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CourseSource

Lesson

Building student literacy and metacognition through reading science in the news

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Abstract

Ensuring students' science literacy is essential for preparation for study in science disciplines and is of critical importance given contemporary challenges in determining the legitimacy and accuracy of science in popular media. This lesson describes the effectiveness of an undergraduate biology course designed to improve students' scientific literacy through meaningful engagement with science news sources. Students were surveyed at the beginning and end of the course to determine their preferred science news sources. Though 45% of students reported not accessing any science news sources in their daily lives at the beginning of the term, 100% of students reported accessing science news at the end of the term. Backward design and Scientific Teaching ensured that assignments meaningfully related to course learning goals, and formative assessment allowed the instructor to track student metacognition regarding science news throughout the term. These findings highlight the value of incorporating science news into undergraduate science courses with meaningful effects for science engagement and literacy beyond the classroom.

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Learning Goal(s)

- In this course, students will explore three current topics in biology that are widely discussed by the news media, portrayed in some popular television shows and movies, and used to make important scientific policy decisions: stem cells and cloning, genetically modified organisms, and the human genome and human genetic diseases. All three of these topics are likely to have significant impacts on students' lives, potentially affecting decisions about medical treatments, the environment, and food choices.
- Students will practice evaluating scientific content and uncovering appropriate and relevant content.
- Students will enjoy reading and learning how biology relates to everyday life and want to talk to others about what they learn to make scientific and policy connections outside of the classroom.
- Students will continue to read science articles from Discover Magazine, Scientific American, or the New York Times or listen to RadioLab and Story Collider after the course is over.

Learning Objective(s)

For each specific topic (stem cells and cloning, genetically modified organisms, and the human genome and human genetic diseases), students will be able to:

- describe the underlying biology and explore how scientific reasoning and methods develop this understanding,
- discuss the types of policy decisions that regulate studies related to biology or its application to human or environmental health,
- evaluate scientific information to distinguish reliable information from propaganda,
- explain how scientific controversies can arise when the same scientific questions are approached in different ways,
- explore why some types of biological issues trigger regulatory decisions that can affect both research that would deepen our understanding of the issue and application of the results to policy decisions,
- write about scientists who are researching topics related to our course, and
- read science writing published in popular media sources.

INTRODUCTION

In a world where citizens are asked to participate in scientific decision-making with increasing frequency--be it individual consumer or medical choices or as voting citizens--college science classrooms represent critical settings to increase students' capacity to be scientifically literate members of society. In general, the US population does not have a thorough understanding of scientific process and decision making (1,2). In addition, recent findings indicate that the very nature of consuming science news has changed (3,4). Despite clarity in the need for science literacy in a changing world, less is known about how to cultivate the skills needed to meet these challenges in college science courses.

Scientific Teaching, where goals, outcomes, and assessments are well-aligned and where students have opportunities as part of the course structure to build metacognition, increases student learning of scientific concepts (5,6). These methods have generated substantial empirical support in improving a range of student outcomes over the past decade, including increased understanding of science content, increased trust in the instructor leading to increased student engagement, improved critical thinking skills, and improved learning outcomes for students from underserved populations (7-11). To date, this research has yet to examine ways that Scientific Teaching can be used to build scientifically literate citizens through engagement with science news sources. While there is reason to believe that we can develop students' science literacy and ability to become critical consumers of science news, research and course-based interventions are needed to clarify the connections between how classroom design, assessments, and student interactions with science news may lead to increased development of student science literacy. We developed a course-based intervention to build student metacognition and increase consumption and critical reading of science news as a means to developing science literacy.

As others have reported, science courses are ideal settings to build science literacy by providing opportunities for students to read and critically analyze science news, understand the societal context for scientific of social controversies, and develop skills to identify credible and reliable scientific news sources (12,13,14). However, making informed scientific decisions is difficult without the ability to understand scientific research or judge the quality of popular press information. These skills are often particularly difficult for non-science majors (15,16).

The goal of supporting students' development as discerning consumers of written science news and scientifically literate citizens became the foundation of a biology course for non-science majors. With this goal in mind, we designed a course-based intervention to improve student metacognition regarding science news where students had opportunities to reflect on their own learning and develop their own sense of agency as consumers to identify high-quality science information (6). Metacognition may involve a wide range of approaches to learning, and typically describes a process of students actively monitoring their thoughts, problem-solving strategies, and external factors that influence their learning (17). This includes an understanding of one's own strengths, weaknesses, and biases in addition to successful methods for engaging learning materials. Students high in metacognitive processes can be expected to think critically both about course content and their own process for effectively engaging this content (18). We anticipated that students with strong metacognitive abilities would be able to recognize when their learning of potentially controversial content might be influenced by their prior knowledge. Therefore, these students could build awareness of how their life experiences would impact their reading and analyzing of science news articles. However, we expected that this would be a new and novel experience for many of our students.

Metacognition is a skill that students 1) may need to learn to apply within a specific course context (e.g., reading science news); 2) can build and develop over an academic term; and 3) may benefit students in the long-term given its implications outside academia. By encouraging students to practice skills of reading and analyzing science news with guidance and support, we hoped to build students' skills and interest in reading science news. Developing students' capacity for metacognition around reading science news was a key element in designing the course, assessments, and assignments with an explicit goal of improving students' science literacy.

Fewer people, including students, are consuming science news and many turn to non-traditional media sources, which may come from increasingly polarized online media (3,4). Students might also have different perceptions of science based on the sources they regularly access (19). This raises questions of whether students know how to find information regarding high-quality sources of science. To build students' capacity to make critical decisions and be comfortable with science in the media, we created opportunities for students to read, discuss, and write about science in the popular press. In class, we discussed instances when science was misrepresented or exaggerated in the media especially through headlines or titles used to capture the reader's attention (20). Additionally, we wanted students to locate credible science articles and demonstrate the ability to distinguish factors in sources that indicated the source material was of high-quality. Given that many students were not reading science news on their own upon entry into the course, we also scaffolded structured opportunities for students to engage quality sources to develop their ability to make critical decisions about the science presented before we asked them to independently find and analyze science news. In designing an introductory general education biology course for non-science majors focused on improving the quality and quantity of student science news consumption, we wrestled with the following questions focused on science literacy, metacognition, and scientific decision-making:

- How can we help students become more scientifically literate?
- How can students become engaged in and excited about science that is relevant to their lives?
- How do we prepare students to be global citizens who understand the complexities of science, recognize their own biases, and use scientific information to make scientific decisions?
- How can we support student development as consumers of high-quality popular press sources to aid their scientific decision making?

Here, we report on a course-based science news intervention and components of the course design that developed students' metacognitive skills regarding science news consumption as a means to improve their science literacy.

Intended Audience

This course-based intervention was designed for an introductory biology course for non-science majors at a large public research university and as described could be implemented in any size non-science majors course. Students represented thirty-five separate majors and ranged from first year students to seniors. To modify for a science majors course, instructors might consider reading both a primary literature article and science news article on the same discovery research so students could compare the way that the science is described in each type of publication.

Required Learning Time

The course as described was conducted in a 10-week quarter. The course met in two 80-minute full class (100 students) lecture times and one 50-minute discussion section with 25 students per section.

Prerequisite Student Knowledge

The course was designed to assume that students did not have prior knowledge about the biological concepts. Students were expected to have minimal experience and exposure to reading science as reported in the popular press. Students were asked to read science news articles that accurately presented scientific topics included in the course (although some examples of exaggerated reports and headlines were included in class discussion). Readings were used as a basis for additional in-class activities and learning in much the same way a textbook or any pre-class readings can be incorporated. The example "Three-Parent" Baby activity was used in class during week 9 of the 10-week quarter and built on students' learning from the term (Supporting File S1. Science News - Worksheet; Supporting File S2. Science News - Class Slides).

Prerequisite Teacher Knowledge

Teachers should be comfortable with searching for and determining the appropriateness of science as presented in popular press. As with adding any reading for a course, we first identified the learning objectives and topics for the course and then searched for articles that aligned with the appropriate content. Between each iteration of this course, our teaching team reviews the potential scientific advances and reads a variety of news articles on the topics we want to update. We frequently share science news that we read or hear (radio or podcasts) with each other. We save these articles as pdfs to post on the course learning management system in case the websites change or if news articles are behind a paywall that makes them inaccessible for students. In some instances, we ask students to read an older article plus a newer article on the same topic to discuss advances over time. In other cases, students only read a new article because it provides sufficient information. We are conscious of ensuring that articles selected align with and support the learning objectives for the unit and class session. In-class activities, clicker questions, or worksheets, can be tailored to different science news stories to support the intended learning objectives for students. For example, some objectives might be more skills based and others might be more focused on content, and activities are tailored to meet these objectives. Teachers need to have experience supporting student development of metacognitive abilities.

SCIENTIFIC TEACHING THEMES

Active learning

Students engaged with daily readings from science news sources and the textbook in class through group assignments, worksheets, discussions, and clicker questions. Activities were explicitly designed to support students' deep engagement with the content, develop transferrable metacognitive skills related to consuming science news (such as source quality and easy reference of original primary literature), and practice extracting information from news articles. Students participated in a variety of structured activities, including clicker questions, reflections, in-class worksheets, debates, partnered group work, jigsaws, building with manipulatives, mini-lectures, and whole class discussions to support their learning of the biology content and relevance to daily life.

Assessment

Students completed a pre- and post-survey to identify their sources of science news. Formative assessments (40% of final grade) included daily reading assignments (from science news articles and parts of three textbooks) with students responding to two or three questions based on daily learning outcomes before class on the online learning management system (21). On alternate weeks students either completed an online quiz designed to promote transfer (22,23) or a scientist spotlight to read and write about scientists conducting research related to course content (24) or to counteract some of the potentially negative media representation of scientists (19). Across the course students completed three summative assessments during the term, one for each unit (60% of final grade): they wrote a letter to their elected officials about stem cells or cloning (25); played a Reacting to the Past game focused on genetically modified foods (26); and for the final take home final reflected on their learning in the course, found a new scientist to spotlight who conducts research related to the course, and located and wrote about a recent science news article. Summative assessments were aligned to course goals and outcomes and developed using best practices of transparent design (27).

Inclusive teaching

Students read a range of science news articles from a variety of sources related directly to the class content and relevant to their lives outside of college. Throughout the term students completed five scientist spotlight activities where they read science news stories and wrote short responses about scientists, including women and people of color who are often underrepresented in sciences, conducting research directly related to course content (24). Scientist spotlights have been shown to lead to increased student understanding of and identification as scientists (24). During class sessions, students had multiple opportunities to interact with the material from the news articles and demonstrate their knowledge and understanding of the content. In class, we used name tents to learn and use students' names, always had students work in small groups before participating in a full class discussion, changed roles that students had on in-class activities, including varying the reporter, and provided opportunities for students to

reflect on both their previous exposure to scientific and social controversies and ways that the course content was relevant to their own lives.

LESSON PLAN

Course Structure

One hundred students were enrolled in the non-science majors course at a large public research university in the Pacific Northwest where they learned about underlying basic biological principles (e.g., mitosis, protein synthesis, DNA structure, genetic basis of inheritance, etc.) through exploration of biological topics frequently discussed in popular press. Course goals, learning outcomes, summative assessments, and formative assessments were aligned using backward design principles (5,28) to directly relate to student engagement with science in the news. Students read and analyzed science news articles related to each course topic over the course of a 10-week quarter (Table 1). To develop metacognition, students completed formative assessments based on the science news read for the course, reflections about how they consume science news, and a final summative assessment that measured their ability to find and recognize a high-quality science news story.

To make content as relevant as possible and support development of reading science news, student daily readings included 51 articles and five videos from 25 different sources and readings from two related introductory biology textbooks and a Reacting to the Past gamebook (26). The most common sources included fifteen articles from *The New York Times*, five from *Nature News*, and four each from federal government science agency websites and *Science*. Students answered 2-3 questions about the daily readings (based on the daily course learning objectives) on the learning management system before class.

Topics and specific student learning outcomes for each unit and class session were designed to include scientific content in contexts relevant to students and their scientific decision-making. For example, students learned about the policies and regulations of stem cells while at the same time learning about the underlying basic biology. Daily class learning included a variety of activities that were aligned to the daily learning objectives. Student news consumption was assessed at the beginning and end of the quarter, while additional formative assessments examined metacognitive skills throughout the course.

Pre- and Post-Surveys

On the first day of class, students were asked to respond on a notecard to an open-ended question, "Where do you get your science news?" Students could write as many responses as they chose. Student responses were coded into thirteen emergent categories (Table 2). For example, Facebook and Twitter were coded as a *Social Media* category and individual online or print newspapers coded as *Newspaper*. Students often included multiple sources of science news and these were coded individually.

On the final summative assessment, completed as a take-home final submitted on the course learning management system, students were asked again, "Where do you get your science news?" Students could select multiple items from a checklist menu of the thirteen categories coded from the original pre-survey responses.

Daily Class Activities

Students engaged with daily readings from science news sources in class through group and individual assignments, worksheets, discussions, and clicker questions. Activities were explicitly designed to support students' deep engagement with the content, develop transferrable metacognitive skills related to consuming science news (such as source quality and easy reference of original primary literature), and practice extracting information from news articles. Classroom activities and formative assessments were based on the readings that students completed. For example, students read two recent articles (one published during the term) about "three-parent" babies (29,30). During class, students completed a group worksheet to answer questions related to the science in the articles (Supporting File S1. Science News - Worksheet). The worksheet included multiple elements such as assigned roles for group participation (recorder, reporter, time keeper, and Googler) and a Google doc for students to post questions to reflect on their own previous knowledge and personal interests. As a class, we stopped periodically to discuss student answers to the questions, and students answered clicker questions to build their metacognition and check their understanding (Supporting File S2. Science News - Class Slides). We also discussed the quality of the science as presented in the news stories.

On other days throughout the term, students participated in classroom debates about the pros and cons of using technology to bring back mammoths or Neanderthals. They explored how genetically modified corn impacted butterfly populations. They evaluated ethical concerns of cloning through a series of clicker questions about different potential types of cloning. Each day, the classroom activities were tailored to specific readings and designed so students read science news articles, evaluated the claims within the articles, and applied the concepts from the news to the biological content in class to build their metacognitive abilities. The teaching team was transparent during class about identifying ways in which the science content was presented in the news and provided multiple opportunities for students to have deep engagement with the material they read. We paid attention to supporting student development of metacognition through opportunities for reflection and conversation about the topics.

Formative Assessments

Students completed structured formative assessments (40% of final grade), both in and out of class, to read and engage with science in the news and build capacity for critical analysis and metacognition. First, twice a week, students completed daily readings and answered two or three online questions on the learning management system. Questions were based on daily learning outcomes and created a framework so students were familiar with the basics of the content before class (21).

Second, students engaged with daily readings in class through individual and group assignments, worksheets, discussions, and clicker questions. Activities were explicitly designed to support students' deep engagement with the content, develop transferrable metacognitive skills related to consuming science news (such as source quality and easy

reference of original primary literature), and practice extracting information from news articles. Third, students completed five online multiple-choice quizzes every other week. Quizzes included images directly from popular press articles students had not yet read and required transfer of knowledge to new situations (22,23). Quizzes also included short passages from news articles that students interpreted.

Lastly, students wrote five scientist spotlight reflections focused on scientists doing research directly related to course content (24). In each scientist spotlight, a video of the scientist discussing their research was paired with a popular press reading that included societal implications of the research. In each of these formative assessments, students practiced communicating both with classmates and in writing to answer questions about what they were learning. Students and instructors received feedback through these formative assessments about students' abilities to read and interpret material and successfully answer questions related to course goals.

Summative Assessments

Students completed three summative assessments (60% of final grade), and as part of a final take home exam students located and wrote about a recent science news article. Summative assessments were aligned to course goals and developed using best practices of transparent design (27). The final take home exam related to science news reading and was designed to assess how well students had developed critical reading skills and the ability to demonstrate the metacognition targeted by formative assessments and classroom activities throughout the quarter (Supporting File S3. Science News - Summative Assessment). After describing how they located an article and their reasons for trusting the source, students wrote a short essay response to specific questions about the article. The grading rubric included evaluation of students' responses using nine criteria: 1) complete citation; 2) description of how the article was located; 3) description of the quality of the article; 4) summary of the science; 5) connections to the course; 6) description of how the science was well-represented; 7) description how the science was poorly-represented; 8) thoughtful questions for the author; and 9) grammar and mechanics.

TEACHING DISCUSSION

Pre- and Post-Surveys

In the pre-survey at the start of the term, 45% of students self-identified that they did not read science news, but by the end of the term that number dropped to zero, with 100% of students providing at least one source they accessed for science news (Figure 1). On the pre-survey, the second highest category for science news source (36.3%) was social media (primarily Facebook and Twitter); this number jumped to 77% at the post-survey. In addition to an increase in the number of students who were reading science news, in the post-survey we also saw an increase in the number of types of sources that students were using to access information. In the pre-survey, 80 students responded with 140 separate codeable sources. In the post-survey, 93 students responded with 510 separate codeable sources.

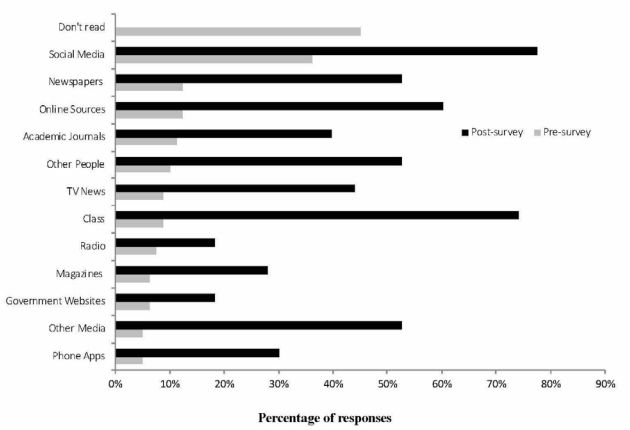

Figure 1. Students were asked on the first day of class in a pre-survey and on the final summative assessment in a post-survey "Where do you get your science news?" In the pre-survey, students could list as many sources as they chose and emergent categories were coded. On the post-survey, students could choose from any 13 categories coded from the pre-survey.

Final Summative Assessment

Ninety-three students completed the final exam and cited 81 separate articles from 28 unique sources. Twenty-three articles were from *The New York Times*, 12 from *Scientific American*, 10 from *Science Daily*, and 9 from *Science News*. Of the other top sources that we read for class, students cited zero from *Nature News* and three each from government websites and *Science*.

Students identified six main emerging criteria that they used to select a science news article for their final exam:

- read other articles from the same source earlier in the course;
- included citations of peer-reviewed research;
- credible or reputable;
- unbiased;
- written in a format that was easy to understand; or
- recommended by a trusted associate.

Students listed their rationale for trusting the conclusions from the article based on:

- citations of peer-reviewed research or
- from a reputable or credible source.

Students demonstrated a range of abilities for describing why the source they selected was reputable. Exemplary student answers included multiple criteria, provided evidence from the article to support their criteria, and clearly demonstrated that the student engaged in metacognition while evaluating the credibility of the news article (Table 3). Student answers that were less-well developed might have used some of the key wording (e.g., credible or unbiased) without defining the terms or providing an example from the article, and it was unclear whether the student engaged in metacognition of their own biases or learning when evaluating the quality of the article. In the least well-developed answers, students could not articulate what criteria they used to select an article in a way that showed discrimination between excellent and poor-quality science news writing.

Discussion

We were surprised by the small number of students who reportedly read science news at the beginning of the course. However, results from this pre-survey reflect national trends in the nature and frequency of science news consumption, whereby students are less likely to access science news from traditional media (3,4). These findings were especially surprising given that we had identified developing metacognition with regards to reading science news as an important skill for students to develop. One of our colleagues describes that in courses for non-science majors, "I want students to read *The New York Times* science section when they are in college and be interested enough in science to still read it five years after they graduate." We intentionally built the course-based intervention around these goals.

However, upon further reflection, most students in previous science coursework may only be asked to read science in a textbook, a skill that is qualitatively different than critically reading and analyzing science news, as reading a textbook often does not provide opportunities for students to grapple with source quality. Consequently, science faculty collectively may not be preparing students to read and analyze science in popular media. Many upper division science majors courses rely on students learning to read, interpret, and use primary peer-reviewed literature because that is a skill faculty have determined is important for students (31). Learning to read secondary science sources that are not textbooks is equally important for non-science majors and a skill they can develop (32). One repeated statement from student final exams was that students selected a source because "we read it in class." How can students learn to distinguish high-quality sources if they are not asked to do this with scaffolding and aligned expert classroom support throughout a course?

With encouragement and multiple opportunities for practice, non-science major students in this course were able to meaningfully engage with science news by the end of the term. Through daily course activities and regular formative assessments grounded in student learning outcomes, students were given incentives to read science news and guidance for identifying key, important elements while reading. By providing opportunities for students to engage with science news, student discussions can improve their understanding of science (33). In our course, students first had guidance on reading examples of high-quality science new articles. We purposefully created a structured learning environment where students were not expected first to learn the skill of how to find science news on their own. Final exam results nonetheless demonstrated that students were able to transfer the knowledge they gained in class to a final summative assessment where they were asked to identify and critically analyze a science news item. The purposeful design incorporating Scientific Teaching allowed us to create scaffolding for students to explore science in the news and use the content in course activities and assessments.

In addition to the backward design elements of Scientific Teaching, the classroom environment also fostered an inclusive learning environment, another key element of Scientific Teaching, where students could explore their uncertainties and the societal implications of scientific discoveries (5). Through student responses to clicker questions, group discussions, and written assignments, we found that students in the class held a diversity of beliefs about topics such as stem cells and genetically modified organisms. In the classroom, we built trust with the students so they would be willing to engage in conversations and learning about these potentially controversial topics (11). Readings and associated activities provided students with structured (8), meaningful opportunities to learn to read material critically, determine validity, relate popular press news writing to science content, and ultimately make their own decisions regarding the quality of the news source and content. In so doing, students developed their metacognitive skills in an inclusive, structured setting where assignments and in-class activities scaffolded growth to support learning for all students. This scaffolding was especially important to build trust to encourage student engagement and create an inclusive learning environment given the low percentage of students who were independently reading science news before the start of the course and the reliance placed on this ability throughout the term.

In some instances, reading and learning about content changed students' perspectives. For example, learning about the science behind genetically modified organisms caused some students to question the anti-GMO movement. Sometimes learning more solidified students' established beliefs. For example, learning about genetic diseases reinforced a desire to be screened for genetic mutations. All of this was accomplished in an inclusive environment where the learning was grounded in science news relevant to students' daily lives.

However, during the course, we learned that we had to provide greater support for recognizing and distinguishing high-quality science news than we had originally expected. Students demonstrated the ability to report that a source was credible, though many were unable to connect this claim with evidence (e.g., describing the source as unbiased or the quality of available data). We needed to be more explicit with students about what constitutes reliability as well as methods for recognizing source quality. Novices often over-estimate their abilities to draw these conclusions effectively, and we expect this is true of students distinguishing high-quality science sources (34,35). We realized that this ability to discern source quality is something to which we need to pay more direct attention. We demonstrated how to select and read high-quality sources through the types of articles we asked students to read and in our comments to the class; however, we did not explicitly state or practice the discernment process in the course, nor were we clear regarding elements that constitute "quality."

We found it was difficult to teach the process of how to build healthy skepticism into the process of reading science news. While activities we used in class helped students to become actively engaged in readings, they simultaneously required students to build capacity for metacognition and more clearly identify what they were learning and potential biases. Ultimately, we hope students will continue to be active consumers of science news. Practicing skills of reading science news articles from high-quality sources in college may inform students' life-long habits as to where they will access science news in the future (36).

At the conclusion of the term, we generated a list of tenets of reputable sources that we will share with students in the future. Much like others (37), we do not want to create a

checklist of items that students must remember, but instead want to build these tenets directly into learning objectives and formative assessments and provide students with opportunities to practice. Some of these tenets we explicated directly with students, and others were inferred but not directly practiced. Six tenets of reputable science news are:

1. The source has a history of high-quality science reporting.
2. The writer references original scientific studies.
3. It is easy to find the original scientific research.
4. The writing style is accessible without obscure jargon.
5. It is possible to determine who is funding the reporting on the research.
6. There is a direct connection between evidence presented and conclusions drawn.

What students did gain through this course was an opportunity to read science news, explore content more deeply, and make connections to their own lives while building their metacognitive abilities. From our course-based intervention, we learned that by requiring students to frequently read science news and guiding them to practice with news articles, we could increase their self-reported reading of science news. We wonder if this will carry forward in life. Will students continue to seek out high-quality science news sources? After their academic requirements are completed, will they return to social media as their primary source of science news? At the end of the course, asking students to find a science news article that they found to be interesting and related to the course required that they transfer knowledge and skills from the course to a new activity. By demonstrating various levels of competency with describing how they chose an article on the summative assessment, we hope students are on the path to becoming thoughtful consumers of science news and scientifically literate citizens who can identify bias or illegitimacy in science news and make decisions based in sound science.

SUPPORTING MATERIALS

- Supporting File S1. Science News - Worksheet. This is a sample formative assessment that doubled as a classroom activity based on two popular press readings about “three-parent” babies. Students each had a group role and answered the questions in small groups followed by whole class discussions spaced throughout the class session.
- Supporting File S2. Science News - Class Slides. This a sample classroom activity with clicker questions that was paired with S1. Science News - Worksheet. Each slide has a note describing how the slide was used in class, answers to clicker questions, rationale for each worksheet question that students answered, and answers to each question at the level that was appropriate for the course.
- Supporting File S3. Science News - Summative Assessment. This includes the questions students were asked and the grading rubric for the final course take-home exam.

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Figures of the pedigree of Lehigh Syndrome and Spindle transfer are reprinted from Reproductive BioMedicine Online, 34, Zhang, J., Liu, H., Luo, S., Lu, Z., Chávez-Badiola, A., Liu, Z., Yang, M., Merhi, Z., Silber, S.J., Munné, S., and Konstantinidis, M., Live birth derived from oocyte spindle transfer to prevent mitochondrial disease, 361-368, Copyright (2017) with permission from Elsevier.

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Table 1. Lesson plan timeline for course summative and formative assessments

Activity	Description	Estimated Time	Notes
Pre-Survey (Week 1)			
Pre-survey question about students' science news habits	On the first day of class students answered the question "Where do you get your science news?" on a notecard that was collected at the end of the first day of class.	10 minutes	• Students could write multiple ideas. • Notecards were collected and student responses were coded into 13 emergent categories.
Daily student activities throughout the term			
Daily Readings and Questions Readings	1. Students read 1-3 articles before each class (two times per week) based on science as presented in news articles and parts of a textbook. 2. Students responded to daily reading questions on the learning management system based directly on the daily learning objectives.	About 20-30 minutes of reading per class session.	
Daily Class Activities	Students had opportunities during each class to explore in more depth the science read in the news articles. Activities included: 1. Completing a worksheet in small groups during class dissecting the information presented in an article. 2. Responding to clicker questions about the biological content as described in the news articles. 3. Engaging in debate about contemporary biological topics and societal implications.	80 minutes per class session (two times per week)	Example: Three-Parent Babies in-class worksheet (S1, S2).
Formative Assessments			
Quizzes	Students completed five online quizzes based on science, including interpretation of images and articles from popular science articles.	40 minutes per quiz (every other week)	Students completed quizzes on the learning management system. Questions from an instructor generated quiz-bank were randomly selected for each student.
Scientist Spotlights	1. Students completed five scientist spotlight assignments. 2. Students read popular press articles and watched videos about scientists describing their work. 3. Students learned about scientists from groups who are traditionally underrepresented in science.	1 hour per assignment (every other week)	Scientists were selected to represent the diversity of scientists who conduct research on topics related to the course content.
Summative Assessments			
Take Home Final and Post-Survey	1. Students found science news article related to genes, genomes, and human disease. 2. Students wrote an essay responding to a series of questions about the science news article. 3. Students answered the question "Where do you get your science news?" and could select from the 13 emergent categories from the pre-survey.	1 hour	Instructions and grading rubric (S3)

Table 2. Emergent codes for responses to pre-survey question: "Where do you get your science news?"

Emergent Codes	Examples
Don't read	I don't read science; Nowhere
Social media	Facebook, Twitter
Online sources	Online
Newspapers	New York Times, Wall Street Journal
Academic sources and journals	PubMed, Google Scholar
Other people	Bill Nye, friends
Class	Academic courses
TV News	CNN
Radio	NPR
Government publications	NASA, EPA
Magazines	Scientific American, National Geographic
Apps	Curiosity app, news aps
Other media	Ted Talks, podcasts

Table 3. Sample student responses with explanations for why they selected an article and determined that it was a high-quality source. Table presented with exemplar examples, less well-developed examples that are missing an important piece, and examples where student ideas are not fully developed for each of the six tenets of reputable science news.

Tenets of reputable science news	Exemplary student examples	Less-well developed student examples	Examples where student ideas are not fully developed
1. *The source has a history of high-quality science reporting.*	"Truthfully, before taking this class, I didn't have a go-to source for scientific news that was both accessible and reliable. After being accustomed to reading articles on the Scientific American throughout this class, I decided to go on their website, type "genomes" into their search engine."	"From previous research, I have done I am able to semi-confidentially say that this site is reliable. Not only do they publish articles on studies, but they sometimes post copies of the report from the actual study. This leads me to believe it is fairly reliable."	"I believe this source is trustworthy because I navigated throughout the website and the information they provided appears to be legit."
2. *The writer references original scientific studies.*	"The article, while interesting, is not trust-worthy. To begin, the author did not mention any of the study's researchers. There were no direct quotes, or any indication that the researchers confirmed that the information was accurate. Additionally, the information that author chose to include about the research was unclear. She did not reveal any statistics; she only wrote that connections between drinking tea and health outcomes seemed to have occurred."	"I would consider this article trustworthy, considering that Vox chose to name the paper the study was published in, and quantifiable data was cited as opposed to opinion and conjecture."	"This is also an interview with a correspondent who witnessed the discussions on this very topic so he would have the correct information on this subject. This science is well represented because all the info in this article is from a large discussion of scientists who specialize in this field."
3. *It is easy to find the original scientific research.*	"The New York Times is a trustworthy news source because they provide links to the research for the reader to check. This kind of transparency makes me feel more confident that the information I am reading is true. The science is well represented in this article because they explain the scientific terms they use and describe the processes that resulted in their findings."	"While I find the article to be not completely untrustworthy, I did note quite a few flaws or questions after analyzing it. It makes me wonder how often news sources simply choose a dramatic title to draw the audience in, when in reality the article does not have nearly enough information or research to back it up."	"The only thing that worries me about how the science is presented in this article is that this author is not one of the direct researchers who conducted studies on this epidemic."
4. *The writing style is accessible with limited and obscure jargon.*	"Additionally, the science is easy to read, which allows any type of reader to engage with the science and not distance themselves from the words on the page by being too complex or unheard of. For instance, when writing "transcription factors," Maxmen made sure to define it in the sentence by writing, "genes that control other genes" right after mentioning the word."	"Science is well-represented in the article because it explains what was done, a large amount of people were used in the study, and there is a good explanation of what takes part of Autism in the genetic level."	"I think that this article was clearly written and showed no biases towards the information that it reported."

Tenets of reputable science news	Exemplary student examples	Less-well developed student examples	Examples where student ideas are not fully developed
5. *It is possible to determine who is funding the reporting on the research.*	"...this is a sponsored article, which could make it less substantiated. Specifically, the article was produced for Nestle by Scientific American Custom Media. This is concerning because Nestle, while a research center, is also a for-profit company that produces, things like baby food, bottled drinks, cereals, and chocolate. Put simply, Nestle could use this research to position their brand and their products in a certain, potentially misleading, way that leads consumers to believe Nestle products are better for them and their children."	"This is a trusted news source because for one we have used it in class and from my personal knowledge they are still privately owned and are impartial in their writing of fact and not out of interest or interest of big companies."	*No examples
6. *There is a direct connection between evidence presented and conclusions drawn*	"Moreover, the science incorporated in this article is quite astonishing and is supported with data and research from various scientists. The science behind this article is well-explained and connects several concepts to support the author's claims."	"Science is very well represented in this article because it shows the constant work scientists and researchers are doing to find out more and more about the complexity of our genes."	"I saw how the title of the article was relevant to what we have learned in class about CRISPR, Cas9, and genetic diseases so I read it. As I was reading it I evaluated the science it displayed and it matched perfectly with what we learned in class so I selected this as my article."