"Scientists are People too": Biology Students Relate More to Scientists When They are Humanized in Course Materials

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ABSTRACT

Featuring scientists in classroom materials provides opportunities for students to relate to scientists as role models and see themselves in science. However, it is unclear what information students find most relatable when encountering scientists throughout their education. In this study, we manipulated the amount and type of information provided about scientists featured in biology courses. Within the context of activities focused on a scientist's research study and data, we provided students with either no personal information about the scientist (Control treatment), pictures of the scientist (Visual treatment), or pictures and humanizing details about the scientist (Humanizing treatment). We asked students to describe how they related to the featured scientist, and qualitatively coded responses. Results showed that students related to the scientist's 1) professional research interests (e.g., research topic, science as a career) and 2) personal information (e.g., life experiences, hobbies, personality characteristics, race/ethnicity, gender, and socioeconomic status). In addition, we observed differences in how students related to scientists across our treatments. Students were twice as likely to relate to featured scientists, and related in a greater variety of ways, when course materials included personal, humanizing information. We discuss implications for curriculum development and call for intentionality in how we present scientists throughout biology education.

INTRODUCTION

Sharing the stories of scientists in science, technology, engineering, or mathematics (STEM) curricula can broaden student perceptions of who contributes to these fields (Damschen *et al.*, 2005; Schultheis *et al.*, 2022; Metzger *et al.* 2023). Scientist role models enable students to see themselves as scientists (Schinske *et al.*, 2016; Ovid *et al.*, 2023), enhance student sense of belonging (Drury *et al.*, 2011; Rosenthal *et al.*, 2013), and increase student interest in STEM careers (Gladstone and Cimpian, 2021; Schultheis *et al.*, 2022). These documented impacts have led to the development of resources that enable instructors to feature more scientists throughout their curriculum (Simpson *et al.*, 2021; Costello *et al.*, *in revision for this same special issue*).

Although scientist role models are broadly viewed as beneficial for students, many resources still perpetuate the exclusionary depiction of scientists as only White, *cis*-men (i.e., the stereotypical scientist; Chambers, 1983; Miller *et al.*, 2018; Finson, 2002). For example, in a sample of chemistry textbooks, for every page that

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featured a woman scientist, 63 pages featured men (Becker and Nilsson, 2021). According to Xiang and colleagues (2024), across 13 representative undergraduate physics textbooks, only 2.5% of the 750 scientists mentioned were women. In biology, Wood *et al.* (2020) found that while 41% of enrolled college students possessed an excluded race/ethnicity (i.e., were not White), only 3% of scientists featured in common biology textbooks held these excluded identities. Similarly for gender, while 60% of enrolled college biology students were women, only 13% of featured scientists in biology textbooks were women. When textbooks are revised to include more scientists, new editions may inadvertently exacerbate the gender divide further (Becker and Nilsson, 2021). Exclusionary representation leads to a mismatch between the identities of scientists featured in classroom materials and the students who use them (National Research Council, 1987; Sax, 2001; Seymour *et al.*, 2019; Simpson *et al.*, 2021). The outcome is that many students may graduate without ever encountering a scientist role model to whom they can personally relate.

A mismatch in the identities of featured scientists and students can prevent students from seeing their possible selves in STEM. Markus and Nurius (1986) conceptualized *possible selves* as a theory to describe how individuals connect their current and past selves to representations of their future selves. For example, one may think, "*Now* I am a student, but I *could be* a scientist." Possible selves offer incentives for behaviors that could influence what individuals might become, or disincentives for behaviors to avoid. This can be a challenge for students who possess identities that are not embodied by the stereotypical scientist (Chambers, 1983) and therefore do not typically see themselves among scientists featured in their STEM curriculum. For such students, this messaging can decrease a sense of belonging in STEM and lead to disinterest in STEM careers (Rosenthal *et al.*, 2013). However, if students are given opportunities to relate to scientists, they may be able to conceive that they too can become scientists (Sparks *et al.*, 2019; Kricorian *et al.*, 2020; Crane *et al.*, 2022; Metzger *et al.* 2023).

To help *all* students see themselves in STEM, educators, scientists, and curricular developers have been successful at working together to develop accessible and evidence-based materials showcasing scientists that counterstereotypes (see Costello *et al.*, *in revision*, for a full table of resources). Short, targeted interventions can change the perception of who does the work of science (Damschen *et al.*, 2005; Schinske *et al.*, 2016; Schultheis *et al.*, 2022). For example, Schinske *et al.* (2016) found that, after exposure to weekly assignments featuring counterstereotypical scientists in their biology course, students in a demographically diverse community college shifted to more counterstereotypical descriptions of scientists. When only 2–10% of classroom material was altered to feature more women scientists, students' knowledge of women scientists increased (Damschen *et al.*, 2005), and just three examples of counterstereotypical scientists were enough to increase the extent to which students engaged with course material (Costello *et al.*, 2024).

Early evidence suggests featuring counterstereotypical scientists can not only shift student perceptions of who does science but can also help students see aspects of their own identity represented in STEM. For example, Scientist Spotlights are activities that feature scientists and engage students through reflective assignments with biographical and science content. These materials include visual and humanizing information about featured scientists. According to Schinske *et al.* (2016), after exposure to Scientist Spotlights, students were more likely to use phrases, such as "like me" or "I am also…", that made connections between their own identity and that of the featured scientists. Metzger *et al.* (2023) reported first-generation and women students related more to scientists when they were presented with Scientist Spotlight assignments. Other studies on college-level and secondary school assignments demonstrated significant shifts in how students related to scientists in biology courses (Yonas *et al.*, 2020; Aranda *et al.*, 2021; Metzger *et al.*, 2023; Ovid *et al.*, 2023). Beyond Scientist Spotlights, Rosenthal *et al.* (2013) studied women considering a career in medicine and demonstrated that materials featuring successful women physicians led to an increased sense of belonging and interest in medical careers. Through Project Biodiversify, Zemenick *et al.* (2022) showed that students found scientists more relatable after completing a lesson in which they created a biography about a scientist's research and personal interests. Furthermore, Data Nuggets, quantitative activities that feature a diversity of scientists, increased high school students' interest in science careers, which teachers attributed to the authentic research and scientist stories shared in each activity (Schultheis *et al.*, 2022).

While it is clear that there is a need to increase the presence of counterstereotypical scientists within classroom materials, we need more information about the impact of the types of scientist stories we tell, and how we should tell them. Uncovering *how* students relate to scientists can potentially maximize the positive effects of educational materials featuring scientists. Here we fill a gap in the literature by uncovering the components of scientist stories that impact students in a positive way. To do so, we developed treatments that varied the type and extent to which quantitative biology activities shared information about a featured scientist. We then studied how our treatments impacted the extent to which students related to these scientists, and whether this effect depended on the type of personal and professional information shared. Using student written responses, we then investigated they type of information shared about featured scientists that students found most relatable. Specifically, we addressed the following research questions about scientists featured in curricular materials: 1) To what aspects of scientist stories do students relate? and 2) Does the amount and type of information shared affect how students relate?

MATERIALS AND METHODS

DataVersify Quantitative Biology Activities

Our project used the curricular resource, DataVersify—a collaboration between Data Nuggets and Project Biodiversify (Box 1). DataVersify pairs quantitative biology exercises with scientist profiles highlighting counterstereotypical scientists. Scientist profiles include humanizing information about the featured scientists by sharing photos, along with biographical elements that provide students with a broad, nuanced, and holistic perspective on featured scientists. The resulting

BOX 1. DataVersify activities are the integration of two established programs, Data Nuggets and Project Biodiversify.

Data Nuggets. Data Nuggets (https://datanuggets.org) are free educational resources, codesigned by scientists and educators (Schultheis and Kjelvik, 2015; Schultheis *et al.*, 2022). Each activity is written in collaboration with a featured scientist (or scientists) and begins with a research background sharing science content and the research design. These backgrounds include photos and stories centered on the scientist's motivation to pursue their area of research. Students engage with an authentic dataset to answer scientific questions, create graphs, and construct explanations. The goals of Data Nuggets are to 1) help scientists share their story, research, and data with a broad audience, and 2) to engage students in the work of scientists through authentic research and data experiences (Schultheis and Kjelvik, 2015). Compared with typical classroom instruction, Data Nuggets have been found to increase students' abilities to use data as evidence to support claims, confidence in their abilities to work with data, and interest in science, technology, engineering, or mathematics careers (Schultheis *et al.*, 2022).

Project Biodiversify. Project Biodiversify (www.projectbiodiversify.org) is a free online repository of teaching materials and methods aimed at making biology classrooms inclusive to students of all backgrounds by humanizing biologists and increasing the diversity of biologists highlighted. To facilitate easy inclusion of a diverse set of biologists into coursework, Project Biodiversify constructs teaching slides and instructor notes based on the research and life experiences of biologists that self-identify as part of an underrepresented group in biology. Each Scientist Profile includes photos of the scientist, information on the scientist's background and personal interests (humanizing material), as well as an explanation of their scientific work (research material).

materials focus on core science content, along with scientist stories that humanize scientists. Because DataVersify is the fusion of two established curricular resources, we detail each briefly in Box 1.

This project complements and expands on concurrent DataVersify research (Costello *et al.* 2024). While Costello and colleagues explore the impact of humanizing featured scientists on quantitative measures of student outcomes, the current study focuses on qualitative data and *how* students relate to scientists via an open-ended prompt. To our knowledge, the present study is the first to identify what specifically students are relating to when humanized information is shared about featured scientists.

Participants

Our study included instructors and students from 36 U.S. undergraduate institutions in 20 states, spanning R1 universities to community colleges (Supplemental Table S5 in Costello *et al.*, 2024). In total, we selected 43 instructors from 289 applicants. We prioritized instructors who 1) taught introductory biology, 2) taught the same course for three consecutive semesters, 3) were from a diverse range of colleges and institution types, and 4) expressed enthusiasm based on their response to our prompt that asked why they wished to participate in our research study. We recruited instructors using Data Nuggets and Project Biodiversify mailing lists and social media accounts. We also used academic and conference listservs, the NSF Research Coordination Network project, Equity and Diversity in Undergraduate STEM (NSF-RCN-UBE-1919462), and suggestions from members of our network. Collectively, these 43 instructors taught 37 introductory-level biology courses and four upper-level courses.

During the study, we asked students to complete a demographics survey. A subset of 3102 students completed the survey. Self-reported demographic information reflected a student pool that was 60.0% White, 10.8% Asian, 10.5% Black, 9.6% multi-racial, 9.2% Latino/a/x, 0.6% American Indian or Alaska Native and 0.2% Native Hawaiian or other Pacific Islander students. This student population consisted of 64.5% women, 31.5% men, and 3.9% gender diverse.

Research Design

To manipulate the way counterstereotypical scientists were highlighted in instruction, we developed 12 DataVersify activities. These activities were developed in collaboration with the featured scientists who told their own stories and chose what information to share. Featured scientists were compensated for their effort. In an additive manner, our treatments increased the amount and type of information students received about the featured scientist. All DataVersify activities were modified to reflect all three of our treatments. These three treatments included the same core activity and added either: no personal information about the scientist (Control treatment), pictures of the scientist (Visual treatment), or pictures and humanizing details about the scientist (Humanizing treatment) (Figure 1). Across all treatments, we shared details of the featured scientist's research and career in STEM, such as stories of their academic pursuits and the methods used in their work.

Our study was fully randomized and controlled. We used a block design approach, randomly assigning one treatment per iteration of the focal courses over three academic terms. In this way, instructors implemented all three treatments and served as their own control. Within each iteration (semester, quarter, or section) of their course, instructors implemented three DataVersify activities and embedded them within the context of typical classroom biology instruction. After each of the three activities, students responded to the open-ended prompt, "Describe how you related to the featured scientist, if at all." All treatments were implemented via Qualtrics and responses were submitted directly to the authors. There were no word minimums or character limits for open-response questions.

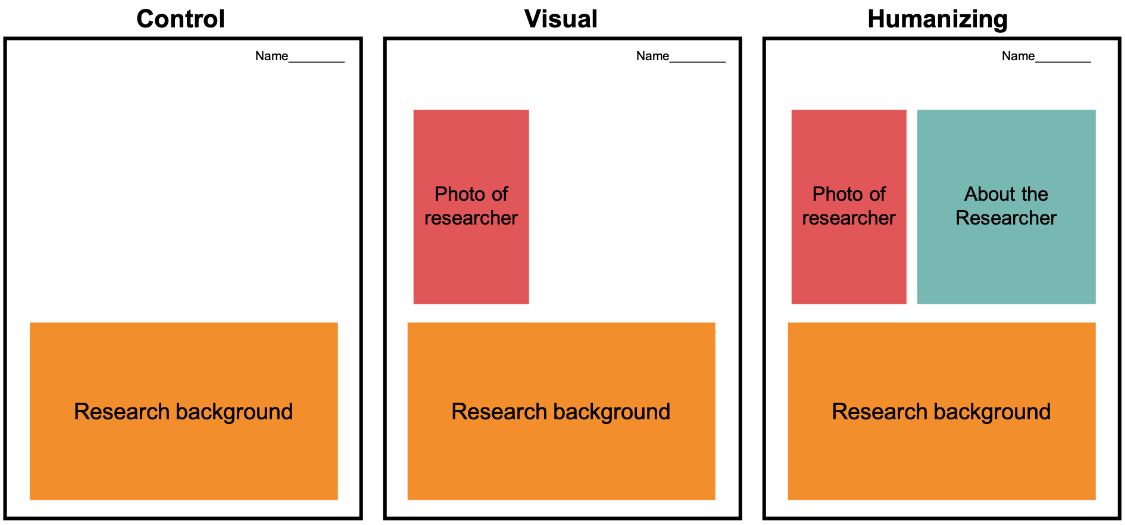

FIGURE 1. Schematic of DataVersify biology materials with varying levels of scientist information included along with the research background and quantitative activity.

As an example, Instructor A may have been assigned the randomized order of Visual treatment, Humanizing treatment, and Control treatment. Instructor A would then have selected three of our 12 available DataVersify activities, based on the content covered in their course. All students in Instructor A's first iteration would receive the Visual treatment for three DataVersify activities over the term. These students would complete quantitative biology activities featuring photos of featured scientists and details about their research, but would not see any personal, humanizing information about the featured scientists. In their second iteration, Instructor A would assign the same three DataVersify activities modified to reflect the Humanizing treatment, and in the third iteration they would repeat the process with the activities modified for the Control treatment.

Inductive Thematic Coding

We used inductive thematic coding to create codes describing the types of student responses to our open-ended prompt, "Describe how you related to the featured scientist, if at all" (Saldaña, 2015). Two researchers independently reviewed student responses collected in the first semester, developed codes characterizing student responses, met to compare and revise the codes, and developed a unified codebook. The final codebook included 24 different codes (Figure 2). After the development of the codebook, the same two researchers used axial coding to group and abstract codes into three different student response categories (Saldaña, 2015). The three different categories included 1) the student related to the personal information about the scientist, 2) the student related to the research interests of the scientist, and 3) the student did not relate to the scientist (Figure 2).

Every student response was coded by at least two different researchers and was assigned to all appropriate codes, meaning a single student response could fit in multiple codes. The average initial percent agreement was 59%. After coding independently, the researchers met to come to 100% consensus. In total, five different researchers used this codebook to code student responses. Co-author R.M.Y. led this qualitative coding process, coding and collaboratively reaching consensus for every student response to ensure consistency in the final code for each response.

Quantitative Data Analysis

We used mixed effects logistic regression models to determine whether the approach of featuring scientists in curricular materials (i.e., the treatments) affected how students related to those scientists. We employed three different models, one for each category of student response (Figure 2). Each model included treatment as the independent variable and the student response category as the dependent variable. We included student ID nested within the course and the specific DataVersify activity as random effects in our models. We fit our models with the R package *lme4* and specified a binomial distribution (Bates *et al.*, 2015). We calculated odds ratios for each logistic regression. Odds ratios are natural exponentials of the model's estimated coefficients and provide predictions for how students will relate to scientists across treatments. All analyses were conducted in R version 4.3.1 (R Core Team, 2023).

RESULTS

Overall, there were 5094 responses from 2952 students to the question "Describe how you related to the featured scientist, if at all." We analyzed these responses to (RQ1) understand aspects of counterstereotypical scientist's stories to which students related and (RQ2) investigate which types of information students related to most frequently. Our findings are organized below by our two research questions. The number of student responses varied by analysis.

RQ1. To What Aspects of Scientist Stories do Students Relate?

Students related to several aspects of the featured scientist's story (Figure 2). We categorized student responses as 1) relating to personal information about the scientists (e.g., sharing the same personality characteristics, similar life experiences,

Category	Code	Explanation	Student Examples
Student Relates to Information About Scientist	Race/Ethnicity	Student states they relate to scientist's race or ethnicity.	"He talked about being an Asian-American in STEM, which I am as well."
	Gender	Student states they relate to scientist's gender.	"I related to her because she is a female."
	Age	Student states they relate to scientist's age.	"I did because we were close in age and were interested in similar things."
	LGBTQIA+	Student states they relate to scientist's LGBTQIA+ status.	"We are both LGBTQIA+."
	First Generation	Student states they relate to the scientist's first generation status.	"I related to her being a first-generation and low-income."
	Low Income	Student states they relate to scientist's low income status.	"I am similar to the scientist in the sense that I am a hispanic woman from a low-income family and am a somewhat first generation college student."
	Other Identity	Student states they relate to the scientist through an identity that the student does not share.	"He was a minority in science. I am not a racial minority but I am a minority in terms of my sexuality."
	Overcoming and Encountering Barriers	Student states they relate through the shared experience of overcoming or encountering barriers due to a minoritized identity.	"I related to the scientist because she is a female that was being undermined for her abilities because of her gender, and I am a female and can relate to this treatment."
	Shared Characteristic to Family or Friend	Student relates to the scientist because the scientist shares an identity with the student's family or friend.	"My friend is non-binary and the scientist was non-binary."
	Relates to Mental Health	Student relates to scientist's mental health.	"It seems like he has anxiety, which I can relate to."
	Similar Life Experiences	Student states they relate to the scientist due to shared experiences or connections to the scientist.	"My cousins who live next door to me grew up raising chickens, so I grew up noticing their habits and collecting eggs."
	Shared Hobbies	Student states they relate to the scientist due to shared hobbies.	"[the scientist] has so many things he is passionate about, especially fantasy worlds. I am a Harry Potter fan myself, and love escaping to an imaginary world!"
	Scientist is a "Normal" Person	Student states they relate to the scientist because they are a "normal" person, like them.	"I could tell he was just a normal person like me with unique interests."
	Relates to Curiosity of Scientist	Student states they relate due to being curious like the scientist.	"I am a curious person as well."
	Relates to Personality Characteristics	Students states they relate to personality characterstics of scientist.	"I relate heavily to the scientist. Particularly when he mentioned that he is competitive and strove to outpace his peers."
Student Relates to Research Interests of Scientist	Shared Scientific Interests and Intent to Pursue Science	Student states they relate to scientist due to shared interest in scientist's research topic or that they intend to pursue science.	"I am a Marine Biology major, so the animal behavior part of the study was interesting, and something I can see myself doing as part of my future field."
	Knows Scientific Methods	Student states they relate to the process of doing the scientific methods.	"I related to the featured scientist because she was performing an actual experiment based on an hypothesis that she proposed. This is what we do in Biology Lab."
	Science Will Be Helpful for Future	Student states they relate because the scientific activity will be helpful practice for the future.	"As a biology major, these types of examples are very relevant to the work we do. The data itself may not be extremely important to me, but the process of which I filled out the questions and analyzed the data is very good practice moving forward."
	Expresses General Interest in Science	Student states they relate because they are generally interested in science like the scientist.	"I related to her in the way that we are both interested in science and how the world works."
	Science Relates to Class Curriculum	Student states the activity relates to what they are learning in class.	"The only way I relate to her is the research she has conducted. It is very similar to what I have recently been studying in class."
Student Did Not Relate	Did Not Remember Scientist	Student states they did not remember the scientist, or that a scientist was not mentioned.	"I did not remember the featured scientist."
	Not Enough Info Given	Student states that they cannot relate because they were not given enough information about the scientist during the activity,.	"I can't really say, not enough information was given for me to make a judgment."
	Different Research Interests	Student states they do not relate to the scientist because they have differing research interests.	"I related to the scientist because in the future I would like to study things and find trends, but I do not relate because I do not want to study plants."
	Did Not Relate	Student states they did not relate to scientist.	"I didn't really relate to the scientist but it was interesting information."

FIGURE 2. Codes to analyze student open-ended responses to the prompt, "Describe how you related to the featured scientist, if at all." Figure adapted from Costello *et al.* (2024).

shared elements of their identities) and 2) relating to the research interests of the scientist (e.g., sharing the same scientific interests, considering science as helpful for their future, expressing general interest in science). There were also students who 3) did not relate to the featured scientist. Here, we expand on each of these categories and their sub-categories and provide example student responses pulled from all three of our treatment conditions.

1a Information about the Scientist. Overall, 1230 responses (24.15%) mentioned relating to information about featured scientists, including shared life experiences, hobbies, personality characteristics, being a "normal" person, and relating to counterstereotypical identities that scientists held. In this section, we provide one example for each code under the theme of "Information about the Scientist."

Shared Similar Life Experiences: Students noted that they related to the featured scientists because they shared similar life experiences. These life experiences ranged from spending time in the outdoors, a shared hometown, a shared undergraduate institution, or having a shared identity that led to similar experiences. For example, a student wrote about their shared enjoyment of science and the outdoors with the featured scientist.

> "Similar to the scientist mentioned, I have grown up around nature and have always loved it, and wanted to learn more about the things I was seeing."

Hobbies: Students related to the featured scientist's hobbies. These included activities such as gardening, shared favorite books, a love of nature, caring for pets and houseplants, fishing, and more.

> "I related to her in that we both enjoy the outdoors and working with others."

Personality Characteristics: Students related to characteristics of the featured scientist's personality. These included intense interest in a topic, passion, and curiosity for the natural world, creativity, imposter syndrome or not being as smart as others in the room, and a challenging academic history. Students also related to aspects of the scientist's mindset, including self-doubt, or conversely enjoying solving problems and the resilience to work hard and push through a challenge.

> "As someone who often feels like I might not be good enough for the sciences, it was comforting reading this scientist say that she felt like that sometimes as well and to try and not let that hold you back."

Being a "Normal" Person: Students related to the fact that the featured scientist presented themself as a "normal" person. Student responses mentioned that these activities made them realize that scientists are people too, and their stories made them seem down to earth, cool, humble, and no different from the students themselves. Many responses included a reference to the "typical" scientist and how these scientist stories didn't resemble what they were used to seeing.

> "I felt like the featured scientists made me realize that scientists are people too and they have thoughts just like me."

Race/Ethnicity: Students mentioned relating to the featured scientists' race/ethnicity.

> "I related to the featured scientist because I am also an African-American living in our modern-day society so I could relate to some of the things that he had mentioned about being African-American in his field, although I am not going to become a biologist."

Gender: Another identity that students related to was the scientists' gender.

> "I related to the scientist because I plan on pursuing a degree in STEM and I identify as a woman. It was nice to see another woman in STEM that I could relate to."

LGBTQIA+: Students also mentioned relating to the scientists' status as a member of the LGBTQIA+ community.

> "The biologist discussed being an LGBTQ+ scientist, and I related to her in that aspect. As a queer, woman scientist I know that a lot of scientists in the queer community tend to get overlooked and she is bringing awareness to them."

Age: The age of some of the featured scientists was also relatable for students.

> "I did relate because we were close in age and were interested in similar things."

First-Generation: Students mentioned relating to the scientists' status as a first-generation college student.

> "I related to her being first-generation and low income."

Overcoming/Encountering Barriers: Students wrote that they could relate to overcoming and encountering different types of barriers, similar to the scientist.

> "I related to the scientist because she is a female that was being undermined for her abilities because of her gender, and I am a female that can relate to this treatment."

Friend/Family: Even if the student did not relate to a personal aspect of the scientist themselves, some noted that they could relate because they have a friend or a family member with a shared identity of the featured scientist.

> "My friend is nonbinary, and the scientist was nonbinary."

Taken together, students related in a variety of ways to the diverse identities held by the featured scientists, and to the different elements of the stories shared by featured scientists.

1b Research Interests of the Scientist. Students commonly related to the research interests of the scientist. Specifically, we identified 1765 student responses (34.65%) that mentioned relating to the research interests of the featured scientists.

Shared Interests: students noted shared scientific interests with the featured scientist.

> "We're both interested in mutualism and the positive interactions between species."

Curiosity: Students related to the scientist's curiosity for the subject they study.

> "I understood their curiosity in the subject and especially that of animals and insects."

Methods: Students expressed their shared experience using the scientific methods.

> "I related to the featured scientist because I've had questions about things in life before and put them to the test."

Future: Student participants expressed interest in the scientist's research because they are interested in studying a similar topic in their own career, or see science as helpful for their future.

> "I will also have to carry out the scientific method and create a hypothesis and carry out an experiment just like the scientist did."

General Interest: Students expressed a shared general interest in science.

> "I related to the featured scientist through her enjoyment and passion for biological discovery."

Similarity to the Course: Students related the featured scientist's experiment because they did something similar during their class.

> "I said I could relate to this scientist due to an experiment that they were working on; it was a little while ago that we were working on something remarkably similar within my classroom."

1c Did Not Relate. Across all treatments, the most common student response was to describe not relating at all to the scientist. We found 2647 responses (51.96%) reported not relating to the featured scientist. We address how treatment impacts this response below. For example, our Control treatment does not provide any information beyond the scientist's name, pronouns, and research.

Don't Remember: Students noted they did not remember the scientist that was featured in the activity.

> "I cannot recall a specific scientist being mentioned."

Not Enough Information: Students said there was not enough information given about the scientist for them to be able to relate to them.

> "I didn't relate much to her because we didn't know much other than she was working as a lab technician collecting data."

Different Interests: Students noted they did not relate to the featured scientist because they had different research or career interests.

> "I personally am not looking to be in the biology field and I do not relate to the scientist's personal experience, but I found his story to be interesting."

Undisclosed Reason: Lastly, students noted that they simply did not relate to the scientist without giving a more specific explanation of why they did not relate.

> "I didn't really relate to the scientist."

RQ2. Does the Amount and Type of Information Shared Affect How Students Relate?

The extent to which students related to featured scientists depended on the type and amount of information shared (Figures 3 and 4). Our treatments impacted the likelihood that students would relate to scientists overall ($X^2_{2,\,5094} = 52.46$, $P < 0.0001$), with the greatest chances of relating occurring in our full treatment that included humanizing, personal information along with photos and research information about the scientist. Logistic regressions revealed that our treatments impacted the ways students related to scientists as well. Treatments impacted the likelihood that students related to the personal information shared about the scientists ($X^2_{2,\,5094} = 165.30$, $P < 0.0001$), which serves as a negative control comparison as no personal information was shared in our Control treatment and only visual identity information was shared in our Visual treatment. Our treatments also impacted the likelihood that students related to the research interests of the scientists ($X^2_{2,\,5094} = 14.23$, $P = 0.00081$), which was shared across all three treatments.

2a Personal Information about the Scientist. The number of students that related to a featured scientist's personal information varied across treatments (Control: 271 students - 16.73%; Visual: 376 students - 19.54%, and Humanizing: 583 students - 37.61%; Figure 4A). Students in the Humanizing treatment had 4.37 times higher odds of relating to personal information about the scientists compared with students in the Control treatment ($P < 0.0001$, Table 1; Figure 3) and 3.03 times higher odds compared with students in the Visual treatment ($P < 0.0001$, Table 1). Students in the Visual treatment also had higher odds of relating to information about the scientists than students in the control treatment (odds ratio = 1.44, $P = 0.0016$, Table 1; Figure 3). There were various ways (codes) by which students related to scientists' personal information (Figure 2). A higher percentage of students related to gender, overcoming barriers, personality characteristics, and life experiences when they were exposed to the Humanizing treatment, among other categories (Figure 4B).

2b Research Interests of the Scientist. Many students related to the research interests of the scientist, and this varied by treatment (Figures 3 and 4). Overall, 611 students exposed to the Control treatment related to the science (37.72%), 698 students exposed to the Visual treatment related to the science (36.28%), and 456 students exposed to the Humanizing

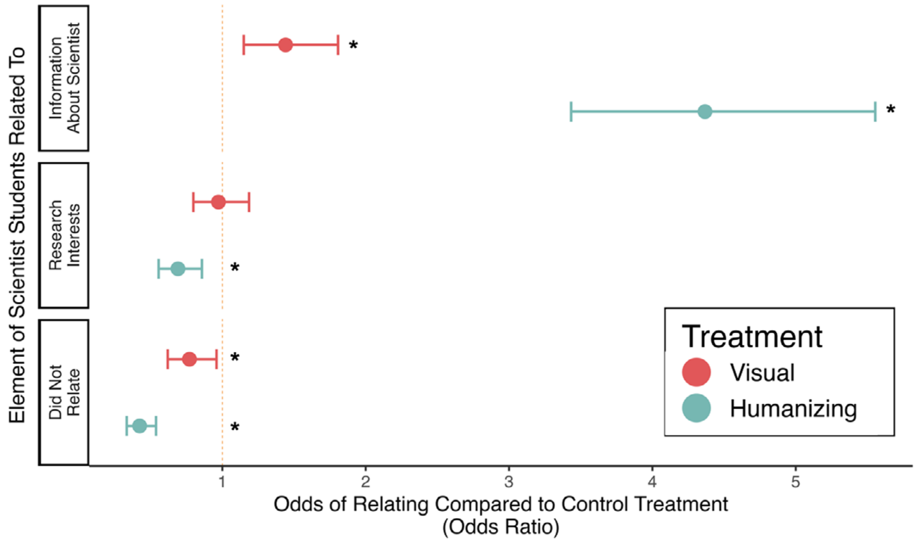

FIGURE 3. Odds ratios and 95% confidence intervals of students in the visual and humanizing treatments across the categories of student responses to the open-ended prompt "Describe how you related to the featured scientist, if at all." Students in the control treatment served as the comparison group. Confidence intervals that do *not* cross the dashed line at $x = 1$ are statistically significant, indicated by asterisks.

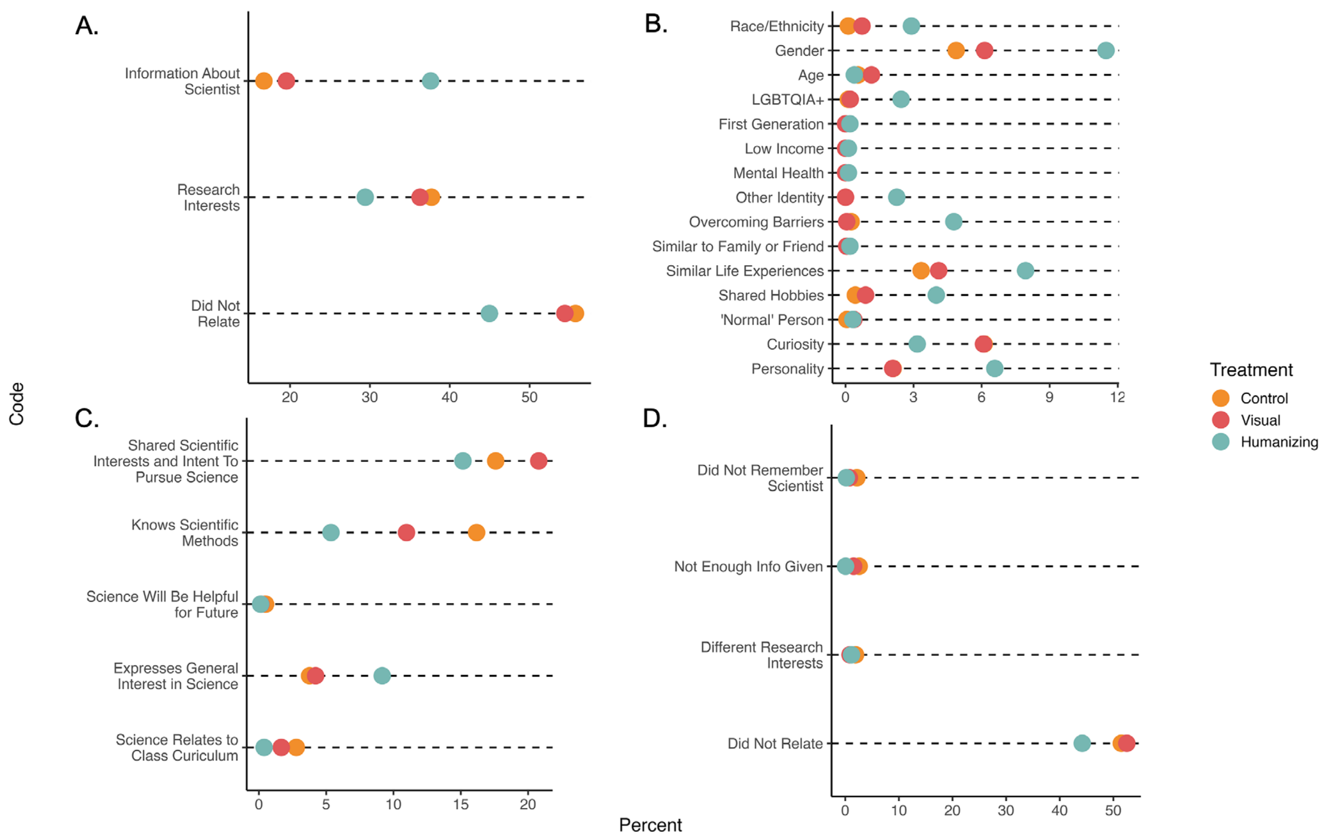

FIGURE 4. The percentage of students reporting how they related to featured scientists across control, visual, and humanizing treatments. (A) Overall thematic categories, (B) ways in which students related to personal information about the featured scientists, (C) ways in which students related to the science of the featured scientists, and (D) ways in which students did not relate to the featured scientists. Please note that the dots on the figure are not jittered, and in cases where the control treatment orange point is not visible, it falls under the visual treatment red point.

TABLE 1. Mixed effects logistic regression models exploring the effect of scientist role model treatment on student responses to the open-ended prompt: "Describe how you related to the featured scientist, if at all." Each of the three models includes a different category of student response to the prompt: students either related to the scientist's research interests, related to personal information about the scientist, and/or did not relate to the scientist. Regression coefficient estimates (estimate), standard errors (SE), odds ratios, and significance values are reported. Either the control or the visual treatment served as the comparison group, as indicated. Significant *P*-values at $\alpha \leq 0.05$ are in bold

Model	Fixed effect	Comparison group	Estimate	SE	Odds ratio	*P*-value
Relate to Information about Scientist	**Visual**	**Control**	**0.365**	**0.116**	**1.441**	**0.0016**
	Humanizing	**Control**	**1.474**	**0.123**	**4.367**	**<0.0001**
	Humanizing	**Visual**	**1.109**	**0.110**	**3.030**	**<0.0001**
Relate to Research Interests	Visual	Control	− 0.028	0.101	0.973	0.785
	Humanizing	**Control**	**− 0.371**	**0.111**	**0.690**	**0.00081**
	Humanizing	**Visual**	**− 0.343**	**0.104**	**0.710**	**0.00094**
Did Not Relate	**Visual**	**Control**	**− 0.261**	**0.112**	**0.771**	**0.020**
	Humanizing	**Control**	**− 0.861**	**0.122**	**0.423**	**<0.0001**
	Humanizing	**Visual**	**− 0.600**	**0.113**	**0.549**	**<0.0001**

treatment related to the science (29.42%; Figure 4). Students in the Humanizing treatment had lower odds of relating to the research interests of the scientists than students in the control (odds ratio = 0.690, $P = 0.00081$; Table 1; Figure 3) and Visual treatment (odds ratio = 0.710, $P = 0.00094$; Table 1). Students in the Visual and Control treatments had similar odds of relating to the research interests of the scientists (odds ratio = 0.973, $P = 0.785$; Table 1; Figure 3). Generally, a lower percentage of students exposed to the Humanizing treatment related to the research interests of the scientists (Figure 4A). However, a higher percentage of students in the Humanizing treatment expressed a general interest in science (Figure 4C).

2c Students Who Did Not Relate. Our treatments had a strong effect on the chances that students did not relate to featured scientists (Figures 3 and 4). Overall, 903 students exposed to the Control treatment did not relate (55.74%), 1047 students exposed to the Visual treatment did not relate (54.42%), and 697 students exposed to the Humanizing treatment did not relate (44.97%; Figure 4D). When students were presented with humanizing information about the featured scientists, the odds that they did not relate at all to the scientists were halved compared with the other two treatments (*compared with control*: odds ratio = 0.423, $P < 0.0001$; *compared with Visual*: odds ratio = 0.549, $P < 0.0001$; Table 1; Figure 3). Similarly, students presented with photographs of featured scientists had lower odds of not relating compared with students in the control treatment (odds ratio = 0.771, $P = 0.020$; Table 1; Figure 3). There were various ways (codes) in which students reported not relating to the featured scientists (Figure 2). A lower percentage of students exposed to personal, humanizing information about the featured scientists (i.e., students in the Humanizing treatment) explicitly stated that they did not relate to the scientist (Figure 4D).

DISCUSSION

Our work identifies the many ways in which students relate to counterstereotypical scientists, and how these ways of relating shift depending on the amount and type of information shared about scientists. In our national, multi-institutional study, we found that undergraduate biology students related to scientists' research, visual identities, and personal information. Overall, *how* students related to scientists varied depending on the amount and type of information that was shared. When the activity offered no personal information or only a photo of the featured scientist, most students did not relate and those who did tended to relate to the scientist through their research interests. When the activity included personal, humanizing information about the scientists along with photos and research interests, students were twice as likely to relate to the featured scientist, and they related in a greater variety of ways. Overall, we found that the type of information we share about scientists changes the ways in which students related, and the likelihood that they related at all, with implications for how to effectively share scientist stories during STEM instruction.

Recommendations

Here we make several recommendations to guide the development and implementation of biology curricular materials that feature scientists, in order to increase the opportunities for students to relate to these scientists. This is crucial, as students who are given opportunities to relate to scientists may be more likely to believe that they too can become scientists (Sparks *et al.*, 2019; Kricorian *et al.*, 2020; Crane *et al.*, 2022; Metzger *et al.* 2023). Our research reveals ways to strengthen the impact of materials that feature scientists; it is not as simple as just adding more scientist examples into the curriculum; intentionality in *how* we represent scientists is important as well.

Humanize Scientists When Sharing their Research

When creating classroom materials featuring scientists, we found that including humanizing information, alongside photos and details about research, can make scientists more relatable to students (Figures 3 and 4). Students related to our featured scientists in a wide variety of ways, mentioning information about their professional research interests (e.g., research topic, science as a career) and personal information (e.g., life experiences, hobbies, personality characteristics, race/ethnicity, gender, and socioeconomic status). Often in their responses, students related to more than one element of a scientist's story. Therefore, presenting scientists as multi-faceted presents more opportunities for students to relate to them either in singular or intersectional ways.

Given that individual identities are multi-faceted, it might be challenging to choose what humanizing information to include about featured scientists when creating STEM course materials. The codes from our dataset can act as a guide (Figure 2), capturing ways in which students related most to scientists. Some of these may be surprising, and inspire scientists to share information about themselves they otherwise would not have thought relevant. Examples include sharing photos of their lives in and out of science, providing anecdotes that showcase the scientist's curiosity, and including personal information about the scientist's hobbies, how they overcame professional barriers, and their life experiences. We often hear from scientists when sharing their story that they remove the human element to maintain objectivity, but that does not acknowledge that scientists are people too and that our own humanity informs our work and passions.

Feature a Diversity of Scientist Identities

Though our treatments impacted the likelihood that a student would relate, even in our most effective treatment—in which photos, research, and humanizing information about the scientist was highlighted—only 59.5% of students related to the featured scientist. While a student may not relate to every scientist that is featured in course materials, students who see multiple scientists throughout their education may have a greater chance at identifying figures with whom they share identities, experiences, or hobbies. Thus, it is important to expose students to a diversity of scientists, increasing the chance that they will learn about someone to whom they personally relate. We expect broad exposure to different examples of scientists will cause student perceptions of scientists to gradually shift. In this way, intentional curriculum development can counter student perceptions of scientist stereotypes throughout education.

Include Hidden Identities

Scientists can be introduced within the curriculum in a variety of ways. A popular strategy is to include photos of scientists along with details of their scientific work. Photos allow students to relate to visible aspects of a scientist's identity and can provide valuable information to students about the scientist. However, our research indicates that students are most likely to relate to scientists' visible identities (e.g., age and gender) if scientists explicitly share those identities along with other humanizing information (Figure 4B). In addition, many human identities are "hidden" or "concealable", meaning they are not visibly obvious. Including images alone can mask these nonvisual aspects of diversity (Hall, 1976; Vandrick, 1997; Quinn, 2006). Overall, our research supports that a photo alone may not be enough to increase the extent to which students relate to scientists.

Previous work supports the idea that sharing hidden identities of scientists can benefit student outcomes, though these identities must be intentionally communicated in order for students to make connections and relate. For example, Laiduc *et al.* (2021) investigated the impact of a brief intervention delivered to first-generation students across two institutions that highlighted first-generation status as a hidden identity of faculty role models. The intervention increased the extent that first-generation students related to the faculty role model, the reported intention to visit that faculty's office hours, and student belonging. Importantly, the researchers found that materials had to be explicit about describing the first-generation status of role models in order to benefit first-generation students (Laiduc *et al.*, 2021). Similarly, Busch *et al.* (2022) found that when an instructor communicated that they were LGBTQ+ to their class, students who identified as LGBTQ+ and/or women felt an enhanced sense of belonging. Busch *et al.* (2023) found women were more likely than men to reveal hidden identities and serve as role models for students with those shared identities. These studies highlight the benefits of revealing scientists' hidden identities that would not be apparent from photos alone. Aligned with these studies, we found that students reported relating to a wide range of hidden identities in the treatment that offered this information to students (i.e., Humanizing treatment; Figure 4). Our results underscore the positive impact of showcasing humanizing, personal aspects of a scientist's identity during biology activities, which may or may not be visibly apparent.

Limitations and Future Directions

Alternative Hypothesis. We designed our three treatments to build on each other, each adding a new piece of information about a featured scientist. An alternative explanation for our results is this addition of information about a scientist caused students to relate more, not the type of information provided in each of our treatments. We have reason to believe that this is not the case, as the ways in which students related to personal information and the science of the featured scientists varied across treatments. However, future research controlling for the amount of information shared about featured scientists will determine how much of our effect is due to the increased content.

Implementation of Classroom Resources Featuring Scientists. While our research is consistent with previous studies that found materials featuring counterstereotypical scientists matter a great deal for student outcomes (Damschen *et al.*, 2005; Schultheis and Kjelvik, 2015; Schinske *et al.*, 2016; Gladstone and Cimpian, 2021), few studies have focused on the impact of variation in the implementation of these classroom materials (Schultheis *et al.*, 2022; Ovid *et al.*, 2023). Ovid *et al.* (2023) was the first study to demonstrate one form of implementation, the inclusion of in-class discussions alongside Scientist Spotlights assignments, was associated with positive shifts in how students related to descriptions of featured scientists. In our study, materials were implemented in a variety of contexts, including as homework and during class time as individual or group work. Future work will address how these different contexts impact how students relate to featured scientists. According to Ovid *et al.* (2023), future work can also observe classroom discussions and instructor language to inform how and why discussions about scientists lead to positive student outcomes, through measures of Instructor Talk (e.g., Seidel *et al.*, 2015; Harrison *et al.*, 2019), the Classroom Discourse Observation Protocol (Kranzfelder *et al.*, 2020), or the Teaching Practices Inventory (Wieman and Gilbert, 2017).

Caveat. While our research demonstrates that including humanizing information about counterstereotypical scientists leads to several benefits for students, we acknowledge that many scientists have legitimate reasons to not share personal stories or hidden identities. Examples include the possession of stigmatized identities, having experienced trauma, not having time to share their stories due to their own pursuits of tenure or promotion, or simply not wanting to share personal information about themselves. Without proper compensation (which was provided in this study), sharing personal stories is an additional tax atop other obligations that disproportionately impact people with excluded identities in higher education (Akin, 2020). We also acknowledge that it is problematic to only ask scientists with counterstereotypical identities to provide humanizing information, and we should strive to have all scientist identities represented within curricular materials. While in the current study, we only tested our treatments across resources featuring scientists with counterstereotypical identities, we encourage all scientists to provide more relatable information about themselves, and for curricular developers to compensate scientists for sharing their stories.

CONCLUSION

The inclusion of scientists in course content allows students to relate to scientists and see their own place in STEM. Role models have been shown to have positive effects on students: increasing student interest in STEM and STEM careers (Shin *et al.*, 2016; Schultheis *et al.*, 2022), identity as scientists (Shin *et al.*, 2016), ability to relate to scientists (Schinske *et al.*, 2016; Brandt *et al.*, 2020; Aranada *et al.* 2021; Metzger *et al.*, 2023; Ovid *et al.*, 2023), and engagement with material (Yonas *et al.*, 2020; Costello *et al.*, 2024). Because role models are critical in the development of students' sense of belonging in STEM (Drury *et al.*, 2011; Rosenthal *et al.*, 2013), it is important to understand the key components that make scientist stories effective.

According to Gladstone and Cimpian (2021), one key component of scientist role models is that they are relatable. While past research has determined that counterstereotypical scientists increase the extent to which students relate (Schinske *et al.*, 2016; Brandt *et al.*, 2020; Aranada *et al.*, 2021; Metzger *et al.*, 2023; Ovid *et al.*, 2023), our work builds on these studies to explore the *ways* in which students relate to featured scientists, and whether the amount and types of information that are shared about scientists affected these ways of relating. We found that students can relate to featured scientists through their research and photos, but sharing personal, humanizing information had the greatest impact on whether students could relate. Thus, we recommend curriculum developers and scientists collaborate to develop materials that feature scientists as "people too."

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