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Empirically Supported Strategies for Encouraging Critical Thinking

Sarah D. McCrackin

The University of Waterloo, sdmccrac@uwaterloo.ca

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ABSTRACT

Critical thinking is the ability to construct and evaluate arguments (Facione, 1990). Teaching students to think critically is undeniably one of the most important goals of university education. Accordingly, much of the teaching literature provides suggestions for improving critical thinking among students. Unfortunately, many of these papers contain anecdotal evidence, relying heavily on personal testimony without the support of empirical data and statistical analysis (Abrami et al., 2008; Behar-Horenstein & Niu, 2011). These findings have important implications for instructors who try to foster critical thinking in their classrooms. The present workshop addresses this problem by discussing the following three teaching techniques which have been empirically tested and found to reliably improve critical thinking across multiple investigations: (a) the use of higher-order questioning (Barnett & Francis, 2012; Fenesi, Sana, & Kim, 2014; Renaud & Murray, 2007; Renaud & Murray, 2008; Smith, 1977; Williams, Oliver, & Stockdale, 2004); (b) peer-to-peer interaction (Abrami et al., 2008; Smith, 1997); and (c) explicit critical thinking instruction (Abrami et al., 2008; Bangert-Drowns, & Bankert, 1990; Behar-Horenstein et al., 2010; Tiruneh et al., 2016).

This workshop is intended for members of all disciplines seeking to work together to develop an empirically supported framework for teaching critical thinking at the university level.

KEYWORDS

critical thinking; higher education; explicit instruction; higher-order questioning; peer-to-peer interaction

LEARNING OUTCOMES

By the end of this workshop, participants will be able to:

- Describe what critical thinking means for their disciplinary context and classroom.
- Appraise pre-existing literature on fostering critical thinking.
- Implement three empirically supported techniques for improving critical thinking.

ANNOTATED BIBLIOGRAPHY

Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Surkes, M. A., Tamim, R., & Zhang, D. (2008). Instructional interventions affecting critical thinking skills and dispositions: A stage 1 meta-analysis. *Review of Educational Research*, 78(4), 1102-1134.
<https://dx.doi.org/10.3102/0034654308326084>

The authors began by searching the literature for papers describing critical thinking interventions and found 3270. Then they narrowed down this list to include only papers which 1) used an intervention lasting longer than 3 hours and 2) performed statistical analysis to show that students' critical thinking abilities had actually improved. With these two criteria, they were only left with 117 studies, and these studies typically used weak research designs. The findings from this part of the paper are used in the workshop to demonstrate that there is a need for empirically supported studies on critical thinking, and a need to appraise the pre-existing critical thinking literature carefully. The second part of the paper describes a meta-

analysis investigating how effective the interventions in the 117 papers were. Collaboration among students was found to convey a critical thinking advantage, so this part of the paper is used in the workshop to provide support for the idea that peer-to-peer interaction can improve critical thinking. Critical thinking intervention type was also examined, including general (critical thinking skills are the explicit course objective), infusion (critical thinking skills are imbedded into course content and stated as a course objective), immersion (critical thinking is regarded as a by-product of instruction) and mixed (critical thinking is taught as an independent track in the course) designs. The mixed method produced the largest critical thinking improvements, with moderate improvements following general and infusion approaches, and the smallest improvements following the immersion method. This part of the paper provides evidence suggesting that the mixed method produces the largest critical thinking gains, and that critical thinking should be explicitly taught.

Bangert-Drowns, R. L., & Bankert, E. (1990, April). *Meta-analysis of effects of explicit instruction for critical thinking*. Boston, MA: Annual Meeting of the American Educational Research Association, April 16-20, 1990. (ERIC No. ED328614).

The authors performed a meta-analysis of 20 studies that compared classes designed explicitly to teach critical thinking compared to those that were not. They found that explicit instruction was better at improving critical thinking skills, so this paper supports the use of explicit critical thinking instruction in the workshop. Furthermore, while the length of treatment did not seem to have an effect, studies providing intensive critical thinking training were more effective than those providing periodic critical thinking training.

Behar-Horenstein, L. S., & Niu, L. (2011). Teaching critical thinking skills in higher education: A review of the literature. *Journal of College Teaching and Learning*, 8(2), 25-42.
<https://dx.doi.org/10.19030/tlc.v8i2.3554>

The authors perform a meta-analysis of studies that attempts to quantify changes in critical thinking in response to various types of instruction. This paper does an excellent job of grouping the studies by experimental design, pointing out that only 3 of the 42 studies used a proper experimental design. They demonstrate that the weaker study designs are more likely to report increases in critical thinking, which suggests that many critical thinking studies may be subject to experimental design issues leading to false results. This part of the paper is used at the start of the workshop to emphasize the need for empirically supported studies with strong research designs, and to help participants appraise the current critical thinking literature. The authors also investigated whether certain instructional approaches led to critical thinking growth more than the others. They found that immersion instruction led to a lower percentage of significant critical thinking improvements than infusion, programmatic, and general approaches. This finding is used in the workshop as support for the idea that critical thinking should be explicitly taught.

Renaud, R. D., & Murray, H. G. (2007). The validity of higher-order questions as a process indicator of educational quality. *Research in Higher Education*, 48(3), 319-351. <https://dx.doi.org/10.1007/s11162-006-9028-1>

The authors completed three studies investigating the effect of higher-order questioning on critical thinking. In study 1, students in three different educational psychology classes performed better on test questions if they had previously answered higher-order questions about the content instead of lower-order questions. In study 2, participants were split into two groups and given either higher-order or lower-order review questions before being tested on course content. Their pre and post general critical thinking ability was measured by the Watson-Glaset Critical Thinking Appraisal (WCGTA). Participants performed better on the test if they had completed the higher-order questions than if they had completed the lower-order questions, though there was no effect of these questions on the general WCGTA scores. The last study demonstrated that the more higher-order questions used in assignments and tests across many different courses and disciplines, the larger the average gain in critical thinking between the start and the end of the term (measured by the Watson-Glaset Critical Thinking Appraisal). This paper is used in the workshop to demonstrate that asking students to answer higher-order questions about course content promotes critical thinking.

Smith, D. G. (1977). College classroom interactions and critical thinking. *Journal of Educational Psychology*, 69(2), 180-190. <https://dx.doi.org/10.1037/0022-0663.69.2.180>

The authors investigated what classroom behaviours were associated with increased critical thinking in 12 undergraduate classes. Classes were taped and then coded for instances of 1) professor encouragement 2) frequency and degree of professor questioning, 3) frequency and degree of student participation, and 4) peer-to-peer interaction. Critical thinking was measured using the Watson-Glaser Critical Thinking Appraisal (measured at the start and end of the term; Gadzella et al., 2006) and self-reported critical thinking behavior as measured by Chickering (1972; measured only at the end of the term). The authors found that increases in critical thinking were significantly related to student participation, convergent and evaluative student responses, divergent and evaluative questions, encouragement, and peer-to-peer interaction. This paper is used in the workshop to support the use of higher-order questioning and peer-to-peer interaction as tools to improve critical thinking.

ADDITIONAL REFERENCES

Defining Critical Thinking

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Examples of Domain-Specific Critical Thinking Measurements

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Using Higher-Order Questions to Improve Critical Thinking

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WORKSHOP CONTENT AND ORGANIZATION

DURATION (min)	SUBJECT	ACTIVITY	PURPOSE
10	Introduction	<p>Participation: Introduce yourself as the facilitator. Then ask participants to introduce themselves, their discipline and the reason for their interest in the workshop.</p> <p>Lecture: Explain the learning objectives of the workshop, as well as give a brief overview.</p>	To familiarize the participants with the facilitator, each other, and the learning goals.
10	Defining Critical Thinking	<p>Lecture: Explain that critical thinking can be affected by an individual's inherent characteristics, development, and behaviours and abilities (Halonen, 1995). We can define what behaviours and abilities will make our students good critical thinkers.</p>	To gauge knowledge of the area and to develop a working definition of critical thinking.

		<p>Participation: Ask the participants to turn to the person beside them, and discuss which behaviours and abilities they think make up critical thinking. Write key terms from participants on the whiteboard for future reference.</p> <p>Lecture: Reveal the definitions given in previous research (see Facione, 1990 for a detailed list of critical thinking behaviours and abilities).</p> <p>Discuss how Bloom's taxonomy defines higher-order thinking (Anderson et al., 2001). Add any new points to the whiteboard.</p>	
15	Critical Thinking Assessment	<p>Participation: Ask the group how they would measure critical thinking and what kinds of assessments they think are commonly used in papers on critical thinking.</p> <p>Activity: Ask participants to pair up and look at the two examples of critical thinking tests found in their handout (see Appendix) and discuss how they are similar and how they are different (Tiruneh et al., 2017; Facione, 1991). After a few minutes, take up the answers with the group.</p> <p>Lecture: Briefly discuss how critical thinking is usually measured in the literature, discussing domain-specific (e.g. Tiruneh et al., 2017; Lawson, 1999) and domain-general (e.g. Gadzella et al., 2006; Ennis & Millman, 1971; Facione, 1991) measurements.</p>	<p>To familiarize participants with the tools used to measure critical thinking, and get them thinking about how they would assess critical thinking.</p> <p>To understand that how critical thinking is measured greatly impacts how we should appraise critical thinking literature.</p>

15	Establishing the Need for Empirical Data	<p>Lecture: Point out that many papers suggest strategies for teaching critical thinking based on anecdotal evidence (Abrami et al., 2008; Behar-Horenstien & Niu, 2011), meaning that they are overly reliant on personal testimony as evidence or their collection method is informal. Many of these papers do not have any empirical evidence to support the effectiveness of these strategies.</p>	To emphasize the importance of empirically supported teaching methods, and to allow for better appraisal of critical thinking literature. This is also a critical thinking exercise in itself.
20	Strategy #1: Explicit Instruction	<p>Lecture: Ask participants to think of a specific course (either one they are teaching or have taken themselves). Discuss different approaches to critical thinking instruction, defining the General, Immersion, Infusion, and Mixed approaches (defined by Ennis, 1989). After each definition, ask participants to put their hand up if they believe that the definition would fit for the course they are thinking of.</p> <p>Participation: Review which critical thinking approaches seem to be most common based on when participants put up their hand.</p> <p>Lecture: Present evidence showing that while the Immersion approach is the most common (Behar-Horenstein & Niu, 2011), approaches which use explicit critical thinking instruction are more effective (Abrami et al., 2008; Bensley et al., 2010; Tiruneh et al., 2016). With any luck, the distribution of how often each type of intervention is reported in the literature will roughly match the distribution reported in the group.</p> <p>Activity: Ask participants what they believe the pros and cons to each instructional approach are, and how</p>	To encourage participants to think about how they might structure their critical thinking content to be most effective.

		they might address the cons in their own classroom.	
20	Strategy #2: Using Higher- Order Questioning	<p>Lecture: Present data suggesting that the use of higher-order questioning promotes critical thinking (Renaud & Murray, 2007; Renaud & Murray, 2008; Williams, Oliver, & Stockdale, 2004; Smith, 1977; Fenesi, Sana, & Kim, 2014; Barnett & Francis, 2012).</p> <p>Activity: Ask participants to form groups of 4-5. Then ask them to look at the example higher and lower-order questions in the handout (see Appendix), and discuss what distinguishes the two. Take up with the whole group.</p> <p>Activity: Have each group choose a sample lower-order question related to their discipline from the handout (see Appendix). Have them work together to make a higher-order question which tests the same content. Take up some examples with the whole group.</p>	<p>To get participants thinking about how they can use higher-order questioning in their classroom, and to understand what distinguishes a higher-order and lower-order question.</p> <p>To give participants some practice writing higher-order questions related to their discipline.</p>
20	Strategy #3: Peer-to-peer Interaction	<p>Lecture: Present findings suggesting that interaction between students can foster critical thinking (Abrami et al., 2008; Smith, 1997). Emphasize that the literature has not yet systematically studied which peer-to-peer teaching methods are most effective.</p> <p>Participation: Have participants discuss in their groups which teaching methods promoting peer-to-peer interaction they think would be most successful for promoting critical thinking in their own classroom. Take up some examples with the group.</p> <p>Activity: Ask participants to discuss in their smaller groups how to</p>	<p>To get participants thinking about which types of peer interaction might be the most effective at promoting critical thinking.</p> <p>To give participants a chance to exchange ideas about using interaction between students in their own classroom.</p>

		incorporate these peer-to-peer interactions in their own classroom. Take up some examples with the whole group.	
10	Conclusion/ Questions	Lecture: Summarize the take-home message from the workshop and allow participants to ask questions or provide any insight they might have.	To give participants a final overview of the important points brought up in the workshop, and to answer any questions they might have.
Total Time: 120 minutes			

PRESENTATION STRATEGIES

This workshop is designed for 20-30 participants per session. Ideally, participants should be seated at tables in groups of 4 or 6 (even numbers for pairing exercises). If the room is a lecture hall without tables, participants can sit in clusters of 4 or 6.

The facilitator is advised to bring/have access to:

- Copies of the handout for each participant (Appendix).
- A whiteboard for writing down participant generated ideas.
- A PowerPoint slide deck for lecture components. Suggestions are provided below in italics.

Defining Critical Thinking

PowerPoint Slide Suggestion: 1) Present key phrases from Facione (1990) describing critical thinking behaviours and abilities. 2) Present an image representing the levels of Bloom's taxonomy and the skills with which they are associated.

Critical Thinking Assessment

The differences that participants notice between the sample domain-general and domain-specific questions should allow for an easy transition into talking about these two main question types. Domain-specific measurements test critical thinking in the domain of study, and these can be unstandardized (e.g. course questions) or standardized (see examples in the Additional References section). Domain general measurements test for general critical thinking skills, which students can apply to any domain.

PowerPoint Slide Suggestion: Share the definitions of Domain-specific and Domain-general measurements. Under each definition, list some examples.

Establishing the Need for Empirically Supported Data

The findings from Abrami et al. (2008) and Behar-Horenstien & Nui (2011) can be used to emphasize that few papers actually measure critical thinking improvements and use statistics to show that critical thinking has improved. Furthermore, the number of papers with strong research designs is even lower. This is concerning because Behar-Horenstien & Nui (2011) found that critical thinking studies with weaker designs were statistically more likely to report significant critical thinking improvements, which means that many papers might be reporting false improvements due to poor study designs.

PowerPoint Slide Suggestion: 1) The inclusion criteria for these two meta-analyses can be listed and the number of studies that did not meet the criteria can be emphasized. 2) Pie graphs demonstrating how many of studies were pre-experimental, quasi-experimental and true experiments can be shown to visually display the breakdown of research designs. This data can be found in the original papers. 3) The Behar-Horenstien & Nui (2011) paper contains a figure showing the proportion of significant and non-significant effects found for each type of research design. This is a great graphical depiction of the fact that weaker study designs were more likely to find significant results.

Strategy #1: Explicit Instruction

The facilitator can ask if anyone has any questions about the distinction between the different interventions types discussed by Ennis (1990), because the distinctions are subtle.

PowerPoint Slide Suggestion: 1) A definition of each approach can be shown. 2) Behar-Horenstein & Nui (2011) have a figure showing the distribution of approaches used in the literature. 3) Present the take home message about which approaches result in the biggest critical thinking gains. Perhaps showing: "Mixed Approach > General and Infusion Approaches > Immersion Approach", with an added point that the largest critical thinking improvements are seen when the instructor intervention involves explicit critical thinking training.

Strategy #2: Higher-order Questioning

The facilitator can supplement participants' answers with examples of how higher-order questioning has been defined in the literature. For example, Renaud and Murray (2007) state that lower-order questions simply elicit answers directly from the text or lecture, while higher-order questions require answers that cannot simply be recalled. Similarly, Smith (1997) stresses that questions which require a memorized answer are lower-order questions compared to those which require evaluation or imagination.

Strategy #3: Peer-to-Peer Interaction

Make sure to note that neither the Abrami et al. (2008), nor the Smith (1997) papers attempted to investigate which peer-to-peer activates promote critical thinking the most, and this is an area that needs to be addressed further in the literature.

PowerPoint Slide Suggestion: Show some examples of peer-to-peer interaction included in the two meta-analyses.

APPENDIX A: Handout

Empirically Supported Strategies for Encouraging Critical Thinking

Defining Critical Thinking

Critical thinking can be defined in terms of behaviours and abilities. **Some critical thinking behaviours and abilities are:**

Measuring Critical Thinking

Activity: Examples of Critical thinking tests

Example 1: Inspired by questions on the CTEM assessment (Tiruneh, et al., 2017):

Kara is performing an experiment. She uses a wire to create a positively charged piece of metal. Then she brings the piece close to a metal can, and finds that the can is attracted to it.

Kara is surprised with the results, because she expected the can to remain at rest. Specifically, she expected that the negative charge of the metal piece's electrons would cancel out the positive charge she added, such that the metal piece should exert no effect on the can.

Can you make Kara's argument fit with the results of the experiment? Describe all the possible explanations you can identify. .

Example 2: Inspired by questions on the CCTT assessment (Facione, 1991)

If you are aware that:

The peach pit is inside of the box.

The peach is inside the box.

Is it true that the peach pit is inside the peach?

What are some of the key similarities and differences between the two examples?

Domain-specific critical thinking assessments measure critical thinking in the domain of study. Some examples include:

Domain-general critical thinking assessments measure critical thinking by using tests that do not require any domain-specific knowledge. Some examples include:

The Need for Empirically Supported Studies

Teaching students to think critically is undeniably one of the most important goals of university education. Unfortunately, many of the papers suggesting strategies to improve critical thinking contain anecdotal evidence, relying heavily on personal testimony without the support of empirical data and statistical analysis showing that the suggested methods are effective (Abrami et al., 2008; Behar-Horenstein & Niu, 2011).

- A recent meta-analysis indicated that out of 3720 papers on improving critical thinking, only 161 attempted to demonstrate that their classroom interventions had a statistically significant effect on students' critical thinking abilities (Abrami et al., 2008).
- Many of the papers which have performed statistical analyses have weak study methods.
- Of the 161 cited by Abrami et al. (2008), only 27 were true experiments. Another recent meta-analysis found that out of 42 papers linking instructor interventions to critical thinking improvements, only 3 used a proper experimental design, and weaker study designs were statistically more likely to report increases in critical thinking as a result of the instructor interventions (Behar-Horenstein & Niu, 2011).

Types of Critical Thinking Instruction (defined by Ennis, 1989) and Strategy #1 – Explicit Instruction

General Approach: Critical thinking is taught independently from the rest of the course content. This may be a separate track within a course, or an entire course on critical thinking.

Infusion Approach: Critical thinking is infused into pre-existing subject matter. Critical thinking instruction is taught explicitly in relation to the subject matter to encourage students to think critically about the content.

Immersion Approach: Students are equally as immersed in the subject matter as in the Infusion approach, but critical thinking is never made an explicit goal. Instead, critical thinking is expected to result from immersion with the course material.

Mixed Approach: A combination of the General approach and either the Immersion or Infusion approaches

The literature suggests that how critical thinking skills are integrated into the course is important. Several groups have demonstrated that assuming course subject matter will guide critical thinking implicitly appears to be flawed; the largest critical thinking improvements occur when critical thinking is explicitly taught (Bensley, et al., 2010; Abrami et al., 2008; Tiruneh et al., 2016; Bangert-Drowns & Bankert, 1990; Behar-Horenstein & Nui, 2011). The Mixed approach produces the largest critical thinking improvements, with moderate improvements resulting from the General and Infusion approaches, and the smallest improvements from the Immersion approach.

What are some pros and cons to explicitly teaching critical thinking within your own classroom? How might you address the cons?

Strategy # 2 – Higher-order Questions

The most empirically supported technique to improve critical thinking is the use of higher-order questioning. Multiple experiments have found that students demonstrate improvements in critical thinking (Renaud & Murray, 2007; Renaud & Murray, 2008; Williams, Oliver, & Stockdale, 2004; Smith, 1977) and perform better on test questions (Fenesi, Sana, & Kim, 2014; Renaud & Murray, 2007; Renaud & Murray, 2008; Barnett & Francis, 2012; Williams, Oliver, & Stockdale, 2004) when they have previously answered higher-order questions about the material.

Activity: Examples of lower-order and higher-order questioning (inspired by the questions used by Williams, Oliver, & Stockdale, 2004):

Example of a Lower-order question:

What claim would a doctor be most likely to make regarding the use of Ritalin to treat ADHD?

- a) Children with ADHD are not given Ritalin anymore.
- b) Most children with ADHD respond very well to Ritalin.
- c) Ritalin is an effective treatment in most cases.
- d) In small doses, Ritalin can calm a child, but it is unlikely to help the child focus.

Example of a Higher-order question:

A doctor who has strong faith in the use of Ritalin to treat children with ADHD called the parents of children who had been given Ritalin. The doctor asked them, "Haven't you seen some great improvement in your child after they began taking Ritalin?" Almost all parents said that they had.

What would you conclude based on the results of this study?

- a) Parents feel better after their children with ADHD are given Ritalin
- b) The answers that parents gave are direct support for Ritalin being effective.
- c) The question asked to parents was a fair assessment of their beliefs.
- d) None of the above.

How do the higher-order and lower-order questions differ?

Activity: Sample lower-order questions to convert to higher-order questions**Example A:**

Vegetables and fruits are good sources of

- a) antioxidants
- b) unsaturated fats
- c) free radicals
- d) saturated fats

Example B:

What does it mean if two variables have a correlation of $r = .78$?

- a) They have a strong and positive relationship.
- b) They have a moderate and negative relationship.
- c) They have a weak and positive relationship.
- d) They have a strong and negative relationship.

Write your higher-order version of one of the sample questions below:

Strategy # 3 – Peer-to-Peer Interaction

In their meta-analysis, Abrami et al. (2008) found that collaboration among students was associated with significant critical thinking improvements. Similarly, Smith (1997) found that within a sample of 12 classrooms, increases in peer-to-peer interaction were associated with increases in critical thinking ability.

Write down your ideas for using peer-to-peer interaction to foster critical thinking below. Are there any challenges you might face using these techniques? How might they be overcome?

References for More Information (Handout)

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