DIVERSE STEM EXPERTS IN THE MIDDLE SCHOOL CLASSROOM

by

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of

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DEDICATION

This paper is dedicated to the many people who helped me stay focused and get through my Capstone. To Brendan, for making me dinner, staying up late to Google Excel formulas with me, and for telling me that I would need better excuses and more money if I really wanted to quit so late in the game. To my parents, for helping me analyze data and letting me lay on the couch when it was just what I needed to do. To my distracting and conniving friends, especially Jason, for forcing me into a work-life-master's balance for about a year. Finally, to my COVID class of students. I can't believe you were so surprised that a woman could be a software engineer. You made my data worth collecting and my videos worth editing.

ACKNOWLEDGEMENTS

I am so grateful to the people who made this project possible and took time out of their busy lives to work with me or allowed me to interview them. I was able to talk to men and women in jobs I didn't know existed and learn about what it takes to be truly immersed in the STEM world. More importantly, though, the interviewees helped open the eyes of 160 seventh grade students to a smattering of the endless possibilities STEM has to offer. Sarah Bailey, Elizabeth Juarez Colunga, Jordan Dario, Devin Gaskins, Angela Hemingway, Leslie Kim, Shannon Kobs Nawotniak, Jessica Marquez, and Kelsey Yoder; you are all so cool, and you made this project possible. Thank you for showing me and my students what potential looks like.

I can't forget to mention the people who helped me write and develop my Capstone Paper, either. Thank you Jason, Lainey, Lou, and Kristin, for reading drafts, helping me with data language, and coaching me through every little point of confusion when it came to numbers, grammar, and formatting (even though you didn't have to). To my fellow students in the MSSE program, thank you for making me better throughout this process and for helping me think like a writer and scientist. Suzanna Soileau, thank you for being the perfect reader for my project, an example of a STEM-azing role model, and for giving me the feedback I needed when I needed it. And of course, John Graves, I cannot thank you enough for being kind, wise, flexible, critical, and incredibly patient as an advisor. I truly could not have asked for a better guide during these strange times.

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ABSTRACT

How does bringing in a diverse group of science, technology, engineering, and math professionals impact student perceptions of what people in these fields look like and do for a living? By interviewing women and people of color in these careers and showing recorded and edited versions of the interviews to students, some students showed growth in tests like the Draw-A-Scientist-Test, proving that they learned anyone could be a scientist. Additionally, results from the Thinking about My Future Survey showed that students also had a change in attitude regarding their beliefs that they would be capable of having a career in one of these many fields. Class discussions also indicated that students had started to understand that no one in any of the jobs we discussed had to look a certain way or fit a specific mold. Many stereotypes were removed from student perceptions, but some were difficult for students to move away from mentally.

BACKGROUND AND INTRODUCTION

Context of the Study

Vallivue Middle School (VMS) sits at the top of a hill in Caldwell, Idaho overlooking the Treasure Valley. When the school first opened in 1961 as the original Vallivue High School in the Vallivue School District (VSD), the population in the district was substantially lower than it is today (World Heritage Encyclopedia, 2015). Fast-forward to 2020, where that particular building currently houses approximately 300 eighth graders and the additional buildings on the same campus hold anywhere from 600-700 other sixth and seventh grade students. The population of this now over-crowded school fluctuates between 950-1000 students from year to year and has students from a variety of backgrounds. VMS is one of two general middle schools in the district, with another under construction and set to open in the fall of 2021. Other schools in the district include two high schools, seven elementary schools, and an alternative high school (Vallivue School District, 2020).

While students may come from a multitude of different backgrounds in our school, there isn't much diversity. Fifty-one percent of Vallivue Middle's student population is white, 43.7% is Latinx or Hispanic, 3.7% are multiracial, 0.7% are black, 0.5% are Asian, 0.3% are Native American or Alaskan Native, and 0.1% are Native Hawaiian or Pacific Islander (Idaho State Department of Education, 2020). Additionally, 92% of the teachers at Vallivue Middle School are white (Vallivue School District, 2020). Canyon County, the surrounding area that encompasses all Vallivue School District and includes the cities of Caldwell and Nampa, has even less diversity than VMS.

The three leading ethnicities in Canyon County are White, Non-Hispanics at 70.6%, the Hispanic population at 25.1%, and multiracial Non-Hispanic people at 2.17%. All other races and ethnicities fall below the one percent mark (Deloitte & Datawheel, 2018).

Outside of general demographics for our school and area, there are some important statistics regarding the availability of science, technology, engineering, and math (STEM) careers in Idaho. During a personal interview with Dr. Angela Hemingway, who was the Executive Director of the Idaho STEM Action Center at the time of our interview, stated that there are over 7,000 open STEM jobs in the state of Idaho. While having available STEM jobs is excellent for the community, Idaho is struggling to fill those roles, particularly with local students. Idaho outsources many of its STEM positions to people from out-of-state; students graduating from Idaho high schools are not setting their sights on STEM careers (A. Hemingway, personal communication, November 25, 2020). This made me curious; why wouldn't students be setting goals to pursue these higher-paying jobs in their own state? More specifically, what could I do in my seventh-grade science classroom to help my students see themselves as people holding STEM careers in the future?

I brainstormed reasons why they might not be interested in these jobs. My first thought was that students might not know what STEM jobs look like in the field. Many of them might think that, in order to get a job in STEM, they would need a lengthy degree from a school they couldn't afford. Others might assume that STEM jobs were only for Einstein-type people or geniuses. Maybe they saw a lack of diversity in what they considered STEM careers and hadn't ever seen anyone who looked or acted like them in a STEM field; perhaps even media portrayal of STEM characters didn't support the idea that they could one day have a future in STEM. Additionally, some might not be able to picture themselves in STEM careers due to a lack of interest; maybe they imagined someone in STEM would sit around writing or staring at long equations on a chalkboard alone in an empty lecture hall. Regardless of what the problem was, I wanted to find out what I could do to help them see what diversity in STEM really looked like.

Focus Statement

The goal of my Capstone was to introduce my students to women and people of color (POC) in STEM fields around the nation through pre-recorded and edited Zoom interviews. These interviews were intended to take the place of guest speakers during the COVID-19 school year, and to show students the diversity of both the people working in these different careers as well as the diversity of the careers themselves. I interviewed nine separate STEM professionals in the fields of biostatistics, graphic design, aviation, athletic data analysis and statistics, medicine, human systems engineering, executive leadership for a STEM non-profit, software engineering, and geosciences. I also tried to make sure I included male and female gendered interviewees as well as people of different races or ethnicities in different interviews. My hope was that the interviews would help my students see who our leaders are in the STEM industry while also helping them see that they, too, could be in these or other positions one day.

My focus question was, How are student perceptions of potential STEM careers and professionals in STEM impacted when introduced virtually to women and POC in STEM?

Additionally, my sub question was, How are student perceptions of their own abilities to pursue STEM careers and educational pathways impacted when introduced virtually to new STEM careers as well as women and POC in STEM?

CONCEPTUAL FRAMEWORK

STEM Portrayals in Media

It's no secret that the media has been known to portray people in science, technology, engineering, and math (STEM) as white males. In the past, fictionalized film and television often showed women in STEM as subservient to their male counterparts, socially inadequate in a physical, mental, and/or emotional sense, or nurses (Steinke, 1999). This was the case for white women, explicitly. People of color, women and men included, were facing other types of challenges in the media, both in fictional and national news coverage. They weren't portrayed in STEM roles, but in stereotypical roles that made them appear less-than in many ways; they were also being covered in a demeaning way by the mass media. One example, the Latinx community, was almost explicitly represented by language issues, immigration, and gang-related stories or storylines (Cort, 1987).

The importance of media representation of diverse, female, STEM role models has been substantiated in multiple reports published by the Geena Davis Institute on Gender in Media (GDIGM), whose slogan is "If she can see it, she can be it." The research done by this institution focuses on females impacted by STEM role models in media and uses studies of young girls as well as adult women. In a study titled "The Scully Effect," researchers found that 63% of women who watched the X-Files felt that the character Dr. Dana Scully helped them see the importance of STEM and 50% of the women surveyed said that Scully also made them more interested in pursuing a STEM career or education. More data suggests that consistently watching this character directly impacted female viewers to be involved in a STEM career at some point in their life compared to people who rarely watched the show (The Geena Davis Institute on Gender in Media et al., 2018). Another study conducted by GDIGM reviewed and analyzed children's television shows in the United States to find out how STEM Careers were portrayed to children. According to their data, they found that American children's television was sending both negative (Figure 1) and positive (Figure 2) messages related to STEM portrayals in their programming (The Geena Davis Institution on Gender in Media & Lyda Hill Foundation, 2019).

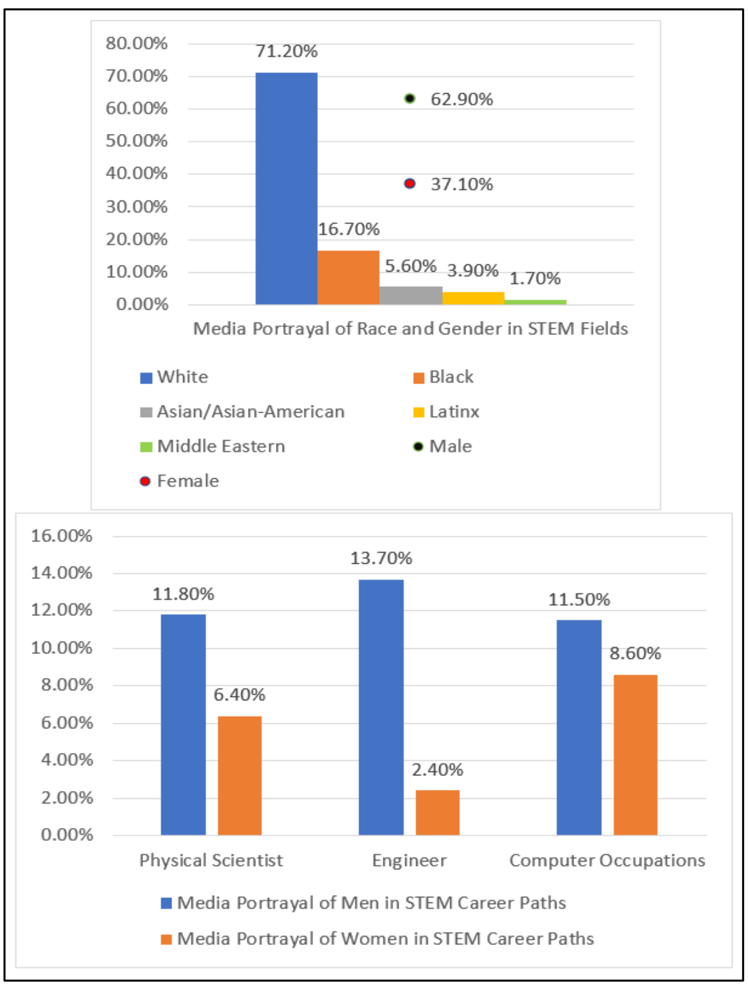


Figure 1. Negative trends in STEM portrayed by media. Data found in research through the Geena Davis Institute on Gender in Media, 2019.

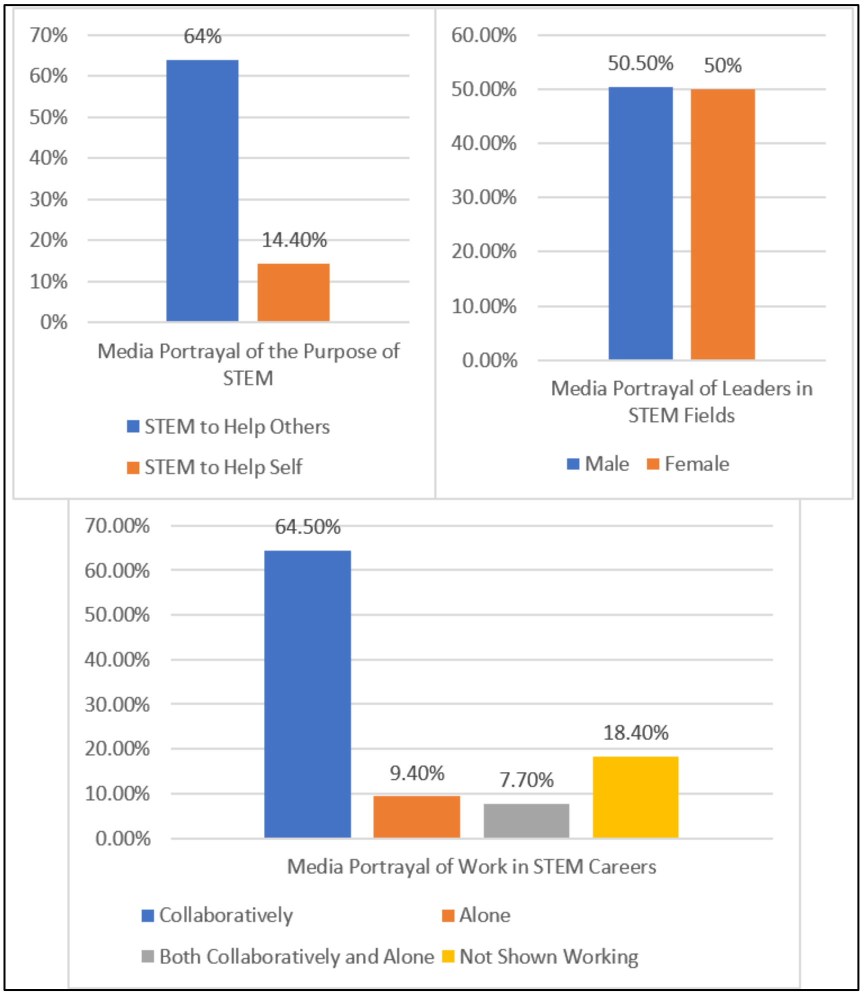


Figure 2. Positive trends of STEM portrayals in media. Data found in research from the Geena Davis Institute on Gender in Media, 2019.

Diverse representation in media is important because children ages 8-18 spend so much of their free time interacting with media every day. One study, aimed at observing children's engagement with media and conducted by the Keiser Family Foundation, found that, on average, kids were using media for seven and a half hours a day. Although the physical timeframe was determined to be seven and a half hours, children were engaging in more than one type of media at any given time, deemed as media-multitasking, and brought the actual amount of dedicated time with media to ten hours and forty-five minutes in that seven-and-a-half-hour period. Additionally, Latinx and Black children were engaging with media for longer than White children. The sub-groups used media for 13 hours, 12 hours and 59 minutes, and 8 hours and 36 minutes, respectively, with the most substantial differences in time attributed to watching television (Keiser Family Foundation, 2013).

While previous sources focused on children's television and media, there are also examples of women of color in STEM in the written media and film industry. Articles and magazines focusing on this subgroup are popping up at the international level, one example being an article about girls who attended the 2019 International Science and Engineering Fair (ISEF). With the focus being explicitly placed on the young women of different races and nationalities competing in the fair, the article encourages girls to get into STEM (Kalb, 2019). Some widely-known examples of positive STEM role models in film include Letitia Wright's character Shuri, an engineer and princess in 2018's *Black Panther*, and Taraji P. Henson, Octavia Spencer, and Janelle Monáe portraying Katherine G. Johnson, Dorothy Vaughan, and Mary Jackson, respectively, in 2016's *Hidden Figures*. These are all roles of Black or African women in STEM played by Black women (Padilla, 2019). Regardless of these positive trends, a University of Southern California Annenberg study from 2018 shows that Hollywood still has a long way to go before it can be considered an institution of diversity and inclusion (Smith et al., 2018).

Diversity and Retention in Higher Education

There are great disparities regarding race and gender when it comes to diversity of graduates in STEM fields and professionals pursuing STEM fields after college. While there has been an uptick in students earning STEM degrees, with .238% people in the US doing so, only .161% of Black people are leaving college with a degree in one STEM field or another (Ladyzhets, 2020). Data from the National Center for Science and Engineering Statistics (NCSES) and National Science Foundation (NSF) also shows that many minority groups are seeing this effect down the line when it comes to STEM careers (Figure 3).

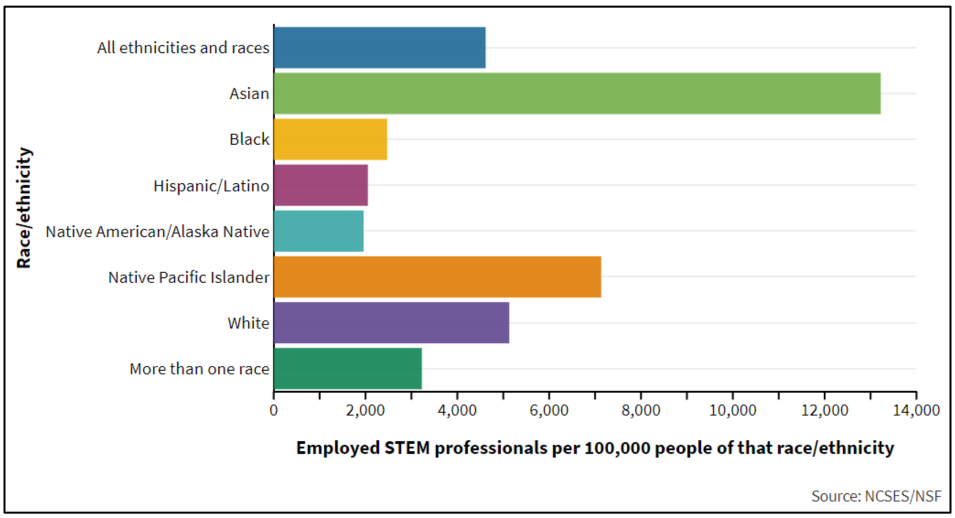


Figure 3. Discrepancies between people employed in STEM careers based on race and ethnicity. Data collected in 2017 by the NCSES and NSF.

Extensive data also shows that minority students switch out of STEM majors at a higher rate than White students and are more likely to drop out of college altogether compared to White students. Latinx, Black, and White STEM students switch out of STEM majors at a rate of about 37%, 40%, and 29%, respectively, while they leave college at a rate of 20%, 26%, and 13%, respectively (Riegle-Crumb et al., 2019). Data collected by the Pew Research Center show these rates lead to a leak in the STEM career pipeline as well, with Hispanic/Latinx and Black employees finding jobs outside of STEM at a higher rate than their White counterparts (Figure 4).

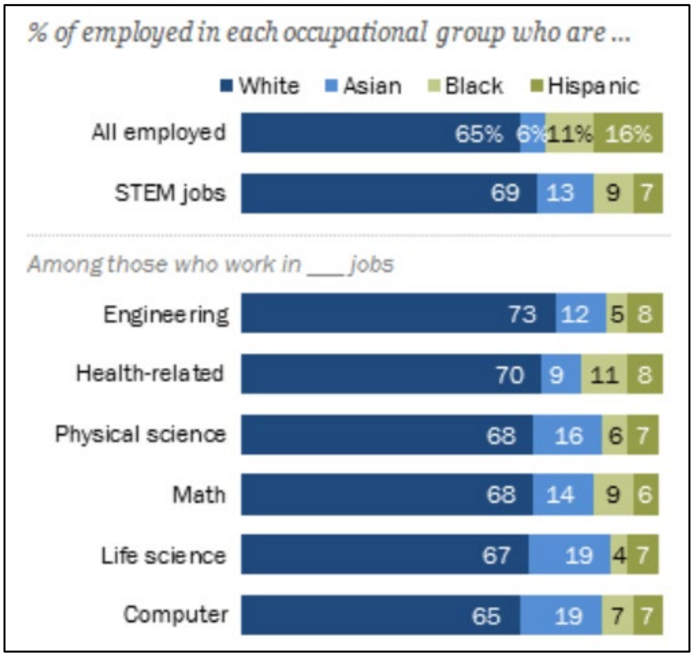


Figure 4. Representation of Racial Groups in STEM Careers. Data collected by the Pew Research Center from 2014-2016 shows that certain racial groups are underrepresented or overrepresented regarding STEM career paths.

One way to encourage retention in STEM majors is to create relationships between underserved students and mentors who are from the same social backgrounds when possible (Cornwall, 2020). Not unlike the conclusion drawn by The Scully Report, research shows that having encouraging mentors and role models who are similar to students or can connect easily with them increases the retention rate of those students in STEM (Herrmann et al., 2016). More data describes the lack of diversity in higher education for both faculty and graduate assistants that could potentially keep students from seeing people who look like them or who belong to the same social groups as they do (Taylor et al., 2020) (Figures 5 & 6).

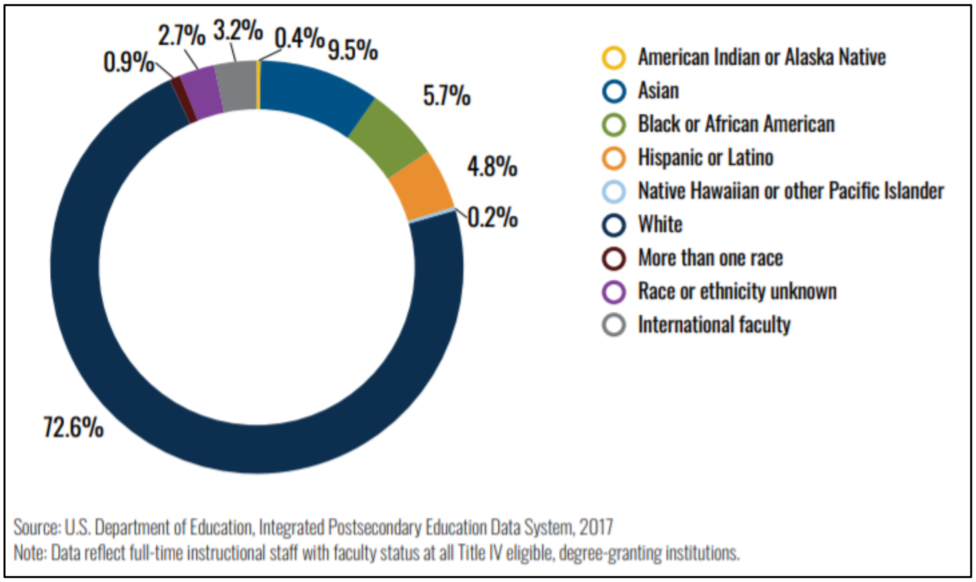


Figure 5. Racial Diversity of Full-Time Faculty. The percentage of faculty at the post-secondary level indicates that full-time faculty members are overwhelmingly White with skewed numbers of other races being represented in classrooms and on staff in colleges across the United States, according to data collected in 2017.

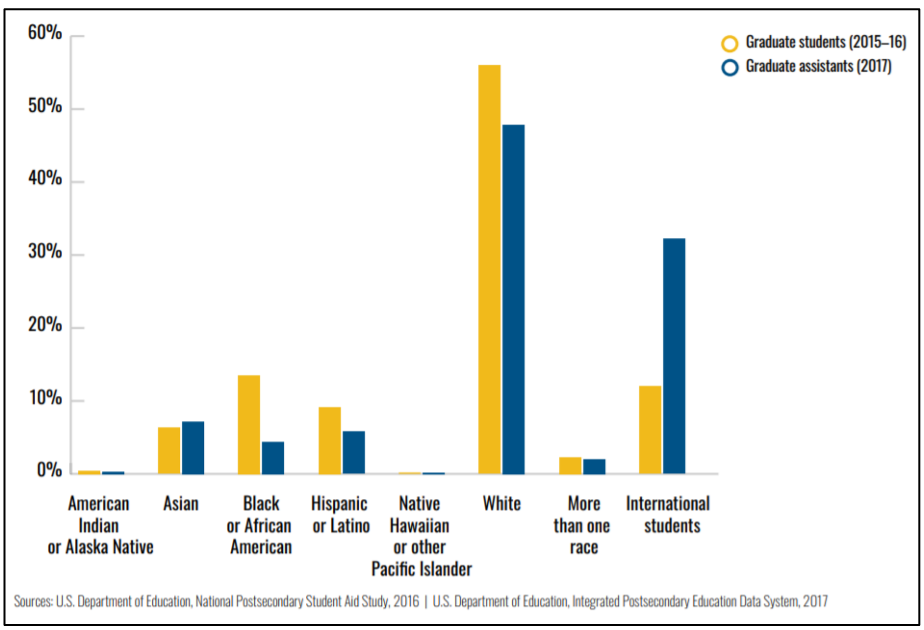


Figure 6. Racial Representation of Graduate Assistants. Data are skewed at the post-secondary level, with the majority of graduate assistants being white at 47.9%. These data, collected in a study in 2017, also indicate that Black graduate students outweigh assistants by over 50% and Hispanic/Latinx students by nearly 25%, leaving many students without mentors or role models who are from the same social backgrounds as they are.

Introducing Students to Diverse STEM Professionals through Videos

In a study where data were collected during the 2017-2018 school year, nationally, kindergarten through 12th grade public school teachers were found to be 79% White, 9% Hispanic/Latinx, 7% Black, 2% Asian, 2% two or more races, 1% American Indian/Alaska Native, and less than 1% Pacific Islander in classrooms across the United States (National Center for Education Statistics, 2020b). In contrast, the same data were collected for national kindergarten through 12th grade student enrollment, showing that the same racial groups were represented by 48% of students, 27% of students, 15% of students, 5% of students, 4% of students, and less than 1% in the last two racial and ethnic categories of students, respectively (National Center for Education Statistics, 2020a). These data indicate that students aren't always seeing mentors or role models who belong to the same social groups as they do. Programs like Zoom-a- WiSE-Woman and Skype a Scientist are programs that were created to counteract these skewed numbers and introduce diverse people in STEM to students in classrooms all over the nation. The programs were intended to show students what real scientists look like and what they do for a living while also teaching them that science is fun and for everyone (Skype a Scientist, 2021; WiSE TAMU, 2021). By creating similar situations using pre-recorded interviews with STEM professionals, students can still learn about these careers but allow themselves to choose the pace at which the videos are played. Students learn effectively through video interactions that they are able to control on their own. For example, if they are able to play, pause, skip, go back, speed up, slow down, etc. just as they do when they are reading complex text, they can take away as much information from videos as if they had been reading on their own or with help (Merkta et al., 2011).

Video recordings allow students to see media representation of a diverse and inclusive group of STEM professionals, which can help them see themselves in those roles in the future (The Geena Davis Institution on Gender in Media & Lyda Hill Foundation, 2019). This is not unlike having STEM guest speakers in the classroom, which have proven to help students see themselves in the profession of the role models who most remind them of themselves (Zirkel, 2001). Students connect with guest speakers when they know about the person's profession, hobbies, personal lives, and backgrounds as well as seeing that these same STEM role models have a sense of humor and are like the students in some way. Therefore, diversity in guest speakers and STEM role models for students is essential when choosing who to invite into the classroom. It allows students to see the diversity of STEM and the professionals represented while creating an opportunity for them to see themselves in the same positions as those who seem the most like them (Mosatche et al., 2012).

METHODOLGY

Demographics

The children who participated in this study were seventh grade life science students from the west side of Vallivue School District located in Caldwell, Idaho. Each student was assigned a unique number at the beginning of the data collection process to simplify the anonymity of participants and to avoid any bias when sorting through data. This also simplified things when new students joined the class or when students moved to another class or teacher; it was particularly helpful when schedules changed drastically at the beginning of the spring semester.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A). Additionally, this project was approved by administrators at Vallivue Middle School, and students were made aware that their participation in this project, or lack thereof, would in no way impact or affect their grade.

Treatment

Treatment for students included watching eight pre-recorded and edited Zoom interviews between a science, technology, engineering, or math (STEM) professional and me. Overall, nine videos were recorded, but for time purposes, not all of them were shown to the students. The professionals chosen for the interviews were selected based on availability, demographics associated with low numbers of participation in STEM fields, and STEM career or educational pathways. Their areas of specialization were not intended to coincide with any particular units or lessons completed in class for the 2020-2021 school year. Professionals were chosen based on my ability to contact them and my own general lack of understanding about what they do in their particular careers. My assumption was, if I didn't know what these professionals did, then it was unlikely that many students would know what their jobs entailed. Students were asked to take notes while watching the videos to help them keep track of their notices and wonders while also reflecting and thinking about the career or interviewee.

Data Collection and Analysis Strategies

In order to collect both qualitative and quantitative data on student opinions regarding STEM careers and the people who pursue them, multiple pre and posttests were given. The first test given was the Draw-A-Scientist-Test (DAST) and was analyzed using the Draw a Scientist Checklist (DAST-C) (Finson et al., 1995). These were used to analyze how students perceived scientists or people in STEM to look physically and what tools they use (Appendix C). When students drew their scientist or person in STEM, different stereotypes were marked on the checklist to determine a score. The higher students scored on this test, the more stereotypes they included in their drawings. The highest possible score that a student could receive was 15, and 0 was the lowest. Therefore, a higher score in the pretest and a lower score in the posttest would indicate growth for a student who learned that scientists don't all look, act, or even work in a certain way or location. Both the pre and posttest were completed on a blank sheet of printer paper. Students were asked to complete the DAST by drawing a scientist doing science, and, again, were reminded verbally that their participation or lack of participation would not impact their grade in any way. The data method for the DAST was to create a scale and assign each student a raw score based on their drawings. Each category on the DAST-C counted as one point and went towards a total, and total scores were placed on a box-and-whisker-plot to compare medians and the size of each quartile between the pre and posttest. Additionally, each category was compared using the raw total from pre to posttest as well in order to see which areas were the most directly impacted by the interviews.

The pre and post survey Thinking about My Future was given directly after students completed the DAST (Appendix F). Both the pre and post surveys asked the same questions and had a variety of quantitative and qualitative questions to help indicate student beliefs in where they were headed educationally and career-wise. These questions made up for much of the data collection. The analysis of the pre and post surveys included Likert-type questions as well as multiple choice, short answer, and checkbox options. The Likert-type area assessed student feelings about science, the multiple choice section questioned their interest in college and STEM careers as well as their perceived ability to personally pursue STEM careers, and the short answer section asked them what their dream job might be. Additionally, the checklist area asked them to select up to three career categories that they were interested in learning more about.

The Likert-type portion of the Thinking about My Future pre and post surveys helped to showcase student feelings about science from a scale of one to five. A score of one showed very negative feelings towards science, a two showed negative feelings, a three showed neutral feelings, a four showed positive feelings, and a five showed very positive feelings. These questions directly measured the level of difficulty, interest, and importance students associated with science in general, in that order, and were represented as Q1, Q2, and Q3, respectively, in the analysis. A score of one, depending on the question, indicated that science was really difficult, really boring, or worthless. A score of five would indicate that science was really easy, really interesting, or essential, depending on the question. The analysis of this section showed areas where students did or did not change their feelings towards science after viewing the STEM interviews. The surveys were conducted before showing any of the STEM interviews, and once more at the conclusion of showing all of the STEM interviews. The Likert-type items were analyzed by comparing the frequency of each numerical score from one to five that students assigned to their feelings from the presurvey to the postsurvey.

The same survey used multiple choice questions to get a basic understanding of students' attitudes toward attending college, their potential interest in STEM careers, and their self-esteem regarding whether or not they thought they were capable of pursuing a STEM job before and after treatment. Students were given the option of answering yes, no, or maybe, and these data were used to compare the raw number of students who said they would or wouldn't consider college, try out a STEM job, or if they thought they were or were not capable of having a STEM job in the future.

A short answer section was created to find out what student dream jobs were in the Thinking about My Future Survey. I used the responses for the short answer section to look for trends and determine the percentage of students who changed their opinions from the pretest to the posttest to include STEM careers as potential dream jobs. I also included data where students didn't have dream jobs for this category and counted them as non-STEM related careers. Beyond this, in a separate question, I also asked students to list as many STEM jobs as they could think of and measured the number of students who were able to identify at least one STEM job in their answers. I then found the change in percentage of students who could come up with a STEM job from the presurvey to postsurvey.

The checkbox section of the same survey allowed students to select up to three categories of careers that they were interested in learning more about. Some of the categories included STEM careers and others did not. This made it easier to compare the number of students who were interested in learning more about STEM careers versus other types of careers from pre to postsurvey. A simple comparison of the total number of students who selected each category in each survey was used to show areas where student interest grew and where student interest waned.

The variety of assessments and surveys helped to check the attitudes and beliefs of all students who participated (Table 1).

Table 1. Data Triangulation Matrix.

Focus Questions	Data Source 1	Data Source 2
1. How are student perceptions of professionals in STEM careers impacted when introduced virtually to women and POC in STEM?	DAST-C	STEM Career Interview Notecatcher
2. How are student perceptions of their own abilities to pursue STEM careers and educational pathways impacted when introduced virtually to women and POC in STEM?	Thinking about My Future Pre and Postsurvey	STEM Career Interview Notecatcher

DATA ANALYSIS

Results

The results of the Draw-A-Scientist-Tests (DAST) showed that 63% of student scores decreased by at least one point from pre to posttest (*N*=115). The results of the Thinking about My Future survey showed that student identification of STEM careers increased by 15% and student feelings of their own capabilities to pursue STEM careers increased by 19% (*N*=113).

For the DAST, data showed that students had a varying degree of opinions regarding what scientists look like or what they do for their jobs in the pre and posttest, but general trends showed that students carried stereotypical interpretations as well, both before and after treatment. Total scores in each category showed areas where students had preconceived notions as well as where students were starting to move away from stereotypical assumptions of scientists. Students showed a score decrease in all areas but facial hair, male gender, technology, and indications of danger (Figure 7). A lower score indicates a less stereotypical image. One trend that changed from pre to posttest was the addition of volcanologists and geologists in some student drawings. While not indicated on the DAST directly, no students drew any type of geology or earth science career in the pretest whereas 16 in the posttest created drawings that included volcanologists or geologists.

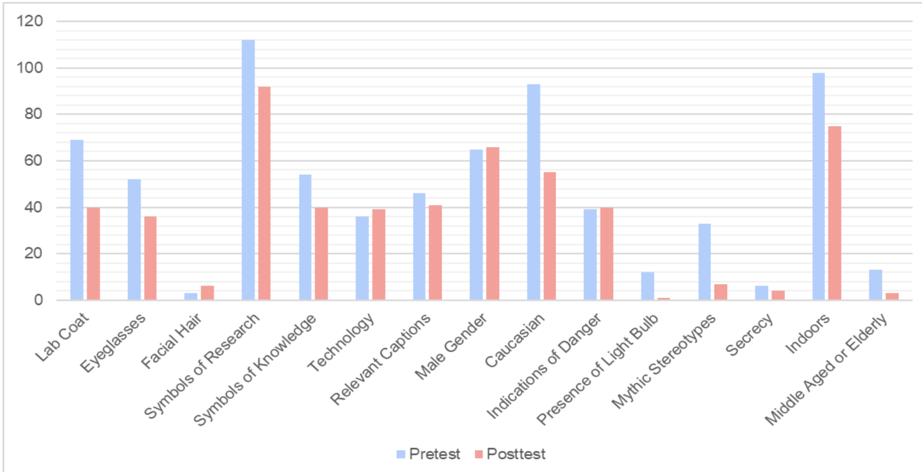


Figure 7. Total Scores of All Students in Each Category of the DAST. Each student earned a one or zero in each category, and raw scores in each section were added together to compare how student mindsets may or may not have shifted from pre to posttest.

Overall, there were declines in student scores in different areas from pre to posttest, with lower scores indicated less stereotypical images. Highest earned scores in the pretest were 14 compared to 10 in the posttest, average score shifted down from a mean of 6.4 to 4.7, and the median as well as the mode both shifted from 6 to 5. Additionally, the range of the test also declined from 13 to 9 from the pre to posttest (Figure 8).

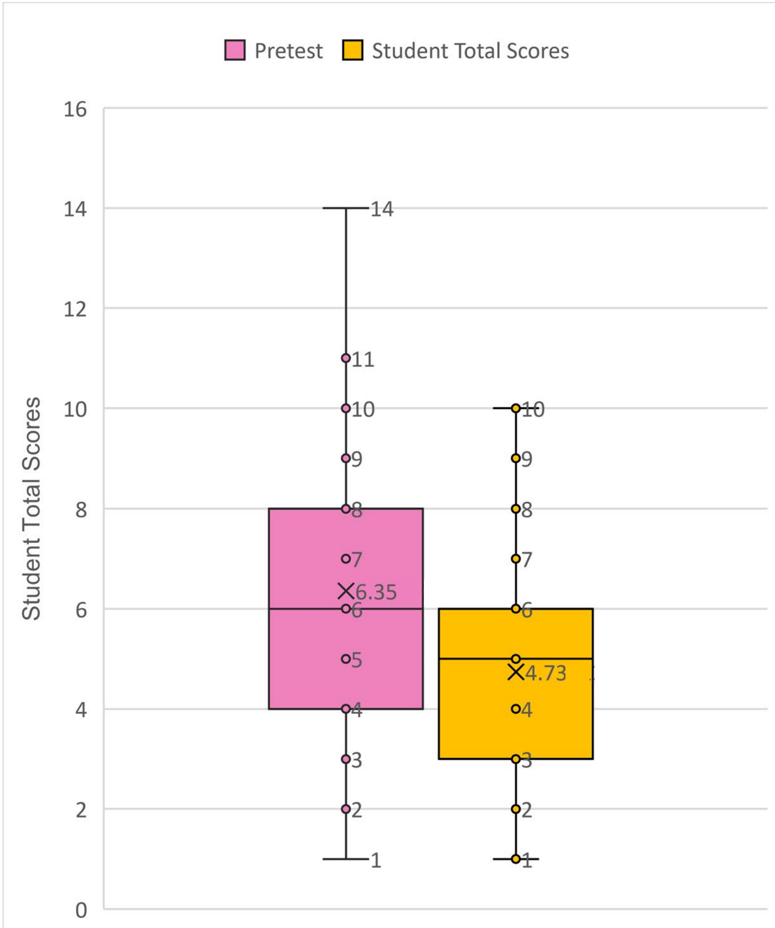


Figure 8. Ranges in DAST Scores from Pre to Posttest. In the DAST, the range of the posttest was lower, as was the mean and median, when compared to scores of the pretest. Mean is indicated with X's. The highest possible score a student could receive was a 15 and the lowest possible score was a zero (*N*=115).

After adding up all students' raw totals in the pre and posttest, the total combined scores went down from 731 points to 545 points, showing a 25.5% decrease in raw score overall. Pre and posttest drawings showed positive, negative, and no shift in student scores depending on the student drawing the pictures (Figure 9). The most extreme score shifts showed tests that lost up to eight total points and tests that gained up to seven total points from pre to posttest. There were no substantial differences in scores between male and female students.

Figure 9. Student Samples of DAST Pre and Posttests. Student pretests are located on the left and posttests are located on the right for the same student. Based on raw scores, there were some students with no change in score, as the first student; a negative change in score, like the second student; and students who saw an increase in score, like student three. Reminder that a lower score indicates a less stereotypical drawing than a high score.

In the Thinking about My Future presurvey, data indicated that students were more interested in learning about careers that weren't focused in STEM fields and changed very little in that regard from pre to postsurvey (Figure 10). Some trends in the postsurvey showed an increased interest in areas we did not discuss in class and a decrease in areas we did discuss, two examples being a decrease in interest for math-based careers and an increase in politically-based careers. Job categories we watched interviews about in class that did see an increase in interest from students included life sciences, academic research, medicine, and the arts.

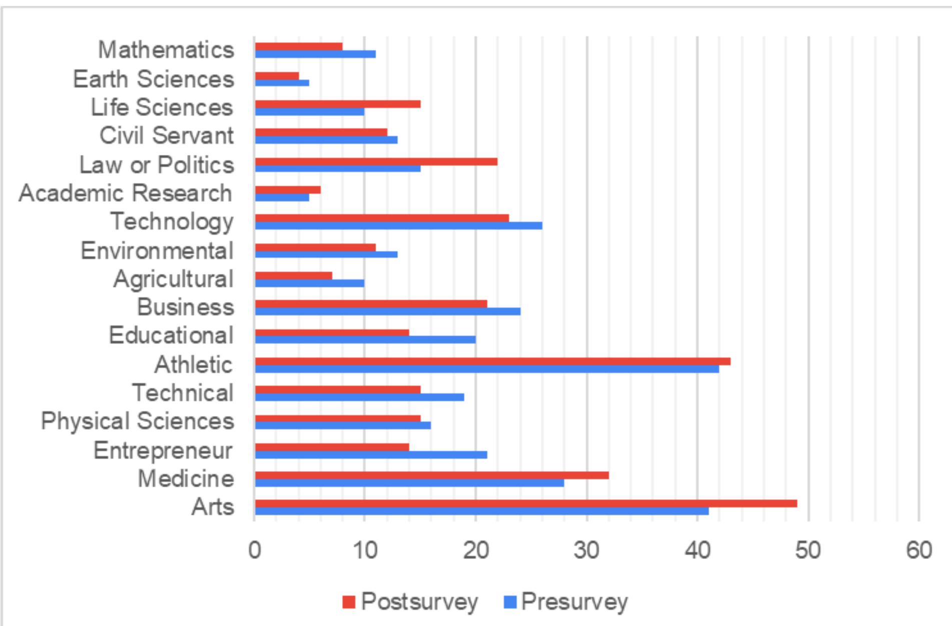


Figure 10. Thinking about My Future Pre and Postsurvey Career Interest Results. Students selected up to three different career areas that they were interested in learning more about before and after treatment (*N*=113).

Likert-type items in the Thinking about My Future survey asking students about their perceptions of science in regard to how difficult they thought science was, how interesting they thought science was, and how essential they thought science was, in that order, showed trends of increase in all areas (Figure 11). No student who took both the pre and postsurvey selected the number one in any category in either survey.

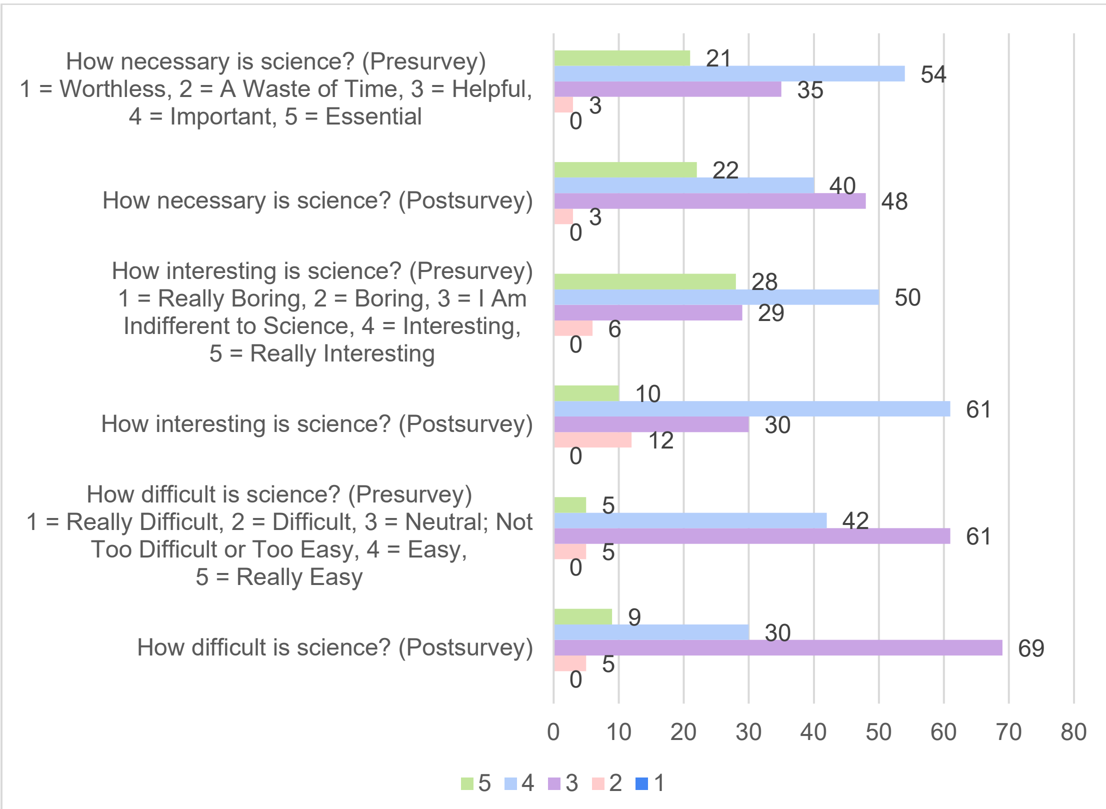
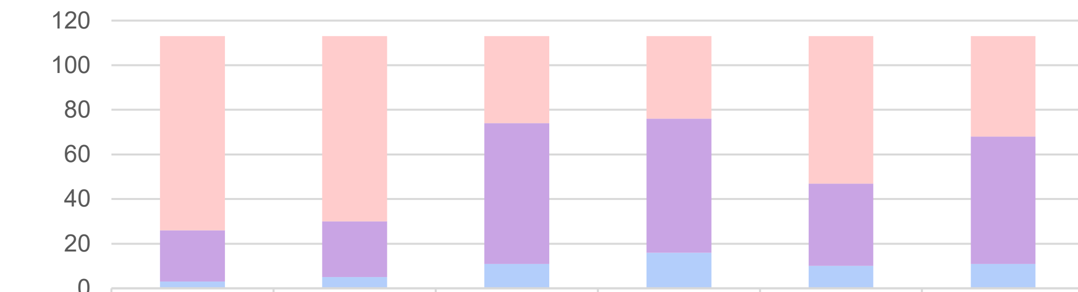


Figure 11. Thinking about My Future Science Feelings Likert-Type Surveys. Likert-type items show changes from pre to post survey (*N*=113).

The same survey also included multiple choice questions about students' feelings toward attending college, whether or not they were interested in having a STEM job one day, and if they thought they were capable of having a career in STEM. In every response category, the number of students who answered No decreased and the number of students who answered Maybe and Yes increased (Figure 12). Student responses of

Yes to the question about their capability to have a job in STEM increased by 19% from pre to postsurvey.



	Do you want to go to college? Postsurvey	Do you want to go to college? Presurvey	Are you interested in having a career in STEM one day? Postsurvey	Are you interested in having a career in STEM one day? Presurvey	Do you think that you are capable of having a job in STEM one day? Postsurvey	Do you think that you are capable of having a job in STEM one day? Presurvey
Yes	87	83	39	37	66	45
Maybe	23	25	63	60	37	57
No	3	5	11	16	10	11

Figure 12. Thinking about My Future Interest and Capability Questions. Postsurvey data is posted in front of the presurvey data (*N*=113).

When students were asked what their dream job was, 52% of the students did not mention a STEM job in that category. This was the case for both the pre and postsurvey as the same number of students responded with jobs outside of the STEM world. Another question that asked students to list as many STEM jobs as they could think of showed that 21% of students in the presurvey couldn't think of any jobs related to STEM whereas 6% in the postsurvey couldn't identify or list any STEM careers.

CLAIM EVIDENCE AND REASONING

Claims From the Study

As I look back over the work that I did, I know that there is a lot I would change if I were to do similar studies with my students again in the future. First of all, I would develop a new version of the Draw-A-Scientist-Test (DAST) so that it better reflected today's stereotypes of scientists. I was not impressed with some of the categories that were selected in the 1990s because science has changed so much in the past 30 years and so have the students who are perceiving the scientists. That being said, I was incredibly pleased to see that the number of students who drew White or Caucasian scientists went down as well as the number of students who drew male scientists when comparing general results rather than the whittled-down results for the data analysis section. Additionally, something that isn't mentioned in the DAST is that almost every student tends to draw scientists working alone in a closed off lab, but some students shifted from people working alone to people working in groups from pre to posttest.

The Thinking about My Future Survey proved to me that many middle schoolers are either very dedicated to what they consider a dream job, or they have no desires regarding work in any facet. Very few students were willing to change their direction when asked what they would like to do in the future, but I think it would be interesting to do this same process with sophomores or juniors at the high school level and see if there were any changes. Beyond career focuses and desires, though, the survey showed that students were more confident in their own abilities to pursue science, technology, engineering, and math (STEM) careers, and that alone made me think that the whole process was important for more of them than I thought it would be.

Value of the Study and Consideration for Future Research

Interviews were conducted over Zoom due to the interviewees' locations as well as COVID-19 restrictions. The intention of the treatment was to give students an opportunity to see diverse STEM careers and diverse people in said STEM careers; few of the interviewees' jobs were lab-related jobs, and none of the interviewees were white males. Ideally, after watching the videos, students would think about themselves in similar STEM roles because they somehow identified with the people in the videos and they would have a different idea of the people working in STEM roles. Encouraging students to pursue STEM careers that may seem out of reach, regardless of upbringing, passions, or their demographics, was an additional hope for this process.

The study that I did, while very interesting to me, proved to be a bit disappointing in some areas. I was hoping to see more gains from the DAST pre and posttest but didn't really find the changes I wanted. I was disappointed that more data couldn't be used from the 140-160 kids that were surveyed and tested because they had missed either the pre or post sections of the research, but I was glad to get as much data as I did. I would like to see this research done on a larger scale and try to implement it with multiple grade levels in the future.

Another data point I would like to be able to articulate or quantify is the classroom discussion that took place before, during, and after interviews. Those taught me a lot about what the students were learning and hearing, and I also gleaned a lot of knowledge by listening to some of the things that the students said when they thought I couldn't hear them; discussions and spying turned out to be more valuable to me, personally, than any of the data I collected on paper or on the computer.

One thing that disappointed me about my research—and didn't hit me until months after I completed it—was my inadvertent lack of inclusion for other subgroups that I had missed in my interviews. Perhaps some of the people I interviewed were part of more than one demographic or background, but I would like to be more conscientious in the future of including more groups in my interviews. I realized that, because I chose to focus on people of color and women as my emphasis groups, I didn't think as deeply as I could have to include other marginalized groups who are doing great things in the scientific community. This stems from my own privilege and unintended lack of consideration for groups outside of my own; it is something I'm working on and one of the many reasons why I think a partner or partners in future research from populations other than my own will be valuable for what I'm trying to accomplish. This is something I plan on improving in the future and being more intentional about; I still have many areas in which I need to grow as a person and researcher. Diversity and inclusion in my own professional endeavors will continue to be things I strive for to make myself and my students better.

As I look forward, I would like to continue doing these interviews and showing them to kids in middle and even high school, but I would change my strategy if I were to do it again. I would try to do in-person interviews rather than Zoom interviews, try to spread out the presentation of the interviews better so that kids had more time in between each interview, and I would try to get more on the screen than just my face, the interviewee's face, and a few pictures that they might have shared with me. I could make the videos more interesting to help kids stay more engaged, and I could also ask for more student input when it came to questions for the interviewee. Additionally, it would be fun to get suggestions from students to figure out who they would want me to interview rather than me just picking out people who I would think would interest them (Figure 13).

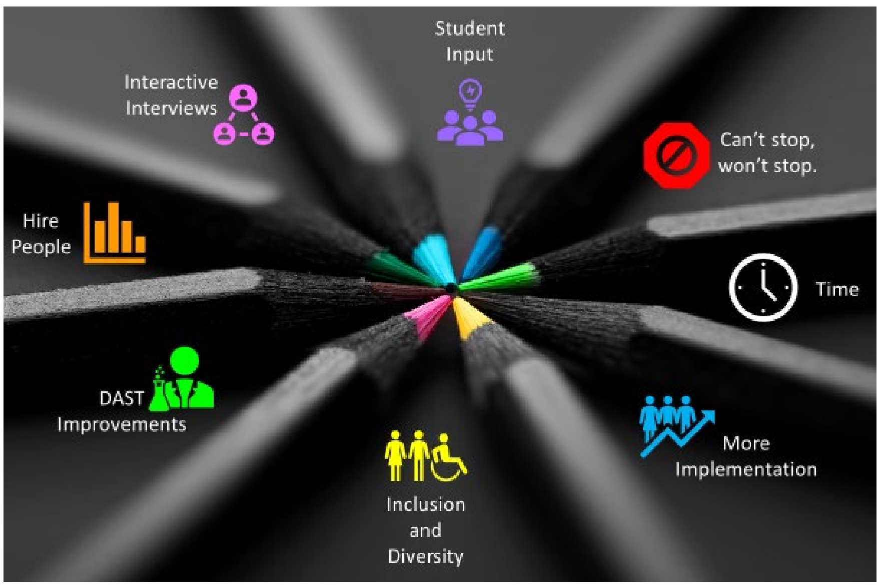


Figure 13. An image displaying many of the ideas I have for improving this research in the future and providing my students with a better experience when I do this action research again.

<u>Impact of Action Research on the Author</u>

One thing that every interviewee said to me after our interviews was that they wished someone had encouraged them to pursue STEM or had taught them about these careers when they were younger. That made me realize that this wasn't something I should have been incorporating into my classroom just because I was working on a degree, but something I should continue to push and implement on a regular basis for the rest of my career. This project also opened my eyes to the many, many incredible women and people of color working in the STEM field and helped me to personally realize just how diverse STEM can look. As I read through literature for my conceptual framework section, I found myself paralyzed with sadness when I would read about the lack of diversity and inclusion in media and academics. It was encouraging for me to realize that I could make a change in my own classroom and implement something that would encourage all of my students to see themselves as potential pursuers of STEM. While that may or may not happen, I am grateful that it at least opened their eyes to their potential.

Interviewing STEM professionals is something I would like to continue doing outside of school so that I can learn more from them about how to help my students. Continuing to do these interviews is also important to me because they will help me show more kids what they are capable of and allow them to explore these careers more comfortably in their own classrooms or homes. While the videos were great, informationally, I know that they could be recreated and made more interesting for children to help them enjoy the content more. Finding new STEM careers and interesting pieces of information for the kids won’t be challenging, especially as STEM continues to evolve and change. While these interviews taught my students that anyone they see walking down the street could be someone working in STEM, they really taught me just how much is out there and how much I still don’t know about these career options my students have available to them.

Playing these interviews for my students was eye opening to me in a sense that we still have an incredibly long way to go, culturally, when we think about who we might picture in the STEM world. When I showed the students the first interview, which featured Leslie Kim, a Korean woman working as a senior software engineer for a fitness app, one of the students yelled out, “Oh my gosh, it’s a lady!” at the top of his lungs as I hit play. He was completely shocked that a software developer could be a woman. Fast-forward to my last interview a few weeks later featuring Sarah Bailey, a Canadian woman working as the data analyst for the Los Angeles Rams. At this point I assumed that students would no longer be surprised by the fact that women could do any job a man could, but most kids were positively shaken by the fact that there was a woman doing stats and analytics for an NFL team. These interviews, among the many others I showed them, proved to me that this is not something I can stop doing any time soon.

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APPENDICES

APPENDIX A

IRB APPROVAL FORM

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

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MEMORANDUM

TO: Hailey Bull and John Graves

FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 13, 2020

RE: *"Encouraging Student Engagement in STEM Careers and Educational Pathways through Zoom Interviews with Women and People of Color in STEM" [HB111320-EX]*

The above research, described in your submission of November 13, 2020, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_	(b) (1)	Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
_X_	(b) (2)	Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).
____	(b) (3)	Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
____	(b) (4)	Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
____	(b) (5)	Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
____	(b) (6)	Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

STEM CAREER INTERVIEW NOTECATCHER

Students were asked to fill out this form for each interview that they observed. The form changed slightly from the first implementation to the second and was adjusted slightly later on to reduce printing and any waste of space in later copies.

STEM Career Interview Notecatcher

This assignment will not impact your grade in any way and your participation is completely voluntary

Name: ______________________________ **Period:** _______ **Date:** ________________

BEFORE THE VIDEO STARTS: Imagine someone who works as a [INSERT STEM CAREER HERE].

1. Write down the first words that come to mind when you think about this career.

2. Write a short, quick description of what you picture someone in this career looking or acting like.

Name of Interviewee: ______________________________

Job Title: ______________________________

Degree(s) or Certificates Earned: ______________________________

Notices:	Wonders:

Please go to the back of the page for the rest of the assignment →

1. What surprised you about the person being interviewed?

2. What are AT LEAST three things you learned from the person being interviewed?

   a.

   b.

   c.

3. STEM stands for science, technology, engineering, and math. Do you consider this a STEM career? Is this person a scientist? Why or why not?

4. What are some new things you will think of when you picture a person working in this career? Why?

5. Do you think this sounds like an interesting career after watching this interview? Why or why not?

APPENDIX C

DRAW A SCIENTIST TEST CHECKLIST (DAST-C)

This checklist was taken directly from the original PDF in the 1995 study. In an attempt to change it in a way that helps it make more sense with formatting, I have edited items at certain points, but I wanted the overall DAST to keep its integrity. It is likely that there are typos or interesting formatting that I simply missed in uploading the writing.

Instructions

Each item on the checklist represents one stereotypical image characteristic. The items on the checklist have been derived from reviews of literature, primarily the work of Chambers (1983) and Mead and Metraux (1957). The "upper" checklist items (items #1-7) relate specifically to those characteristics discussed by Chambers (1983) and others' work and/or items representing stereotypes that have emerged (in science education literature, at least) as concerns over the past few years. Item #16 is an open-ended item provided for specific details not indicated in items #1-15, such as type of scientist (chemist, biologist, etc.), facial expressions, hairstyle, etc.

1. Use one checklist sheet per subject drawing.
2. Place a maximum of only one mark per blank on the checklist.
3. If multiple images are present in the drawing (such as two or more scientific instruments), count the drawing as having ONE, NOT TWO.
4. If multiple images of persons appear, such as a group of scientists, mark for any and all stereotypical images that are present. (Note: If one member of the group is male and one is female, record a mark in the "male gender" blank but note the presence of the female in item #16.)

5. For item #4, #4b, and #6a, the sub-category blanks for "size" are not counted into the checklist score. These sub-categorical items are for more detailed analysis of the images and do not in and of themselves represent stereotypical images.

6. Any relevant captions (item #7) should be written down in item #16 if room doesn't allow under #7 itself.

7. TOTALS:

A. Add the number of marks for the upper checklist and record in the box at the checklist's lower left corner. REMEMBER to add ONLY ONE mark per blank.

B. Add the number of marks for the lower checklist and record in the box at the checklist's lower left corner. REMEMBER to add ONLY ONE mark per blank.

C. Add the upper and lower checklist scores for the TOTAL SCORE, and record on the blank at the bottom right corner.

8. ANALYSIS:

A. You may select to use the TOTAL SCORE for analysis purposes or you may select to use only the upper (or lower) checklist scores. Use of TOTAL SCORE provides for more variance than use of only half scores.

B. The checklist has been used in a pretest-posttest format with ANCOVA procedures. Other analytical procedures will likely work as well.

C. Report other data (such as those in item #16) as percentages of drawings possessing specific images.

Checklist

Draw-A-Scientist Test 199

RATER: ________

STUDENT NAME: ______________________

ASSESSMENT 1 2 3

1. Lab Coat (usually but not necessarily white)

2. Eyeglasses

3. Facial Growth of Hair (beards, mustaches, abnormally long sideburns)

4. Symbols of Research (scientific instruments, lab equipment of any kind)

a. Size of Scientific Instruments/Equipment in Relation to Scientist:

1. Small _____

2. Normal _____

3. Large _____

b. Types of Scientific Instruments/Equipment:

5. Symbols of Knowledge (principally books, filing cabinets, clipboards, pens in pockets, etc.)

6. Technology (the "products" of science)

a. Types of Technology (tv, telephone, missiles, computers, etc.):

7. Relevant Captions (formulae, taxonomic classification, the "eureka!" syndrome)

Alternative Images:

8. Male Gender

9. Caucasian

10. Indications of Danger

11. Presence of Light Bulbs

12. Mythic Stereotypes (Frankenstein creatures. Jekyll/Hyde figures, "Mad/Crazed")

13. Indications of Secrecy (signs or warnings of "Private," "Keep Out," "Do Not Enter," "Go Away," "Top Secret," etc.)

14. Scientist Doing Work Indoors

15. Middle Aged or Elderly Scientist

NOTE: Several indicators of the same type in a single drawing count as ONE indicator (e.g. Two scientists each with eyeglasses counts as one, not two).

16. Open Comments (dress items, neckties/necklaces, hair style/grooming, smile or frown, stoic expression, bubbling liquids, smoke/steam, type of scientist. chemist, physicist, etc.)

Upper / Lower Score:

Total Score:

APPENDIX D

THINKING ABOUT MY FUTURE PRE AND POSTSURVEY

This was the pre and postsurvey given to students to understand more about how they saw themselves when it came to STEM careers and educational pathways. It was created as a Google Form and given to students over their Chromebooks.

Please answer these questions as honestly as possible; this will not impact your grade!

What is your FIRST name?

What is your LAST name?

What is your assigned number?

What is your gender?

Female

Male

Prefer not to say

Other…

What is your ethnicity? (Choose the boxes that represent you)

Asian or Pacific Islander

Black or African American

Hispanic or Latinx

Native American

White or Caucasian

Prefer not to say

Other…

On a scale of 1-5, how do you feel about science?

Science is...

(1) really difficult. (2) difficult. (3) difficult & easy. (4) easy. (5) really easy.

On a scale of 1-5, how do you feel about science?

Science is...

(1) really boring. (2) boring. (3) boring & interesting. (4) interesting.

(5) really interesting.

On a scale of 1-5, how do you feel about science?

Science is...

(1) worthless. (2) a waste of time. (3) helpful. (4) important. (5) essential.

What do the letters in STEM stand for?

What does STEM mean to you? (Not what the letters stand for.)

What ONE class are you most excited to take in high school?

If you could learn more about ONE college major or class, what would you choose to learn about? (Need some ideas? Use the following link to look through a list of possible college majors.) http://catalog.montana.edu/undergraduate/#undergraduateminorstext

Do you want to go to college?

Yes

No

Maybe

If you said yes, what do you want to study? If you said no, what would you like to do after high school? If you said maybe, why?

What is currently your dream job?

What three careers would you be most interested to learn more about? Check three that apply.

A Career in the Arts (music, acting, writing, design, painting, sculpting, etc.)

An Athletic Career (working as an athlete or working with athletes)

A Medical Career (helping and healing people, surgery, delivering babies, physical therapy, etc.)

An Education Career (teaching at the elementary, middle, high school, or college level)

A Business Career (marketing, advertising, accounting, management, event planning, etc.)

A Technical Career (video broadcasting, carpentry, plumbing, electrician, contractor, mechanic, etc.)

A Career in Agriculture (farming, ranching, dairy, flower farm, seeds, breeding, etc.)

An Environmental Career (forest ranger, ornithologist, activist, EPA, BLM, marine biologist, etc.)

A Career in Technology (computer science, drafting, app or videogame design, software development, etc.)

A Career in Academic Research (laboratory technician, professor, anthropologist, historian, etc.)

A Career as an Entrepreneur (starting and maintaining your own business or idea)

A Career in Law or Politics (judge, lawyer, governor, senator, city council, ambassador, translator, etc.)

A Career as a Civil Servant (police, firefighters, child protective services, sanitation, librarian, etc.)

A Career in the Life Sciences (microbiology, medical, veterinarian, environmental studies, etc.)

A Career in Physical Sciences (physicist, astronomer, rocket scientist, chemist, engineer, architecture, etc.)

A Career in Earth Sciences (geologist, paleontologist, EPA, oceanography, GIS, big oil, etc.)

A Mathematics Career (statisticians, mathematicians, actuary, economist, teacher, analyst, etc.)

Other…

List as many STEM careers as you can think of. (Let Miss Bull know if you need help spelling anything!)

Are you interested in having a career in STEM one day?

Yes

No

Maybe

What made you choose your answer for the previous question?

Do you think you could have a job in STEM one day?

Yes

No

Maybe

What made you choose your answer for the previous question?

If you could ask a person in a STEM career ONE question, what would that question be?

Is there anything else you want me to know or any other questions you have for me?