Special Series: Scientific Literacy

JMBE Journal of Microbiology & Biology Education

# Connecting Ethical Reasoning to Global Challenges through Analysis of Argumentation

Caroline A. Sjogren,[a] Gary Comstock,[b] and Carlos C. Goller[a,c]

[a]Biotechnology Program, North Carolina State University, Raleigh, North Carolina, USA
[b]Department of Philosophy and Religious Studies, North Carolina State University, Raleigh, North Carolina, USA
[c]Department of Biological Sciences, North Carolina State University, Raleigh, North Carolina, USA

**KEYWORDS** critical thinking, argumentation, ethical reasoning, case studies, discussion, literacy, collaborative learning, mastery learning, communicate

## INTRODUCTION

A primary goal of university education is to teach students to think critically. Critical thinking is one of the most valued skills employers seek (1), yet universities struggle to teach it. According to results of the Collegiate Learning Assessment, a troubling proportion of students graduate from U.S. higher education institutions without proficiency in critical thinking (2). As our societies become more interconnected, the ability to train students to assess the credibility of information and apply it is paramount. As our world continues to become more complex and as scientific discoveries and technologies advance, our approaches to educational training methods will need to advance in tandem.

In science, technology, engineering, and math (STEM) disciplines, training approaches have advanced with the successes of course-based undergraduate research experiences (CUREs) (3–5). Learning outcomes and scientific identity development are clear advancements from CURE implementation, while ethics of responsible conduct of research (E/RCR) training, which is mandatory for federally funded research labs, is not required for CUREs (4). Educator training opportunities, such as the Ethics Network for Course-based Opportunities in Undergraduate Research (ENCOUR), provide mentoring on how to integrate E/RCR education into CUREs (6), and case studies have emerged as a part of a critical framework for E/RCR training in CUREs (7).

We propose a four-step instructional approach to collaborative ethical reasoning with critical analysis of argumentation (Fig. 1):

(i) Collaborate to set student expectations
(ii) Learn the basics of argument analysis and evaluation
(iii) Practice these skills by applying them to responsible conduct of research case studies
(iv) Exchange ideas and learn from new perspectives

This approach is implemented at North Carolina State University in BIT 295 Biotechnology & Sustainability, a CURE taught by us where students learn about genetics and microbiology as potential tools to discover sustainable solutions to recycle electronic waste (see Table S1 in the supplemental material). Class size is small (10 to 16 students), open to all majors, any year, without prerequisites and mostly attracts nonbiology STEM majors. These activities are designed as asynchronous assignments through the Learning Management System (LMS). Materials can be adapted to virtual or in-person usage, applied to a diversity of research subject matter, or used separately.

## PROCEDURE

### Ethics statements

There are no known safety issues. Students engage asynchronously using the LMS and do not interact with live organisms or hazardous chemicals.

Research involving human subjects has complied with all relevant federal guidelines and institutional policies, including institutional review board (IRB) approvals. IRB number 24414 was approved as exempt by the NC State University IRB.

### Collaborative E/RCR education approach

We describe our collaborative E/RCR educational approach in four steps (Fig. 1):

**(i) Collaborative community guidelines.** The first assignment students complete in the course is the collaborative community guidelines activity (Text S1 in the supplemental

Editor Justin Shaffer, Colorado School of Mines
Address correspondence to Biotechnology Program, North Carolina State University, Raleigh, North Carolina, USA. E-mail: ccgoller@ncsu.edu.
The authors declare no conflict of interest.
Received: 30 September 2022, Accepted: 27 February 2023, Published: 16 March 2023

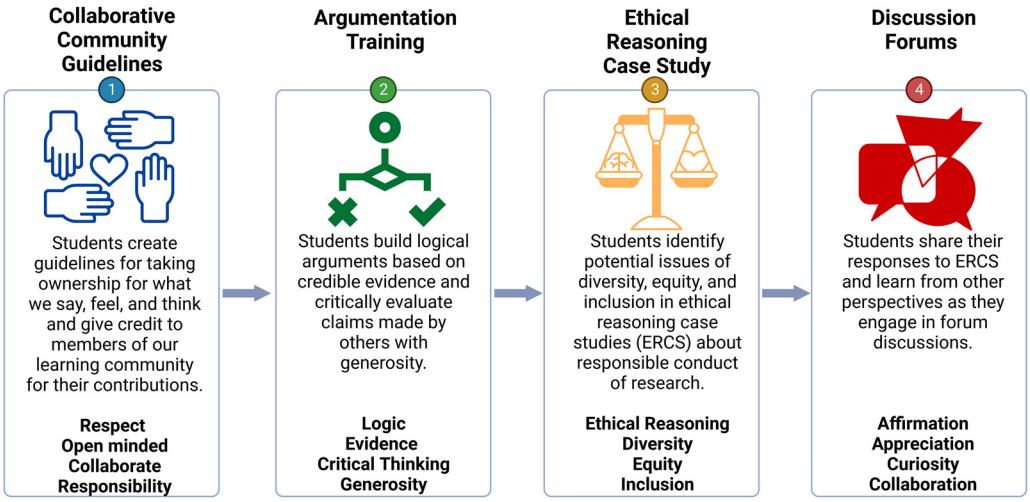


FIG 1. Overview of activities used to promote ethical reasoning, curiosity, and collaboration among participants.

material), where we share examples of effective collaboration and highlight their value (Table S2). Students contribute to the learning community guidelines for collaboration to ensure that everyone can come as they are to discover and assert their ideas by empowering their voices. Implementation of this activity at the beginning of the term sets expectations that students will contribute and model the values that will be upheld through actions that are community defined. This work is not graded and is expected participation (Table S3).

**(ii) Argumentation training.** Students build and evaluate arguments by applying logic and credible evidence to build an argument, as well as consider how we can be generous in understanding other people's lived experiences that vary from our own. Both *How We Argue* (Text S2) and *How We Evaluate* (Text S3 and Table S4) are organized into mastery lessons where students complete at a rate of 1 to 2 lessons per week (with 14 lessons total). Students must complete lessons sequentially to progress through the module as part of mastery learning (8). Students complete this training over the course of the semester while also responding to ethical reasoning case studies (ERCS), so it is likely to see improvement in their responses as they progress. This work is graded for completion and is weighted to be 10% of their course grade (Table S3).

**(iii) Ethical reasoning case studies.** Students read case studies addressing 10 critical E/RCR scenarios adapted from *Responsible Conduct of Research* by Shamoo and Resnik (9) (Text S4). Students can select 5 of the 10 scenarios to write a response (Table S5) using the ethics case studies instructions (Text S5) and the scaffolded ethics case study response template provided (Text S6). These 0.5- to 1-page student responses are then assessed using a rubric provided in the ethics case studies instructions (Text S5). Students complete one case study every 2 weeks throughout the semester, except during the first 2 weeks of the semester to acclimate and the last 2 weeks to provide grace if needed. This work is graded for content and is weighted to be 15% of their course grade (Table S3).

**(iv) Discussion forum.** After students upload their own original responses to the ERCS, other students will have access to read and learn from one another. This encourages students to learn from different perspectives, appreciate new ways of understanding content, and value differences as a required component of deeply understanding life. This work is graded for completion and is included in the weight (15%) of the ERCS (Table S3).

## CONCLUSION

Our preliminary findings suggest that students describe and identify ethical issues in research and build credible support for their arguments (Table S6). Our results are limited due to our small sample size and voluntary participation. We can expect to increase our sample size as we continue to offer this course over future semesters. In the meanwhile, we are contributing to the collaborative education research studies E-CURE (10) and ENCOUR. Some future directions for this work include adapting materials to support student structure and to achieve learning goals prioritized over research deliverables.

## SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

**SUPPLEMENTAL FILE 1**, DOCX file, 0.03 MB.

## ACKNOWLEDGMENTS

This course would not be possible without the curious and brave BIT 295 students, with heightened gratitude for our Spring 2022 inaugural learning community. We thank our

numerous funding sources for supporting this ambitious work. We appreciate the DELTA team and NCSU for their tremendous guidance and support that enabled us to run BIT 295 online through our learning management system. We are grateful for the opportunities we have had to share our work as conference presentations.

C.C.G. and C.A.S. are supported by the Innovative Programs to Enhance Research Training (IPERT) funded by the National Institutes for Health (1R25GM130528-01A1). C.C.G. is a National Science Foundation (NSF) Ethics Network for Course-based Opportunities in Undergraduate Research (ENCOUR) Fellow (NSF-DBI 1919312); C.A.S. and C.C.G. participate in the NSF course-based research assessment program E-CURE. The E-CURE material is based upon work supported by the National Science Foundation under grant 1836033 (Jill Singer, Principal Investigator). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

The NC State University Libraries Open Pedagogy Grant provides support for two student Science Ambassadors that coordinated virtual events and connected the class to other courses and communities. The HHMI Inclusive Excellence program at NC State provides funding for dissemination of this work. NCSU Biotechnology (BIT) Program & Office of the Provost fund the development of BIT CUREs. NC State DELTA Course Improvement Grant helped support the design of the blended sessions and preparation for Quality Matters certification of the course.

We declare no conflict of interest.

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