An Investigation of How Humans Are Portrayed in High School Mathematics Textbooks

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Abstract

Mathematics textbooks convey messages to students about people in mathematics. Unfortunately, past research has shown that mathematics textbooks generally provide few examples of people of color, women, non-binary genders, and STEM careers. Further, textbooks have been found to perpetuate problematic stereotypes. Given these findings, textbooks could be running counter to efforts attending to diversity, equity, inclusion, and belonging in mathematics. We present our investigation of how humans are portrayed in high school mathematics textbooks and encourage teachers to investigate their own materials. Our findings confirmed a low human presence as well as few named characters, non-inclusive gender identities, and few examples of STEM careers. Teachers can be mindful of representation within their materials and can foster an inclusive classroom by deliberately showcasing examples of diverse professionals in STEM careers.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. What ideas do you have for helping each individual student to feel included in mathematics classes?

2. How big of a role do your textbook or curriculum materials play in your mathematics classroom? Do you use the textbook or curriculum problems verbatim or do you make modifications?

3. Based on interactions you've had with your textbook or curriculum materials, what examples of humans doing mathematics, if any, do you recall? What do you recall about the diversity of the humans being portrayed in the materials? Do you recall any examples of STEM careers?

4. Now, begin to leaf through your textbook or other curriculum materials while paying attention to the human presence. What do you notice? How are humans portrayed? How are they using mathematics? How, if at all, do your materials showcase people from diverse backgrounds using mathematics? How, if at all, do they showcase people in STEM careers?

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Introduction

Mathematics textbooks provide information to students on how mathematics is applied. Textbooks usually contain sets of exercises, some computational and some contextual. The contextual exercises may show examples of humans using mathematics. The authors of mathematics textbooks have an opportunity to promote diversity and inclusion in science, technology, engineering, and mathematics (STEM) careers. Thus, it is important to consider representation among the humans who are showcased within textbook exercises, as well as the variety of contexts and careers within.

However, it is not enough to simply promote more STEM careers within textbooks; we must also address problematic stereotypes that continue to be perpetuated in the media and larger society by considering whether textbooks also reinforce these stereotypes (Hottinger, 2016; Simpson et al., 2021). Ideally, textbooks should show students examples of diverse professionals, such as women and people of color, utilizing mathematics in career contexts (Marzocchi et al., 2023; Piatek-Jimenez et al., 2014; Simpson et al., 2021). After observing a lack of racial/ethnic and gender diversity in mathematical spaces, such as academic conferences, we sought to research representation of these dimensions of diversity in textbooks. However, we note that other important dimensions of diversity—including religion, disability status, linguistic repertoire, national origin, and immigration status—are likely absent in textbooks as well. This is important to consider because students who identify with groups that have been historically marginalized in STEM may have fewer mentors and role models from their communities (Simpson et al., 2021).

Unfortunately, past researchers have found stereotypes promoted in mathematics textbooks such as women frequently being portrayed as nurturing caretakers while men were often portrayed as active, confident, and career-driven individuals (Piatek-Jimenez et al., 2014). There is a lack of representation of non-binary genders and non-heteronormative roles. Instead, textbooks could provide a venue for students to see examples of diverse STEM professionals (Marzocchi et al., 2023; Simpson et al., 2021).

This article aims to increase mathematics teacher awareness of how humans are portrayed in high school mathematics textbooks. To do so, we share what we learned from past research on this topic, followed by findings from our own investigation. We include recommendations for teachers to support students from diverse backgrounds in mathematics.

What We Know From Past Research

Inspired by Gutiérrez's (2016) call to rehumanize mathematics, we explored how to enact creative insubordination by questioning how mathematics is being presented to students, especially those from historically marginalized groups. Our review of past research on representation in textbooks started in alignment with the Piatek-Jimenez et al. (2014) suggestion that:

> if we can create ways to gain and keep the interest of women and certain minorities in mathematics and help individuals in these groups feel confident about their capabilities in the field, then we can gradually change the face of STEM (p. 72).

We wondered about the role that textbooks played in either dismantling or reinforcing pervasive equity issues in mathematics education. After all, mathematics textbooks are an important part of the STEM curriculum and characteristics of the humans present in textbook exercises communicate information to students about who belongs (Simpson et al., 2021). McBride's (1989) foundational textbook research indicates that textbooks do not contribute to students' understanding of the interconnection of culture, language, and thought.

The following subsections will provide teachers with the background information we learned on mathematics textbook research. We summarize past research that examined contexts of exercises in mathematics textbooks and the characteristics of humans found in textbook exercises with context. We share findings on gender representation, race/ethnicity representation, and career representation. We recognize that other dimensions of diversity, such as religion, disability status, linguistic repertoire, national origin, and immigration status, are underrepresented in textbook research. With awareness of past research on mathematics textbooks, teachers will be positioned to notice representation in their own curriculum materials.

Context in Past Research

When examining *contexts*, we consider exercises which contain a real-world situation. A context could help shift an exercise to be more than just computational (Damarin, 2010). If students are not given examples with context, it may be harder for them to relate to the material, which could, in turn, lead to "mathephobia" (Damarin, 2010, p. 75). This further impedes students from being able to effectively translate mathematics across other disciplines (Kastberg et al., 2005). Lubienski (2000) specifically found benefits of using problems with contexts for students from low-income backgrounds. When exercises had contexts, these students were more likely to use language and common-sense reasoning as they were problem solving. Exercises with context may or may not have a human present.

Human Presence in Past Research

Several studies have examined human presence in STEM curricular materials (e.g., Bright, 2017; Clarkson, 1993; Di Pasqua et al., 2021; Esmonde, 2011; Garcia et al., 1990; Marzocchi et al., 2023; Piatek-Jimenez et al., 2014; Simpson et al., 2021; Sleeter & Grant, 2011; Tang et al., 2010). Human presence in textbooks has been generally low, with far more computational exercises than contextual, and scant human presence among the contextual exercises (Marzocchi et al., 2023). When humans are present in the exercises, research has considered characteristics of the humans such as gender (Clarkson, 1993; Damarian 2010; Di Pasqua et al., 2021; Esmonde, 2011; Garcia et al., 1990; Marzocchi et al., 2023; Simpson et al., 2021; Sleeter & Grant, 2011; Yeh, 2017), race/ethnicity (Bright, 2017; Civil, 2016; Garcia et al., 1990; Gutstein, 2016; Sleeter & Grant, 2011; Yeh, 2017), and career (Di Pasqua et al., 2021; Marzocchi et al., 2023; Piatek-Jimenez et al., 2014; Tang et al., 2010). This is important because course materials, whether intentionally or not, shape student perceptions about what a STEM professional looks like (Simpson et al., 2021).

Gender representation in past research. There are many studies that researched gender representation in STEM textbooks (Clarkson, 1993; Damarian 2010; Di Pasqua et al., 2021; Esmonde, 2011; Garcia et al., 1990; Marzocchi et al., 2023; Rubel, 2016; Simpson et al., 2021; Sleeter & Grant, 2011; Yeh, 2017). A common finding across most studies of gender is an overrepresentation of men among the characters in the exercises. Simpson et al. (2021) state that research on common introductory biology textbooks found that "textbooks highlighted only one woman scientist for every seven men, even though 60% of students awarded undergraduate biology degrees are women" (p. 6). There is also a lack of gender non-binary characters with textbooks showcasing only women and men and no overt exercises containing characters with other gender identities. Marzocchi (2019) warns that "considering gender as binary or all relationships as heterosexual is tempting for some mathematicians. However, people do not fit into exclusively boy/girl categories, and we may be further alienating already-marginalized students by ignoring the full gender spectrum" (p. 14).

Further problematic is the reinforcement of gender stereotypes in textbook exercises (Hottinger, 2016; Yeh, 2017). For instance, Yeh (2017) found that:

> Contexts related to looking pretty, being helpful, and being a homemaker were attached to problems with girls' names; problems with boys' names reinforced athleticism, competition, and masculinity. Any one of these scenarios are unproblematic of and by themselves, but when looking at patterns across several problems, we see a consistent message about gender normativity—the idea that there is only one way to be a boy and another, different way to be a girl. (p. 1)

Related, Hottinger (2016) notes many instances where boys were shown as "active mathematical knowers" while girls were seen as needing help from other characters or the reader (p. 164). Reinforcement of gender stereotypes in textbook exercises could further marginalize students and turn them away from STEM.

Race/ethnicity representation in past research. Race/ethnicity representation has also been examined in multiple studies (Bright, 2017; Civil, 2016; Garcia et al., 1990; Gutstein, 2016; Sleeter & Grant, 2011; Yeh, 2017). The Simpson et al. (2021) research on science textbooks revealed that not only were people of color underrepresented (with only 6.67% of total showcased textbook scientists being people of color despite a 35% representation of students of color in biology bachelor's degree programs) but that when people of color were included in textbooks, their roles were generally unrelated to scientific contributions. To create a more diverse STEM field, we must improve representation of people of diverse races/ethnicities in mathematics textbooks in general, and in scientific roles in particular. Garcia et al. (1990) suggest that "providing minorities with role models and instilling...an interest in mathematics is fundamental in altering students' perceptions and attitudes toward the discipline" (p. 9). Without examples of people like themselves, students of diverse races and ethnicities may feel that they do not belong in STEM (Simpson et al., 2021).

In one instance, researchers found race/ethnicity representation that was more diverse than that of the general population according to Census data (Sleeter & Grant, 2011). However, deeper analysis of the contexts of the exercises showed reinforcement of stereotypes across races and ethnicities. As publishers update their textbooks, it is important to create a world within the textbook that has fair representation for people of varying races and ethnicities, without the reinforcement of stereotypes.

Career representation in past research. Career representation has also been examined in past studies (Di Pasqua et al., 2021; Marzocchi et al., 2023; Piatek-Jimenez et al., 2014; Tang et al., 2010). Unfortunately, research shows that gender and career representation intersect problematically in mathematics textbooks. For example, Piatek-Jimenez et al. (2014) indicate that men in textbooks are more often shown in professional roles than women and that twice as many men are shown as having careers than women. This finding is worrisome because students may internalize the stereotype that men should have more professional roles than women.

With these potentially problematic findings from past research in mind, we encourage teachers to be mindful of how humans are portrayed in their own curriculum materials. Below, we detail a framework for considering representation in textbooks and share the findings from our own investigation of high school textbooks used in a local school district.

A Procedure for Investigating Human Presence in Textbooks

Our research investigated the human presence in high school mathematics textbooks. We encourage teachers to begin noticing how humans are portrayed in their own curriculum materials. In the subsections that follow, we share our framework for analyzing textbooks. Though we do not expect most teachers to do a formal research study of their curriculum, we believe our process of analyzing textbooks can assist teachers with noticing the messages that their materials are portraying to students. In what follows, we present our method for acquiring the data set, coding, and analyzing the data. Although our investigation focused on name, gender, and career, teachers could also consider other dimensions of diversity such as religion, disability status, linguistic repertoire, national origin, and immigration status.

Selection of Textbooks

To start our investigation, we selected a local school district. The selected district, located in the southwestern United States, is attended by approximately 25,000 students in approximately 35 schools, approximately 10 of which are high schools. According to 2018 data from *U.S. News and World Report*, minority enrollment is approximately 70% of students and economically disadvantaged students comprise approximately 25%.

Our set of textbooks included the textbook used for the highest level of mathematics offered within each grade level including geometry (primarily 9th-grade), algebra 2 (primarily 10th-grade), precalculus (primarily 11th-grade), and calculus (primarily 12th-grade) courses. Although we do not advocate for tracking students, and we hope that every student will have the opportunity to see examples of diverse professionals in STEM careers within their mathematics textbooks, we selected the textbook used for the highest-level course for each grade level because we conjectured that these books would be more likely to showcase professionals in STEM careers. If so, this would provide more data for us to analyze in terms of characteristics of the portrayed STEM professionals. Because we were primarily interested in uncovering STEM career representation alongside names and genders of characters, we sought books that we conjectured would provide the largest sample to analyze. With this data, we can advise textbook publishers and teachers on how to provide every student with examples of diverse professionals in STEM careers through their textbooks. To obtain the list of books, our research team contacted teachers, administrators, and/or support staff. Appendix A lists the books included in our sample.

Selection of Exercises

We chose to focus our investigation on all individual numbered textbook problems, which most textbooks labeled as "exercises," at the end of each section within each chapter. For instance, we included the numbered exercises at the end of section 1.1, the end of section 1.2, the end of section 1.3, and so on until the last section of the last chapter. These exercises are typically intended to be done by students as homework. Each numbered exercise was considered one unit of analysis, even if it had multiple parts. Practice exams, quizzes, and end-of-chapter review sets were not included in our data set because pilot data found many redundancies between end-of-section and end-of-chapter exercises. We also did not include unnumbered problems interspersed throughout the instructional portion of textbook sections, typically used by teachers to develop their lessons (often called "practice" problems).

Coding and Analysis

We built on the methods developed by other members of our research team, which involves using a coding flowchart (see Appendix B) to capture the human presence in textbook exercises (Marzocchi et al., 2023). We applied the previously-developed framework to a new sample of textbooks; our previous study researched human presence in precalculus textbooks across an entire county whereas this study focused on four sequential textbooks used in a single district. Unlike our previous study, this study allows us to understand the experience of a single student in a single district. The coding procedure, including the training and reliability process, is described in greater detail in the previous study (Marzocchi et al., 2023).

Under our method, each exercise is coded for context, human presence, name, gender, and hobby/career (STEM or non-STEM). We go exercise-by-exercise and execute the following procedure (readers are encouraged to view the flowchart in Appendix B alongside reading this procedure):

- Determine whether the exercise has a context or not, based on whether it contains a real-world situation as opposed to a purely computational exercise. We used a spreadsheet to enter 1 for context of 0 for no context. If the exercise does not have a context, move on to the next exercise. If the exercise has a context, continue coding.
- If the exercise has a context, determine whether it has a human present (coded as 1) or not (coded as 0), based on whether there is at least one human portrayed in the exercise. If the exercise does not have a human present, move on to the next exercise. If there is a human present, continue coding.
- If the exercise has a human present, determine the name, gender, and hobby/career by doing the following:
    - Determine whether the human is named (coded as 1) or not (coded as 0). If named, record the name.
    - Regardless of whether the human is named, code for gender based on pronouns, gendered nouns, or an empirically gendered name (we used W for woman, M for man, and I for indiscernible if the exercise did not provide any gender clues; note we did not encounter any examples of humans with discernible non-binary genders).
    - Regardless of whether the human is named or gendered, record the hobby/career of the portrayed human (we recorded the hobby/career or used I for indiscernible). If a career is given, determine whether it is a STEM career (coded as 1) or not (coded as 0).
- Move on to the next exercise and repeat the process.

Once a textbook is fully coded, percentages were used to measure several constructs including context, human presence, and gender representation. Frequency counts were used for names and STEM careers.

Results of Our Investigation of Human Presence in High School Mathematics Textbooks

Below we share our findings from investigating high school mathematics textbooks. We report on context, human presence generally, gender representation, career representation, and names.

Context in Sampled Exercises

Recall that we consider a mathematics exercise with a *context* to be one that contains a real-world situation. On the other hand, a mathematics exercise without a context is one that does not contain a real-world situation and is likely entirely computational. Table 1 provides one example of an exercise with context from each textbook. When being mindful of representation in their own materials, teachers should first note exercises with context as these would provide opportunity for human presence. In our sample, the percentage of total exercises with context is 15% in the 9th (total of 3268 exercises with context) and 10th (total 3714) grade textbooks, 14% in the 11th-grade (total 6621) textbook, and 10% in the 12th-grade (total 5358) textbook. This is important for teachers to consider because a low number of exercises with context means limited opportunity to showcase diversity in STEM careers within the textbooks.

Table 1

An example exercise with context from each grade's textbook

<table>
<tr><th>Grade</th><th>Example Exercise with Context</th></tr>
<tr><td>9th</td><td>Section 1.1 #47. Explain why a four-legged chair may rock from side to side even if the floor is level. Would a three-legged chair on the same level floor rock from side to side? Why or why not?</td></tr>
<tr><td>10th</td><td>Section 4.2 #15. During a recent period of time, the numbers (in thousands) of males M and females F that attend degree-granting institutions in the United States can be modeled by $M = 19.7t^2 + 310.5t + 7539.6$ and $F = 28t^2 + 368t + 10127.8$ where t is time in years. Write a polynomial to model the total number of people attending degree-granting institutions. Interpret its constant term.</td></tr>
<tr><td>11th</td><td>Section 7.4 #58. When light passes from a more-dense to a less-dense medium--from glass to air, for example--the angle of refraction predicted by Snell's Law (see Exercise 57) can be 90° or larger. In this case the light beam is actually reflected back into the denser medium. This phenomenon, called total internal reflection, is the principle behind fiber optics. Set $\theta_2 = 90°$ in Snell's Law, and solve for θ_1, to determine the critical angle of incidence at which total internal reflection begins to occur when light passes from glass to air. (Note that the index of refraction from glass to air is the reciprocal of the index from air to glass.)</td></tr>
<tr><td>12th</td><td>Section 15.1 #6: A 20-ft-by-30-ft swimming pool is filled with water. The depth is measured at 5-ft intervals, starting at one corner of the pool, and the values are recorded in the table. Estimate the volume of water in the pool.
<table>
<tr><th></th><th>0</th><th>5</th><th>10</th><th>15</th><th>20</th><th>25</th><th>30</th></tr>
<tr><td>0</td><td>2</td><td>3</td><td>4</td><td>6</td><td>7</td><td>8</td><td>8</td></tr>
<tr><td>5</td><td>2</td><td>3</td><td>4</td><td>7</td><td>8</td><td>10</td><td>8</td></tr>
<tr><td>10</td><td>2</td><td>4</td><td>6</td><td>8</td><td>10</td><td>12</td><td>10</td></tr>
<tr><td>15</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>8</td><td>7</td></tr>
<tr><td>20</td><td>2</td><td>2</td><td>2</td><td>2</td><td>3</td><td>4</td><td>4</td></tr>
</table></td></tr>
</table>

Human Presence in Sampled Exercises

Next, we ask teachers to consider the exercises with context within their textbooks and to notice whether humans are presented within those exercises. Table 2 provides one example of an exercise with a human present from each textbook. Among our sample, Figure 1 shows the percentage of mathematics exercises with a context that have a human present for each of the sampled textbooks. The percentage of exercises with context that have a human present range from approximately 13% to approximately 51%. The human presence in the sampled mathematics textbooks is especially low when also considering the large number of exercises without context, and therefore without a human present. Teachers should note that a limited number of exercises with a human present again means diminished opportunity for students to see examples of diverse professionals in STEM careers within their textbooks.

Table 2

An example exercise with human presence from each textbook

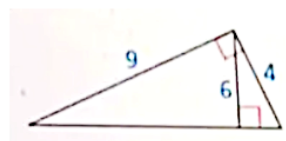
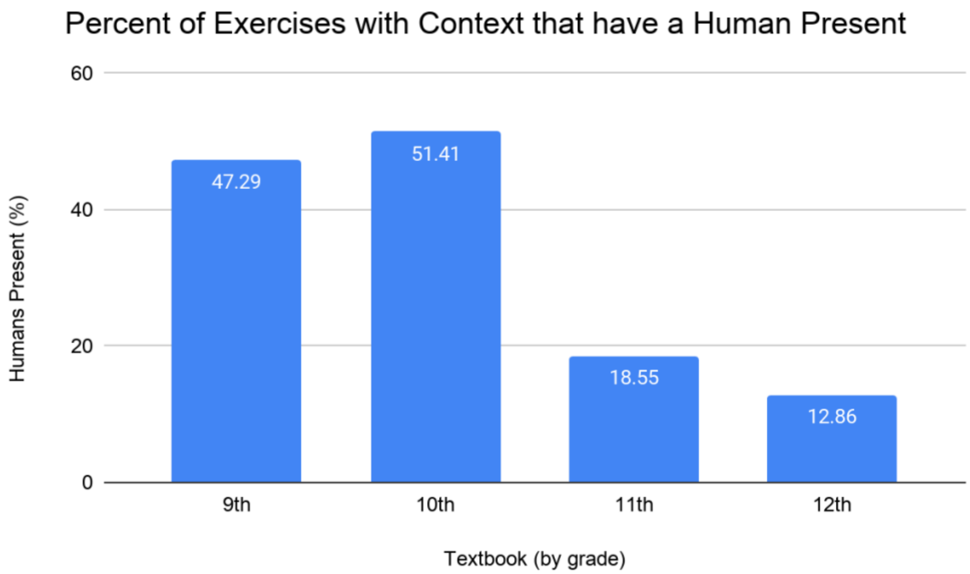
Textbook	Example Exercise with Human Presence
9th	Section 9.3 #40. Your friend claims the geometric mean of 4 and 9 is 6, and then labels the triangle as shown. Is your friend correct? Explain your reasoning. 
10th	Section 8.3 #57. You are buying a new car. You take out a 5-year loan for $15,000. The annual interest rate of the loan is 4%. Calculate the monthly payment.
11th	Section 5.4 #62. On a day when the sun passes directly overhead at noon, a 6-ft-tall man casts a shadow of length $S(t) = 6\|cot \frac{\pi}{12} t\|$ where S is measured in feet and t is the number of hours since 6 A.M. (a) Find the length of the shadow at 8:00 A.M., noon, 2:00 P.M., and 5:45 P.M. (b) Sketch a graph of the function S for $0 < 1 < 12$. (c) From the graph, determine the values of t at which the length of the shadow equals the man's height. To what time of day does each of these values correspond? (d) Explain what happens to the shadow as the time approaches 6 p.m. (that is, as $t \rightarrow 12$).
12th	Section 12.2 #31. A woman walks due west on the deck of a ship at 3 mi/h. The ship is moving north at a speed of 22 mi/h. Find the speed and direction of the women relative to the surface of the water.

Figure 1

Percent of exercises with context that have a human present for each textbook. Total number of exercises with context – 480 (9th-grade), 566 (10th), 926 (11th), and 560 (12th)



Gender Representation in Sampled Exercises

For exercises with a human present, teachers can consider the gender of the characters. Our research coded a character's gender as woman, man, or indiscernible. We did not encounter any characters with discernible non-binary, genderqueer, or non-conforming genders so these codes were not included in our study. Gender was coded as indiscernible if the exercise did not contain gendered pronouns, gendered nouns, or an empirically gendered name. Table 3 provides one example of an exercise with a discernible gendered character from each textbook.

Based on our research, alongside past research cited above, it is possible teachers will notice a gender imbalance in their textbooks with an overrepresentation of men. This was true for three of the four textbooks in our study. Figure 2 shows the percentage of characters with gender coded as indiscernible, woman, and man for each textbook. Indiscernible gender had the highest number of instances across all textbooks. Considering gender representation among characters with a discernible gender of woman or man, men were represented at least twice as often as women in all but one book. Although the percentages are low, we note an exception in the 9th-grade textbook where representation of women is greater than that of men. It is important for teachers to consider gender representation in their textbooks because it is possible women are being underrepresented and non-binary genders are being ignored. Textbooks may be perpetuating gender imbalances in STEM.

Career Representation in Sampled Exercises

Teachers can also keep an eye towards whether and how STEM careers are presented within their textbooks. This is important because textbooks have an opportunity to showcase STEM careers to students. Our research tracked the number of exercises in each book that contained a STEM career, shown in Figure **3**. In the case of STEM careers, we report the total number, as opposed to a percentage, to capture the number of distinct STEM careers a student could be exposed to through their use of the textbook. To determine whether a career was a

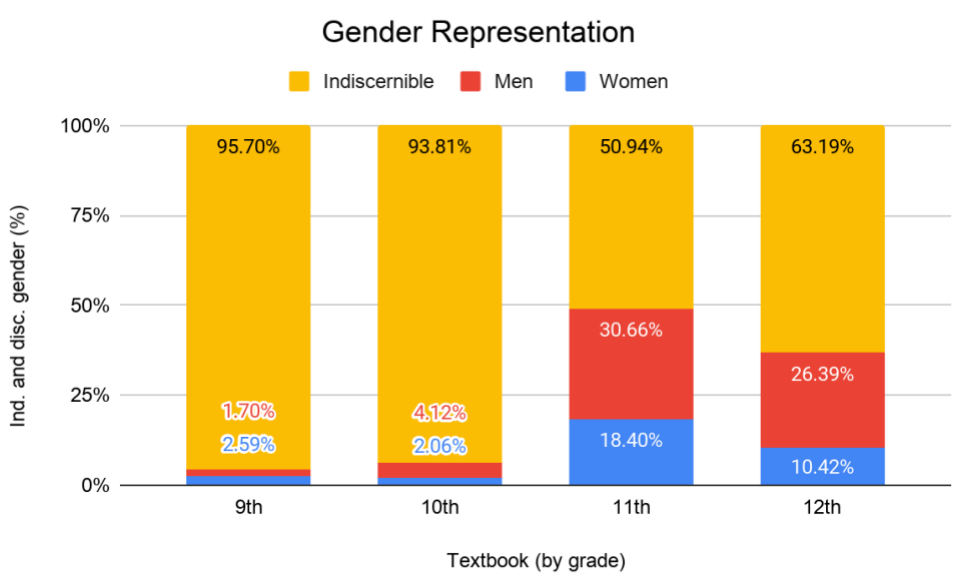
Table 3

An example exercise with a discernible gendered character from each grade's textbook

Grade	Example Exercise with a Discernible Gendered Character
9th	Section 2.3 #31. Decide whether inductive reasoning or deductive reasoning is used to reach the conclusion. Explain your reasoning. Each time your mother goes to the store, she buys milk. So, the next time your mom goes to the store, she will buy milk.
10th	Section 9.3 #35. At what speed must the in-line skater launch himself off the ramp in order to land on the other side of the ramp? 
11th	Section 14.7 #17. An experiment is described. (a) Describe some possible confounding variable(s) in the experiment. (b) Suggest an experimental design that would eliminate the confounding variable(s). Identify the type of design you are suggesting. To determine whether exercise helps to prevent cancer, a medical professor selects 60 sedentary students from his class and 35 people who exercise regularly at the gym in his uncle's retirement home. He then tracks their medical history for a 5-year period, recording the number of cancer cases that arise.
12th	Section 4.7 #9. A farmer wants to fence an area of 1.5 million square feet in a rectangular field and then divide it in half with a fence parallel to one of the sides of the rectangle. How can he do this so as to minimize the cost of the fence?

Figure 2

Percentage of characters in each gender category in each textbook. Exercises by grade with human present – 227 (9th-grade), 291 (10th), 172 (11th), and 72 (12th)



STEM career, we noted every instance of a hobby or occupation during the first round of coding. Once all the hobbies and occupations were documented, we looked at the entire set of occupations together to determine whether or not each one was a STEM career. We drew upon the meaning of the acronym STEM--science, technology, engineering, and mathematics--to categorize careers as STEM or non-STEM. For instance, careers such as biologist, engineer, or mathematician were coded as STEM careers. Other examples of STEM careers are pilots, professors that teach a STEM subject, architects, and surveyors. If the character included a student, teacher, or professor but did not specify the discipline, we did not classify this as a STEM career. Once we coded for STEM careers, we checked our codes against past research documenting career representation in textbooks, namely Piatek-Jimenez, Madison, and Przybyla-Kuchek (2014) and Tang, Chen, and Zhang (2010).

Across all textbooks, the representation of STEM careers was consistently low, with the lowest number of STEM careers being twelve in the 9th-grade mathematics textbook and the highest number of careers being 34 in the 11th-grade textbook. Table 4 provides one example of an exercise with a STEM career from each textbook. Overall, the books contained surprisingly low instances of STEM careers. If teachers notice this trend within their own textbooks, they may choose to showcase STEM careers in their classrooms in other ways. This can be achieved by hanging posters of diverse professionals in STEM careers, by inviting guest speakers from diverse backgrounds who work in STEM careers, or by assigning projects where students profile diverse STEM professionals.

Figure 3

Number of distinct STEM careers present in each textbook. Total number of exercises with context – 480 (9th-grade), 566 (10th), 926 (11th), and 560 (12th). Percent of exercises with context that contain a STEM career – 2.5 (9th-grade), 4.2 (10th), 3.7 (11th), and 2.9 (12th)

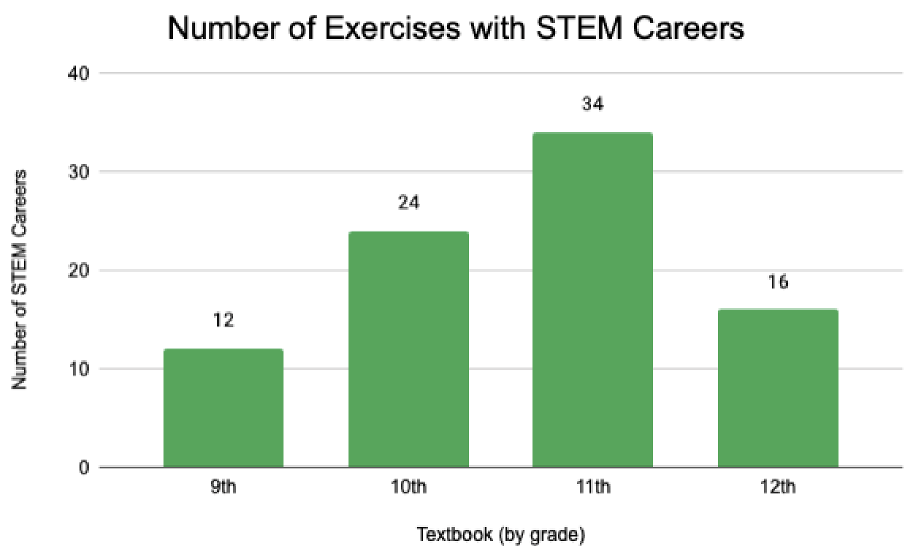
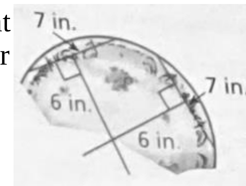


Table 4

An example exercise with STEM career from each textbook

Textbook	Example Exercise with STEM Career
9th	Section 10.3 #17. An archaeologist finds part of a circular plate. What is the diameter of the plate to the nearest tenth of an inch? Justify your answer. 
10th	Section 3.1 # 60. According to legend, in 1589 the Italian scientist Galileo Galilei dropped rocks of different weights from the top of the leaning tower of Pisa to prove his conjecture that the rocks would hit the ground at the same time. The height h (in feet) of a rock after t seconds can be modeled by $h(t) = 196 - 16t^2$...
11th	Section 14.3 #39. The participants at a mathematics conference are housed dormitory-style, five to a room...It turns out that 30% [of attendees] are smokers. Find the probability that Fred, a nonsmoking conference participant, will be housed with: (a) Exactly one smoker. (b) One or more smokers.
12th	Section 6.2 #69. Some of the pioneers of calculus, such as Kepler and Newton, were inspired by the problem of finding the volumes of wine barrels...A barrel with height h and maximum radius R is constructed by rotating about the x-axis the parabola $y = R - cx^2$ ...where c is a positive constant. Show that the radius of each end of the barrel is $r = R - d$, where $d = ch^2/4$...

Named Characters in Sampled Exercises

Lastly, teachers can turn their attention towards the names of the characters within their textbooks. This is important because names can provide a way for students to connect to the exercises. Table 5 provides one example of an exercise with a named character from each textbook. Our research tracked the number of named characters contained within the exercises in each textbook, displayed in Figure 4. Overall, there were three textbooks that had a substantially low number of named characters within the exercises with both the 9th and 10th-grade textbook containing only five names in the entire sample and the 12th-grade book containing sixteen. Although the 11th-grade textbook, with 89 named characters within the exercises, appears to have many named characters compared to the other textbooks, it is still quite low considering there were over 6,500 exercises coded in that book. Overall, we see that there is a very low number of named characters within our sample. If teachers notice a similar lack of named characters within their textbooks, they may intentionally incorporate names during classwork or assessments. Teachers might survey students on their interests and aspirations and create tasks showcasing their students' names in contexts that align with their survey responses.

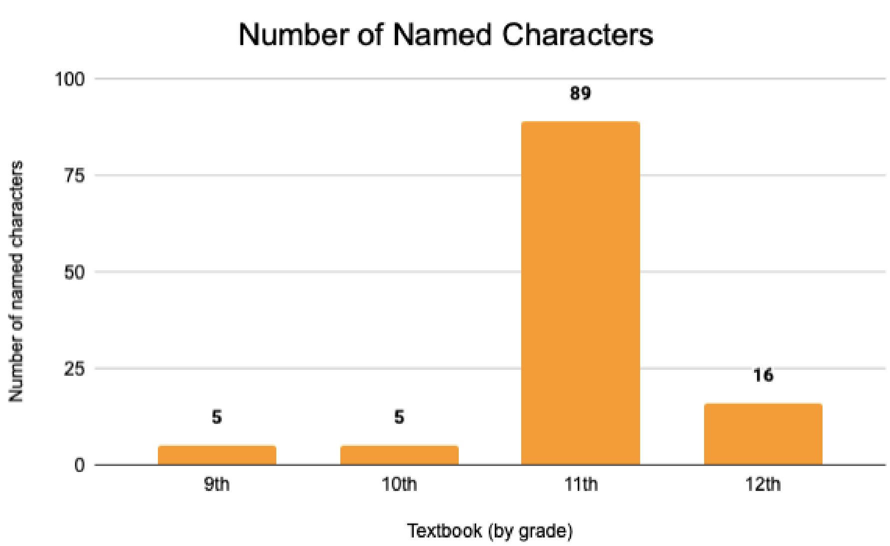
Table 5

From each grade's textbook, an example exercise with a named character

Textbook	Example Exercise with Named Character
9th	Section 2.1 #50. Rewrite the conditional statement in if-then form. Then underline the hypothesis and circle the conclusion. "You have to expect things of yourself before you can do them."--Michael Jordan.
10th	Section 3.1 #60. According to legend, in 1589, the Italian scientist Galileo Galilei dropped rocks of different weights from the top of the Leaning Tower of Pisa to prove his conjecture that the rocks would hit the ground at the same time. The height *h* (in feet) of a rock after *t* seconds can be modeled by $h(t) = 196 - 16t^2$. a. Find and interpret the zeros of the function. Then use the zeros to sketch the graph. b. What do the domain and range of the function represent in this situation? 
11th	Section 4.4 #73. Vilfredo Pareto (1848-1923) observed that most of the wealth of a country is owned by a few members of the population. **Pareto's Principle** is $\log P = \log c - k \log W$ where W is the wealth level (how much money a person has) and *P* is the number of people in the population having that much money. (a) Solve the equation for *P*. (b) Assume that $k = 2.1$ and $c = 8000$, and that *W* is measured in millions of dollars. Use part (a) to find the number of people who have \$2 million or more. How many people have \$10 million or more?
12th	Section 7.4 #55. The German mathematician Karl Weierstrass (1815-1897) noticed that the substitution $t = \tan\left(\frac{x}{2}\right)$ will convert any rational function of sin *x* and cos *x* into an ordinary rational function of *t*. (a) If $t = \tan\left(\frac{x}{2}\right), -\pi < x < \pi$, sketch a right triangle or use trigonometric identities to show that $\cos\left(\frac{x}{2}\right) = \frac{1}{\sqrt{1+t^2}}$ and $sin\left(\frac{x}{2}\right) = \frac{t}{\sqrt{1+t^2}}$ (b) Show that $\cos x = \frac{1-t^2}{1+t^2}$ and $\sin x = \frac{2t}{1+t^2}$ (c) Show that $dx = \frac{2}{1+t^2}dt$.

Figure 4

Number of distinct named characters within each textbook.



Recommendations for Teachers

Upholding the results of past textbook studies, the four textbooks we researched showed similarly low human presence, few named characters, no instances of discernibly non-binary gender identities, and few examples of STEM careers. We worry that textbooks authors are perpetuating pervasive inequities in mathematics education, rather than dismantling them. We encourage teachers to begin noticing representation in their own curriculum materials. Teachers can go beyond the dimensions of diversity investigated in our research by also considering religion, disability status, linguistic repertoire, national origin, and immigration status. When considering diversity among their own materials, teachers likely notice a need to find alternative ways to foster inclusivity in their classrooms.

Of course, a long-term goal is to see textbooks improve. Districts can also consider diversity when selecting new textbooks. We note that the 12th-grade book used in this study is over twenty years old. When time for replacement, the district could consider the representation among characters within the book options. However, we recognize that it will take time for the textbooks to improve, and even more time for school districts to adopt improved textbooks. Further, we recognize that many teachers do not have control over textbook selection. Thus, we believe there are actions teachers can take in the meantime to promote inclusivity. Gutiérrez (2016) notes that we must often find ways to navigate the education system using administration's rules and regulations, while striving to put students at the forefront of their learning. Simpson et al. (2021) recommend several short-term actions including enriching existing course materials with supplemental readings, recommending websites highlighting diversity, and asking students to analyze real-world data on racial disparities. They also recommend that teachers humanize scientists and avoid reinforcing stereotypes of scientists.

In the meantime, teachers can modify existing textbook exercises to be more inclusive. We provide recommendations for this in more detail elsewhere (Di Pasqua et al., 2021). As mentioned earlier, teachers might survey their students at the beginning of the year to determine their interests and aspirations. Teachers can modify textbook exercises, while preserving the mathematics content, by incorporating the names and interests of their own students. This ensures that the modifications are accurate representations of students and their communities, as opposed to superficial or stereotypes. Teachers might include names of community leaders or local heroes. If using fictional names to humanize textbook exercises, teachers should intentionally select names from diverse cultures. If teachers would benefit from assistance with finding names, they could consult databases of diverse STEM professionals such as *Living Proof: Stories of Resilience Along the Mathematical Journey* or *I Am a Scientist*.

While modifying existing exercises, attention should be paid to the genders of the characters with a specific eye towards counteracting the overrepresentation of men. Teachers could also include characters with non-binary gender identities. Teachers could use gender-ambiguous names such as Alex or Sam, and/or non-binary pronouns like they/them. Further, modified exercises could feature characters in non-stereotypical gender roles such as a woman who is coaching or a man who is making school lunches. Teachers could also modify exercises to push back on the heteronormativity and mononormativity currently reinforced in textbooks.

Furthermore, we recommend an increased number of STEM careers showcased in the textbook exercises. Students frequently ask teachers, "When are we going to use this?" and textbooks may be doing little to help answer this important question. A number of sources exist which feature diverse STEM professionals, including 500 Queer Scientists, Lathisms, and Mathematically Gifted and Black, to name a few. Teachers can use these resources to feature authentic examples of STEM professionals.

While efforts are underway to diversify STEM professions, textbook authors may be hindering these efforts. To counter a textbook lacking diversity, teachers can deliberately showcase a variety of STEM professionals. Though this might seem as if it is a daunting task and more work on the teacher, Gutiérrez (2016) also emphasizes the importance of having colleagues that are committed to the same work. Teachers can work together to make modifications to existing materials and create a library of inclusive mathematics tasks. District colleagues could also work together to invite inspiring guest speakers to campus or to acquire posters of diverse STEM professionals to hang around the school. Many such posters already exist, such as the SACNAS Biography Project.

Conclusion

It will take time for publishers to diversify textbook exercises. In the meantime, teachers can counteract issues in textbooks by showcasing diverse STEM professionals in their classrooms in other ways. Teachers can rewrite textbook exercises to include diverse names, diverse genders, a variety of races, ethnicities, and cultures, and a multitude of STEM careers (Di Pasqua et al., 2021). They can have guest speakers from diverse backgrounds visit their classes and/or highlight news articles featuring the accomplishments of diverse STEM professionals. By taking actions such as these, teachers can reinforce that every student can pursue a career in STEM. Gutiérrez (2016) encourages us to ask ourselves questions such as *Am I inviting all students into the curriculum? Am I actively showcasing a different vision of STEM? If not, what will I do on my part to change this?* By making these adjustments, we expand the vision of what is considered the face of STEM (Piatek-Jimenez et al., 2014).

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Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. How would you summarize the main ideas of this article to a colleague who did not read it?

2. Come up with a few questions or activities you could use to learn information about your students' interests, backgrounds, and future goals that can be used to modify textbook exercises to be more inclusive.

3. Choose a set of exercises from your textbook or curriculum materials and consider the set with respect to the coding hierarchy in this article. Do any exercises contain contexts? Are there humans present? What are the characteristics of the humans in terms of name, gender, and career? What are the intersections between gender and career?

4. Look through your textbook or curriculum materials and find an exercise that could be modified to be more inclusive. How could you modify the exercise?

5. What, if anything, do you plan on doing differently in your classroom after reading this article?

Appendix A

Set of textbooks included in this study

Grade	Topic	Citation
9	Geometry	Larson, R. (2015). *Big ideas math geometry: Common Core* (1st ed.). Houghton Mifflin Harcourt.
10	Algebra 2	Larson, R. (2015). *Big ideas math algebra 2: Common Core* (1st ed.). Houghton Mifflin Harcourt.
11	Precalculus	Stewart, J., Redlin, L., & Watson, S. (2015). *Precalculus: Mathematics for calculus* (7th ed.). Cengage Learning.
12	Calculus	Stewart, J. (2002). *Calculus: Early transcendentals* (5th ed.). Brooks Cole.

Appendix B

Flowchart of codes