Using a Student-Generated Mock Magazine Issue To Improve Students' Awareness of Diverse Scientists†

Jennifer D. Robison1*, Nicolas F. Berbari2, and Anusha S. Rao3

1Niswander Department of Biology, Manchester University, North Manchester, IN 46962;
2Department of Biology, Indiana University-Purdue University Indianapolis, Indianapolis, IN 46202;
3Center for Teaching and Learning, Indiana University-Purdue University Indianapolis, Indianapolis, IN 46202

This study explores whether integrating multicultural content within a genetics laboratory course affected students' awareness of diversity and their perceptions of scientists' identities. Genetics laboratory curricula typically focus on content and experimental procedures, with cursory references to the scientists who made these discoveries. The resulting poor racial and gender representation in the curricula propagate biases about the abilities and contributions of scientists from underrepresented groups, which may adversely affect the retention and success of students in these groups. Initially, students completed a pre-test in which they were asked to recall the names of geneticists and their scientific contributions. Later students created a mock magazine issue featuring a diverse set of experts in genetics, specifically members of traditionally underrepresented gender/sexuality and/or racial/ethnic groups. To facilitate this assignment, students were randomly assigned a geneticist from a pool of active research scientists, spanning a wide range of scientific and cultural backgrounds and identities. Each student wrote a 500-word biography of their assigned geneticist and read biographies composed by peers. Then, in groups, the students categorized biographies based on student-selected unifying themes into a table of contents. On the final exam, the pre-test was repeated as a post-test. In the pre-test, scientists listed by students were 94% male and 6% female, with no members of other underrepresented groups included. In the post-test, scientists listed by students shifted to 84% male and 16% female with 18% from underrepresented groups. These data suggest that this intervention increases awareness of the multicultural nature of scientists.

INTRODUCTION

As higher education student bodies continue to diversify in terms of race/ethnicity, gender, and sexuality, they increasingly do not fit the societal stereotypes attributed to STEM career practitioners. For example, according to the U.S. National Science Foundation (NSF), in the biological and social sciences, women received 55%, 57%, and 49%, while Black, indigenous, and people of color (BIPOC) received 22%, 13%, and 9% of Bachelor’s, Master’s, and Doctorate degrees, respectively (1). However, a meta-analysis of five decades of draw-a-scientist studies in the United States showed that the majority of elementary children drew images depicting predominantly male scientists (2). While science curricula have made great strides in recognizing the contributions of women to science, such as Rosalind Franklin being included with Watson and Crick, they are still lacking in their representation of BIPOC and lesbian, gay, bisexual, transgendered, and queer (LGBTQ) individuals (3–5).

The intentional use of inclusive pedagogy through curriculum development may help increase students' awareness of diversity in science (6–11). Inclusive pedagogy encompasses using dynamic and creative classroom practices and assessments to promote a safe learning environment for all students (7). Many students, specifically BIPOC and LGBTQ, struggle to feel included in science courses as they fail to identify with or relate to the role models typically presented in the curriculum (12). Additionally, integrating social context and focusing on the journey of discovery of scientists makes it easier for students to humanize these scientists and connect to their discipline (13). Instructors could, and should, act as “tour guides” for students by presenting the work of a broad spectrum of scientists to increase retention in STEM (14). Indeed, students who are exposed to articles featuring diverse scientists expand their perceptions of who belongs in the field of science (15).

This study examines whether the introduction of a multicultural writing assignment will increase students’ awareness of the diversity of scientists. For the purpose of this study, we used data from the NSF National Center for...
Science and Engineering to identify groups that are traditionally underrepresented in STEM (1). This includes racial or ethnic groups that have traditionally been marginalized in the United States, people with a disability, and those identifying as LGBTQ. The study hypothesis was as follows: The introduction of multicultural content will increase awareness and appreciation of the diversity of scientists in the field of genetics.

**Intended audience**

This intervention was designed for a genetics laboratory; however, it is easily adaptable to any STEM course by changing the pool of scientists to fit the course material. It is ideal for relatively small class sizes (fewer than 30 students), as students will need to read the biographies generated by the entire class. For larger classes, subgroups of students can be created for the peer review steps of reading and categorizing the biographies.

**Learning time**

Since the primary feature of the intervention is an assignment, students are expected to work on the assignment outside class meeting times. The instructor introduces the assignment briefly during the lecture or lab session and provides 2 weeks for the final submission. A second lecture or lab session is dedicated to the group discussions to categorize the biographies into a table of contents (ToC).

**Prerequisite student knowledge**

Students need to know how to find and identify suitable resources via the internet or library to research their assigned geneticist.

**Learning objectives**

This intervention included three major objectives. First, the main purpose of the intervention was to expose students to the diversity of scientists researching genetics. Second, contemporary examples were used to increase the comprehension, understanding, and awareness of current research in genetics, which could lead students to take career paths in science postgraduation. Third, students were asked to write for a lay audience to improve their engagement with this intervention and increase their ability to explain complicated research. The second and third objectives are unique to this study and set it apart from the work performed by Schinske et al. (14). Schinske et al. (14) presented students with “Scientist Spotlights,” which were prewritten news pieces for diverse scientists; the students read these news pieces and composed a reflection. In the intervention described in the current study, students created spotlights themselves by composing biographies. The introduction of writing assignments has been shown to improve student knowledge and engagement across a variety of disciplines (16–19), which fueled our decision to have students compose biographies about scientists rather than reading them.

In an attempt to mitigate student effects within the participant pool, students were not given the three objectives of this intervention. Instead, the student learning objectives (SLOs) provided were:

- **SLO1**: Students will explain complicated genetic research to a lay audience in the form of a magazine article.
- **SLO2**: Students will evaluate and categorize scientist biography articles to create a ToC.

SLO1 ties directly into the third objective of this intervention, pushing students to explain complicated genetic research to a lay audience, while supporting the first objective to increase student awareness of diversity in the field. SLO2 ties directly into the first objective of this intervention by having students interact with and categorize all the geneticists presented in the intervention. SLO2 also ties into the second objective as each student will be exposed to the research of every scientist featured in the magazine, providing them with tangible examples for future career paths.

**PROCEDURE**

**Materials**

Prior to the start of the course, the instructor generated a list of scientists from which students would create biographies. The list included at least one scientist per registered student so that each student could write a different biography from their peers. The master list of scientists for this study was created using the following criteria, in order of priority: (i) living scientists (note: Ben Barres and Warwick Kerr died after this list was generated and distributed to the students during field testing), (ii) representative of gender and racial/economicities of students in our courses based on the published student body enrollment gender and racial/economicities percentages reported by the university, (iii) have made a significant contribution to the field, (iv) conducting genetically focused research. The lab sections were capped at 30 students and, therefore, the scientist list generated contained 30 scientists, of which 14 were female and 16 were male. The ethnicities of the scientists were: 16 (53%) Caucasian, 4 (13%) Black or African American, 4 (13%) Asian, 4 (13%) Hispanic/Latinx, and 2 (7%) other. Additionally, 3 (10%) of the scientists identified as LGBTQ. The full list of scientists is provided in Appendix 1.

On the first day of the semester, the instructor printed out enough versions of the pre-test (Appendix 2) to administer to every student. This test was repeated at the end of the semester as an essay prompt during the final exam, which was administered via learning management systems (LMS). Instructors have the option of administering these
A
The popular (imaginary) magazine Gene News Now is going to run a featured issue entitled “Modern Geneticists You’ve Probably Never Heard Of, But Should Have” and because of your extensive knowledge of both the scientific and socio-cultural impacts of this field, they have commissioned you to write a biography of an impressive geneticist. Your biography should introduce this person by summarizing their scientific contributions (250 – 300 words) in a way that their audience can understand (for the general population they shoot for a 7 – 9th grade reading level), as well as, feature personal details (200 – 250 words) that reminds the general population that scientists are humans too. You will be randomly assigned a member of the list found at the end of this assignment in class.

Be sure to think about their accomplishments in and out of the lab and any dilemmas they would have faced or overcome to make these contributions to the field of genetics. If you can, locate and upload a photo of your nominee with the biography. Hints: Use PubMed & Google Scholar to search by author name for finding publications by this geneticist. For personal information, Wikipedia and Science News can be good starting points. Finally, you can use http://www.hemingwayapp.com/ to verify if your biography meets the criteria that an audience with 7 – 9th grade reading level can understand it. You can check this Ruth Sager biography from a previous issue as an example.

B
Having successfully completed your Scientist Biography for the upcoming Gene News Now magazine, you have been assigned to editorial teams to generate a Table of Contents. You will have to create 4 – 5 category headings and assign at least 3 biographies to each heading.

Consider how you wish to present these geneticists to the magazine audience. How would you categorize these geneticists? What unifies the biographies? What distinguishes them? Once you have created this Table of Contents, write 1 - 3 sentences that explains your thought process behind the categories chosen. Each member of the group will submit a copy of the Table of Contents along with the explanation paragraph as a single PDF.

FIGURE 1. Student prompts for the Gene News Now assignment. A) Biography assignment prompt. Students are provided with the address to the Hemingway App, which provides grade level information (http://www.hemingwayapp.com/), and with a biography example of Ruth Sager, which can be found in Appendix 3. B) ToC assignment prompt.

tests via paper or LMS. Student prompts and rubrics for each part of this assignment can be found in Appendix 2.

Student instructions

The pre-test was administered at the first course meeting. This pre-test was a single open-ended prompt with a 2-minute time limit: “List all the geneticists and their accomplishments that you know in the space below.” The post-test was the same prompt provided as an essay question on the final examination for the course; however, due to the online format, there was no separate time limit on this essay question.

The second part of the assignment was the creation of a mock magazine by students. This was completed in two parts: in the first part, students generated biographies; in the second part, student groups generated a ToC for the magazine. In the first part of the assignment, each student was instructed to compose a 500-word biography of their assigned scientist that was evenly focused on the scientist’s contribution to the field of genetics, as well as that scientist’s personal life and hobbies (Fig. 1A). Students were encouraged to include images of their assigned scientist with proper citation.

The biographies were collected by the laboratory section instructor and put into a single PDF file with identifiable information removed. The collection of biographies was provided to the students via the university’s LMS. In the second part of the assignment, students worked in small groups to organize and categorize the scientists using specific criteria to generate a ToC for the mock magazine. Students were allowed to use any criteria they wished as long as they met the minimum requirements for the assignment (Fig. 1B). Each group had to come to a consensus and submit a single paragraph reflection on why they categorized the scientists in this fashion.

Faculty instructions

As was done in this study, the instructor will need to create the pool of scientists that represent diverse groups and are relevant to the coursework. The authors suggest that instructors perform searches using a search engine to determine the ease with which students will be able to locate information on their assigned scientist, as this will be the first step for most students. Resources and instructional support from the library could also be used to make the research process more transparent and scaffolded for students.

The instructor should be prepared to administer the pre-test on the first day of class to ensure accurate baseline data is collected prior to any course learning experience. The scientists’ biographies can be assigned in any manner the instructor deems appropriate, though the authors recommend having students select names randomly. The students should be given a sufficient amount of time to research and compose their biographies; based upon student feedback, we suggest a minimum of 2 weeks. To support maximum student engagement, the instructor needs to ensure that this assignment is not due during exams or other assignment-heavy periods.
After the biographies have been submitted, the instructor will need to anonymize submissions and compile them into a single document so that the entire class (or subsections of the class for large classes) can read them to prepare the ToC. The authors suggest providing a single class period during which groups can work to prepare their ToC. This will give the instructor an opportunity to answer students’ questions about the second part of the assignment and reinforce the value of the assignment within the course. It is critical that students have read all the biographies before the ToC class session so they can contribute to the discussion.

In this study, students were given broad instructions on how to arrange the ToC. Each group was to discuss and determine four to five categories, with at least three geneticists per group, and each geneticist could only be assigned to a single category. The categories should reveal meaningful unifying themes about the geneticists to the magazine’s audience. During pilot testing, the authors were careful not to give the students theme suggestions to avoid biasing them. However, the authors did tell students that the categories had to be in greater depth than simply alphabetizing by name. Once the ToCs were arranged, the groups were required to compose their rationale for their chosen arrangements and submit this with their categories.

Suggestions for determining student learning

Comparing the pre- and post-test lists of scientists will allow the instructor to determine whether students’ awareness of diverse groups of scientists increased and how their perception of the scientists’ work informed the creation of their ToC. Student feedback on this intervention is provided in Tables 1 and 2.

Sample data

Data were collected over seven sections of a 300-level undergraduate genetics laboratory course. Each section had 20 to 25 students, for a total of 165 students enrolled. Data collected included pre- and post-test scores, student-generated ToCs, and a post-assessment student survey. ToCs were analyzed qualitatively for thematical representation.

Safety issues

There are no safety issues associated with this study. The Institutional Review Board (IRB) of Indiana University approved the study as an Exempt Protocol.

DISCUSSION

Field testing

This study took place in the fall of 2017 across seven sections of the K323 Genetics Laboratory at Indiana University-Purdue University Indianapolis. Students’ self-reported gender identities were 35% male, 62% female, and 3% undisclosed (Fig. 2A). Self-reported races/ethnicities were 63% white, 10% Black/African American, 9% Asian/Pacific Islander, 8% Hispanic/Latinx, 5% other, and 5% undisclosed (Fig. 2B). To facilitate analysis, the pre/post-test results were entered into a spreadsheet and the gender and race/ethnicity of each reported scientist were added. For each reported scientist, the number of times the scientist was reported was divided by the number of students in the section [e.g., (number of times that Scientist 1’s name was reported)/ (number of students in section)]. These values were used to generate average percentages with standard deviations for each scientist, to account for the differences in student numbers per section. During statistical analysis, each section was treated as a replicate.

All ToC submissions were read by the lead author to identify recurring themes for qualitative analysis (20). The major themes used to categorize scientists by the students were scientific (research area/type), geographic (country of origin or research), and demographic (gender, ethnicity, sexuality, age). Once these themes were identified, the ToCs were coded for the presence of one or multiple themes. For example, a single ToC could have sorted scientists using categories that reflected the science (e.g., studies plants) and
Evidence of student learning

Effectiveness of the intervention in increasing awareness. Pre-test responses: The names of 14 different scientists were listed in the pre-test responses of at least one of the seven sections. The top three scientists listed were Gregor Mendel, James Watson, and Francis Crick, with each reported on average by more than 60% in all seven sections (Fig. 3). The first woman to appear was Rosalind Franklin, who was also the only woman reported in all sections. The only other woman to appear was Elizabeth Blackburn, who was only reported in a single section. There were no racial and ethnic minorities nor LGBTQ-identifying scientists (BIPOC/LGBTQ) represented in the pre-test.

Post-test responses: In the post-test, the number of scientists reported increased sharply from 13 to 41 scientists, including Kary Mullis, Martin Chalfie, and Hermann Muller. Because these Nobel Prize winners were the subject of a different written assignment in the course that was not tied to this intervention, these names were left out of the dataset. Of the 38 remaining names, James Watson, Francis Crick, and Gregor Mendel were still well represented in the post-test (Fig. 4) as they had been in the pre-test (Fig. 3). All 30 scientists included in the intervention were reported at some level on the post-test (Fig. 4). Due to the randomness of scientist assignment and the different number of students in each section, only 4 out of the pool of 30 were assigned to every section, which complicated the analysis. The top 10 scientists mentioned in the post-test included two women (Mary-Claire King and Joan Roughgarden) and three BIPOC/LGBTQ scientists (Rick Antonius Kittles, Ben Barres, and Joan Roughgarden) (Fig. 4).

When comparing the pre- and post-test results, there was a clear increase in number of reported scientists in the post-test. When analyzed based on gender alone, student responses were predominantly male, but the overall percentage decreased from the pre- to the post-test (Fig. 5).
The reported number of women increased on average in the pre- and post-test from 4 to 19 and the number of men increased from 58 to 110 (Fig. 5A). When examining these data as percentages, only 6% of student responses in the pre-test were women. This value increased to 16% in the post-test, a 2.5-fold increase (Fig. 5B).

When the pre- and post-test results were analyzed based upon BIPOC/LGBTQ identities, the student-reported scientists were predominantly Caucasian/heterosexual (C/H), though the overall percentage decreased from the pre- to the post-test (Fig. 6). In the pre-test, there were no BIPOC/LGBTQ scientists reported, and this value increased in the post-test to 22 (Fig. 6A). The reported number of C/H scientists increased from the pre- to post-test from 61 to 99 (Fig. 6A). Examining these data as percentages showed a clear increase in student awareness of different demographics represented in the field of genetics. There were no BIPOC/LGBTQ scientists reported in the pre-test, while in the post-test, 18% of reported scientists were BIPOC/LGBTQ (Fig. 6B). Although the fold change cannot be calculated from a starting point of 0, this is clearly a substantial increase.

**ToC themes.** A total of 42 ToCs were generated by the seven sections. The majority of these ToCs were organized solely based upon scientific criteria, such as study species or specific study area (Fig. 7A). Very few groups used exclusively geographic or demographic categories in organizing their ToCs. Only a single group used demographics exclusively, organizing scientists by age (Fig. 7B). Almost 20% of the groups had at least one demographically based category along with scientific criteria, and 7% had at least one geographical category in their ToCs. Some student groups (7%) used a mix of scientific, demographic, and geographic criteria in their ToCs. A sample ToC from each criterion shown is provided in Fig. 7.

**Student feedback on intervention.** Student feedback was sought to understand their perception of this intervention via a Qualtrics survey administered on the last day of the lab, which was the week after the ToC group work was completed. The survey questions are provided in Appendix 2. Students were asked to rate their awareness of the diversity of scientists and their backgrounds before and after the intervention. Before the intervention only 5% of students reported having a high awareness and 27% a moderate awareness (Fig. 8). After this intervention, 36% had a high awareness and 56% a moderate awareness of the diversity of scientists and their backgrounds (Fig. 8). These data suggest that this intervention markedly increased stu-
dent awareness of women, BIPOC, and LGBTQ geneticists, which was the first goal of this study. When asked to rate the helpfulness of this intervention in increasing their understanding of research performed in the field of genetics, 16% of students found it “very helpful,” 29% of students found it “helpful,” 31% of students found it “somewhat helpful,” 17% of students found it “not helpful,” and 7% of students found it “not at all helpful” (Fig. 9). These data indicate that this intervention was successful in reaching the goal that students would increase their awareness of current genetic research, the second aim of this study.

To get a sense of student engagement with this intervention, students were asked to rate how enjoyable performing the intervention was to them. This intervention was rated as “very enjoyable” by 7%, “enjoyable” by 25%, “somewhat enjoyable” by 40%, “not enjoyable” by 19%, and “not at all enjoyable” by 9% of the students (Fig. 10A). There was no effect of gender on reported student enjoyment (Fig. 10B). More students who identify as an underrepresented minority reported a “very enjoyable” experience (10%) than did students who did not identify as an underrepresented minority (2%). The reverse of this was noted in the “not at all enjoyable” category, where 2% of students who identify as an underrepresented minority reported a “not at all enjoyable” experience compared with 10% of students who did not identify as an underrepresented minority (Fig. 10C). As this intervention was designed to provide role models representative of our entire student body, the increased enjoyment of underrepresented minority students may speak to their ability to see themselves as geneticists, which could lead to increased persistence in STEM as suggested by Estrada et al. (3).

The open-ended survey questions asked students to identify the most valuable aspect of the intervention, its least valuable aspect, and ways to improve it. We received a wide range of responses that mirrored the helpfulness and enjoyable ratings. The top three themes that emerged in the most valuable aspect of this intervention were Knowing Scientists (39%), Research Knowledge (33%), and Seeing Diversity (17%) in the open-ended question (Fig. 11A).
TABLE 1. Representative student responses to the open-ended survey question, “What aspect of the Gene News Now assignment was the most valuable to you?”

| Category                | Sample Responses                                                                                                                                                                                                 |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Knowing scientists      | “I thought that it was very valuable to read about how the geneticist got into the field. I tend to think of scientists as ‘super humans’ or ‘geniuses,’ so to read that some of these geneticists did not even start out in the field of science was very interesting. Learning that some of these famous geneticists are actually practicing in Indiana was very exciting to me as well!” |
|                         | “Getting to know the accomplishments of these scientist was pretty cool, we learned a lot of these facts as memory but i always wonder what the person was like who discovered these breakthroughs”                                                                 |
|                         | “Being able to learn about the scientists’ personal lives, and see that they were just like every other undergrad student trying to get through school.”                                                                 |
| Research knowledge      | “It was interesting to see what diverse pathways people could take in genetics, as well as being exposed to topics that I either did not know about, or did not know existed.”                                                    |
|                         | “Learning about how the concepts being taught in lab and lecture are being applied in the real world and making an impact on a lot of things in my life. Making me aware that some of the things that I encounter every day/ things I do are because of the work of these geneticists” |
|                         | “Gaining knowledge about the different categories of genetic research and what developments have occurred over the years.”                                                                 |
| Seeing diversity        | “The ability to stay relevant, and study current scientists in the field. I enjoyed researching people from different cultures.”                                                                                                               |
|                         | “Learning about geneticists of color and their contributions to science.”                                                                                                                                                     |
|                         | “What was most valuable to me was learning about the different women who have made a huge impact to the field of genetics.”                                                                                                     |
|                         | “Learning about how scientists are also people just like us. It was cool to read about their contributions, but it was also interesting to hear about their personal lives.”                                                        |

Rate your awareness of the diversity of scientists and their backgrounds in the field of genetics research before and after the Gene News Now assignment

![Graph showing diversity awareness](chart.png)

FIGURE 8. Student responses to the post-activity survey examining the increase in awareness of diversity in the field before (closed) and after (open) the assignment.

Rate the helpfulness of the Gene News Now assignment in increasing your understanding of research performed in the field of genetics.

![Graph showing helpfulness](chart2.png)

FIGURE 9. Student responses to the post-activity survey examining the increase in understanding of current research in genetics.
Many students commented that they appreciated learning that these scientists had personal lives, were real people with real struggles, and/or being able to relate (Table 1, top row) in comments concerning Knowing Scientists. Other students commented that value came from learning about research today, application of concepts in the real world, and/or seeing the breadth of the field (Table 1, middle row) in comments considered Research Knowledge. Students also mentioned the value of seeing people from different cultures in the field, learning about people of color, and/or learning about women’s accomplishments in science in comments concerning Seeing Diversity (Table 1, bottom row). Students who self-reported as female and/or underrepresented minority were more likely to have Seeing Diversity as the most important aspect of this activity (data not shown), which correlates well with increased enjoyment of this activity by underrepresented minority students (Fig. 10C). These data combined demonstrate the importance of this activity for providing diverse role models.

In the least valuable aspect, the top three themes that emerged were the ToC (37%), Timing (13%), and Nothing was Valuable (11%) (Fig. 11B). Many students voiced their dislike of the ToC, including it being unimportant to understanding research, completely useless, and not enjoying group work, among other things (Table 2, top row). The ToC activity was assigned in the last third of the semester, which is an assignment-heavy time of the semester, and many students noted this to be the reason they disliked this portion of the activity (Table 2, middle row). This portion of the activity took place in the last two weeks of classes, which added additional anxiety to end of the semester, with final exams upcoming. Several students suggested moving the activity to the beginning of the semester as an introduction to the world of genetics. The third least valuable item mentioned by students was the entire intervention (Fig. 11B). The reasons provided varied (Table 2, bottom row). Several students indicated that lab assignments should be only techniques without any personal stories. A few responses implied that students’ implicit biases were challenged by this activity which led to their dislike of the activity.
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Overall, this intervention was successful at meeting its three objectives. It is clear from the data presented above that this intervention did increase awareness and appreciation of the diversity of geneticists (objective one), as well as increasing awareness of current avenues of genetic research (objective two). Additionally, students were pushed to write for the lay audience by requiring the biographies be written at a 7th to 9th grade level and were graded accordingly (data not shown). This intervention could be easily modified for use in any STEM course to add multicultural content into the curriculum.

Supplemental Materials

Appendix 1 List of scientists
Appendix 2 Student prompts, rubrics, and survey questions
Appendix 3 Biography exemplars

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