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

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Abstract
THINK is a new initiative at NC State University focused on enhancing students' higher-order cognitive skills. As part of this initiative, we emphasized critical and creative thinking in an existing biotechnology-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 setting scenarios, as well as several specific scenarios created for the described course. I also present three intertwined aspects of the scenarios in review of the primary literature enrich the activity: 1) assessment using critical thinking skills using a pre- and post-test model of the Critical Thinking Assessment Test (CAT), developed by Tennessee Technological University (NSF funding) followed by post-tests given in small groups. Results were then compared and/or self-assessment and self-assessment of the students who were not involved 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 science disciplines in the social sciences and humanities.

Transferrable Critical Thinking Gains

<table>
<thead>
<tr>
<th>Skill Assessed by CAT Question</th>
<th>Max points</th>
<th>Pre Mean</th>
<th>Post Mean</th>
<th>Probability of differences*</th>
<th>Effect sizeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Evaluate whether data supports a hypothesis.</td>
<td>2</td>
<td>0.71</td>
<td>1.06</td>
<td>*</td>
<td>+0.8</td>
</tr>
<tr>
<td>Q2. Avoid making inappropriate inferences from data.</td>
<td>3</td>
<td>1.83</td>
<td>2.16</td>
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<tr>
<td>Q3. Provide alternative explanations for spurious associations.</td>
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<td>1.36</td>
<td>1.67</td>
<td></td>
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<tr>
<td>Q4. Avoid making inappropriate inferences to evaluate a hypothesis.</td>
<td>1</td>
<td>0.80</td>
<td>0.50</td>
<td></td>
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<td>Q5. Provide alternative explanations for spurious associations.</td>
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Student Learning Objectives
A. Students will recognize inappropriate inferences and will question overstated conclusions in the words 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).

Critical-thinking Scenario Structure

Lay out scenario, provide image, or present data.
G1. “What does the author want you to infer?” Provide an example.
G2. “Provide alternative explanations.”
G3. “What additional information would you need to draw a conclusion?”

Critical Thinking Scenario Example

1. What does the work 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 alternative above.

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References

Acknowledgements

Bayer CropScience BioCare Center provided financial support for this course. Tennessee State University provided a training workshop for designing discipline-specific, real-world scenarios. (https://www.itttech.edu/cat/training/)