Unintentional plagiarism frequently occurs in undergraduate writing assignments because students are unaware of the complexity of correct paraphrasing and citation rules. There is often a lack of formal instruction in science courses on proper paraphrasing and citation to reduce plagiarism. To address this deficit, we developed a brief activity to teach students to recognize the range of paraphrasing and citation errors that can result in plagiarism. The activity was used in a biology-focused scientific literacy course, but it can be incorporated into different instructional settings, with undergraduate students of all levels. During this classroom activity, part 1 addresses the nuances associated with proper paraphrasing and citation in scientific writing and part 2 asks students to practice paraphrasing and properly citing a passage from a scientific source. Pretest results revealed that students were proficient at identifying plagiarism when a citation error occurred but were less proficient at recognizing improper paraphrasing (patchwriting or direct plagiarism). Posttest results indicated that the activity was effective at increasing the students’ ability to recognize a paraphrasing error even when a correct citation was present. Students also reported higher confidence in their understanding of what constitutes plagiarism and that they are more confident in their ability to properly paraphrase and cite scientific source content.

INTRODUCTION

Plagiarism is a form of academic dishonesty that often occurs in college writing (1). In educational settings, unintentional plagiarism frequently occurs because students fail to understand the complexity of what constitutes plagiarism (2, 3). Assisting students in understanding this complexity is an ongoing challenge for educators (4–8). Students are often left to develop these skills on their own or receive formal instruction in the context of other disciplines such as the humanities (9). There tends to be a lack of formal instruction on plagiarism, proper paraphrasing technique, and citation style in the context of scientific writing. Thus, students may fail to understand the intricacies of what constitutes plagiarism and how to avoid it in scientific writing.

There have been several attempts described in the literature to teach students what constitutes plagiarism and how to avoid it by discussing plagiarism scenarios, stressing the importance of comprehending the subject matter before paraphrasing, and teaching citation skills (10–12). These attempts used homework assignments (11), online training (12), or detailed assignment descriptions (10). Some are integrated into content-based courses or lab-based courses, while others are embedded in skills-based courses designed to teach scientific literacy and/or scientific writing (10–12). Additionally, these practices have been used in both face-to-face and online courses (13, 14). These attempts have varied in their ability to reduce plagiarism.

In this paper, we describe a two-part learning activity designed to improve students’ ability to recognize plagiarism and practice their paraphrasing skills. Our approach directly engages students in recognizing common misconceptions about paraphrasing and citation errors in an interactive exchange and then asks students to properly paraphrase source text. This activity differs from other approaches in that it provides students with focused instruction on plagiarism with immediate feedback from peers and the instructor and offers students the opportunity to practice paraphrasing. While others have used similar approaches independently, our activity links them together to maximize understanding of unintentional plagiarism and develop the ability to properly paraphrase. The activity generates meaningful discussion about plagiarism, proper citation, and paraphrasing and reveals to the students and instructor the types of unintentional plagiarism that students find difficult to recognize accurately. Our results demonstrate that the activity was effective in improving students’ ability to recognize less obvious forms of plagiarism and improved their confidence in recognizing plagiarism.
Intended audience

Our activity can be directly implemented in any biology course (lecture or laboratory, content-based or skills-based) and is appropriate for use with undergraduate students at any level (freshman to senior). Though the content of our specific activity will be most effective with biology students, the activity can be easily adapted to other disciplines where scientific writing is relevant. The activity was used in a lecture course with an enrollment of 55 students but could be used in higher- or lower-enrollment courses without any modifications.

Prerequisite student knowledge

To maximize learning with this specific example, students should be familiar with basic biological concepts and understand how to cite scientific literature. The source content in the activity describes the structure of ATP synthase which is taught in most introductory biology courses. As a result, this activity could be used during, or any time after, an introductory biology course. If the source text is not appropriate for the course, the passages in the activity can be tailored to meet the needs of the course content and align with students’ prior knowledge. In our application of the exercise, two weeks prior to using the activity in class, students were introduced to different types of scientific literature (primary research papers, review articles, etc.), and they learned and practiced how to create in-text and end-reference citations using the Council of Science Editors (CSE) name-year style. Students should have had some prior instruction around paraphrasing source text, such as 1) reading the source text multiple times to gain sufficient understanding of the content, 2) taking notes on the source text only retaining key words, and 3) writing in one’s own style. Paraphrasing instruction could also be delivered prior to using the activity.

Learning time

The entire activity uses approximately 30 minutes of class time. We used both parts of the activity in succession, but they could be delivered separately. Part 1, recognizing plagiarism, and part 2, paraphrasing practice, each take approximately 15 minutes of instructional time. These estimates take into consideration a moderate amount of student participation and discussion. When incorporating this activity into high-enrollment courses, the instructor should consider allowing extra time for additional questions and discussion.

Learning objectives

Upon completion of the activity, students will:

1. understand the need for proper paraphrasing and citation in scientific writing to avoid plagiarism
2. be able to recognize plagiarized writing
3. practice proper paraphrasing and citation skills, which include:
   a. properly paraphrasing all source text and including an in-text citation
   b. avoiding patchwriting, as this is plagiarism even when an in-text citation is provided
   c. not using the author’s words without quotation marks even with an in-text citation, as this is plagiarism
   d. avoiding direct quotations, as they are not commonly used in scientific writing

PROCEDURE

Materials

Part 1, recognizing plagiarism, utilizes a series of interactive presentation slides (see Appendix 2) that provide an excerpt from a scientific source text followed by three different examples of “report” text that illustrate hypothetical student work. Our scientific source text is a biology example around the structure of ATP synthase, but the source text used can be tailored to meet the needs of any course. Students can participate by using an in-class polling system such as clickers or online smartphone polling software or by holding up one or two fingers to vote. We used the low-tech option of holding up one or two fingers. Part 2, paraphrasing practice, incorporates a handout with source text to be paraphrased and a space for students to write (see Appendix 3). Some instructors might consider forgoing the handout and just project the source text on a presentation slide, but we find that students prefer to interact with the source text on a handout.

Student and faculty instructions

During part 1, recognizing plagiarism, the instructor uses an interactive approach to guide students through three common mistakes related to plagiarism. Briefly, the instructor asks students to read a jargon-heavy passage related to the structure of ATP synthase (see Appendix 1). The instructor then asks students to describe the meaning of the passage. After discussing the meaning of the passage, students are asked to read an example of how a student might paraphrase the passage (report text). Students are then asked to identify whether the report text is plagiarized using an in-class polling system. A discussion of what plagiarism error(s) were found ensues. This is done for three example report text passages. At the conclusion of part 1, recognizing plagiarism, each student is given a handout to begin part 2, paraphrasing practice. During part 2, students are asked to read a passage and instructed to paraphrase it in their own words (see Appendix 1). Students then exchange their paraphrase with the student next to them to discuss and share with the larger class.
Suggestions for determining student learning

Much of the student learning that occurs in this activity can be observed during the discussion part of the activity itself. Most students recognize that they have committed unintentional plagiarism in the past by improperly paraphrasing or failing to include an in-text citation. Discussing unintentional plagiarism openly while providing students with the tools to avoid it, makes for a lively and important discussion.

Pretests and posttests were used to measure changes in ability to recognize plagiarism in paraphrased report text. Questions were adapted from an assessment described by Emily Holt (12). Students were asked to read two passages from secondary literature sources, one from an ecology review article (15) and one from a cell biology review article (16). Directly below the passage were six different paraphrased sentences that ranged in plagiarism severity. Students were instructed to place an X next to any sentences that were plagiarized (see Appendix 4). Results were used to determine the effectiveness of the activity but were not used in the calculation of a student’s course grade. However, this test could be easily administered as a quiz or part of a larger exam and incorporated into a student’s course grade.

We used an annotated bibliography as the signature assignment in our scientific literacy course, and this assignment contributed to the final course grade. Students were asked to find five to seven sources for a biology-related topic. For each source, they needed to describe the search strategy they employed to locate it, provide a summary of the article, give an end-reference citation in CSE name-year citation style, and paraphrase a part of the source text. For the paraphrased section, students were asked to provide the original source text alongside their report text. This allowed both the student and the instructor to see the original source text and the student’s paraphrased report text side by side. This part of the annotated bibliography was graded by determining how well the student paraphrased the source content in their own words, without patchwriting or direct plagiarism, and whether they provided a correct in-text citation.

Safety issues

None.

DISCUSSION

Field testing

This research was approved by the Stockton University Institutional Review Board (2014.005 and 2015.008). Students were not incentivized to participate in the study, and any identifying information was removed from their responses. Data were collected only from students who provided informed consent.

The activity was developed to use in a one-credit, undergraduate scientific literacy course required for all biology majors at a public four-year primarily undergraduate institution in the mid-Atlantic region of the United States. The course met once a week for eight weeks and is designed to teach students how to 1) locate and access primary scientific research articles, 2) read and evaluate the literature, and 3) effectively paraphrase and cite the literature without plagiarism. The activity was adapted from content presented in the course textbook (17) and an online plagiarism risk quiz from Goucher College (http://faculty.goucher.edu/writingprogram/sgarrett/Default.html).

Implementation and assessment of the paraphrasing activity occurred during the spring 2014 and spring 2015 semesters in eight different course sections with three different instructors. Students enrolled in the course during these semesters were invited to participate in the study. Each course section had a maximum enrollment of 55 students. During the spring 2014 semester, class sizes ranged from 43 to 55 students, and during the spring 2015 semester, class sizes ranged from 28 to 52 students. Of the students enrolled in the spring 2014 and spring 2015 semesters, 1% identified as freshman, 21% as sophomores, 50% as juniors, and 28% as seniors.

The signature assignment of the course is an annotated bibliography, and paraphrasing and citing source content is a major requirement of the assignment. The activity was delivered during the first half of the course. Other class meetings did not focus on paraphrasing instruction or activities, but students were required to paraphrase source content on other course assignments throughout the course. Formal instruction on how to cite scientific sources using the CSE name-year citation style was delivered prior to the activity.

Students completed pre- and posttests to measure changes in 1) ability to recognize plagiarism, 2) confidence in ability to paraphrase and cite scientific content without plagiarism, and 3) understanding of what constitutes plagiarism.

To assess students’ ability to identify plagiarized content, a test was adapted from an assessment described by Emily Holt (12). Students were asked to read two passages from a secondary literature source. They completed this task for two different biology-related review articles, ecology (15) and cell biology (16). Directly below the passage were six different paraphrased sentences that ranged in plagiarism severity. Students were instructed to place an (X) next to any sentences that were plagiarized (see Appendix 4). To measure changes in confidence and understanding, students rated their level of agreement on a Likert scale ranging from strongly agree (5) to strongly disagree (1) for three statements (see Appendix 4). Pretests were administered during the second week of class prior to using the activity, and posttests were administered at the end of the course.

A total of 262 students (137 from spring 2014, 125 from spring 2015) completed both the pretest and posttest and were used in the analysis. Since these data did not meet the assumption of parametric statistics, non-parametric tests
were used. McNemar’s test was used to measure learning gains on the plagiarism identification questions (nominal, two category, paired data). To compare responses of self-reported questions of confidence and understanding (ordinal, non-parametric, paired data), a Wilcoxon signed-ranked test was used. To compare responses in confidence questions, a Mann-Whitney U test was used (ordinal, non-parametric, paired data). All data were analyzed using SPSS software.

**Evidence of student learning**

Holt provides a useful framework to determine which aspects of plagiarism (paraphrasing, citation, or both) students struggled with or have misconceptions about (12). In this framework, different examples of report text are ranked from good to poor. At one extreme is Good 1, which describes report text that is properly paraphrased and properly cited, and Good 2, which describes report text that is properly quoted and cited. At the other extreme are the most severe examples of plagiarism. Poor 1 describes report text that uses the author’s words directly (direct plagiarism) with no citation and Poor 2 describes report text that contains patchwriting plagiarism and lacks a citation. Patchwriting plagiarism occurs when students keep much of the source text largely intact but replace or delete some words or phrases (2). In the center of this framework are report texts that include an in-text citation but contain patchwriting plagiarism (Fair 1), or report text with proper paraphrasing that lack a citation (Fair 2). We used this framework to score the plagiarism assessment questions to determine where students were making errors (see Appendix 5). One modification that we made to this framework was to change the category Poor 1 to describe text that uses the author’s words directly without quotation marks (direct plagiarism) with a correct in-text citation. This framework was used for assessment purposes only and was not shared with students. Pretest and posttest questions were scored on whether students could correctly identify report text as plagiarized or not. For example, if a student was presented with report text that was directly plagiarized with a correct in-text citation (Poor 1) and marked the sentence as plagiarized, their answer would be considered correct.

Pretest results indicated that our students struggled most with identifying plagiarized report text when a correct in-text citation was provided. When shown report text containing patchwriting plagiarism and a correct in-text citation (Fair 1), only 20.6% (ecology example) and 21.0% (cell biology example) of students correctly identified this as plagiarism (Figs. 1 and 2). Similarly, when shown report text containing direct plagiarism and a correct in-text citation (Poor 1), 41.6% (ecology example) and 39.7% (cell biology example) of students correctly identified this as plagiarism (Figs. 1 and 2).

Conversely, students were better at identifying plagiarized report text when a citation error was present. When shown report text that was properly paraphrased but did not contain an in-text citation (Fair 2), most students (61.8%, ecology example, 82.8% cell biology example) correctly identified this as plagiarism prior to the intervention (Figs. 1 and 2). Similarly, when shown report text containing patchwriting plagiarism and no in-text citation (Poor 2), 86.6% (ecology example) and 88.5% (cell biology example) of students correctly identified this as plagiarism (Figs. 1 and 2). Taken together, it appears that students look to the in-text citation first to determine whether report text is plagiarized or not.

![FIGURE 1](image1.png) Ability of students to correctly identify different levels of plagiarism in paraphrased examples when given source text from an ecology journal article. Data represent the percentage of correct student responses before and after the in-class intervention. N = 262. McNemar’s test, *p < 0.05. Good 1: properly paraphrased, correct in-text citation; Good 2: quotation, proper in-text citation; Fair 1: patchwriting plagiarism, correct in-text citation; Fair 2: properly paraphrased, no in-text citation; Poor 1: direct plagiarism, correct in-text citation; Poor 2: patchwriting plagiarism, no in-text citation.

![FIGURE 2](image2.png) Ability of students to correctly identify different levels of plagiarism in paraphrased examples when given source text from a cell biology journal article. Data represent the percentage of correct student responses before and after the in-class intervention. N = 262. McNemar’s test, *p < 0.05. Good 1: properly paraphrased, correct in-text citation; Good 2: quotation, proper in-text citation; Fair 1: patchwriting plagiarism, correct in-text citation; Fair 2: properly paraphrased, no in-text citation; Poor 1: direct plagiarism, correct in-text citation; Poor 2: patchwriting plagiarism, no in-text citation.
Prior to the intervention, pretest results show that students were able to correctly identify properly paraphrased and cited report text (Good 1) in both examples (88.2%, ecology example, 96.7% cell biology example) and properly quoted and cited report text (Good 2; 89.7%, ecology example, 92.4% cell biology example; Figs. 1 and 2). Students’ ability to recognize patchwriting plagiarism (Fair 1) or direct plagiarism (Poor 1) as plagiarism, even when a correct in-text citation was present, improved significantly at the end of the course based on posttest results (\(p < 0.05\) McNemar’s test, Figs. 1 and 2). There continued to be no obvious differences between whether the source text came from an ecology or cell biology review article.

The data regarding students’ interpretation of direct quotations with a proper in-text citation (Good 2) are less clear. Prior to the activity, most students correctly identified this as not plagiarized, but this percentage significantly declined in posttest results (\(p < 0.05\) McNemar’s test, Figs. 1 and 2) for both article examples (ecology and cell biology). Some students may have incorrectly identified quotations as plagiarism when instead they should have identified them as poor scientific writing because, during the activity, instructors explained to students that quotations are not generally accepted in scientific writing and should be avoided. This distinction between writing style and plagiarism is an area that should be clearly explained when employing the activity.

Following the activity, students reported a significant increase in their understanding of what constitutes plagiarism (pretest mean Likert score 4.488 ± 0.617, posttest mean Likert score 4.587 ± 0.523, \(p = 0.02\), Wilcoxon signed-rank test, Fig. 3). Confidence in their ability to paraphrase source content without plagiarism also increased following the activities (pretest mean Likert score 3.912 ± 0.970, posttest mean score 4.313 ± 0.679, \(p < 0.001\), Wilcoxon signed-rank test, Fig. 3). Student confidence in their ability to correctly cite scientific literature also significantly increased (pretest mean Likert score 3.645 ± 0.970, posttest mean Likert score 4.580 ± 0.573, \(p < 0.001\), Wilcoxon signed-rank test, Fig. 3). On pretests, students were more confident in their ability to paraphrase scientific content without committing plagiarism (pretest mean Likert score 3.912 ± 0.818) than in their ability to cite scientific sources (pretest mean Likert score 3.645 ± 0.970, \(p = 0.002\) Mann-Whitney U test); however, the opposite pattern was observed following the activity. Posttests revealed students were more confident in their ability to cite scientific content (posttest mean Likert score 4.580 ± 0.573) than in their ability to properly paraphrase source content (posttest mean score 4.313 ± 0.679, \(p < 0.001\), Mann-Whitney U test).

In order to demonstrate understanding of source text and avoid unintentional plagiarism in scientific writing, students must learn to both properly paraphrase and cite source text. Our findings reveal that formal instruction and practice in proper paraphrasing is an effective way to teach these skills. This activity aims to improve students’ ability to recognize the subtleties associated with plagiarism severity and allow them to practice their paraphrasing skills. Our assessment results indicate that students are initially better at recognizing citation errors and less adept at identifying paraphrasing errors. This is interesting, in that they self-report being more confident in their ability to paraphrase correctly and less confident in their citation ability at the outset. The activity results in students having increased ability to recognize patchwriting plagiarism and direct plagiarism even when a correct citation is present. These are important nuances to consider when teaching students how to avoid unintentional plagiarism.

**Possible modifications**

Assessment results revealed that students became more conservative in their identification of plagiarism. During part 1 of the activity, it should be emphasized to students that while cited quotations are not plagiarism, they are not commonly used in scientific writing and should be avoided. On the assessment, students were only given the option of selecting whether the statement was plagiarized or not. Students may have recognized that direct quotations are not commonly used in scientific writing, and therefore felt this was an error, and may have selected plagiarism because there were no other options. A modification to that assessment could provide students with the option of “not acceptable in scientific writing.” This would afford students the opportunity to demonstrate their ability to differentiate between plagiarism and poor scientific writing. With minor modifications, this activity can be used in almost any undergraduate STEM course. By selecting source text from the field of interest, the activity can be tailored to meet the needs of a variety of courses. In addition, instructors could administer part 2 of the activity, paraphrasing practice, at multiple points during a semester, allowing students to continually practice paraphrasing and citing.
SUPPLEMENTAL MATERIALS

Appendix 1: Instructor guide
Appendix 2: Lecture slides
Appendix 3: Student handout
Appendix 4: Assessment questions
Appendix 5: Assessment questions key

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REFERENCES

1. Roig M. 1999. When college students’ attempts at paraphrasing become instances of potential plagiarism. Psychol Rep 84:973–982.
2. Howard RM. 1995. Plagiarisms, authorships, and the academic death penalty. Coll Engl 57:788.
3. Park C. 2003. In other (people’s) words: plagiarism by university students—literature and lessons. Assess Eval High Educ 28:471–488.
4. Roig M. 1997. Can undergraduate students determine whether text has been plagiarized? Psychol Rec 47:113–122.
5. Breen L, Maassen M. 2005. Reducing the incidence of plagiarism in an undergraduate course: the role of education. Issues Educ Res 15:1.
6. Jackson PA. 2006. Plagiarism instruction online: assessing undergraduate students’ ability to avoid plagiarism. Coll Res Libr 67:418–428.
7. Selwyn N. 2008. “Not necessarily a bad thing …”: a study of online plagiarism amongst undergraduate students. Assess Eval High Educ 33:465–479.
8. Roig M. 2014. Critical issues in the teaching of responsible writing. J Microbiol Biol Educ 15:103–107.
9. McCabe DL, Butterfield KD, Treviño LK. 2012. Cheating in college: why students do it and what educators can do about it. Johns Hopkins University Press, Baltimore, MD.
10. Flaspohler MR, Rux EM, Flaspohler JA, Grossel M. 2007. The annotated bibliography and citation behavior: enhancing student scholarship in an undergraduate biology course. CBE Life Sci Educ 6:350–360.
11. Freeman E, Lynd-Balta E. 2010. Developing information literacy skills early in an undergraduate curriculum. Coll Teach 58:109–115.
12. Holt EA. 2012. Education improves plagiarism detection by biology undergraduates. BioScience 62:585–592.
13. Holt EA, Fagerheim B, Durham S, Siegel V. 2014. Online plagiarism training falls short in biology classrooms. CBE Life Sci Educ 13:83–89.
14. Divan A, Bowman M, Seabourne A. 2015. Reducing unintentional plagiarism amongst international students in the biological sciences: an embedded academic writing development programme. J Furth High Educ 39:358–378.
15. May ML. 2013. A critical overview of progress in studies of migration of dragonflies (Odonata: Anisoptera), with emphasis on North America. J Insect Conserv 17:1–15.
16. Scherer D, Kumar R. 2010. Genetics of pigmentation in skin cancer — a review. Mutat Res Rev Mutat 705:141–153.
17. Knisely K. 2017. A student handbook for writing in biology. Sinauer Associates, Inc., Sunderland, MA.