

TEACHING CONCEPTS OF DIVERSITY, EQUITY, INCLUSION AND SOCIAL RESPONSIBILITY THROUGH ELEMENTARY STATISTICS

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The use of antiracist and critical pedagogy has become a growing movement across higher education within the United States but has not been generally considered within STEM curricula. Similarly, community-engaged learning, a decades-old movement in civics learning within higher education, has made relatively little headway in STEM coursework. These two movements, however, complement each other, and both have much to contribute to how we teach statistics. Over the past five years, I have leveraged these two approaches to civic learning to incorporate themes around diversity, equity, and inclusion into my elementary statistics class. This paper outlines those efforts and provides a preliminary analysis of student-provided course evaluation data.

INTRODUCTION

The need for reform in statistics education has been a subject of deep study for many decades now, from the 1992 report of the Mathematical Association of America (Cobb, 1992) through the *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) reports of 2005 and 2016 (Aliaga et al., 2005; GAISE College Report ASA Revision Committee, 2016). Recommendations for elementary statistics coursework include the integration of “real data with a context and purpose,” teaching “statistics as an investigative process of problem-solving and decision making,” and fostering “active learning” (GAISE College Report ASA Revision Committee, 2016, p. 3). Community-engaged learning provides a meaningful, high impact framework (Kuh, 2008) for achieving those goals. At Slippery Rock University (SRU), our community-engaged elementary statistics course involves a semester-long data collection and analysis project completed for a local nongovernmental organization. Students work directly in the community to collect data, perform data entry, and collaboratively analyze the resulting data. Further details on this approach are provided in Asher and Goodrick (2021) and Asher (2020).

Although our community-engaged statistics class has achieved remarkable results, a new initiative on campus has allowed us to consider possible areas in which this course could be improved. Specifically, in response to increasing understanding of societal inequities within the United States, our undergraduate program has been modified to include a required diversity education component for all students entering in or after the 2022–2023 academic year. To accomplish this, a “diversity designation” was created for courses that contain specific learning objectives related to diversity, equity, and inclusion (DEI). A faculty training program was piloted during the summer of 2021, modified, and run during the January 2022 winter break; it was during this January training that a preliminary curriculum for a diversity-designated elementary statistics course was developed (Asher, 2022). That course was then piloted during the Spring 2022 semester *without* a community-engaged component, so that pre- and post-assessments could be used to research the effects of the diversity-designated curriculum.

This paper first reviews the attributes of a community-engaged course. It then outlines the DEI designation training provided by SRU, followed by the curriculum that was piloted during the Spring 2022 semester. A brief, preliminary summary of student evaluation data from the diversity designated course is presented, followed by a plan for a hybrid community-engaged/DEI-designated course trial in Fall 2022.

COMMUNITY-ENGAGED FRAMEWORK

At SRU, training of faculty to engage in community-engaged classroom activities is completed via a Faculty Learning Community (FLC) by the Office for Community-Engaged Learning (OCEL) using a framework derived from Hatcher et al. (2016). Faculty are expected to gain expertise in the following six attributes:

- *Reciprocal partnership between campus and community are present in both community activities and course design.* Universities tend to be resource rich, and university courses are taught by individuals with high educational attainment and socioeconomic status. In contrast, community

organizations tend to be resource poor. This power imbalance can lead to ineffective engagement that does not address the needs of the community. Faculty are therefore trained in ideas of reciprocity of relationships and provided with strategies to amplify community voice within their projects. For example, community partners are asked to help plan the timing and specific details of how the community-engaged project interfaces with the learning goals of the course.

- *Activities based within the community are integrated into the academic content and course design.* This follows from reciprocal partnership and requires student engagement directly with the community. Students are exposed to different points of view, especially within the context of a marginalized population. Through learning about the community and its needs, students begin to develop empathy for and understanding of population groups that are different from them.
- *Civic learning through knowledge acquisition, attitudinal transformation, and/or skills practice are integrated into student learning.* Through the community-engaged project, students learn they can elicit positive change in their community through professional service. Typically, students are unaware of the connection between statistical practice, public policy, and civil society prior to enrolling in the course.
- *Diversity of interactions and dialog across differences are incorporated regularly into the course.* Ideally this diversity of interactions and dialogs is achieved both within the classroom and also through interactions with community members.
- *Critical reflection on the community activities and their connection to the course learning goals is integrated into student learning.* In the community-engaged elementary statistics course, students complete a final reflection during which they consider the public purpose of the field of statistics and the impact of statistics on society; further detail is in Asher and Goodrick (2021).
- *Assessment of achievement of service-learning related outcomes and of course quality is used to allow for continuous course improvement.* At SRU, faculty teaching community-engaged courses are provided with pre/post-assessment instruments for any of 16 civic learning and engagement outcomes (CLEOs) across four categories: knowledge, skills, values, and action. In addition, student reflections are analyzed for acquisition of civic skills and attitudes.

One drawback of the structure of the community-engaged elementary statistics course is that the project of interest varies widely across semesters, leading to very different experiences related to involvement in the community and diversity of interactions. For example, in the Fall 2019 semester the project was data collection for the local recreation center in our primarily middle-class community. In a different semester, the intended project required interaction with rural homeless youth in western Pennsylvania. These semester-to-semester changes in the scope and importance of the data collection and analysis project mean that student motivation, and therefore student learning, might be highly impacted. With this in mind, we turn toward diversity-designated training.

DEI-DESIGNATION FRAMEWORK

DEI designation of a course at SRU involves two stages. In the first stage, the faculty member undergoes an intensive eight-week training over the summer or a condensed six-week training over the winter break. In the second stage, the faculty member prepares their DEI-infused syllabus for review by an oversight committee, which then can approve the course for DEI designation. Any changes to the syllabus in future semesters require re-review by that committee.

DEI Designation Training

The training for faculty to develop courses appropriate for the DEI designation at SRU was developed by a committee in which the author of this paper participated. This training was prepared as an asynchronous online program that would be completed by a cohort of faculty led by two facilitators. The January 2022 training modules were roughly as follows:

1. *Conceptual Foundations:* terminology related to DEI; videos/discussion of systems of power within society; reading/written reflection related to structural oppression and cultural humility.
2. *Self-Awareness and Identity:* creation of personal social identity map; readings/videos on racial/ethnic identity models; discussion related to social/cultural identity, social position, and teaching.
3. *Structure Privilege and Oppression:* readings on white privilege, systemic racism, interpersonal versus structural oppression, and bias in instructional materials; reflection on white privilege and

how institutions of higher education replicate structural privilege; discussion on forms of bias that are common in individual disciplines.

4. *Identifying and Incorporating Concepts of Critical Pedagogy*: readings/videos on definitions and applications of critical pedagogy, readings on infusing inclusive practices into coursework, and readings on constructing a learner-centered syllabus. Participants discussed which aspects of the reading were most applicable to their intended diversity designated course and what revisions they planned to make to their existing syllabus, if applicable.
5. *Assessing and Addressing Institutional Systems of Privilege and Oppression*: readings/videos on existing inequities and methods for teaching about those inequities; reflection on preparing for difficult conversations in the classroom; submission of a syllabus reviewed using concepts learned in Module 4 (above) and this module.
6. *DEI Course Development Strategies within the Disciplines*: readings on the development of strong DEI coursework; readings on different approaches to DEI training within different disciplines; development of specific course outcomes for the proposed diversity designated course. Within this module, a storyboard was begun that would be developed through the remainder of the course. At the end of this module, only the overall learning outcomes were included on the storyboard.
7. *DEI Course Design Part 1*: example storyboards provided for the purpose of aligning module outcomes with course outcomes and aligning instructional activities and assessments with module outcomes. At the end of this module, module-level objectives, along with their alignment to course-level objectives, were included on the storyboard.
8. *DEI Course Design Part 2*: participants completed their storyboard, including placing learning materials, activities, and assessments within each module, as well as indicating the alignment of each element with one or more specific learning objectives for the module. Participants additionally completed a final reflection activity on their experiences during the DEI designation training and how they will apply their new knowledge within the classroom.

Application to Elementary Statistics

The elementary statistics course at SRU has a common set of learning outcomes across approximately 11 course sections; none of those existing course outcomes include DEI concepts. In the community-engaged version of the course, an additional two outcomes from the CLEOs (mentioned above) are included. For the DEI designation, four DEI-specific outcomes were created:

1. Students will articulate the connection between the statistical concepts of demographics, independence, assumptions, bias, causation, correlation, data visualization, and hypothesis testing and the DEI concepts of social identity, diversity, intersectionality, marginalization, discrimination, implicit bias, structural privilege, structural oppression, cultural competence, and social justice.
2. Students will cite examples of how an individual's social and cultural identity can lead to biased scientific conclusions that exacerbate structural oppression.
3. Students will analyze examples of poorly designed/unethical and well-designed/ethical methods for data collection and analysis in the context of structural oppression and/or privilege.
4. Students will articulate the connections between demographic data collection and human diversity and how statistics can create or exacerbate structural oppression of demographic groups.

During 11 of the 16 weeks in the semester, students were assigned reading to be completed by their class on Monday. During class, students were divided into discussion groups of approximately 15-18 students led by a trained undergraduate classroom assistant. Small group discussions, based on the outlined discussion questions in the reading packet, took up the first 30 minutes of the class period. For the last 20 minutes of the period, the students reconvened as a whole class to report back on their individual discussions. Between the Monday and Wednesday classes, students submitted a one- or two-page written reflection guided by a set of reflection questions. The Wednesday class was used for interactive lecture on statistical topics. Statistics problem sets were due on Friday prior to class, and a collaborative, in-class laboratory was completed during the Friday class. The eleven sets of readings used for the DEI component of the course were aligned to the statistics material as shown in Table 1. In other words, each DEI topic was presented at a time when the statistics and DEI topics were mutually reinforcing.

Table 1. Alignment of DEI topics with Statistics topics in the spring 2022 DEI-designated elementary statistics course at Slippery Rock University of Pennsylvania

DEI Learning Outcomes	Statistics Topics
Through readings, group discussion and reflection, students will...	
1a. state definitions for DEI concepts including diversity, equity, inclusion, structural oppression, implicit bias, microaggressions, privilege, power, and marginalization.	1. Data Sources (Observations, Experiments, Censuses, Surveys, Simulations, Administrative, Found Data)
1b. determine ways in which the field of statistics contributes to inequities or equity in society.	
2a. explain through specific real-life examples how individual racism and discrimination can lead scientists to make unethical decisions around data that contribute to structural oppression of marginalized groups.	2. Data Visualization (Bar Graphs, Pie Charts, Histograms, Scatterplots, Rose plots, Time series)
2b. analyze how power that scientists hold in society interacts with societal stereotypes about marginalized groups.	
3a. analyze how a statistician’s social identity translates into biased understanding of the history of statistical thought.	3. Descriptive Statistics
3b. critique the dominant narrative about the history of data visualization by comparing and contrasting euro-centric analysis of the history of statistical thought and more diverse understandings of the history of statistical thought.	
4a. evaluate misleading graphical summaries of data with an equity lens to explore how graphical summaries can exacerbate structural oppression.	
4b. identify best practices for promoting equity through appropriate data visualization techniques.	
5a. analyze how unintentional and intentional misinterpretation of descriptive statistics can influence public debate about DEI-related issues.	4. Probability (Basic rules, Probability Functions, Binomial, Normal, Law of Large Numbers, Distribution of Sample Means, Central Limit Theorem)
6a. critique causal arguments related to race in the United States by analyzing the relationship between the author’s social identity and the appropriateness of the use of statistical concepts within the argument.	
6b. connect cross-classification and Simpson’s Paradox to concepts of intersectionality.	
7a. identify, through describing real examples, how statistical knowledge can be a source of power.	
7b. examine how current statistical methods are not sufficient to describe the complexities of intersectionality.	
8a. define different sexual orientations and gender identities and determine which orientations and identities are better represented in current data collection and analysis practice in the United States.	
8b. connect how data collection and analysis practice on gender expression and sexual orientation can lead to structural privilege or oppression in United States society.	
9a. explain how the incorrect use or collection of statistics by governments can lead to structural oppression of marginalized groups.	
9b. explain how the incorrect application of hypothesis testing can exacerbate structural inequalities in society.	
10a. analyze how the social identities of the originators of modern statistical inference led them to also be proponents of eugenics.	
10b. describe how incorrect scientific assumptions led to the inappropriate application of statistical methods to make eugenics arguments.	
11a. explain how statistics as a field can be a tool for social justice.	
11b. list specific approaches to data collection and analysis that promote equity.	

Table 2 .Summary of course evaluation feedback for spring 2022 DEI-designated elementary statistics course at Slippery Rock University of Pennsylvania

Feedback Type: DEI	Count (%)	Feedback Type: Other ^a	Count (%)
Positive comment re: DEI	18 (28%)	Positive comments	38 (59%)
Negative comment re: DEI	13 (20%)	Negative/neutral comments	34 (56%)
Suggested improvements re: DEI	31 (48%)	Total comments on non-DEI course	54 (84%)
Reduced reading workload	19 (30%)	characteristics	
More lecture/less discussion	14 (22%)	Total Responses	64 (100%)
Total mentioned DEI	50 (78%)		

^aOther feedback included comments on the in-class laboratories, the instructor, etc.

STUDENT OUTCOMES

The effect of the DEI course material on student learning is difficult to tease out without a full experimental design. However, a preliminary analysis of course evaluation data provided by students at the end of the spring 2022 semester suggests that more students liked the DEI training being included than disliked it (see Table 2). Suggestions for improvement included reducing the reading burden and reducing the discussions to allow more time for statistical content. Some student comments follow, representing both positive and negative views on DEI:

“I think the labs were very helpful in increasing my understanding. However, I would like more actual math than just using excel. I also think the DEI is a good idea for the class. However, I think the reading were too long. I also don't think the discussions should take up an entire class period. I think 20-minute cutoffs for discussion would be better” (both positive and negative comment regarding DEI, reduced reading workload, more lecture/less discussion, both positive and negative comments on other aspects of the course).

“I think professor Asher did a wonderful job with being open + flexible with students. I enjoyed using Aleks but sometimes I was confused by the deadlines the site had. I really enjoy the DEI program because it helps me actually apply statistics to real life issues.” (positive comment regarding DEI, both positive and negative comment on other aspects of the course)

“Prof. Asher is a good prof. who genuinely cares about her students, however the DEI readings and reflections were ridiculous. I don't have time to do 3 hours of reading for a stats class” (negative comment regarding DEI, reduced reading workload, positive comments on other aspects of the course).

“I didn't think there were many strengths in this course. Using Aleks was stressful and forced me to look at patterns to complete it and not actually learn. The readings on Monday had almost nothing to do with statistics and were a way for Dr. Asher to force her views on us. I didn't learn very much about statistics” (negative about pretty much everything).

DISCUSSION AND NEXT STEPS

Data remain to be mined to determine the quality of statistics education provided by this format. Pre- and post-assessment data were collected regarding student attitudes toward statistics and understanding of statistics concepts. In addition, data from student reflections will be analyzed to determine overall attitudes towards this type of learning. However, based on this preliminary analysis, enough positive commentary was expressed by students to suggest that the continuation of a DEI-designated section of elementary statistics, with modifications to reduce the reading burden and use of in-class time for DEI discussion, is warranted.

For the Fall 2022 semester a community-engaged/DEI course hybrid will be attempted. Instead of dedicated Mondays for in-class discussions, small group online discussion boards will be utilized. Readings will be reduced or replaced with videos, and the number of written reflections will be reduced from eleven to four. This will mean eleven additional teaching days will be available and the workload on students will be significantly reduced. Finally, only 10 discussion boards will be assigned, allowing the completion of the discussion boards before the intense analysis work related to the community-engaged project occurs during the last two weeks of the semester.

A specific example for Module 8 is as follows: instead of three intensive readings on the mismeasurement of gender and sexuality in data collection leading to disparities in the availability of

public health data for gender and sexuality minorities (Kress et al., 2021; MacCarthy & Elliott, 2021; Westbrook & Saperstein, 2015), a single video will be assigned that describes basic information regarding gender and sexuality in seven minutes (e.g., Osmosis from Elsevier, 2020). Then students will be asked to think about surveys they have taken and how gender has been represented, and to answer the question “If gender is collected as binary, what repercussions could exist for non-cis-gender individuals?” Discussions will be guided by student assistants, and instead of students reading about the issues that could arise, they will determine those issues through critical thinking as a group. Every other week, a reflection will allow students to privately share their thoughts and ideas, to allow privacy if students are struggling with discussing DEI issues due to past trauma or another issue.

In the future, a meta-analysis comparing data from the community-engaged-only format, DEI-only format, and combined format will compare learning of statistical concepts, attitudes towards statistics, and student opinion on the course format across the three course structures.

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