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Examining the Effects of Self-Explanation on Students' Inference Generation and Conceptual Change

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Abstract

This study examined the effectiveness of using self-explanation prompts to enhance students' ability to produce bridging inferences, improve their text comprehension, and correct their misconceptions. College students were prompted to self-explain or think-aloud while reading a non-refutational or refutational text. The students were assessed on their text comprehension, conceptual understanding, vocabulary, and prior knowledge. The results demonstrated that students prompted to self-explain produced more bridging inferences than students prompted to think-aloud. In addition, students who generated more bridging inferences better text comprehension had fewer misconceptions after reading. However, students' conceptual understanding also depended on their prior knowledge and reading skill.

Introduction

Misconceptions are common across domains and are of particular concern in education. Misconceptions hinder learning by preventing learners from making inferences to connect inaccurate knowledge and new information (Kendeou et al., 2014). Refutational texts are one method that researchers have used to counter misconceptions (Allen, McCrudden, & McNamara, 2015). Refutational texts target specific misconceptions by stating the misconception, providing the correct concept, and explaining why the correct concept is true. Studies have shown that the effectiveness of the refutational text depends on students' ability to activate different ideas in the text (Kendeou et al., 2014). Furthermore, the effectiveness of refutational texts depends on the degree to which students can comprehend the text (Allen, McNamara & McCrudden, 2015).

One technique to improve students' text comprehension is by prompting students to self-explain. Self-explanation is the practice of explaining the text to oneself while reading. Students prompted to self-explain while reading use more language connecting ideas in the text, generate more bridging inferences while reading, and better comprehend the text (Dasaclu et al., 2017, McNamara, 2004). In comparison to prompting self-explanation, prompting students to think-aloud increases the students' generation of elaborations, but not bridging inferences (Dascalu et al., 2017). Prompting students to self-explain while reading a refutational text may improve their ability to generate bridging inferences compared to students prompted to think-aloud. Consequently, prompting self-explanation may enhance students' ability to comprehend the text and correct their misconceptions by activating the different ideas in the text (Kendeou et al., 2014).

The current study assessed the degree to which self-explanation, in combination with refutational or non-refutational texts, improves students' ability to generate bridging inferences and the students' ability to correct their misconceptions about natural selection. It was hypothesized that students who self-explain would generate more bridging inferences, and that students prompted to think-aloud would generate more elaborations. Finally, it was hypothesized that students who generated more bridging inferences would better comprehend the text and have fewer misconceptions after reading.

Method

Participants and Procedure

Undergraduate students (N = 240) were randomly assigned to one of four conditions in a 2 (Constructed Response: self-explanation, think-aloud) x 2 (Text: refutational, non-refutational) between-subjects design. The students were given instructions, prompted to read their assigned text, and administered a conceptual test, text comprehension questions, and individual difference measures.

Materials

Texts and prompts. The text is an excerpt from *How the Mind Works* (Pinker, 1997) describing the concept of natural selection. The original, non-refutational text (707 words, FKGL: 11) and adapted, refutational text (716 words, FKGL: 10.5) had similar length and reading difficulty.

Prior to reading, participants were provided with brief instructions to either think-aloud or self-explain with a sample passage, and then prompted to either think-aloud or self-explain at 14 target sentences while reading the passage.

Students' constructed responses were scored by two raters for the presence of bridging inferences and elaborations. One rater scored the entire set of constructed responses. A second rater scored a random 10% subset of the responses to ensure reliability. The two raters had strong weighted kappa for the bridging inference ($\kappa = 0.69$) and elaboration scores ($\kappa = 0.72$).

Comprehension measures. Text comprehension was measured with short answer, bridging comprehension questions. A correct response required students to inference between two sentences. The students' responses were scored independently by two raters ($\kappa = 0.79$).

Conceptual understanding was assessed using the Conceptual Inventory of Natural Selection (CINS; Anderson et al., 2002), a multiple-choice test that evaluates both accurate ideas and common misconceptions related to natural selection.

Individual differences. The vocabulary test from the Gates–MacGinitie Vocabulary Test served as a proxy for reading skill (MacGinitie & MacGinitie, 1989). Participants were also given a prior knowledge test containing multiple-choice questions on physical sciences and mathematics. (O'Reilly & McNamara, 2007).

Results

Means and correlations are provided in Table 1. Consistent with prior research, prior knowledge and vocabulary scores were correlated with bridging inferences, elaborations, and text comprehension and misconceptions.

Table 1.

Means and correlations: bridging inferences, elaborations, comprehension questions, conceptual inventory of natural selection (CINS), and individual difference measures

Measure	Mean (*SD*)	2.	3.	4.	5.	6.
1. Bridging Inferences	0.95 (0.43)	**0.22**	**0.30**	**0.25**	**0.31**	**0.30**
2. Elaborations	1.02 (0.65)		**0.21**	0.05	**0.19**	**0.23**
3. CINS	0.47 (0.17)			**0.26**	**0.47**	**0.51**
4. Text Comprehension	0.30 (0.18)				**0.30**	**0.29**
5. Prior Knowledge	0.78 (0.19)					**0.68**
6. Vocabulary	0.73 (0.16)					

Bolded correlations are significant at p < 0.01

Bridging Inferences and Elaborations

The first set of analyses tested the hypotheses that different constructed response prompts (self-explain, think-aloud) affected students' production of bridging inferences and elaborations.

The linear regression conducted to test the hypothesis that students prompted to self-explain generated more bridging inferences compared to students prompted to think-aloud was significant, $r^2 = 0.21$, $F(4,235) = 12.5$, $p < 0.01$. Table 2 shows the model and Figure 1 shows the estimated means by condition, factoring out prior knowledge and vocabulary. Consistent with our hypothesis, there was a main effect such that students prompted to self-explain generated more bridging inferences while reading.

Table 2.

Linear regression predicting bridging inferences as a function of vocabulary, prior knowledge, text, and prompt

Source	β	SE	*t*	*p*
Intercept	0.34	0.13	2.53	**0.01**
Vocabulary	0.48	0.21	2.29	**0.02**
Prior Knowledge	0.47	0.18	2.58	**0.01**
Prompt (Self-explain vs Think-aloud)	0.27	0.07	3.77	**<0.01**
Text (Refutational vs Non-refutational)	0.01	0.07	0.57	0.56
Text (Ref) * Prompt (SE)	0.01	0.10	0.06	0.95

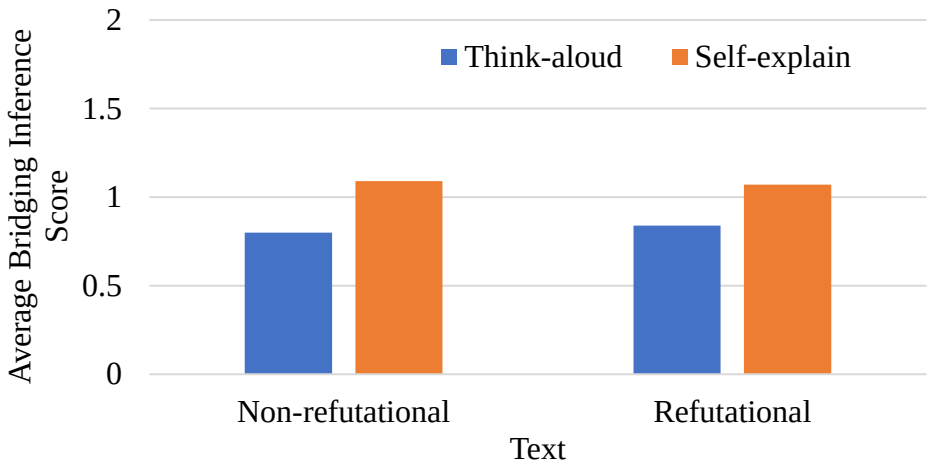

Figure 1. Average bridging inferences as a function of text and prompt, holding prior knowledge and vocabulary score constant.

The linear regression conducted to test the hypothesis that students prompted to think-aloud generated more elaborations compared to students prompted to self-explain was also significant, $r^2 = 0.43$, $F(4,235) = 26.3$, $p < 0.01$. Table 3 shows the model and Figure 2 shows the estimated means by condition, factoring out prior knowledge and vocabulary. Consistent with previous research (Dascalu et al., 2017), there was a main effect such that students prompted to think-aloud generated more elaborations while reading.

Table 3.

Linear regression predicting elaborations as a function of vocabulary, prior knowledge, text, and prompt

Source	β	SE	*t*	*p*
Intercept	0.36	0.17	2.13	**0.03**
Vocabulary	0.68	0.27	2.56	**0.01**
Prior Knowledge	0.15	0.23	0.67	0.50
Prompt (Self-explain vs Think-aloud)	-0.69	0.09	-7.65	**<0.01**
Text (Refutational vs Non-refutational)	-0.27	0.09	-3.02	**<0.01**
Text (Ref) * Prompt (SE)	0.69	0.13	5.38	**<0.01**

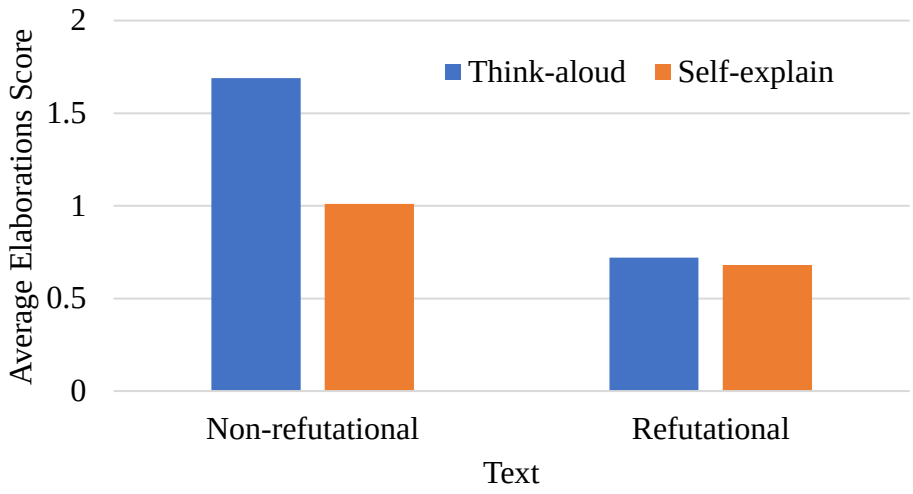

Figure 2. Average elaborations as a function of text and prompt, holding prior knowledge and vocabulary score constant.

Further, there was an interaction such that the increase in elaborations for students prompted to think-aloud was most apparent when they read the non-refutational text. Table 4 contains examples of target sentences and students' responses to those sentences. The responses indicate that students who read the refutational text incorporated weak elaborations such as mentioning "DNA". In comparison, students who read the non-refutational text elaborated on how replication affected different parts of life. Our sense is the refutational text kept the readers 'on point' in the text, though this did not result in more bridging inferences. Further studies are necessary confirm this effect.

Table 4.

Examples of target sentences and responses to different texts.

Target Sentences		Response Examples	
Refutational	Non-refutational	Refutational	Non-Refutational
However, the view that organs must have been designed in advance for a specific purpose is incorrect. This view is incorrect because it fails to take into account the idea of replication.	It is mind-boggling that our bodies can deal with the vast array of specific challenges that we face. This ability points us to the idea of replication.	The idea that organs were made in advance is incorrect due to DNA replication. DNA replication is when creatures (that have survived long enough and are able to reproduce) pass off their DNA to their offspring. This allows the "fittest" creatures to pass off the survivalist DNA.	The idea behind this sentence, is that when we as human interact with an issue mentally or physically we learn to find a way to successfully achieve are goals. When this process is established, we as humans learn to use the same processes and strategies to replicate are succeses over and over.

Table 4.

Examples of target sentences and responses to different texts.

Target Sentences		Response Examples	
Refutational	Non-refutational	Refutational	Non-Refutational
		Since humans share the same DNA we basically replicate ourselves everytime we reproduce making a better version of ourselves. Replication is a good argument becuase it explains alot more.	When our bodies help us adapt to our environment, replication plays a big role because our organs and other parts of our body replicate its functions over and over again. This way the Body doesn't get tired of living until old age and we can continue living healthily.

Comprehension

The second set of analyses tested the hypotheses that students' who produced more bridging inferences while reading would have better text comprehension and fewer misconceptions after reading.

The linear regression conducted to test the hypotheses that students who generated more bridging inferences would have greater text comprehension was significant, $r^2 = 0.13$,

$F(4,235) = 8.80$, $p < 0.01$. Table 5 shows the model. In the regression, only bridging inferences were a significant predictor of students' score on the comprehension questions, indicating students' comprehension of the text depended on their ability to generate bridging inferences.

Table 5.

Linear regression predicting comprehension test score as a function of vocabulary, prior knowledge, bridging inferences, and elaborations.

Source	β	SE	*t*	*p*
Intercept	0.01	0.06	0.06	0.95
Vocabulary	0.34	0.09	1.84	0.07
Prior Knowledge	0.19	0.08	1.78	0.08
Bridging Inferences	0.05	0.02	2.64	**<0.01**
Elaborations	-0.02	0.11	-0.89	0.37

The linear regression conducted to test the hypotheses that students who generated more bridging inferences would have fewer misconceptions was also significant $r^2 = 0.31$, $F(4,235) = 26.3$, $p < 0.01$. Table 6 shows the model. Vocabulary, prior knowledge, and bridging inferences were all significant predictors. These effects indicate that students' conceptual understanding also depended on their production of bridging inferences and their prior knowledge and reading skill.

Table 6.

Linear regression predicting CINS score as a function of vocabulary, prior knowledge, bridging inferences, and elaborations.

Source	β	SE	*t*	*p*
Intercept	0.01	0.04	0.16	0.87
Vocabulary	0.34	0.80	4.27	**<0.01**
Prior Knowledge	0.19	0.69	2.69	**<0.01**
Bridging Inferences	0.05	0.02	2.12	**<0.05**
Elaborations	0.02	0.02	1.33	0.18

Discussion

This study addressed theoretical questions about the effectiveness of using self-explanation prompts to enhance students' ability to produce bridging inferences, improve their text comprehension, and correct their misconceptions. Undergraduate students were prompted to self-explain or think-aloud while reading a non-refutational or refutational texts. The students were assessed on their text comprehension, conceptual understanding, vocabulary, and prior knowledge. The students' constructed responses were scored for bridging inferences and elaborations.

Consistent with our hypotheses, the results demonstrated that students prompted to self-explain produced more bridging inferences compared to students prompted to think-aloud. In addition, students who generated more bridging inferences better comprehended the text and had fewer misconceptions compared to students who generated fewer bridging

inferences. However, students' conceptual understanding also depended on the students' prior knowledge and reading skill.

The findings of the study are consistent with previous research on self-explanation and misconceptions. Prompting self-explanation is an effective intervention to enhance students' ability to generate bridging inferences while reading, and students' texts comprehension depends on their ability to generate bridging inferences. However, students' ability to correct misconceptions while reading refutational texts depends on both the connections between ideas in the text and their prior knowledge.

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