Teaching Innovation Projects

Volume 6 | Issue 1 Article 3

2016

Critical Thinking in the Information Age: Helping Students Find and Evaluate Scientific Information

S. Amanda Ali
University of Western Ontario, s.amanda.ali@gmail.com

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Summary

Convenient access to information is now commonplace with portable internet-capable devices like laptops, tablets, and cell phones. The revolution continues as smart technologies like internet-capable wristwatches meet the market. The result is an abundance of information, available at any time with the click of a button or tap of a screen. When a question arises, the default reaction is to "Google it," rather than attempt to recall an answer, solve the problem, or find information from any other source. While this is a valuable way of accessing information, students should be cautioned against accepting the information at face value, and encouraged to evaluate that information for accuracy, validity, bias, and so on (Weiler, 2004). At a time when critical thinking skills are more necessary than ever, these skills are not being explicitly developed. The convention of teaching large classes in the sciences usually leads to information being received passively, without much room for questioning or challenging the content. Science students are given content rather than the tools for seeking and evaluating scientific information themselves (Pithers & Soden, 2000). Given the continuously evolving nature of scientific theory and the abundance of information available on the Internet, instructors must equip students with tools for finding and analyzing information; these tools can be applied to both classroom and life-long learning. This workshop provides instructors with strategies for active learning that promote development of critical thinking skills in students.

Keywords

information seeking, active learning, critical thinking

Critical Thinking in the Information Age: Helping Students Find and Evaluate Scientific Information

S. Amanda Ali, Western University

"Biology is a way of knowing, rather than just a static body of knowledge."
Allen & Tanner, 2005

SUMMARY

Convenient access to information is now commonplace with portable internet-capable devices like laptops, tablets, and cell phones. The revolution continues as smart technologies like internet-capable wristwatches meet the market. The result is an abundance of information, available at any time with the click of a button or tap of a screen. When a question arises, the default reaction is to "Google it," rather than attempt to recall an answer, solve the problem, or find information from any other source. While this is a valuable way of accessing information, students should be cautioned against accepting the information at face value, and encouraged to evaluate that information for accuracy, validity, bias, and so on (Weiler, 2004). At a time when critical thinking skills are more necessary than ever, these skills are not being explicitly developed. The convention of teaching large classes in the sciences usually leads to information being received passively, without much room for questioning or challenging the content. Science students are given content rather than the tools for seeking and evaluating scientific information themselves (Pithers & Soden, 2000). Given the continuously evolving nature of scientific theory and the abundance of information available on the Internet, instructors must equip students with tools for finding and analyzing information; these tools can be applied to both classroom and life-long learning. This workshop provides instructors with strategies for active learning that promote development of critical thinking skills in students.

KEYWORDS: information seeking, active learning, critical thinking

LEARNING OUTCOMES

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

- identify common sources for scientific information, as accessed by students;
- apply commonly used criteria for evaluating scientific information; and
- implement active learning strategies in large science classrooms to promote development of students' critical thinking skills.

REFERENCE SUMMARIES

Allen, D., & Tanner, K. (2005). Infusing active learning into the large-enrollment biology class: Seven strategies, from the simple to complex. *Cell Biology Education*,*4*, 262-268.

In this article, the authors provide seven active learning strategies that can be applied to large classrooms. Ranging in complexity, these strategies include questions that focus student discussion, classroom technology for on-the-spot feedback, student presentations and projects, learning-cycle models, peer-led team learning, modeling inquiry approaches, and problem-based learning (case studies). An overview of these strategies will be presented during a lecture portion of the workshop, following from the point that active learning promotes critical thinking (Weiler, 2004). This article debunks the common myth that active learning activities can only be performed with smaller class sizes. Several active learning strategies will be used to deliver content throughout the workshop, and participants will be notified of these 'meta-teaching' moments to take note of how active learning activities can be successfully implemented.

Pithers, R. T., & Soden, R. (2000). Critical thinking in education: A review. *Educational Research*, *42*, 237-249.

In this article, Pithers and Soden review the literature to identify practices that inhibit and promote students' critical thinking skills, and they provide ways forward for strengthening these skills through teaching. The authors refer to the work of Sternberg (1987) who listed eight obstructions to the teaching and learning of 'generic critical thinking.' These eight factors will be discussed during the workshop to provide instructors with guiding principles for what to avoid and what to promote in the classroom in order to facilitate development of students' critical thinking skills. A unique perspective offered by this paper puts the onus on the instructor to facilitate development of critical thinking skills, rather than evaluating students' pre-existing critical thinking capabilities. Problem-based learning is suggested as a powerful resource for promoting critical thinking; this is consistent with the notion that active learning strategies facilitate critical thinking. This theme will emerge through discussion of Sternberg's list.

Sternberg, R. J. (1987). Teaching critical thinking: eight ways to fail before you begin. *Phi Delta Kappan*, *68*, 456-459.

In this article, the author describes common practices of instructors that inhibit critical thinking by students. He contends that eight 'teacher fallacies' prevent both the teaching and learning of critical thinking skills. Sternberg describes instructors who believe: that they have nothing to learn from students, that they must think out the responses and present answers seamlessly, that there is one right way or only binary choices for developing a critical thinking program, that what really is important is the 'right' answer, that discussion is a means to an end, that there is an upper limit to good thinking, and that critical thinking must be explicitly taught. In this workshop, Sternberg's eight obstructions are used in a modified jigsaw activity to demonstrate an active learning strategy. It serves the additional purpose of inviting participants to reflect on whether they are 'guilty' of the obstructions in their own classrooms.

Sutherland, W. J., Spiegelhalter, D., & Burgman, M. A. (2013). Twenty tips for interpreting scientific claims. *Nature*, *503*, 335-337.

In this article, the authors provide twenty pragmatic ways in which scientific evidence can be evaluated. Developed for the purpose of bridging the gap between scientists and policy-makers, these tips can be used by any layperson who is attempting to navigate scientific literature. This is well suited to undergraduate students who, like policy-makers, are capable but unfamiliar with the criteria that are applied in evaluating scientific claims. The topic of this paper makes a strong statement in support of the pedagogical perspective of this workshop; given the right tools (in this case, a list of evaluative criteria), anyone is capable of identifying strengths and weaknesses in information. While this article presents criteria for the purposes of interpreting science, the tips can also be applied to interpreting information from other disciplines. The list provided in this article will be used to create a handout for the workshop. The handout will include the tips as stated by the authors, and also a translation of how the tips can be posed as questions to evaluate information.

Weiler, A. (2004). Information-seeking behavior in Generation Y students: Motivation, critical thinking, and learning theory. *The Journal of Academic Librarianship*, *31*, 46-53.

In this article, Weiler reviews the challenges encountered by Generation Y (born between 1980 and 1994) in developing research skills at the college level. Framed in the context of inadequate critical thinking skills, the author explores motivation theory and learning theory to understand why Generation Y students rely so heavily on television and internet rather than books and other literature as sources of information. This article provides a summary of both quantitative and qualitative information-seeking research, which makes it a useful introductory resource for instructors who are interested in, first, understanding and, second, guiding student information-seeking behaviours. The take-home message for science instructors is that active learning strategies promote critical thinking, and that students must learn critical thinking skills by applying them. During the workshop, this paper will be referenced for providing justification for finding ways to incorporate active learning strategies in classes, despite the larger sizes in the sciences.

CONTENT AND ORGANIZATION

Duration (min)	Subject	Activity	Purpose
5	Introduction	Lecture: The instructor provides an overview of the workshop purpose (including a schedule for the 90 minutes), rationale, and learning outcomes.	Convey what participants will learn by the end of the workshop and share the agenda.
	Icebreaker	Participants will be asked to state in one sentence their name, discipline, and one source from which they get their scientific information (scrap paper for notes provided; the same source can only be stated three times among a group of 30 participants).	Increase participant comfort in the group setting. By stating one source of information, participants start to discuss information-seeking.
10	Sources of Scientific Information	Brainstorm: The instructor makes a list (chalkboard) of sources of scientific information that resulted from the icebreaker activity. The instructor asks the participants to rank the sources by the reliability (definition given by the instructor) of the information provided (instructor points to one source and asks for a show of hands if that source is thought to be the first most reliable etc.) Complete list (slide deck) of ranked sources is revealed after this activity.	Gain an appreciation for the variety of sources that are available for seeking information, and apply critical thinking through the process of ranking sources. Use the activity as a “meta-teaching moment” which demonstrates an active learning strategy that teaches critical thinking explicitly through reliability ranking.
5	Incorporating Active Learning Strategies in Large Classrooms	Lecture: The instructor will summarize the key concepts from Weiler (2004) to provide participants with an understanding of students’ information-seeking behaviour. This culminates in justification for using active learning strategies to develop critical thinking. The literature	Understand student information-seeking behaviour and the need to develop strong critical thinking skills in order to evaluate the information they access successfully.

		supports use of active learning strategies and problem-based learning to develop critical thinking (Pithers & Soden, 2000). A list of strategies that are amenable to large classroom sizes will be provided (from Allen and Tanner, 2005).	Identify good active learning strategies that can be incorporated in larger science classes.
25	Teaching Critical Thinking	Group work: Instructor divides participants into 8 groups and assigns each group one of Sternberg's (1987) obstructions to teaching and learning critical thinking. Groups have 5 minutes to discuss how the obstruction relates to their teaching practices: 1) how do they currently promote or hinder development of critical thinking? and 2) how can they improve going forward? One person from each group explains their assigned obstruction and answers to the two questions with the class (approximately 2 minutes per group = 15 minutes).	Learn eight challenges in teaching and learning critical thinking, while relating them to their own experience, and eight strategies for promoting the development of students' critical thinking skills. Use the modified jigsaw activity as a "meta-teaching moment" to demonstrate an active learning strategy that can be used in larger classes to meaningfully (incorporates reflection) cover high volumes of content.
5	Commonly Used Tools for Evaluating Scientific Information	Lecture: The instructor reviews commonly used discipline-specific criteria for evaluating scientific information. A list of criteria in question format (e.g. Is there bias?) is left on the screen to assist participants with the subsequent activity.	Gain a toolbox of ways in which scientific information from different sources can be evaluated. Participants will be able to convey these criteria to students in their classes, effectively providing them tools for critical thinking.
25	Practical Tips for Evaluating Scientific Information	Handout: Participants receive a handout with 20 tips for interpreting scientific claims from Sutherland et al. (2013), and a copy of the article for reference. (Appendix A. Sample Handout) Individually or in pairs, participants are assigned one tip and asked to translate it into a question that can be used to critically analyze information. After 5-10 minutes, each individual/pair shares their answer with the group, which is recorded on the handout for all 20 tips (or as many tips as time permits).	Create practical strategies for evaluating scientific information. These tips can be used to evaluate the critical thinking skills of students, based on their ability to apply the tips to scientific information. Use the think-pair-share activity as a "meta-teaching moment" to demonstrate its suitability and potential for adaptation in larger classes.
15	Summary/	Problem-based learning: Instructor	Apply critical thinking skills

	Questions	presents scientific information relating to evolution theory (instructors may choose to use a discipline-specific example) from three different sources (e.g. Wikipedia, a textbook chapter, and media/news). Participants evaluate the information provided by each source, identifying strengths and weaknesses as discussed throughout the workshop. The instructor emphasizes the take-home message: Active learning promotes critical thinking, which can improve information seeking. The final minutes of this section will be open for any questions.	developed in the previous activity to a real-world example. This serves as an informal assessment of whether those skills were acquired during the workshop. Problem-based learning is another example of active learning, and the group discussion can be used in larger classes. This is described to participants as the final meta-teaching moment for an active learning strategy.
Total Time: 90 minutes			

PRESENTATION STRATEGIES

"I hear and I forget, I see and I remember, I do and I understand." - Confucius

Active learning strategies are embedded throughout this workshop such that the instructor will teach by example (meta-teaching). See "Activity" and "Purpose" for a detailed description of strategies used, such as modified jigsaw, brainstorming, and group work. Emphasis is placed on adapting these strategies to larger classes, with consideration for resources required (e.g. a show of hands is used rather than an electronic clicker system).The instructor is encouraged to answer questions as they arise, and to stop periodically throughout the workshop to ask whether there are any questions from the audience.

The instructor is advised to prepare a slide deck (to be made available to participants at the end of the workshop) following the structure below. For a copy of the presentation slides, e-mail the author at s.amanda.ali@gmail.com

- 3 slides: workshop purpose (schedule for the 90 minutes), rationale, learning outcomes
- 2 slides: workshop schedule and icebreaker activity (e.g., in one sentence state your name, discipline, and one source for scientific information.)
- 2 slides: definition of "reliability", ranked list of sources for scientific information
- 3 slides: introduce Weiler (2004), active learning strategies, Allen and Tanner (2005)
- 1 slide: introduce Sternberg's (1987) obstructions to critical thinking. Ask "how they currently promote or hinder development of critical thinking in their classes, and how can they improve moving forward?"
- 1 slide: "List 3 criteria used to evaluate scientific information (from any source)" (displayed during activity)
- 1 slide: Introduce "Twenty tips for interpreting scientific claims, by Sutherland, W. J., Spiegelhalter, D., & Burgman, M. A. (2013) *Nature*, 503, 335-337" (displayed during activity)
- 1 slide: three facts related to evolution theory from each of Wikipedia, a textbook chapter, and media/news

- 1 slide: resources/works cited. E.g., Pithers, R. T., & Soden, R. (2000); Sutherland, W. J., Spiegelhalter, D., & Burgman, M. A. (2013); Weiler, A. (2004); Sternberg's (1987); Allen, D., & Tanner, K. (2005)
- 1 slide: "Questions?" and facilitator's contact information for follow-up questions

The instructor is advised to bring/have access to:

- Small sheets of scrap paper to be distributed, spare pens/pencils
- Sufficient copies of the handout, one for each person (Appendix A)
- Sufficient copies of the article Sutherland et al. (2013), one for each group
- A chalkboard or whiteboard to compile the participant-generated list of sources for scientific information

APPENDIX A: Sample Handout

Prepare a handout that lists each of the 20 tips described in Sutherland et al. (2013), leaving space beneath each tip for participants to write their answers.
http://www.nature.com/news/policy-twenty-tips-for-interpreting-scientific-claims-1.14183

Sample Handout:

Twenty tips for interpreting scientific claims
Sutherland, W. J., Spiegelhalter, D., & Burgman, M. A. (2013) *Nature*, 503, 335-337.

Instructions: Translate each tip into a question that you can use to analyze information critically.

1. Differences and chance cause variation.

____

2. No measurement is exact.

____

3. Bias is rife.

____

Example Answers:

1. Differences and chance cause variation.
What are possible alternative explanations for the differences presented in the study/information?

2. No measurement is exact.
Do the authors report the degree of error in the measurements?

3. Bias is rife.
Are there sources of bias in the information? (e.g. publication bias, researcher bias)