Effects of Combining Refutation and Self-Explanation on Student Learning

Jake Salem and Emma Geller, Ph.D.
University of California, San Diego

Background

- Misconceptions about the natural world are everywhere, hard to get rid of, and represent a large obstacle for educators.
- **Refutation texts** and **self explanation prompts** assist students in locating gaps and errors in their knowledge and facilitate learning of related material[1,3]. However, minimal research has investigated their joint effect on learning.`
- Moreover, science learning studies seldom measure qualitative aspects of students knowledge beyond accuracy[3] (i.e., explanatory quality).
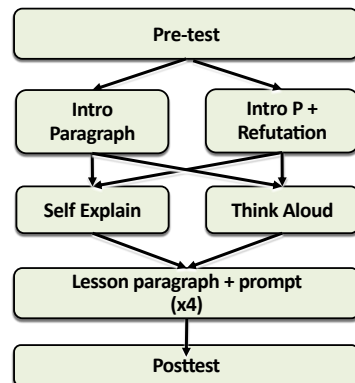
Research questions

1. Do refutation and explanation enhance each other's positive learning outcomes?

2. Are these different learning outcomes related?

Participants & Design

260 UCSD undergraduate students recruited from SONA, 45 excluded (M_{age}= 20.4, 78% Female)

	Refutation	Expository
Think Aloud	N = 51	N = 52
Self Explain	N = 57	N = 55

```
            Pre-test
          /         \
   Intro          Intro P +
   Paragraph      Refutation
          \  X  /
   Self Explain    Think Aloud
          \         /
   Lesson paragraph + prompt
            (x4)
              |
           Posttest
```

Materials & Measures

The entire lesson text about moon phases was adapted from an open license, college textbook called *Astronomy*[2].

Refutation paragraph added to introduction page for one half of participants:

Many people believe that the Moon's changing phases are the result of the Earth casting its shadow onto different areas of the Moon. However, the phase of the Moon is not caused by the Earth's shadow. In fact, the Earth's shadow rarely hits the Moon because the Earth is not big enough at that distance to frequently hit the Moon with its shadow. When it does, the Moon turns red and we call this event a Lunar eclipse.

Prompts randomly attached to the bottom of all five pages of text:

- Self explanation prompt: *Please **explain** what you just read in your own words.*
- Think aloud prompt: *Please write out your thoughts while you were reading. This could be anything that came to mind.*

Post-test knowledge was operationalized in two different ways:

1. **Accuracy**
   ▶ Five Retention Questions: *"Please explain why the moon looks different each night."*
   ▶ Three Transfer Questions: *"Please explain why Venus goes through phases."*

2. **Explanatory Quality:** coded for presence (1) or absence (0), but only 6 qualities were used
   ▶ *Helpful:* Analogy, Causality, Physical Objects
   ▶ *Harmful:* Circularity, Uncertainty, Unnecessary

Accuracy Results

Neither refutation nor explanation had a significant effect on Retention or Transfer, though there are trends in the expected direction.

Effect of Interventions on Retention

Effect of Interventions on Transfer

η_p^2= .01, *p*=.07

Explanatory Quality Results

Qualitative differences in explanations were not impacted by the interventions, but were themselves associated with accuracy.

	Dimension	Frequency	Retention coefficient	Transfer coefficient
Helpful	Analogy	4.77%	0.55†	0.54*
	Causality	50.47%	0.33**	0.29***
	Physical objects	84.01%	0.98***	0.45***
Harmful	Circularity	4.83%	-0.72*	0.051
	Unnecessary descriptors	7.15%	-0.34	-0.53**
	Uncertainty descriptors	9.59%	-0.09	-.01

Discussion

- Implementing new conditions and abridging the post-test may help reveal the effects of these well-supported strategies. It will be impossible to demonstrate an interaction between the interventions without respective main effects.

- Individual differences in explanatory quality and accuracy appear to be strongly related (in expected directions). These findings support the use of explanatory quality as a window into students' knowledge and thinking processes after reading.

References

1. Allen, L. K., McNamara, D. S., & McCrudden, M. (2015). Change your Mind: Investigating the Effects of Self-Explanation in the Resolution of Misconceptions. In *CogSci*.

2. Fraknoi, A. (2016). *Astronomy*. OpenStax.

3. Will, K. K., Masad, A., Vlach, H. A., & Kendeou, P. (2019). The effects of refutation texts on generating explanations. *Learning and Individual Differences, 69*, 108-115.