Tips & Tools
DOI: https://doi.org/10.1128/jmbe.v22i1.2135

JMBE Journal of Microbiology & Biology Education

# Sharing Notes Is Encouraged: Annotating and Cocreating with Hypothes.is and Google Docs†

Carlos C. Goller[1]*, Micah Vandegrift[2], Will Cross[2], and Davida S. Smyth[3]
[1]*Department of Biological Sciences, Biotechnology Program (BIT), North Carolina State University, Raleigh, NC 27695;*
[2]*NC State University Libraries, Raleigh, NC 27695;*
[3]*Eugene Lang College of Liberal Arts at The New School, New York City, NY 10011*

## INTRODUCTION

Reading primary literature can be challenging for those unfamiliar with terminology or methodology (1–3). Often, students highlight long passages or read over unfamiliar jargon without fully comprehending the significance and details of a study. Several approaches have been described to promote the critical reading and analysis of primary literature (4–9). While these methods provide structure, students often read and analyze in isolation, as the methods do not facilitate virtual and open peer collaboration. Additionally, note-taking is a skill that is not commonly taught or emphasized in science courses (10). To create an inclusive and empowering environment of cocreation of knowledge, we've infused an upper-division metagenomics course with activities to reduce the anxiety of reading primary literature and note-taking and promote collective and collaborative constructivism.

Many tools are available that allow collaborative work on electronic documents. Google Docs, Sheets, and Slides can be used to enable participants to contribute. There are also resources to annotate web pages. One such tool often used in the humanities is Hypothes.is (11–14); it is free, open source, and easy to use in classroom settings, including online courses. Initiatives such as *Science in the Classroom* (https://www.scienceintheclassroom.org/) have led to studies highlighting the use of annotation as a pedagogical tool (15–17).

Student collaborative notes and summaries can be used to create an Open Educational Resource (OER). Furthermore, student-created OERs can foster a sense of ownership as class participants work toward creating a common resource that will serve them and a wider audience beyond the course (18).

## PROCEDURE

We introduced the use of Hypothes.is and collaborative notes in the fall of 2019 in an 8-week upper-division undergraduate and graduate student Metagenomics course (19). The course has weekly lectures of 1 hour 50 minutes and 5-hour labs with a course-based research project that relies heavily on the assigned readings. There were 15 students enrolled in the course: 4 undergraduates and 11 graduate students. The study was approved by the NCSU IRB (#20309).

Students annotate articles using Hypothes.is (https://web.hypothes.is/) and have access to all comments. Hypothes.is is a free open-source software package that allows users to highlight and annotate websites and text. Students are required to submit at least 10 meaningful annotations before the in-class discussion (see Appendix 1). A week after the discussion, groups of three or four students assigned to summarize the article post a brief synopsis on the class's Hypothes.is group (Fig. 1 and Appendix 1).

For collective notes, students have access to a Google Doc with the learning outcomes for each class session. Students are encouraged to contribute by providing definitions, examples, and links to additional resources. Notes are not graded but are lightly edited by the instructor for accuracy. Peers can provide constructive feedback and correct, remedy, or amend misconceptions and inaccuracies. Each week the instructor generates a video reviewing the notes and administers individual quizzes based on the content of the class notes.

Students are informed that, with their consent, their notes and annotations can be used to create an OER that would benefit them and others beyond the course. An example of a student-generated OER is available at go.ncsu.edu/bitmetagenomics.

*Corresponding author. Mailing address: 6104 Jordan Hall, Campus Box 7512, North Carolina State University Biotechnology Program, 2800 Faucette Drive, Raleigh NC 27695. Phone: 919-513-4135. E-mail: ccgoller@ncsu.edu.
Received: 12 April 2020, Accepted: 28 November 2020, Published: 29 January 2021
†Supplemental materials available at http://asmscience.org/jmbe

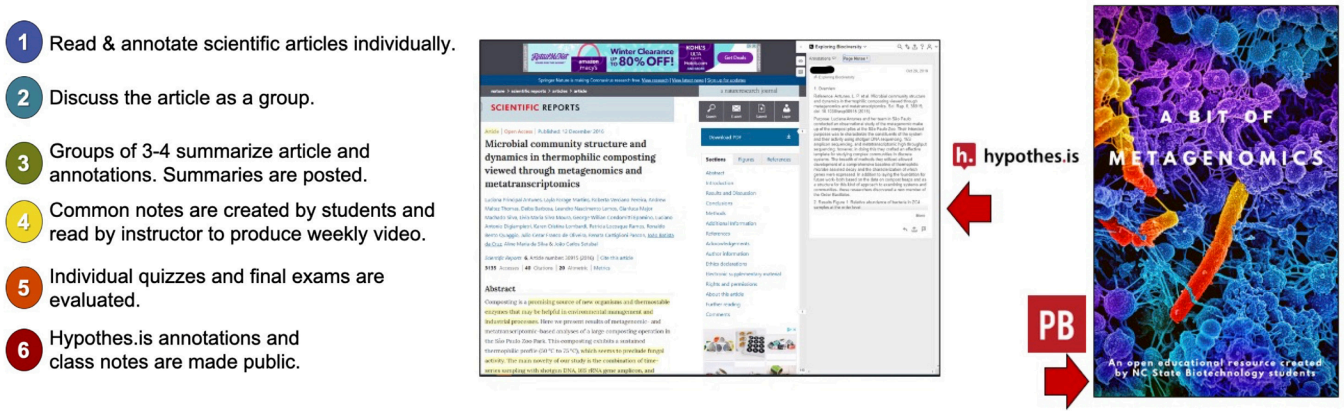


FIGURE 1. "Sharing Notes is Encouraged" workflow. Students annotate and cocreate notes to produce an OER for studying and future course participants. Students use Hypothes.is to annotate primary literature as homework assignments, following set guidelines (for details see Appendix 1), and groups are tasked with creating shared summaries for the class to view within a Hypothes.is group. Students contribute to shared notes both during and outside of the class session. The instructor then uses the notes to produce weekly recaps to provide feedback and encouragement. Student contributions are then compiled to create a final OER, containing all notes and annotations generated over the course of the semester in a publicly viewable dynamic resource (for a sample OER, go to go.ncsu.edu/bitmetagenomics and click on "Meta Book"). PB, Pressbooks.

### Materials and preparation

Instructors create a private course Hypothes.is "group" and share the link with students via their Learning Management System (LMS) or e-mail. Students require free Hypothes.is accounts. If using the Google Chrome browser, there is a useful Hypothes.is extension. Helpful tutorials for using Hypothes.is in education can be found on the website: https://web.hypothes.is/education/. If Google Docs are to be used for shared class notes, the instructor needs to make the document editable by participants. The creation of a short link that is easy to remember may be helpful. The instructor should provide guidelines for annotation (types of annotations including asking questions, clarifying or linking to resources, and examples of tags used by others), expectations for the number of individual annotations, and grading rubrics (Appendix 1). Frequently presenting or projecting the progress of the class notes encourages participation. The instructor can read and discuss the class notes in a short (6- to 15-min) weekly screencast video posted on an unlisted YouTube playlist (e.g., https://go.ncsu.edu/metanotes19).

Students that contribute to class notes can produce a final web-based Pressbooks OER. Pressbooks is an affordable ($20 to $100/eBook) and easy-to-use online eBook creation platform used by universities and the OER community [e.g., Granite State College OERs (https://granite.pressbooks.pub/) and BC Open Textbooks (https://opentextbc.ca/pressbooks/)].

### Modifications and extensions

The Hypothes.is annotation and group summaries assignment has been adapted for other lab-based courses. For example, for an undergraduate and graduate student 8-week Yeast Metabolic Engineering lab module (20), we have modified the assignment guidelines to allow students to complete the minimum number of meaningful annotations after the in-person discussion of articles. This extension resulted in several participants returning to the papers weeks later to provide additional information. Guidelines can be modified to increase the minimum number of annotations, have students ask and respond to each other, find related studies, or alter the due dates (e.g., until after in-class discussion). The rubric for group summaries can be modified for different course learning outcomes (e.g., data analysis). An example of an annotated paper can be shared with students; for example, a microbiome study from *Science in the Classroom* can help students learn to annotate using different tags/elements (https://www.scienceintheclassroom.org/research-papers/whats-normal-scoop-poop).

Instructors can choose to encourage all participants to contribute to class notes by making the assignment credit-bearing. Instead of weekly screencast videos, alternatives include an audio file, podcast, or e-mail announcement. Other OER platforms exist, and some faculty may decide to use WordPress or GoogleSites to create publicly accessible sites to publish the collective contributions of participants. Data privacy and consent cannot be overlooked: talk to your students about posting their names on publicly facing sites, after asking for their consent in writing. Instructors are encouraged to contact other faculty to collaborate on topic-specific OERs.

## CONCLUSION

Students annotate and produce summaries and collaborative notes following the guidelines. Analysis of the

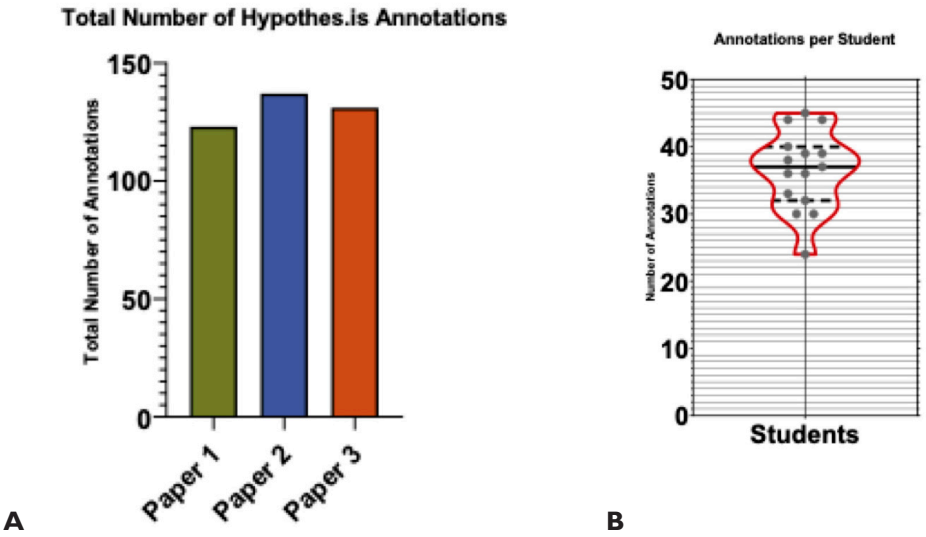


FIGURE 2. Students annotated assigned papers frequently and began using descriptive "tags." (A) Students used the Hypothes.is tool to annotate reading assignments and tag keywords or phrases. Some students responded to other comments and included links and other resources. (B) All students' ($n$ = 15) annotated readings.

annotations and quiz grades suggests that participants are engaging with the articles (Fig. 2) and able to summarize the findings of the studies (Appendix 2). Annotations of student-selected papers by groups indicate students continue to use rich annotations. Participants contribute to a Google Doc and view weekly video summaries.

We note that, while students unfamiliar with Hypothes.is require a demonstration, having seen the demonstration, participants are capable of providing productive comments about the studies. For all the articles we've included as reading, students have contributed definitions, links to additional resources, and even responses to questions posed by peers. We advise that instructors highlight the benefits of collaborative annotation and critical note-taking. Our study demonstrates the impact of creating a scholarly community to promote learning and how it can encourage participation and ownership of an OER project. Our implementation demonstrated that all students made annotations and contributed their thoughts and ideas to the shared notes document. These efforts helped constitute a student-derived OER that could serve not only these students beyond the course but others as well.

## SUPPLEMENTAL MATERIALS

Appendix 1: Guidelines for annotations, summaries, and class notes
Appendix 2: Engagement and assessment data
Appendix 3: Additional suggestions for implementation

## ACKNOWLEDGMENTS

The NCSU OPEN Incubator Program (summer 2019) provided training and inspired us to use Hypothes.is in this course and beyond. We are grateful for funding from the National Science Foundation (NSF) and to the PALM network for providing mentorship and access to active learning resources. The NCSU Biotechnology Program (BIT) provided the resources to offer the *Metagenomics and Yeast Metabolic Engineering* courses in which these activities were implemented. C.C.G. is also supported by an NIH Innovative Program to Enhance Research Training (IPERT) grant, "Molecular Biotechnology Laboratory Education Modules (MBLEMs)" 1R25GM130528-01A1. We thank the students in the fall 2019 BIT 477/577 Metagenomics course for their patience, commitment, feedback, and energy. This study has been reviewed by the Institutional Review Board at North Carolina State University and approved under protocol number #20309. We do not have any conflicts of interest to declare.

## REFERENCES

1. Rawlings JS. 2019. Primary literature in the undergraduate immunology curriculum: strategies, challenges, and opportunities. Front Immunol 10:1857. doi:10.3389/fimmu.2019.01857
2. Nelms AA, Segura-Totten M. 2019. Expert–novice comparison reveals pedagogical implications for students' analysis of primary literature. CBE Life Sci Educ 18:ar56.
3. Abdullah C, Parris J, Lie R, Guzdar A, Tour E. 2015. Critical analysis of primary literature in a master's-level class: effects

on self-efficacy and science-process skills. CBE Life Sci Educ 14:ar34.
4. Liao MK. 2017. A simple activity to enhance the learning experience of reading primary literature. J Microbiol Biol Educ 18. doi:10.1128/jmbe.v18i1.1211
5. Hoskins SG, Lopatto D, Stevens LM. 2011. The C.R.E.A.T.E. approach to primary literature shifts undergraduates' self-assessed ability to read and analyze journal articles, attitudes about science, and epistemological beliefs. CBE Life Sci Educ 10:368–378.
6. Gottesman AJ, Hoskins SG. 2013. CREATE cornerstone: introduction to scientific thinking, a new course for stem-interested freshmen demystifies scientific thinking through analysis of scientific literature. CBE Life Sci Educ 12:59–72.
7. Carmichael JS, Allison LA. 2019. Using "research boxes" to enhance understanding of primary literature and the process of science. J Microbiol Biol Educ 20(2). doi:10.1128/jmbe.v20i2.1743
8. Round JE, Campbell AM. 2013. Figure facts: encouraging undergraduates to take a data-centered approach to reading primary literature. CBE Life Sci Educ 12:39–46.
9. Lo SM, Luu TB, Tran J. 2020. A modified CREATE intervention improves student cognitive and affective outcomes in an upper-division genetics course. J Microbiol Biol Educ 21(1). doi:10.1128/jmbe.v21i1.1881
10. Morehead K, Dunlosky J, Rawson KA, Blasiman R, Hollis RB. 2019. Note-taking habits of 21st-century college students: implications for student learning, memory, and achievement. Memory 27:807–819.
11. Kennedy M. 2016. Open annotation and close reading the Victorian text: using hypothes.is with students. J Vic Cult 21:550–558.
12. Shrout AH. 2016. Hypothes.is. J Am Hist 103:870–871.
13. Perkel JM. 2015. Annotating the scholarly web. Nat News 528:153.
14. Kalir JH, Dean J. 2018. Web annotation as conversation and interruption. Media Pract Educ 19:18–29.
15. Kararo M, McCartney M. 2019. Annotated primary scientific literature: a pedagogical tool for undergraduate courses. PLOS Biol 17:e3000103.
16. Miller K, Zyto S, Karger D, Yoo J, Mazur E. 2016. Analysis of student engagement in an online annotation system in the context of a flipped introductory physics class. Phys Rev Phys Educ Res 12:020143.
17. Sahota M, Leung B, Dowdell S, Velan GM. 2016. Learning pathology using collaborative vs. individual annotation of whole slide images: a mixed methods trial. BMC Med Educ 16:311.
18. Yaeger J, Wolfe T. 2018. Creating the ripple effect: applying student-generated OER to increase engagement in distance education and enhance the OER community. Digital Universities 1/2.
19. Goller CC, Ott LE. 2020. Evolution of an 8-week upper-division metagenomics course: diagramming a learning path from observational to quantitative microbiome analysis. Biochem Mol Biol Educ 48:391–403.
20. Gordy CL, Goller CC. Using metabolic engineering to connect molecular biology techniques to societal challenges. Front Microbiol 2020; doi:10/3389/fmicb.2020.5770004/full