NC STATE

Critical Thinking Scenarios Enhance Higher-order Cognitive Skills in a First-year Undergraduate Course

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Abstract

TH!NK is a new initiative at NC State University focused on enhancing students' higher-order cognitive skills. As part of this initiative, I explicitly emphasized critical and creative thinking in an existing bacteriophage discovery first-year research course. In addition to the typical activities associated with undergraduate research such as review of primary literature and writing research papers, another strategy that was employed to enhance students' critical thinking skills was the use of discipline-specific, real-world scenarios. This paper outlines a general "formula" for writing scenarios, as well as several specific scenarios created for the described course. I also present how embedding aspects of the scenarios in reviews of the primary literature enrich the activity. I assessed student gains in critical thinking skills using a pre-/post- test model of the Critical Thinking Assessment Test (CAT), developed by Tennessee Technological University. I observed a positive gain trend in most of the individual skills assessed in the CAT, with a statistically significant large effect on critical thinking skills overall in students in the test group. I also show that a higher level of critical thinking skills was demonstrated in research papers written by students who participated in the scenarios compared to similar students who did not participate in the scenario activities. The scenario strategy described here can be modified for use in biology and other STEM disciplines, as well as in diverse disciplines in the social sciences and humanities.

Student Learning Objectives

A. Students will recognize inappropriate inferences and will question overstated conclusions in the works of others.
B. Students will avoid making inappropriate inferences from data.
C. Students will provide multiple explanations/interpretations of data.
D. Students will determine ways to assess the best explanation or interpretation of data.

Methods

Students participated in 5 scenario activities during the semester, structured as follows:

1. Respond to the scenario on one side of a sheet of paper independently (` 10 minutes or homework)
2. Discuss in small group of 3-4 students (` 10 minutes)
3. Discuss as a class with feedback from instructor (` 10 minutes)
4. Add any additional ideas on the back of the paper (` 5 minutes)
5. Hand in activity (not graded, but checked for effort)

Students participated in discussion of two journal articles, and were asked to reflect on the following:

1. Did the conclusions follow logically from the data? Provide an example.
2. Did the authors consider alternate conclusions of the data? Provide an example. Are there any interpretations that you thought about that the author did not consider?

Assessment

1. Critical Thinking Assessment Test (CAT) – Developed at Tennessee Technical University (NSF funding)
2. Common Rubric

Critical-thinking Scenario Structure

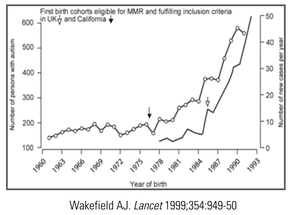
Lay out scenario, provide image, or present data.

Q1. "What does the author want you to infer?" or "Does the evidence strongly support the conclusion?"

Q2. "Provide alternative explanations."

Q3. "What additional information would you need to draw a conclusion?"

Critical Thinking Scenario Example



Wakefield AJ. *Lancet* 1999;354:949-50

1.What does the author of the graph want you to infer? Does the data strongly support the conclusion?

2.Give an alternate explanation for the data shown in the graph.

3.Suggest further data that you could gather to investigate the alternatives above.

Transferrable Critical Thinking Gains

	Skill Assessed by CAT Question	Max points	Pre Mean	Post Mean	Probability of difference[a]	Effect size[b]
Q1	Summarize the pattern of results without making inappropriate inferences.	1	0.71	1.00	*	+.86
Q2	Evaluate how strongly correlational-type data supports a hypothesis.	3	1.83	2.36		
Q3	Provide alternative explanations for a pattern of results that has many possible causes.	3	1.36	1.67		
Q4	Identify additional information needed to evaluate a hypothesis.	4	1.57	1.79		
Q5	Evaluate whether spurious information strongly supports a hypothesis.	1	0.93	0.93		
Q6	Provide alternative explanations for spurious associations.	3	1.93	2.36	*	+.69
Q7	Identify additional information needed to evaluate a hypothesis.	2	0.50	0.43		
Q8	Determine whether an invited inference is supported by specific information.	1	0.86	0.93		
Q9	Provide relevant alternative interpretations for a specific set of results.	2	1.07	1.29		
Q10	Separate relevant from irrelevant information when solving a real-world problem.	4	3.71	3.64		
Q11	Use and apply relevant information to evaluate a problem.	2	1.00	1.07		
Q12	Use basic mathematical skills to help solve a real-world problem.	1	0.86	1.00		
Q13	Identify suitable solutions for a real-world problem using relevant information.	3	2.14	2.29		
Q14	Identify and explain the best solution for a real-world problem using relevant information.	5	3.57	3.64		
Q15	Explain how changes in a real-world problem situation might affect the solution.	3	1.29	1.64		
	CAT Total Score	**39**	**23.33**	**26.02**	*	**+.67**

Table 1. Mean scores on pre-/post- Critical Thinking Assessment test. N=14
a. * p<.05 **p<.01 ***p<.001 (2 –tailed)
b. Mean difference divided by pooled group standard deviation. (0.1 - 0.3 = small effect; 0.3 - 0.5 = moderate effect; >0.5 = large effect)

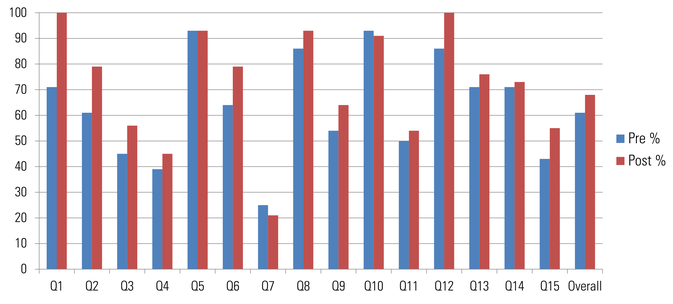


Figure 2. Critical Thinking Assessment test pre- and post- scores by question as percentages of total points. N=14

CAT Questions Mapped to Outcomes

Student Learning Outcome	CAT Question #
A. Students will recognize inappropriate inferences and will question overstated conclusions in the works of others.	2, *5*, 8
B. Students will avoid making inappropriate inferences from data.	1*, 2, *5*
C. Students will provide multiple explanations/interpretations of data.	3, 6*, 9
D. Students will determine ways to assess the best explanation or interpretation of data.	4, *7*

Table 2. Student Learning Outcomes mapped to CAT items 1-9. * indicates questions with statistically significant increases, *italicized* question numbers (5 and 7) indicate items with no observed increase.

Compared to Other High-impact Experiences

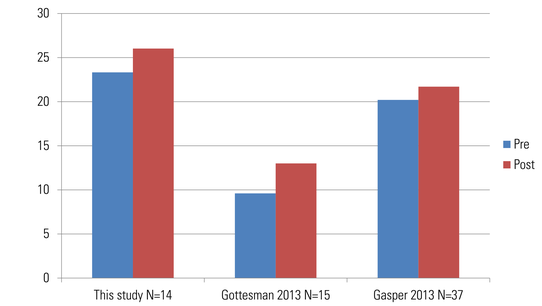


Figure 3. Comparison of gains in critical thinking skills between this course and other high-impact courses

Discipline-specific Gains

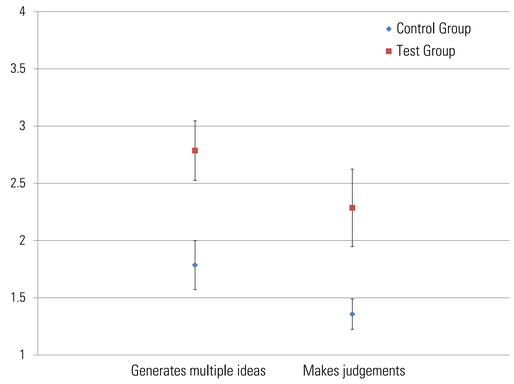


Figure 4. Mean rubric scores with standard error of control group versus test group. N=14 for both groups. p= 0.0064 and p= 0.016 (2 –tailed) for each question respectively.

References

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in Critical and Creative Thinking