

Using the Case Study/Critical Reader (CSCR) Tool to Teach Students Key Aspects of Scientific Writing

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During the Independent Project (IP), a cornerstone of Introductory Biology 152, students conduct and communicate scientific research. Some work in labs on campus, others complete a meta-analysis of an open question in the literature. To address common student misconceptions about both forms of this project, we developed several activities using Case Study/Critical Reader (CSCR), a web-based authoring tool created at the UW-Madison. These activities focus on how to perform a strong analysis and effective literature research. Piloting these activities in Fall 2013, we were able to address diverse learning needs, provide individualized feedback, and even train our TAs more effectively.

Keywords: Meta-analysis, scientific writing, critical reading

Introduction

Laboratory Philosophy and Background

Scientific research and scientific writing go hand in hand, and the undergraduate introductory biology experience must include both aspects of this union. A guiding principle in the educational literature (AAAS 2011; NAS 2003, NSF 1989), this concept underlies the curriculum of Introductory Biology 152 at the University of Wisconsin-Madison, where providing experiences in research and scientific communication is a long-standing, on-going goal. Previous papers have detailed the three-week laboratory module that opens 152 and scaffolds the two tracks of the Independent Project (IP): individual mentored research in a professional lab and meta-analysis of published data (for the second option, students work in 2-3 person groups) (Heitz and Giffen 2010, Heitz 2012). The successful approach explained in these publications helped our students' improve in an array of abilities including:

- formulating research questions
- searching and reviewing the scientific literature
- extracting and analyzing data from published articles
- articulating scientific ideas in a professional format
- understanding what makes data comparable
- revising and editing effectively

Nonetheless, it was clear to us that our students struggled to understand key elements of the assignments, and that students' misconceptions about the project persisted well into the semester. This detracted from one of the IP's most important features, the formative reviews. The IP process involves

iterated formative reviews during which trained Teaching Assistants (TAs) offer specific feedback on each student's paper. This occurs twice before the final product is turned in and graded. The first step in this process requires students to complete a 2-4 page proposal detailing the research they will conduct in a professional research lab on campus (the mentored research track) or the open question in the literature they will address by extracting and analyzing data from published studies (the meta-analysis or "library" track). It was in reviewing these that it became evident that many students struggled to understand key elements of the IP. As a result, review comments on student proposals chiefly served to re-explain the assignment and students lost a valuable opportunity for a meaningful review experience. In effect, despite our intent that students receive two formative commentaries on their project, they only received one, having spent the first round of review on fundamental concept clarification.

Since the TAs were frequently baffled at student's persistent confusion in the face of what, to us, appeared to be clear-cut examples, we hypothesized that the problem lay with students' interaction with the course materials, not the materials themselves. In fact, students often remarked in retrospect that the early lab experiences were ultimately very helpful. Therefore, we decided to make our goal to facilitate deeper engagement and increased time-on-task with these materials. To do this, we developed four web-based modules using Case Scenario/Critical Reader (CSCR), an authoring tool developed at the UW-Madison. These modules were created to slow students down as they read project information, to provide a framework for examining examples in the

scientific literature, and to help students in both independent project tracks focus on pertinent information. CSCR supports decision branching and, as the name suggests, was designed to break information down into manageable, contextualized components. When the authors discovered the program at a campus innovations showcase, it seemed to be the perfect fit.

Overview of the Three-Week Lab and CSCR Modules

The first three weeks of Introductory Biology 152 laboratory have two main goals: one course-specific, the other focused on broader scientific literacy. By the end of these labs, all students should:

- be prepared to complete a proposal for their Independent Project. This includes forming a testable research question, posing hypotheses, and designing an effective methodology.
- be able to differentiate between primary research, meta-analyses, and literature reviews. This includes demonstrating competence in simple meta-analytical techniques during lab.

Therefore, while only roughly half of our students will compose a meta-analysis for their IP, all of our students are expected to master the concept and be able to identify this form of research in the scientific literature.

Several materials have already been developed to accomplish these goals, including our lab manual, *Experiencing Biology from Proposal to Presentation*, developed by Jean Heitz. Working through the lab manual and a published meta-analysis (Taubert et. al. 2007), students work on developing a research question during Week 1, analyzing scientific literature in Week 2, and effectively searching for literature in Week 3. For details, please see Heitz (2012) and Heitz and Giffen (2010).

After consultation with the CSCR support staff, it took a semester to develop pilot versions of four interactive modules:

- A guide to science writing and introduction to the IP, which students complete in lab during Week 1
- A meta-analysis walk-through and practice analysis assignment, which introduces students to the pre-lab for Week 2 and is completed out of lab
- A typology of research goals for each IP track and associated outlining activity, which is completed in-lab during Week 2
- A mock conference with a virtual reviewer, previewing later in-person meetings with TAs, which is completed out of lab before students submit their proposals

With these modules complete, preparation to teach the first three weeks of the semester now takes a standard two-hour meeting with TAs and roughly three hours outside class to review lab materials. The modules delve deeper into literature search, selection, and data extraction practices than previously, meaning that the level of difficulty of these activities is relatively high. In this regard, we have found the modules to be just as useful for training TAs in our expectations for student performance as they have been in helping students

understand the project. Despite their complexity, we have successfully deployed these modules for three semesters now with roughly 1700 students. The students are predominantly sophomores. Each module takes each student roughly an hour to complete.

For instructors outside our course, the materials and methods described in the next section may serve one of three broad uses: as-is implementation, single module application, or module adaptation. Instructions pertaining to the first two options are described below in the Student Outline. Please see Notes for the Instructor at the end of this paper for more information on editing and adapting these modules (or creating your own from scratch).

Student Outline

Learning Goals and Student Experience

The overarching goal of these modules and the labs they accompany is to introduce students to the principal forms of scientific analysis and communication, and to prepare them to write their Independent Projects. The CSCR modules are provided to the students as links in class or via our course website and weekly emails. There is also an option to save stand-alone files that can be loaded onto individual computers and launched in browser windows without the need for an internet connection, if needed.

Links to the modules can be found below. The first three exist in two forms: a manual form that requires correct answers to proceed and an indexed form with a hyperlinked table of contents. Following are outlines of the four modules, including relevant screen shots from the students' perspective.

After completing Modules 1 and 2, students should be able to distinguish between primary and secondary research as well as between literature reviews and meta-analyses, having practiced the latter as part of lab. After completing Module 3, students should be familiar with basic literature search strategies and be able to explain the primary types of information they will need in order to craft a compelling IP. After completing Module 4, students should have reviewed the previous three modules, experienced the type of questions their reviewer may ask during a conference, and created a draft outline for their IP proposal.

Module Links

Module 1, manual: <https://googledrive.com/host/0B6JEzwKbd1llb093ZHJJYTBIVTQ/index.html>

Module 1, indexed: <https://googledrive.com/host/0B6JEzwKbd1llQmhnU5EYTDcMTQ/index.html>

Module 2, manual: <https://googledrive.com/host/0B6JEzwKbd1lldXldEpRWFYxWnM/index.html>

Module 2, indexed: <https://googledrive.com/host/0B6JEzwKbd1llem1BeHViyMZhSms/index.html>

Module 3, manual: <https://googledrive.com/host/0B6JEzwKbd1llQl9nd05KazFiLWc/index.html>

Module 3, indexed: <https://googledrive.com/host/0B6JEzwKbd1llZVlwcXh4R1NYc0E/index.html>

Module 4: <https://googledrive.com/host/0B6JEzwKbd1llblVqajNJeGFInUE/index.html>

Module 1: BPA (completed during Lab 1)

- Students watch the first part of a video about journalists' investigation of the risks of BPA to human health (<http://www.pbs.org/moyers/journal/05232008/watch2.html>)
- TAs stop the video at 13:45 ("...we were crushed!"), students open Module 1 and complete Part 1. During this module, students:
 - learn the difference between primary research, literature reviews, and meta-analyses
 - identify the type of research performed during this part of the video (a literature review – this will contrast with the much more effective meta-analysis performed in the second part of the video)
 - learn what a biological rationale is (i.e., the information about a particular organism/system that leads to a hypothesis)
 - if doing a meta-analysis for their IP (hereafter called "Library students"), focus on the difference between a report and an analysis
 - if doing mentored research (hereafter called "mentored students"), focus on building a powerful introduction to their study
- After the second part of the video, students complete Part 2 of Module 1. During this:
 - all students identify the different variables used in the journalists' meta-analysis and the criteria for including articles in their study
 - Library students practice identifying reports vs. analyses and developing strong research questions
 - Mentored students focus on developing the biological rationale for their research questions

To complete Module 1, students submit or reference the following worksheets:

- BPA in-lab worksheet (to be turned in at the end of lab)
- IP Overview (Library and Mentored documents)

One of the particular benefits of this module is that students are exposed to examples of successful and unsuccessful work from previous semesters' IPs. They then connect these examples to the concepts they have been studying in lab. Mentored students focus on the elements of a strong Introduction, including a biological rationale. We define a biological rationale as the set of information about a particular biological system that makes a hypothesis logical. Students often struggle to provide this, or overlook it entirely. In Module 1, students read an excerpt from a former mentored IP and must identify the biological rationale within it (Fig. 1).

While Library students will wrestle with biological rationales as well, they face a more pressing challenge at this stage

152 - The Independent Project - Module 1

Mentored Papers = Primary Research

Now, next to **Question 11** on your worksheet, write out the research question that drives this study, as well as the basic biological rationale that supports the author's hypothesis.

Your answer might take this form: "Because scientists know ABC, this author predicts that XYZ."

From a paper on Parkinson's disease in rats:

As a neurodegenerative disease associated with degradation of nigrostriatal dopamine, Parkinson disease (PD) results in sensorimotor deficits such as bradykinesia, tremor and muscle rigidity that can be devastating to quality of life. In addition to these deficits, as many as 90 % of individuals with PD also experience cranial sensorimotor dysfunction, such as voice and swallowing deficits, that can be equally devastating, yet do not respond to the standard treatments based on replacing or modulating dopamine. Thus, it is important to explore other pathological mechanisms that may underlie these deficits. Norepinephrine, in particular, may be involved as it is also depleted in PD. ... The purpose of this study was to

Figure 1. Screenshot from Module 1, Part 2. This selection is from the Mentored track through this module, and targets a common problem that mentored students face early in the writing process.

in their IP development: the difference between a report and an analysis. To address this problem, Library students are tracked into a series of sorting questions that present them with written and graphical excerpts from previous Library IPs and ask them to classify these as reports or analyses (Figs. 2 and 3).

Procedure

Each team will test two enzymes: human pancreatic amylase and EITHER alpha amylase from *Bacillus* species or alpha amylase from *Aspergillus oryzae*.

Setting up the Reaction Tubes:

1. Label one large test tube for each pH buffer: pH 4.0, 5.0, 5.8, 7.0, and 8.0.
2. Add 8 ml 0.1% starch and 2 ml of the appropriate buffer to each tube (1-5).
3. Now prepare the iodine tubes. You need a total of 21 tubes (small ones work best for this). Each tube should contain 1 ml of distilled water and 10 μ l IKI. To save pipetting 34 x 10 μ l IKI, make a single batch of water + IKI and pipette 1 ml into each tube. (So you will need 23 ml water and 230 μ l IKI- be sure to mix it well!). Prepare ALL the tubes before you start the enzyme reactions- you need to be super organized for this! I suggest you put the tubes in a rack with the enzyme tubes along the front and the corresponding water IKI tubes behind. You need 4 IKI tubes per pH. The extra tube is the blank.
4. Before you start the reactions by adding the enzyme, PLEASE READ THE NEXT PART.
5. To determine the amount of starch at the start of each reaction, take 0.5 ml of the starch/buffer solution for each pH and add this to the time zero IKI tube.

6. To determine the amount of maltose at the beginning of the experiment, take 1 ml from each tube, place in separate large test tubes and set aside until the end of this experiment.
7. You will start the reaction in all 5 tubes at the same time. Start with tube 1 and add 0.1 ml of enzyme, cover the open end with parafilm and invert to mix. Then do tube 3, 4 5. START YOUR TIMER. One person could be adding the enzyme whilst the other one covers the tubes and mixes.
8. After 3 minutes take 0.5 ml from tube 1 and add it to one of the IKI tubes. Repeat with tubes 2 to 5, using a clean tip each time and adding to the IKI tube directly behind the pH / enzyme tube. Take the samples in the same order as you started the reactions.
9. Repeat at 6, and 9 minutes, taking samples in the same order each time, using clean tips and adding to the next IKI tube.
10. Prepare a blank by adding 0.5 ml water to one of the IKI tubes (contains 1.5 ml water + 10 μ l IKI).
11. Set the spectrophotometer to 620 nm and set zero with the blank.
12. Now measure the absorbance of each tube and record the results in a table.

To Determine the Amount of Maltose Produced:

At the end of the 9 minutes, take a 1 ml sample from each enzyme reaction and add it to a new tube. Add 1 ml of DNSA reagent and boil for 15 minutes. Do the same with the tubes you prepared at the beginning of the experiment. Cool for 5 minutes and add 9 ml water. Measure the absorbance at 540 nm.

Calculation of Starch Concentration from Absorbance Measurements

Now return to the starch absorbance table above. Use the standard curve you made last week to work out the starch concentration at each time point. Make a new table showing the amount of starch remaining at each time point for each pH.

You now have enough information to find the rate of reaction for amylase at each pH.

Plot a graph of starch concentration vs time (use Excel) and use this to find the rate of reaction for each pH.

You can also use the DNSA / maltose standard curve you made last week to find the amount of maltose produced from the starch by amylase at each pH.

- Which pH gave the greatest amount of maltose? At which pH was the reaction rate greatest?
- Does your experimental data support or refute your hypothesis?
- Compare the rates of reaction at different pH for the two enzymes studied by your team. Are they similar or different? Can you explain why?
- Write a summary your results and conclusions using the questions above as an outline.

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Library Papers = Meta-Analyses

To get a better understanding of the difference between a report/review and a meta-analysis, let's look at some examples from previous IPs.

Here is an example from the results section of an IP written by a former 152 student.

Is this is a report or an analysis?

"As mentioned previously, studies by Taylor et al (1998) and Thompson et al (2003) showed an improvement in cardiac function after damage using an injection of skeletal myoblasts. When analyzing the results from bone-marrow studies, a study by Assmus et al (2009) showed that 2 years after the administration of the treatment for the repair of acute myocardial infarction in human patients, they continued to show improved levels of cardiovascular function. In a study by Rajasingh et al (2011), bone marrow progenitor cells that were epigenetically altered with chromatin showed improved left-ventricular function after the area was damaged by myocardial infarction prior to treatment. A study by Wang et al (2010) used sodium dodecylsulfate to damage a region in the porcine hearts obtained from a slaughterhouse and were then treated with bone marrow mononuclear cells with the result of a successfully developed neo-myocardial tissue."

152 - The Independent Project - Module 1

Library Papers = Meta-Analyses

Here's another example from a results section from a previous IP proposal.

Is this one a report or an analysis?

"Among the stem cell transplantation studies analyzed, four out of five showed successful hair cell regeneration. The study that did not have successful hair cell regeneration did, however, result in the survival of embryonic stem cells within the cochlea. All of the studies were performed on laboratory animals: guinea pigs (n=1 study), mice (n=3 studies), and one study used both guinea pigs and mice. The study that had unsuccessful hair cell regeneration differed from the other studies in that embryonic stem cells were transplanted compared to either neural or olfactory stem cells transplanted in other studies."

Figure 2. Screenshots from Module 1, Part 2. This selection is from the Library track through this module and targets a misconception about what constitutes an analysis. The student who wrote the first excerpt merely listed the findings of every study they read. We want our students to recognize that lists or summaries are not enough; they need to compare, contrast, and interpret differences to write a strong meta-analysis, as demonstrated in the second excerpt.

152 - The Independent Project - Module 1

Library Papers = Meta-Analyses

Here's another example from the results section of a previous IP proposal.

Is this a report or an analysis?

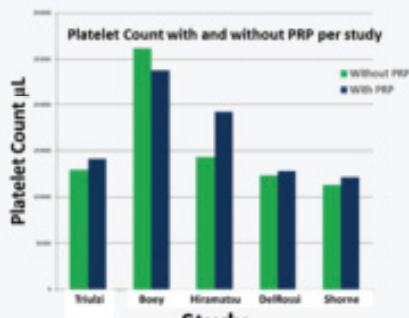
Report

Analysis

◀

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"We identified 5 studies that measured the post-operative platelet count of patients after cardiothoracic surgery up to 2 days after the surgery. For the purpose of this research, the measurements taken 6 hours after surgery were used. Each of the studies examined a minimum of 16 patients, and all were randomized prospective studies. The results of the search are in Figure 2."



Study	Without PRP (µL)	With PRP (µL)
Thull	~40,000	~50,000
Boey	~80,000	~70,000
Hiramoto	~50,000	~60,000
DeRood	~40,000	~50,000
Shorne	~30,000	~40,000

Figure 2. Change in platelet count for control and treatment group in all 5 studies.

152 - The Independent Project - Module 1

Library Papers = Meta-Analyses

Here's one last example from the results section of a previous IP proposal.

Is this a report or an analysis?

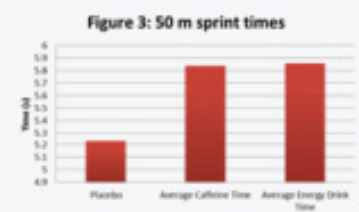
Report

Analysis

◀

Table of Contents

"According to the articles studied, physical abilities were overall increased in response to energy drink consumption. Due to the variances in methods and dosage, the data was scaled linearly to 500 mL of energy drink for a 50 meter sprint. The average increase for this scaled consumption of energy drink was 0.627 seconds compared to the control groups ($p < 0.05$) with a standard deviation of 0.187 seconds (Figure 3)."



Treatment Group	Average Sprint Time (s)
Placebo	~5.2
Average Caffeine Time	~5.8
Average Energy Drink Time	~5.8

Figure 3: Average sprint time in seconds for three treatment groups across 5 studies.

Figure 3. Screenshot from Module 1, Part 2. This selection is from the Library track through this module and targets a misconception that a graph always represents a strong analysis. In the first graph, the student has essentially provided the same sort of results list as shown in Figure 2. Students must compare two specific variables; “study” (on the X-axis) is far too broad for this purpose. The second graph shows a better example.

Module 2: Chocolate and Tea (Pre-lab for Lab 2)

Students are provided with the link to this module on the course website and in the weekly email. This module is the first part of the pre-lab for week 2 of lab. The full pre-lab cannot be completed without first finishing this module, because instructions for the latter pre-lab exercises appear at the module’s conclusion. In the course of this module, students:

- review what a meta-analysis is and practice performing one
- learn about the metric (or measured response variable) and practice identifying metrics in real abstracts
- learn how to organize data they collect from multiple studies into an overview spreadsheet
- are introduced to a meta-analysis paper examining the effects of chocolate and tea consumption on blood pressure (Taubert et. al. 2007), which they will work through in lab. Reading articles that are analyzed in this published analysis, students create a spreadsheet using the skills they practiced in this module. (See Heitz 2012 for more details on the use of the Taubert paper in lab).

To complete Module 2, students must turn in:

- A completed Excel spreadsheet (see Heitz 2012 and Instructor Notes below)
- Answers to questions listed in module

Module 2 includes practice identifying key words in article abstracts and organizing data extracted from selected articles for use in a meta-analysis (Figure 4).

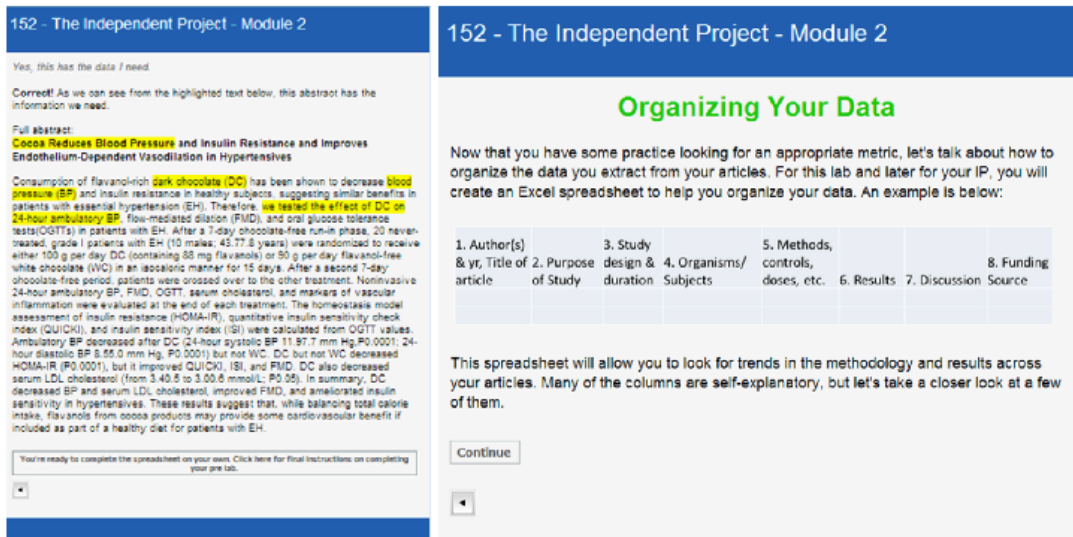


Figure 4. Screenshots from Module 2. The image on the left displays feedback for a question asking students to determine if this article may contain useful data for their meta-analysis. Highlighted words show that this article addresses the students’ topic (relationship between chocolate and blood pressure), and that it measures the metric of choice (blood pressure). The image on the right displays the introduction to data organization. Students are provided with an example of an organizational spreadsheet that makes comparing data easier.

Module 3: Library Search Preparation (completed during Lab 2)

This module works best in lab, where TAs can circulate, encourage engagement, and keep students on task. However, it could also be assigned out of class as homework. By completing this module, students:

- identify the types of information necessary for their research
- Library students work on:
 - Background research (big idea, biological rationale)
 - Meta-analysis research (articles that come to different conclusions, report the same metric, have a basis for comparison, report extractable data, relate to their group's larger question)
- Mentored students work on:
 - Using other papers as models of scientific writing structure
 - Biological rationale
 - Papers as sources of methods
 - Experimental history behind their topic

To complete this module, students must turn in

- Guided outline worksheet for this module

One of the biggest struggles we have encountered is getting our Library students to understand the idea of a common metric. Without a common metric, the quantitative analyses we require of our students will be very difficult. Nonetheless, students typically do not grasp this necessity until late in the IP process, after they have already selected studies they intend to use, many of which turn out to be irrelevant. The definition of a metric has come up repeatedly in the previous modules, and now students practice a higher-level skill: examining a set of preliminary data to determine which of several response variables would be most fruitful to pursue for a hypothetical meta-analysis (Fig. 5).

Great! We have a topic that is ready for a meta-analysis.

Now it's time to see if these articles provide data that is quantitatively comparable. Without this, we could only write a qualitative review, not a true meta-analysis.

Let's start with the metric. If you do not find studies that used the same metric, it will be very difficult to perform a meaningful meta-analysis.

Looking at the Results column (6), what would be the best metric for these students to use?

1. Author(s) & yr	3. Duration	4. Organisms/Subjects	5. Methods	6. Results	7. Discussion
Smith (2008)	3 weeks	Men over 40	Hi/lo dose + control (mg)	blood cortisol levels (mcg/dl)	Side-effects are mild
Yang et al (2011)	2 weeks	Men 30 - 60	Hi/med/lo dose + control (mg)	weight gain (lb), change in resting heart rate (bpm)	No significant side-effects
James and Karr (2010)	8 weeks	Women 20 - 50	dose/control (mg)	change in resting heart rate (bpm)	Side-effects are mild
Landry and Gorski (2012)	6 months	Teenage women	dose/control (mg)	change in resting heart rate (bpm), weight gain (lb)	Side-effects are mild
Allen et al (2004)	9 weeks	Men 25 - 55	dose/control (mg)	reported fatigue (1 - 10 scale), change in resting heart rate (bpm)	Side-effects are major
Giordi (2007)	5 weeks	Men and women over 40	Hi/lo dose + control (mg)	change in resting heart rate (bpm), change in blood pressure	Side-effects are major
Patch et al (2011)	10 days	Women over 35	Hi/med/lo dose + control (mg)	weight gain (lb), change in blood pressure, blood cortisol levels (mcg/dl)	Side-effects are insignificant
Jimson and Eves (2009)	1 year	Men and women 25 - 50	Hi/lo dose + control (mg)	change in hours of sleep (hr/day)	Side-effects are insignificant
Elliot (2001)	6 weeks	People over 40 (gender unspecified)	Hi/med/lo dose + control (mg)	degree of nausea (1 - 7 scale)	Side-effects are mild
Liu et al (2010)	4 weeks	Men and women over 30	Hi/med/lo dose + control (mg)	skin irritation (present/not), change in resting heart rate (bpm)	Side-effects are significant
Leen (2009)	25 days	Women 20 - 40	Hi/lo dose + control (mg)	weight gain (lb), change in resting heart rate (bpm), blood cortisol levels (mcg/dl)	Side-effects are major

Change in heart rate Weight gain Degree of nausea

Figure 5. Screenshot from Module 3, showing a hypothetical data set and asking students to identify which of the variables listed in column 6 would make the best metric for a proposed meta-analysis investigating the impact of Drug X on energy level. To answer correctly, students must determine which response variable is measured in the greatest number of selected studies, making it a good candidate to be the common metric that grounds their meta-analysis.

Module 4: Virtual Conference

The final module diverges somewhat from the first three, and is the least embedded in our laboratory sequence. Students receive the link to this module on the course website and are required to complete it before they turn in their IP proposals. Along with their proposals, they also turn in a set of answers to questions posed in the module's mock conference. This answer set doubles as an outline for the proposal itself. As students progress through this module, they:

- review essential elements of their papers and create outlines
- troubleshoot common IP proposal errors
- Library students must provide:
 - Group research question and individual sub-question
 - Definitions of key terms
 - Evidence of uncertainty in the literature / Open question
 - Metric and independent variables
 - Skeleton graph
- Mentored students must provide:
 - Overarching research question and their smaller sub-question
 - Definitions of key terms
 - Big pictures steps of their methods
 - Study variables both dependent and independent
 - Skeleton graph

An “expertly constructed” stick figure (Fig. 6) guides students through a series of basic questions about their research. This module is designed to target common misconceptions students develop while writing their proposals. Using the module, students are prompted to self-check what information they need to include in their proposal and adjust any misunderstandings they may have about what constitutes an independent vs. response variable.



Figure 6. A screenshot from Module 4, showing the “reviewer” asking the students a question about their metric. The branching capabilities of CSCR allow individualized responses to the most common questions we have received in real conferences over the years, hopefully solving problems before they happen.

When students have completed this module, they must turn in the associated IP Virtual Reviewer worksheet for either the Library or Mentored track. Many TAs have reported that having this worksheet helped them to understand their students’ thought processes. For example, sometimes, students leave important information out of their proposal that they included in their mock conference worksheet. In other words, this was originally designed to emphasize the utility of the worksheet as an outline for the students as they completed their proposals and to help them avoid common errors. In addition, the worksheet has become a backup source of information that has greatly helped our TAs in their reviews. With the worksheet in front of them, it has been easy for the TAs to understand what the students are trying to write. The TAs can also use them to point out the students’ solid ideas that do not end up in their proposals.

Materials

All materials can be found at the following URL: <https://uwmadison.box.com/s/wcpd7itxkiieigzynu8z>. Materials include links to the modules, editable module files*, worksheets associated with each module (both blank student and TA key versions), as well as the chocolate and tea articles referenced in Module 2.

*To obtain a copy of the CSCR authoring program itself, which is needed if you wish to make any changes, please visit: <http://engage.wisc.edu/software/cscr/gettool.php>

Notes for the Instructor

Best Practices

One of the key concerns when implementing the CSCR module is ensuring that students do not simply “click through” the modules. The goal is to increase time on task and to delve more deeply into individually relevant content – not to exercise students’ pointer fingers. This can be challenging in a large laboratory, let alone when students complete their work at home, but a few adjustments have helped a great deal.

First, it is vital that students actively create a written product while working through the modules – simply reading does not help a great deal. The associated worksheets available in our Box site represent our solution. The worksheets are bare-bones intentionally – all question stems are embedded in the modules so that students must read the module actively in order to find (let alone answer) the questions.

There is an added benefit when the assignment product is useful to the students beyond their interaction with the module. For instance, the outlines students create in Module 3 are designed to be referenced during the student’s literature search. Encouraging the use of the assignment products is one of the crucial responsibilities of the instructor or TA during lab. When training TAs, be sure to emphasize that these modules are meant to be handbooks for the writing project – not busywork. By referring back to the modules as the project moves forward, and asking students to check outlines and worksheets they completed while working through the modules, TAs and instructors can create a context for the modules to work as helpful references rather than one-off assignments.

One of the best ways to contextualize the online modules within the laboratory experience is to talk about them. We have found it beneficial to allow (and in fact, encourage) students to talk to one another while working on both in-class modules (1 and 3). While each student needs to be responsible for turning in an independent answer sheet, they are free to collaborate. Most importantly, time should also be set aside during lab to discuss the relevant modules as a whole class. For Module 1, this means pausing after both Part 1 and Part 2 to discuss students’ answers to the worksheet questions; for Module 2, this means discussing the stu-

dents’ pre-lab answers; and for Module 3, this means reviewing the types of information students should be looking for in the library. The main goal of such a conversation is two-fold: first, to summarize the key points of the module so that everyone in the class is on the same page and second, to transition back to lab activities beyond the computer screen.

There are many ways to structure a wrap-up conversation following the modules. One suggestion is to ask students to list the key points from each module, and brainstorm these on the board. The role of the TA here would be to fill in any gaps and to help students synthesize broad themes across the individual points. Another option is to ask students to talk in small groups for a few minutes to generate one or two questions they still had after completing the modules. When sharing these with the class, TAs can solicit answers from the rest of the class and step in as necessary. A final suggestion is for the TA to provide a brief summary of the module as well as an introduction to the next lab activity, and then to ask the class how what they learned in the module would help them with their next task. There are a great many other variations on this theme, of course, but it is important that the module be embedded in the classroom activities. Without this context, there is a greater risk that students will not transfer what they learn online to what they are doing in lab and during the semester.

A final pitfall when implementing these modules is that students work at different speeds: some will finish before others. Therefore, having a back-up activity is important for maintaining classroom order. We have found that the best way to handle student downtime is by asking them to work on researching the topic of their IP and developing their research question.

To end on a technical note, many students encounter problems running the modules on Chrome. Internet Explorer and Firefox seem to be more consistently successful. So if students complain of problems with the modules, changing the browser has been our first – and best – troubleshooting step.

Initial Evaluation

To evaluate the success of these modules in our course, we are in the process of conducting an analysis comparing the proposals of all students from the first Fall semester in which the modules were used to the previous Fall semester. Both semesters feature similar student enrollment and student characteristics as well as lecture topics. All proposals were anonymized and randomized, then coded for several key aspects of a successful proposal. This analysis is still in its early stages – only 46 of over 150 papers have been processed, and all by a single coder. We hope to complete the coding and code validation within the next year. Nonetheless, the initial results are both encouraging and thought provoking.

So far, we have seen significant increases in the percentage of students who present a viable metric, who identify uncertainty in the literature they are analyzing, who present a unique subtopic within a group paper, and who explain their rationale for selecting the studies they include in their analy-

sis (Fig. 7). These results are encouraging, because they suggest increased student metacognition: students are not only able to provide an appropriate metric, but also to explain why it will be useful in answering their research question (i.e., by showing that there is an open question in the literature and making a case for the comparability of their selected studies). The fact that more students (100%, up from just below 70%) are identifying an individual subtopic within a group paper (all Library meta-analysis papers are group papers and each student is required to have a unique topic within their paper) is also a very welcome result – not only does this make the TA reviewers' job much easier, it suggests that students are each engaging with the material individually, which was one of our main goals of creating the CSCR modules.

One puzzling finding was that a statistically significantly greater percentage of students provided what we call “paper parades” – lists of results from individual studies (Figure 8, and the example in Figure 2). This is concerning because we want our students to move away from summary, not toward it. However, taken in light of the increase in viable metrics, this may be an artifact of students' increased attention to the content of their studies' results sections. Further investigation will be needed to determine what has prompted this change, and to decide whether it needs to be corrected (if it is purely a misconception of what it means to analyze data) or used as a springboard to analysis (if it reflects a heightened awareness that results sections must be sufficiently comparable in order to perform an analysis).



Figure 7. Preliminary data comparing student performance on their written IP proposals between Fall 2012 (no CSCR) and Fall 2013 (first CSCR implementation). The data are limited to the first 46 papers coded, but thus far all show significant differences between years. (a) The percentages of students who include a single, viable metric in their papers in Fall 2012 (no CSCR) vs Fall 2013 (the first semester with CSCR). In this preliminary analysis, the difference is statistically significant. (b) The percentages of students who clearly identify the nature of their open question (the uncertainty present in the current literature) in their papers in Fall 2012 (no CSCR) vs Fall 2013 (the first semester with CSCR). In this preliminary analysis, the difference is statistically significant. (c) The percentages of group papers in which the number of subtopics equals the number of authors in Fall 2012 (no CSCR) vs Fall 2013 (the first semester with CSCR). In this preliminary analysis, the difference is statistically significant. (d) The percentages of students who clearly explained their rationale for selecting the papers they chose to include in their meta-analysis in Fall 2012 (no CSCR) vs Fall 2013 (the first semester with CSCR). In this preliminary analysis, the difference is statistically significant.

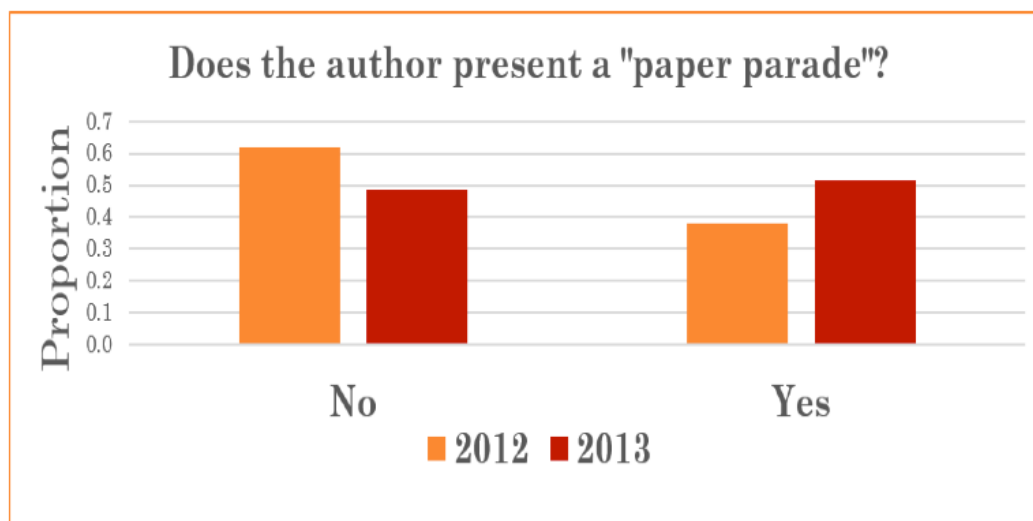


Figure 8. The percentages of students who included a “paper parade” (a list of findings from the studies they selected for their meta-analysis, with no synthetic commentary or emphasis on trends across studies) in their papers in Fall 2012 (no CSCR) vs Fall 2013 (the first semester with CSCR). In this preliminary analysis, the difference is statistically significant.

Conclusion

In sum, the CSCR modules have helped students improve their scientific writing and think more critically about the choices they make during their research. The modules work best when fully integrated into the classroom experience, and when students are able to ask questions about their work. We did not provide in-depth details here about how to adapt the CSCR modules or create your own, but the staff in our Department of Information Technology is incredibly supportive; we recommend contacting them with any technical questions you may have. Using this software has been a fruitful experience that we are very happy to share!

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Appendices

All supplemental materials have been gathered into one Box folder accessible here: <https://uwmadison.box.com/s/wcpd7itxkiieigzynu8z>

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