focused, according to Wylie and Chi (2014), who argued that “focused self-explanation prompts provide more explicit instruction regarding what the content of the self-explanation should include” (p. 422).



Resistors R1 and R2 are plugged into a series circuit. The total voltage is 16V, the voltage drop across R1 is 12V, and the resistance of R2 is 10Ω. Question: What is the resistance of R1? Please use the Ohm's law.

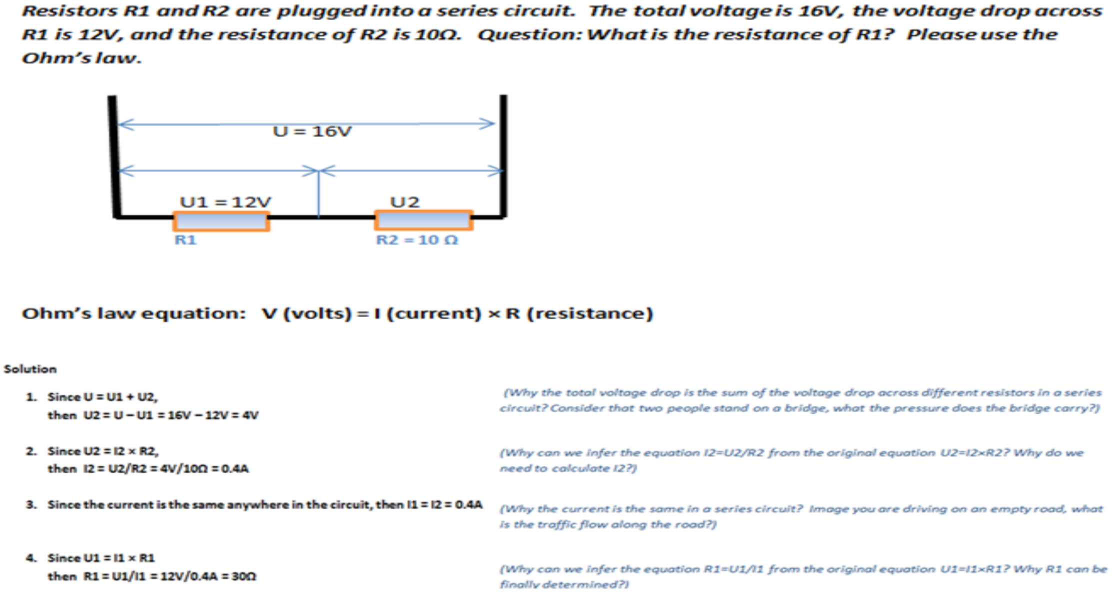
Ohm's law equation: V (volts) = I (current) × R (resistance)

- Electricity travels at the speed of light – more than 186,000 miles per second!
- Electricity can be made from wind, water, the sun and even animal poop.
- Benjamin Franklin didn't discover electricity, but he did prove that lightning is a form of electrical energy.

Solution

1. Since the current is the same anywhere in the circuit, $I1 = I2$.
2. $U2 = U - U1 = 4V$
3. $I2 = U2/R2 = 0.4A$
4. $I1 = I2 = 0.4A$
5. $R1 = U1/I1 = 30\Omega$

Figure 2. Screenshot of the learning environment used in the seductive-details conditions



Resistors R1 and R2 are plugged into a series circuit. The total voltage is 16V, the voltage drop across R1 is 12V, and the resistance of R2 is 10Ω. Question: What is the resistance of R1? Please use the Ohm's law.

Ohm's law equation: V (volts) = I (current) × R (resistance)

Solution

1. **Since $U = U1 + U2$, then $U2 = U - U1 = 16V - 12V = 4V$** *(Why the total voltage drop is the sum of the voltage drop across different resistors in a series circuit? Consider that two people stand on a bridge, what the pressure does the bridge carry?)*
2. **Since $U2 = I2 \times R2$, then $I2 = U2/R2 = 4V/10\Omega = 0.4A$** *(Why can we infer the equation I2=U2/R2 from the original equation U2=I2×R2? Why do we need to calculate I2?)*
3. **Since the current is the same anywhere in the circuit, then $I1 = I2 = 0.4A$** *(Why the current is the same in a series circuit? Image you are driving on an empty road, what is the traffic flow along the road?)*
4. **Since $U1 = I1 \times R1$ then $R1 = U1/I1 = 12V/0.4A = 30\Omega$** *(Why can we infer the equation R1=U1/I1 from the original equation U1=I1×R1? Why R1 can be finally determined?)*

Figure 3. Screenshot of the learning environment used in the self-explanation prompting conditions

Measures

The pre-experimental questionnaire solicited general demographic information and also asked the participants to rate their knowledge of electrical circuits. The prior knowledge measure was a pre-test administered prior to the experimentation intended to test if participants' existing knowledge was similar across different conditions. Specifically, prior knowledge was measured with five self-report questions (excellent internal consistency with Cronbach's alpha = .93) about circuits (e.g., “How much do you know about electrical circuits?”) developed by one of the authors. The self-report questions asked the participants to rate their knowledge on a scale from 1 to 5 (1 being nothing and 5 being very much), yielding a possible score ranging from 5 to 25 points. Self-reported measures were considered a valid measure of prior knowledge and employed in several previous studies (e.g., Harp & Maslich, 2005; Harp & Mayer, 1998) regardless of the fact that it is often regarded as a subjective measure.

Triggered situational interest was assessed on a scale (good internal consistency with Cronbach's alpha = .87) with 5 five-point Likert items (1 = strongly disagree, 5 = strongly agree) focusing on students' spontaneous focused attention and affective reactions to the materials presented (e.g., "I think the material is interesting"). These items were adapted from a study by Flowerday and Schraw (2003). The triggered situational interest measure was included in order to examine the degree to which the seductive details used in the present study contributed to the arousal of interest.

Extraneous cognitive load was measured by three items that were adapted from the scale used by Park, Flowerday, and Brunken (2015). Each of the three items was rated on a five-point Likert scale (acceptable internal consistency with Cronbach's alpha = .72) ranging from 1 to 7 (1 being extremely easy and 7 being extremely difficult). The items are associated with the unnecessary cognitive demands imposed by instructional design (e.g., "How easy or difficult did you find it to collect all information you needed in learning the worked examples?").

Learning performance was assessed with a test containing 10 problems, which were not identical to the problems showed in the worked examples during the learning phase. Five problems assessed procedural knowledge in applying Ohm's law in series circuits and the other five assessed procedural knowledge in applying Ohm's law in parallel circuits. An example item is, "Resistors R1, R2, and R3 are plugged into a series circuit. The total voltage drop across R1, R2, and R3 is 24V. The resistance of resistors R2 and R3 is 2 Ω and 3 Ω respectively. The current through R1 is 4A. Question: What is the voltage drop across R1?" In each task, one point was assigned for each acceptable solution step written by each participant. Because the final solution to each problem could be achieved within five steps, the possible score for each participant ranged from 0 to 5 points. Five points were also given to an answer if the final solution had been reached with a correct answer provided even though one or two steps was omitted. Two independent raters trained with a mutually agreed scoring method scored each answer and reached an interrater reliability rating of $r = .92$.

Procedure

Upon arrival, participants were instructed to sit at one of the computers in a computer lab. Prior to launching the multimedia learning program, all the participants were asked to complete the pre-experimental questionnaire that includes the demographic survey and prior knowledge test. After they completed the questionnaire, the participants were randomly assigned to either SP, S, P, or C condition.

All the participants were told to learn Ohm's law in electrical circuits on computer. First of all, the description of Ohm's law and features of electrical circuits were presented to the participant. Once the participant finished going through the prerequisite knowledge facts, he or she then proceeded to the next screen by clicking on a right arrow and learned through the example with solution steps provided. The participant then proceeded to the third screen where the second example was provided by clicking on a right arrow. The whole learning process is learner-paced. In other words, participants controlled the pace of the presentation by clicking a left or right arrow at the bottom of each screen to continue to the next screen or go back to the previous screen. The learning process was identical across the four conditions (SP, SN, NP, and C) except that those in the seductive-conditions received extra seductive image and text after the problem formulation was presented and those in the prompting conditions had to self-explain each solution step.

After participants learned the worked examples, the multimedia learning program was turned off and was no longer accessible to them. The participants were required to complete the triggered situational interest survey and cognitive load survey and then were presented with the 10 problems on the screen. They were asked to type solution steps and final answers to the problems on computer. Although working through the problems was self-paced, participants generally completed the questions within 40 minutes.

Results

Preliminary analyses

A one-way analysis of variance (ANOVA) was conducted to examine differences in prior knowledge among the conditions (SP, SN, NP, and C) before the intervention was implemented. The result indicated that the difference in the prior knowledge score among the conditions was not statistically significant ($F(3, 76) = .469$, $MSE = 3.512$, $p = .705$; $\eta^2 = .018$). Therefore, the conditions were considered fairly equivalent. Hence, a decision was made not to use the prior knowledge score as a covariate in subsequent analyses. In addition, Table 1 shows the descriptive statistics for the triggered situational interest, extraneous cognitive load, and learning performance measures.

Table 1. Condition differences on extraneous cognitive load, triggered situational interest, and learning performance

	SP (*n* = 20)		SN (*n* = 20)		NP (*n* = 20)		C (*n* = 20)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
TSI	18.2	3.14	17.7	2.99	14.55	2.21	14.3	3.06
ECL	7.75	2.34	9.5	1.73	5.95	1.64	7.55	2.48
LP	30.55	9.73	14.75	5.50	28.05	7.46	21.35	7.21

Note. SP = Seductive-details-prompting; SN = Seductive-details-no-prompting; NP = No-seductive-details-no-prompting; C = No-seductive-details-no-prompting; TSI = Triggered situational interest; ECL = Extraneous cognitive load; LP = Learning performance.

Triggered situational interest

An ANOVA was conducted to examine possible difference between the four different conditions on triggered situational interest and the result indicated that there was a significant difference (F (3, 76) = 10.14, $p < .001$) the seductive-details-promoting and seductive-details-no-prompting conditions scored similar (p = .89), while significantly higher than the no-seductive-details-prompting or no-seductive-details-no-prompting condition ($p < .05$), suggesting that the participants who read the seductive details were much more interested in the learning material as compared to those who did not.

Extraneous cognitive load

A 2 × 2 between-subjects analysis of variance (ANOVA) was conducted with prompting self-explanation (self-explanation prompts vs. no self-explanation prompts) and seductive details (seductive details vs. no seductive details) as the independent variables and extraneous cognitive load as the dependent variable. It showed a significant main effect of self-explanation (F (1, 76) = 12.98, $p < .001$; $\eta^2 = .146$) and a significant main effect of seductive details (F (1, 76) = 16.26, $p < .001$; $\eta^2 = .176$) but no significant interaction (F (1, 76) = .026, $p = .872$, $\eta^2 = .000$).

Post hoc Bonferroni tests detected significant differences for the seductive-details-no-prompting condition vs. no-seductive-details-no-prompting condition (d = .91, $p < .05$), seductive-details-prompting vs. no-seductive-details-prompting (d = .89, $p < .05$). In addition, there was a marginal difference between seductive-details-prompting and seductive-details-no-prompting (d = .85, $p = .057$). However, there was no significant difference between no-seductive-details-prompting and no-seductive-details-no-prompting (d = .76, $p > .05$).

Learning performance

A 2 × 2 between-subjects analysis of variance (ANOVA) was conducted with prompting self-explanation (self-explanation prompts vs. no self-explanation prompts) and seductive details (seductive details vs. no seductive details) as the independent variables and learning performance as the dependent variable. It showed a significant main effect of self-explanation (F (1, 76) = 43.56, $p < .001$; $\eta^2 = .364$) and a significant interaction effect between self-explanation and seductive details (F (1, 76) = 7.14, $p < .05$; $\eta^2 = .086$). Simple effects analysis demonstrated that there was a significant difference between seductive details and no seductive details at no self-explanation ($p < .05$) but no significant difference at self-explanation ($p = .303$). Another simple effects analysis demonstrated that there was a significant difference between self-explanation and no self-explanation at seductive details ($p < .001$) and significant difference at no seductive details ($p < .05$).

Post hoc Bonferroni tests detected significant differences for the seductive-details-prompting condition vs. seductive-details-no-prompting condition (d = 2.00, $p < .001$), no-seductive-details-prompting vs. no-seductive-details-no-prompting (d = .91, $p < .05$), no-seductive-details-no-prompting vs. seductive-details-no-prompting (d = 1.03, $p < .05$). However, there was no significant difference between no-seductive-details-prompting and seductive-details-prompting (d = -.29, $p = .303$).

Mediation analyses on seductive-details condition

With a regression-based approach the mediation analysis helped to answer the questions about whether or not the seductive details effect/prompting effect is mediated by extraneous cognitive load. First, we were interested in a possible mediation effect of seductive details on learning performance through extraneous cognitive load in the absence of self-explanation prompts. Therefore, we tested whether seductive details (no-seductive-details-no-prompting vs. seductive-details-no-prompting) indirectly affected learning performance via extraneous cognitive load. Generally speaking, it is a valid model ($R^2 = .48$, $p < .001$). The analysis demonstrated that seductive details significantly increased extraneous cognitive load ($b = 1.95$, $SE = .68$, $p < .05$; path a in the mediation model). In addition, extraneous cognitive load significantly decreased performance, controlling for condition ($b = -1.74$, $SE = .40$, $p < .001$; path b in the mediation model). The analysis confirmed that there was an indirect effect of seductive details on learning performance ($a*b = -3.40$, $LCL = -7.18$, $UCL = -.96$) via extraneous cognitive load. A visual representation of this mediation model can be found in Figure 4. Also, the results revealed the total effect ($b = -6.6$, $SE = 2.03$, $p < .05$) and the direct effect ($b = -3.19$, $SE = 1.84$, $p = .0912$) of seductive details on learning performance, which indicated the data were consistent with a complete mediation model.

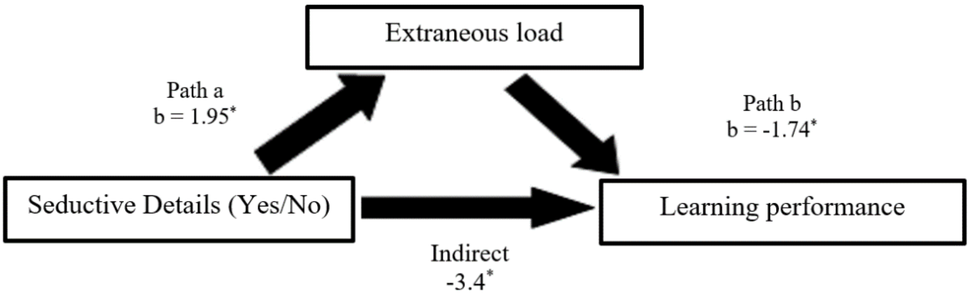


Figure 4. Mediation results in the absence of self-explanation prompting

We also tested whether extraneous cognitive load mediated the relation between seductive details and learning performance in the presence of self-explanation prompts. The no-seductive-details-prompting and seductive-details-prompting conditions were included in the analysis and the results revealed that seductive details significantly increased extraneous cognitive load ($b = 1.92$, $SE = .63$, $p < .05$). Extraneous cognitive load, however, did not significantly decrease learning performance, controlling for prior knowledge and condition ($b = -.88$, $SE = .71$, $p = .221$). Thus, there was no indirect effect of seductive details on learning performance ($a*b = -1.69$, $LCL = -5.68$, $UCL = .58$).

Mediation analyses on self-explanation condition

Given no significant difference between no-seductive-details-no-prompting and no-seductive-details-prompting on extraneous cognitive load, a mediation analysis was not necessary and it can be concluded that the relationship between prompting and learning performance was not mediated by extraneous cognitive load.

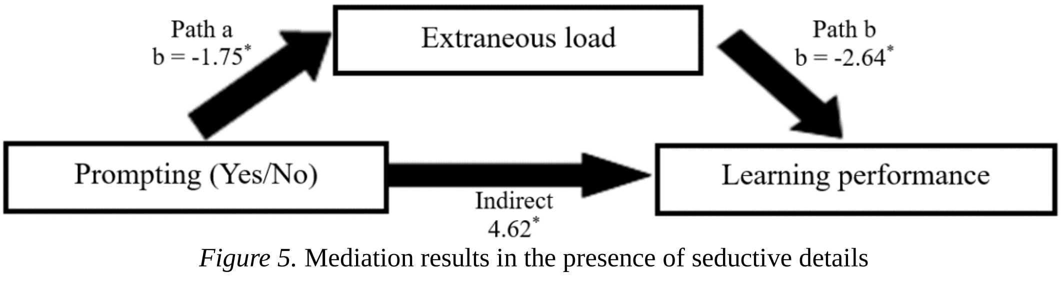


Figure 5. Mediation results in the presence of seductive details

We also tested whether prompting indirectly affected learning performance via extraneous cognitive load in the presence of seductive details. The seductive-details-no-prompting and seductive-details-prompting conditions were included in the analysis and the model summary showed that it is a valid model ($R^2 = .74$, $p < .001$). The results revealed that prompting significantly decreased extraneous cognitive load ($b = -1.75$, $SE = .65$, $p < .05$). Extraneous cognitive load significantly decreased learning performance, controlling for prior knowledge and condition ($b = -2.64$, $SE = .46$, $p < .001$). Thus, there was an indirect effect of prompting on learning performance ($a*b = 4.62$, $LCL = 1.37$, $UCL = 8.93$) via extraneous cognitive load. A visual representation of this mediation model can be found in Figure 5. Also, the results revealed the total effect (*b* = 15.8, *SE* = 2.50, *p* < .001) and the direct effect (*b* = 11.18, *SE* = 2.00, *p* < .001) of prompting on learning performance, which indicated the data were consistent with a partial mediation model.

Discussion

Differences in extraneous cognitive load

As expected, the seductive-details-no-prompting condition reported the highest extraneous cognitive load. This finding is consistent with previous studies (Mayer, Griffith, Jurkowitz, & Rothman, 2008; Sanchez & Wiley, 2006) confirming that seductive details constitute a significant source of extraneous cognitive load. The no-seductive-details-prompting condition reported the lowest extraneous cognitive load suggests that self-explanation prompts help learners concentrate on schema-relevant principles rather than direct attention to search processes / without searching in the vast information pool presented to them (Paas & van Gog, 2006; Sweller & Cooper, 1985). When the seductive-details condition was prompted to self-explain, they reported moderate levels of extraneous cognitive load, as well as the no-seductive-details-no-prompting condition, suggesting that self-explanation was able to substantially relieve the load caused by the seductive details while not reaching the most desirable level.

The role of self-explanation prompting

An important finding of the study is that when learners who received seductive details were prompted to self-explain the worked example, the seductive details effect was reduced substantially. As evidenced by the indirect effect of prompting on learning performance via decreased extraneous cognitive load from the mediation analysis, we safely conclude that self-explanation is an effective learning strategy that can direct learners’ cognitive resources to the construction of problem-solving schema underlying each solution of the worked example, whereas at the same time cognitive processing capacity is not drawn by irrelevant messages, rendering seductive details processed minimally. As Fiorella and Mayer (2015) pointed out, self-explaining, as a generative learning activity, can prime the cognitive processes of selecting, organizing, and integrating, and thus leaves cognitive resources for schema acquisition rather than seductive details.

Another crucial result relates to the comparison between the no-seductive-details-no-prompting and no-seductive-details-prompting conditions. We found that, while seductive details were excluded, prompting enhanced learning but, surprisingly, not through reduced extraneous cognitive load, which is supported by the mediation analysis. Indeed, learning without seductive details does not introduce a source of extraneous load that is needed to be reduced by self-explanation prompts. Better learning outcome associated with the prompting condition is consistent with previous work that has proved that the generation of self-explanations is an effective cognitive activity that yields germane cognitive load and enhances learning (Chi et al., 1989; Renkl, 1997; Renkl & Atkinson, 2002). According to the active processing principle of Cognitive Theory of Multimedia Learning (CTML: Mayer, 2014), learners may not learn most effectively unless instruction methods aim at generative processing whose level is represented by germane cognitive load.

When extraneous cognitive load fails to explain

We also found, unexpectedly, that the learning performance was not in perfect correspondence with the extraneous cognitive load for another comparison. That is, regardless of the higher levels of extraneous cognitive load for the seductive-details-prompting condition versus the no-seductive-details-prompting condition, they performed similarly and outperformed the rest two conditions. One reasonable explanation is that extraneous cognitive load is not the only psychological construct that affects learning. Indeed, increased triggered situational interest for the seductive-details-prompting condition may compensate for some of the negative effect of extraneous cognitive load. An alternative explanation is that it is not always the case that the lower the extraneous cognitive load, the better the learning outcomes. The classic cognitive load theory (CLT: Paas, Renkl, & Sweller, 2003; Plass, Moreno, & Brunken, 2010; Sweller, van Merrienboer, & Paas, 1998; van Merrienboer & Sweller, 2005) infers that free cognitive processing capacity is the difference between the working memory resources and the total load consisting of intrinsic, extraneous, and germane load. Therefore, as long as the load does not exceed the working memory capacity, the level of the extraneous cognitive load is of little concern (intrinsic load is not considered here because it is irreducible by instructional design and germane load is believed to remain constant because both conditions employed prompting). In the present study, the extraneous load of 7.75 for the seductive-details-prompting condition and that of 5.95 for the no-seductive-details-prompting condition might not reach a critical number, above which learning would be hurt.

Conclusions and limitations

The results of this study add significantly to the existing body of evidence showing that including seductive details in an expository text is detrimental to learning performance. Specifically, inserting seductive details to the lesson format of worked examples leads to reduced learning outcomes when compared with materials without any seductive details. As a result, an instructor might simply forgo seductive details when designing worked examples to minimize the student's risk of limited working memory being overloaded. Furthermore, the study attests to the benefit of applying self-explanation prompts in learning when seductive details are received as part of learning materials. Hence, instructors can be encouraged to prompt their students to self-explain crucial elements and/or interactivity of elements covered by a lesson as a way of primarily focusing their cognitive resources on the construction of schema rather than encoding irrelevant information. We also note that it is recommended to design prompts that are focused versus open for beginning learners, because focused self-explanation prompts enable them to proceed under guidance, avoiding another source of load that could have been introduced by open prompts.

On the basis of this study investigating a specific way of presenting the material (seductive details) and a particular instructional technique (self-explanation prompts), our findings can extend and provide empirical evidence for a potential broader interpretation of the relation between cognitive load and learning. We contend that the relationship between extraneous processing and learning outcomes is not linear all the way. As observed in the present study, as long as the total load did not reach a warning level, there would be of less need for reducing extraneous load. One educational implication that can be drawn is that if an instructor is concerned about non-essential material causing a modest amount of extraneous processing, he or she is encouraged to not only reduce extraneous load but also pay attention to seeking learning activities that can promote generative processing to increase germane load.

The results of this study have important educational implications considering the known effect of self-explanation on seductive details. Teachers might incorporate oral self-explanation prompts when illustrating important conceptual and/or procedural skills. Textbook writers and multimedia designers should insert visual self-explanation prompts appropriately in a lesson. Furthermore, future research should focus on seeking and investigating other instructional techniques to reduce extraneous cognitive load caused by processing seductive details. With findings provided by studies on other generative or constructive learning activities, we can make a strong case for how to effectively overcome the seductive details effect in multimedia learning.

There are some limitations in conducting this study. One of the major limitations is that we did not record learners' oral self-explanations or collect their written self-explanations. Without analyzing their oral or written explanations, little is known about the quantity and/or quality of self-explanations they made, which would limit the potential of self-explanation prompts. Second, using self-report scales measuring extraneous cognitive load could be problematic with validity because participants tend to be inaccurate in estimating the load they have experienced relying upon introspection. Future research is needed to examine the objective measures of cognitive load, such as response time to a secondary task during learning proposed by DeLeeuw and Mayer (2008) and the rhythm method suggested by Park and Brunken (2015).

The present research made contributions by means of moving from merely examining the seductive details effect in current literature to seeking pedagogical techniques to overcome seductive details. Given the moderation effect of self-explaining we have observed in this study, we encourage researchers to explore other techniques particularly generative learning activities such as imaging, drawing, and mapping to overcome the seductive details effect.

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