Wesleyan Ψ University

More than a Seat at the Table: A new path to diversifying statistics education

By

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I live my life, because I dare. I dare to show up when everyone else might hide their faces and hide their bodies in shame… If I hadn't been told I was garbage, I wouldn't have learned how to show people I'm talented. And if everyone had always laughed at my jokes, I wouldn't have figured out how to be so funny. If they hadn't told me I was ugly, I never would have searched for my beauty. And if they hadn't tried to break me down, I wouldn't know that I'm unbreakable.

--Gabourey Sidibe

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Abstract

In the academic and professional landscape of the 21st century, statistical education is more important than ever. While the need for statistical literacy grows throughout the world, there is still much work to be done in the way by which we educate our citizens to create and discuss stories using data. The field of statistics also continues to suffer from a lack of diversity. Women and racially underrepresented students still face barriers as they enter math and statistics-based classrooms.

Participants included 794 students enrolled in either a multidisciplinary project-based course or a traditional introductory statistics course between fall 2009 and spring 2013. Multivariate analyses were utilized to evaluate the likelihood of student enrollment in either course while accounting for multiple demographic variables. For students enrolled in the project-based course, pre-post surveys were used to ascertain level of preparedness for the course, experience with the course, and perceived learning.

Underrepresented students, women, and students with lower SAT math scores were more likely to enroll in the project-based course compared to the traditional course. Underrepresented students were more likely to feel that the course was more challenging than other courses at Wesleyan, but also felt that they accomplished more than they expected, and that the effort was worth it.

It is important for statistics educators to recognize the value of creating diverse and inclusive classrooms, which means making both curricular and cultural changes that actively welcome all students. Better evaluation methods are needed across all disciplines to find pathways to the improvement of student experiences and learning.

Introduction

In the 21st century, statistical skills, competencies, and application play a significant role across the sciences, social sciences, and the humanities. Statistical analysis is arguably the most salient point of intersection between diverse disciplines, given that scientists constantly communicate information on varied topics through the common language of statistics (L. Dierker, 2009). Over the last two decades, there has been an increase of attention to both the teaching and learning of statistics and related forms of computational reasoning (Batanero, Burrill, Reading, & SpringerLink, 2011; Bowman, 2010; Tishkovskaya & Lancaster, 2012).

Previous research has recognized the general challenge in teaching courses in statistics at both the undergraduate and graduate level. There is no typical statistics student; instead, students come into statistics courses with differing backgrounds, experiences, learning styles and levels of preparation. Further, many of these students have had negative experiences with mathematics and statistics curricula in the past (J. Garfield, 1995; J. Garfield & Ben-Zvi, 2007). These early experiences color the way students approach statistics courses across instructors and institutions.

Challenges in the Contemporary Statistics Classroom

In "Statistical Education in the 21st Century: a Review of Challenges, Teaching Innovations and Strategies for Reform", Svetlana and Gillian review past and current research discussing barriers to teaching statistics including: a) "Maths-phobia", statistics anxiety, and generally negative attitudes towards statistics (I. Gal, Ginsburg, Lynda. , 1994); b) Ideas of probability and statistics are very difficult for students from other disciplines to learn (J. Garfield, 1995; J. Garfield & Ben-Zvi, 2007); c) Deficiencies in

basic statistical knowledge and mathematical background of students (J. Garfield, 1995); d) The need for alternative approaches to assessment (J. B. Garfield & Gal, 1999); and e) Lack of statistical literacy and the inability of students to apply statistics to everyday life (I. Gal, 2002). Gould et al. also proposed that we must redefine data, create citizen statisticians, and teach technology in order to be maximally successful in today's statistics classroom. The current study, which spans the years of 2009 to 2013, explores how a new introductory statistics course has attempted to address these barriers at Wesleyan University, a small liberal arts school in Middletown, Connecticut. With this study we seek to begin the process of improved evaluation of the statistics classroom with the goal of creating greater insight into the classroom experience and course learning outcomes.

At no time in Wesleyan's history has science and quantitative literacy been a more important part of the liberal arts education. It has long been recognized that liberal arts institutions have a history of student to faculty interactions that is consistent with the collaborative model used in modern scientific research and technology. Student effort is an integral part of the Wesleyan science research enterprise. Wesleyan has recently acknowledged the desperate need within academia to be more intentional in recruitment and retention of women and students of color in the sciences. The university has also suggested that this means changes must be made (both inside and outside of the classroom) in order to make the sciences more appealing and welcoming to students. Additionally, we acknowledge that improvements must be both curricular and cultural.

Diversity in the Classroom

Studies have shown that diversity within a classroom is important for all stakeholders: faculty (as instructors and as mentors), students, and course assistants (Cohen, Steele, & Ross, 1999). Further, previous research has sought to understand the role of stereotype threat and arousal as it relates to student general performance, and on math-related tasks in particular (Ben-Zeev, Fein, & Inzlicht, 2005; Murphy, Steele, & Gross, 2007), for women and racially underrepresented students. Stereotype threat research has reliably demonstrated that the threat of confirming a negative stereotype harms performance on difficult tasks (Gonzales, Blanton, & Williams, 2002). Related research has shown that simply having a seat at the table for women and racially underrepresented students is not enough. Student presence within the classroom is of course vital, but educators must also find ways to create situational realities that are more supportive for underrepresented students. The classroom must also foster an open, communicative environment that is not isolating. Studies by Marx et al revealed that math test performance for women was protected from stereotype threat when a female role model was present and administering the exam. The same study also revealed that even learning about competent female experimenters successfully buffered women's self-appraised math ability (Marx & Roman, 2002).

Wesleyan's Multidisciplinary, Projects-Based Statistics Course

In 2009, Wesleyan's Quantitative Analysis Center embarked upon the creation of an innovative and uniquely supportive introductory statistics curriculum. The curriculum included new learning materials and teaching strategies that were meant to be intensive enough to allow students to constantly move forward with their research, yet broad

enough to force students to creatively and independently explore their own scientific questions and make decisions involved in the data analytic process. The course was designed to model multidisciplinary statistical inquiry, train students in the flexible application of knowledge, support students to analyze data in real world contexts, and to access core statistical concepts through computing. The course would also provide multiple layers of support from faculty/staff, peers, and through Wesleyan's Quantitative Analysis Center (L. Dierker, Beveridge, D. , 2009). This proposed multidisciplinary, projects-based course was granted funding by the National Science Foundation and approved to the Wesleyan University course curriculum under the designation, Applied Data Analysis.

The project-based course differs in several ways from the traditional introductory statists course. The course models a 'flipped-classroom' learning approach (L. Dierker, Cooper, J., Alexander, J., Selya, A., Rose, J. , 2015). This means that students employed most of in-class time towards project progress and work-shopping as opposed to taking in new knowledge via lecture. New material is covered outside of the classroom using online materials from the Open Learning Institute (OLI) and later, an online textbook (IBook) designed specifically for the course (https://oli.web.cmu.edu/) (Lovett, Meyer, & Thille, 2008).

The multidisciplinary, project-based course also endeavored to directly tackle attracting students from underrepresented groups. Noting the fact that African Americans, Native Americans, and Hispanics together comprise only around 5.8% of all employed persons with PhDs in the science and engineering disciplines, and that women hold less that 18% of all tenured positions in the same field (National Science, 2013), the course

creators understood the need to model the course differently, in a way that would attract more students from these underrepresented backgrounds (L. Dierker, Beveridge, D. , 2009). The creators of the course expected that the innovative approach to statistical training would not only bolster the retention of women and racially underrepresented students but also do a better job at attracting them to scientific fields of study. This study will hone in on the course's attempt to diversify empirical research practices at Wesleyan.

Wesleyan's longstanding public commitment to "diversity and inclusion" also makes the university a great place to evaluate the practicality of attracting students from diverse backgrounds and experience levels into the statistics classroom. This study seeks to both assess the potential barriers of entry into either a traditional introductory statistics course or a multidisciplinary, project-based course, and examine the experience of students from underrepresented backgrounds once they enter the course.

The Current Study

Wesleyan currently consistently offers four courses than can generally be considered introductory statistics classes. Aside from the multidisciplinary, project-based course (Applied Data Analysis) which exists within the Quantitative Analysis Center and is cross listed with several other departments, the Psychology department houses "Statistics: An Activity-Based Approach"; the Economics department offers "Quantitative Methods in Economics"; and the Math department offers "Elementary Statistics". After an assessment of course content, the number of seats available in each course over the five-year period between 2009-2013, and the method of curricular approach, the traditional introductory statistics course, Elementary Statistics, was chosen to be the best point of comparison to the multidisciplinary, project-based course, Applied

Data Analysis. The traditional introductory course boasted a similar number of total seats over the years, was not designed for a specific major, and like the multidisciplinary project-based course, had no pre-requisites for enrollment.

Our first hypothesis suggests that racial representation plays an important role in the type of course a student chooses to enroll in. This builds upon the research that stereotype threat can lead students to avoid entering environments where a negative bias association may be triggered (Ben-Zeev et al., 2005). The hypothesis also complements the mission of the multidisciplinary, project-based course at inception, to 'create a welcoming space at the table' (L. K. Dierker, E., Rose, J., Selya, J., Beveridge, D., 2012).We expect to find that women and students from underrepresented racial groups will be more likely to enroll in the multidisciplinary, project-based statistics compared to the traditional statistics course.

Our second hypothesis focuses on the multidisciplinary, project-based statistics course. We hypothesize that women and students from underrepresented racial backgrounds within the field of statistics are more likely to come into the course with less exposure to the field and, not unrelated, have less confidence in their abilities to learn new statistical skills and understand course content.

Our third hypothesis predicts that women and underrepresented students will find the course challenging, maybe even more so than men and non-underrepresented students in the course. However, we also believe that they will find the course rewarding and useful, and perhaps even more so than other classes that students have enrolled in at Wesleyan. We propose however, that these students will leave the course with more confidence in

statistical skills and will have the desire to take more courses related to quantitative research in the future.

Methods

Participants

Participants included 794 students enrolled in either the multidisciplinary, project-based course or the traditional introductory statistics course between fall 2009 and spring 2013. 319 students (40.18%) were freshmen or sophomores at the time of enrollment; 475 students (59.82%) were juniors or seniors. For students taking more than one of these courses during this 5-year period, only their first course was considered.

The multidisciplinary, project-based statistics course was offered through the Quantitative Analysis Center, a collaborative effort of academic and administrative departments that supports quantitative analysis across the curriculum and provides an institutional framework for collaboration across departments and disciplines in the area of statistics and data analysis. Titled Applied Data Analysis, it was described in the university's on-line course catalogue as a "project-based course, [in which] you will have the opportunity to answer questions that you feel passionately about through independent research based on existing data. Students will have the opportunity to develop skills in generating testable hypotheses, conducting a literature review, preparing data for analysis, conducting descriptive and inferential statistical analyses, and presenting research findings. The course offers unlimited one-on-one support, ample opportunities to work with other students, and training in the skills required to complete a project of your own design. These skills will prepare you to work in many different research labs across

the University that collect empirical data. It is also an opportunity to fulfill an important requirement in several different majors."

The **traditional introductory statistics course** was offered through the math department. Titled Elementary Statistics, it was described in the university's on-line course catalogue as "covering the topics of organizing data, central measures, measures of variation, distributions, sampling, estimation, conditional probability (Bayes' theorem), hypothesis testing, simple regression and correlation, and analysis of variation."

Both courses were open to all undergraduate students regardless of their class year. There were also no prerequisites for enrollment in either course. The project-based course could be used as one option to fulfill a major requirement for biology, earth and environmental science, government, neuroscience and behavior, and sociology. Both courses counted toward the major requirements for psychology, but only as alternatives to an introductory statistics course offered directly through the psychology department. Both courses could also be applied to the natural sciences and mathematics general education recommendations.

Measures

The institutional research office supplied administrative data, based on the students' application to the university. This data included gender, US citizenship status, and the following variables:

Race/Ethnicity. Self-reported race/ethnicity included endorsement of one or more of the following categories, Black White, Hispanic, Asian or other. Those not endorsing any of those categories were considered unknown. Black, Hispanic,

Hawaiian/Pacific Islander, and multi-racial students were collapsed into a secondary variable representing underrepresented student status (URM).

Financial Aid. Students with demonstrated need receiving grants and or self-help financial aid vs. those enrolled in the university without financial assistance.

High school type. Students' high school backgrounds were collapsed based on whether they attended a public vs. non-public high school. The non-public category included private schools, religious schools, and home-schools.

SAT scores. A total of 84% of the multidisciplinary, project-based students and 83% of traditional statistics students provided SAT scores for math, critical reading, and writing.

Class Status. Class year (freshman, sophomore, junior, senior) was dichotomized into lower vs. upper classmen. Freshmen and sophomores represented students enrolled in a statistics course prior to declaring a major while students in their junior and senior year had declared and were completing one or more majors.

In addition, all students who completed the multidisciplinary, projects-based course participated in an extensive survey both before (pre) and after (post) the fall course. The survey was completed online via the Checkbox program for years 2009-2012. In 2013, the survey was conducted using Qualtrics. This data included, but was not limited to, the following variables:

Confidence in Statistics. Students were asked to evaluate their confidence in multiple areas related to introductory statistics education, data analysis, and scientific research including: evaluating codebooks, understanding statistics, developing research questions, literature searches, conducting research, expressing results, tolerating

difficulties, science writing, utilizing a reference software, data management, statistical analysis, graphing, poster design, presenting results, and ability to master introductory statistics material. These questions were asked in both the pre and post surveys to serve as a means of comparison over the course of the semester. An **overall confidence** score was created by summing responses to all individual confidence questions.

Interest in conducting research. Students were asked if they were interested in conducting research. This question was asked in both the pre and post surveys to serve as a means of comparison over the course of the semester. Students could respond that they were not at all interested, somewhat interested, interested, or very interested in conducting research. Responses were then dichotomized to those who were interested or very interested in conducting research, and those who were not.

Plans to write a thesis. Students were asked if they are planning to write a thesis. Respondents were divided into groups based on those who were not planning to write a thesis or hadn't thought about it, and those who said 'yes, definitely' or 'maybe' about plans to write a thesis.

Past experience with math courses. Students were asked, "How well did you do in mathematics courses in the past?" Responses were given on a scale from 1 (Very Poorly) to 7 (Very Well). The variable was categorized into students who did poorly in math (rating of 4 or below) in the past and those who reported doing neutral or well in math courses.

Math skill. Students were asked, "How good at mathematics are you?" Responses were given on a scale of 1 (Very poor) to 7 (Very well). The variable was

categorized into two groups: students who were less skilled at mathematics (rating of 4 or below), and students who were more skilled.

Plans to have a job related to statistics. Students were asked, "In the field in which you hope to be employed when you finish school, how much will you use statistics?" Response options ranged from 1 (Not at all) to 7 (A great deal). The variable was categorized into two groups: those who thought that they would likely use statistics in their field of employment after school (5 or higher), and those who did not.

Choice to take course if it weren't required. Students were asked, "How likely is it that you would have taken any course in statistics if such a course was not required for your studies?" Response options ranged from 1 (Not at all likely) to 7 (Very likely). The variable was dichotomized into 'likely' (5 or higher) and 'not likely' categories based on their responses on a 1-7 scale.

Pace of the poster. Students were asked if they felt that the pace at which the poster presentation, which served as a portion of the students' final grade, was introduced and covered too quickly, too slowly, or at just the right pace during the course, on a scale of 1 (much too quickly) to 5 (much too slowly). The variable was then dichotomized into those who felt that the pace of introduction and coverage of the poster presentation was too quick (a response of 1 or 2) and those who did not.

Challenge of research project. Students were asked, "How challenging did you find the research project?" They rated the level of challenge on a scale of 1 (not at all challenging) to 5 (the most challenging project I have ever completed for a course). The variable was then dichotomized into those who thought the project was challenging (3 or above) and those that did not.

Reward of research project. Students were asked, "how rewarding did you find the research project?" They rated how rewarding they felt the project was on a scale of 1 (not at all rewarding) to 5(most rewarding project I have ever completed for a course). The variable was then dichotomized into those who thought the project was rewarding (3 or above) and those that did not.

Using statistics later in degree program. "As you complete the remainder of your degree program how much will you use statistics?" Responses ranged from 1 (not at all) to 7 (a great deal). A variable was then created dichotomizing those students who felt that they would use statistics later in their degree (3 or above) and those that would not.

Likeliness of taking another statistics course. Students were asked, "If you could, how likely is it that you would choose to take another course in statistics?" Responses ranged from 1 (not at all likely) to 7 (very likely). A variable was then created dichotomizing those students who felt that they were likely to take another statistics course in the future (5 or higher), and those who felt that it was not very likely.

Effort in course worth it. Students were asked, "Was the effort involved in completing the research project worth the skills you developed?" Responses ranged from 1 (not at all worth the effort) to 5 (completely worth the effort). A variable was then created dichotomizing those students who felt that the effort in the course was worth it (3 or higher), and those who did not.

Course Recommended. Students were asked, "Would you recommend this course to other students?" A variable was then created dichotomizing those students who felt that they would or probably would recommend the course to other students, and those who would not.

Usefulness of Resources. Students were asked, "How useful [was this resource] in the completion of your research project?" Resources included instructor office hours, tutors within the Quantitative Analysis Center, and course TAs which were rated on a scale of 1 (not at all useful) to 5 (extremely useful)

Interest in follow-up courses. Students were asked, "which type of course would you be interested in taking as a follow-up?" Examples given included: science writing, graphing, constructing a data set, advanced statistics, and computer programming. They also had the option of choosing no follow-up course.

12 variables were extracted from the Survey of Attitudes Towards Statistics (SATS)-28 Scale (Hilton, 2003). Response options ranged from 1(not at all confident) to 4 (very confident). The responses were then dichotomized to those who were confident (3 and above) and those who were not. The question was asked for each of the following statements. These 12 variables were chosen as indications of progress or lack thereof for student confidence levels in areas that could have been altered throughout an introductory statistics course:

I (plan to) work(ed) hard in my statistics course. I (will) like statistics. Statistics should be a required part of my professional training. Statistical skills will make me more employable. I (will) have no idea what's going on in this statistics course. I use statistics in my everyday life. I (will) enjoy taking statistics courses. I am scared by statistics. I am interested in learning statistics. I can learn statistics. Statistics is irrelevant to my life. I will find it difficult to understand statistical concepts.

Results

Statistic Students' Matriculation—Project-based vs. Traditional statistics course

In Table 1, demographic characteristics of students by class year are displayed for both the multidisciplinary, project-based course and the traditional introductory statistics course. When examining student matriculation into either the traditional introductory course or the multidisciplinary, project-based course, both courses were similarly successful in enrolling White, Asian and Hispanic students, students from public high schools, and those receiving financial aid. Average SAT scores in critical reading and writing were also statistically similar among students in both courses. The project-based course however, attracted marginally higher rates of Black students (12.7%) compared to the traditional statistics course (8.7%). When this analysis was stratified by class status, the p value reached statistical significance and paired comparisons showed that the project-based course attracted significantly higher rates of Black freshmen and sophomores than the traditional course, but not higher rates of Black juniors and seniors. Further, the project-based course enrolled students with lower average SAT scores in math (M = 685.9, SD = 69) compared to the traditional introductory statistics course (M = 696.3, SD = 59.0), $F(1,663) = 4.17$, $p = .04$.

When analyses were conducted based on underrepresented student status (inclusive of Black, Hispanic, Hawaiian/Pacific-Islander, and multi-racial students), underrepresented students were found to be significantly more likely to enroll in the project-based course (24.0%) compared to the traditional statistics course (15.7%), and this finding remained significant after individually controlling for class status, gender, financial aid, public school attendance, and writing and critical reading SAT scores in logistic regression analyses. Further, a significant interaction between underrepresented student status and math SAT score was found. This demonstrated that lower math SAT scores for those enrolled in the project-based vs. traditional course were only found

within the underrepresented students group. That is, the project-based course attracted underrepresented students with significantly lower SAT scores than the traditional course, but no differences were found in math SAT scores among non-underrepresented students.

Though both courses show similarly high rates of female enrollment (>60%), when examining this finding by lower vs. upper classmen, juniors and seniors enrolled in the project-based course were significantly less likely to be female than lower classmen in both the project-based and traditional introductory statistics course (Table 1). This finding, however, was confounded by math SAT scores and did not remain significant in the logistic regression model.

Students' background and attitudes—Project-based course

Table 3 illustrates student background characteristics and attitudes of underrepresented and non-underrepresented students at the beginning of the project-based course. 342 students (76.0%) were racially non-underrepresented in the fields of math and statistics. 204 of these students were women, 131 of these students were receiving financial aid (38.3%), 196 of these students had attended a public high school (57.3%), 146 of these students attended a private high school (42.7%). The average SAT Math score was 706.94 (SD=51.88), the average SAT critical reading score was 696.4 (SD=64.86), and the average SATW score for this group was 710.8 (SD=59.16).

A total of 108 students (24.00%) were racially underrepresented in the fields of math and statistics. 70 of these students (64.8%) were women, and 88 of them were receiving financial aid (81.5%). 50 of these students had attended a public high school (46.30%) while 58 of them had attended a private high school (53.7%). The average SAT

math score for underrepresented students was 619.23 (SD=74.18); the average SAT critical reading score was 635.05 (SD=77.92); and the average SAT writing score was 640.34 (SD=85.78).

Non-underrepresented students were found to be significantly more confident in their scientific writing abilities as they entered the course (40.3%) compared to underrepresented students (25.3%) (p=.015). Students from both groups were unlikely to come into the course with previous software experience (21.9% for non-underrepresented students, and 23.15% for underrepresented students). Non-underrepresented students were significantly more likely to enter the course with an interest in conducting research (78.0%) than underrepresented students (64.0%)(p=.015). When individually controlling for SAT math scores, gender, high school type, financial aid status, class status (freshman/sophomore vs. junior/senior), and student math skill, the significant relationship between underrepresented student status and student interest in conducting research remained significant.

Non-underrepresented students were also significantly more likely to report that they would have chosen to take this course even it were not required for the completion of their degree of study (51.4%) compared to underrepresented students (37.8%) (p=.024).When controlling for the above listed factors, the relationship between underrepresented student status and a student's choice to take the statistics course even if it weren't required, was moderated by SAT math scores. That is, those students with lower SAT math scores were less likely to report that they would have taken the course even if not required.

Nearly all students from both groups agreed that they planned to work hard in their statistics course at the beginning of the semester. Both groups also similarly responded at moderate rates of agreement to the statement that they would like statistics. Students were moderately likely to think that statistics should be a part of their professional training. The majority of students from both groups also agreed that statistical skills would make them more employable. Students in both groups agreed moderately that they would use statistics in their everyday life. Both non-underrepresented and underrepresented students agreed at moderate rates that they were scared by statistics.

Non-underrepresented students were more likely to agree that they were interested in learning statistics (87.3%) than underrepresented students (77.8%) ($p=.047$). Interest in learning statistics was confounded by SAT Math scores and financial aid status. Gender was found to moderate the relationship between underrepresented student status and interest in learning statistics. The negative relationship between interest in learning statistics and underrepresented student status is significant for female students, but not for male students. The majority of both groups believed that they could learn statistics. Both groups were unlikely to agree that they would find it difficult to understand statistical concepts.

Whether or not a student designated having plans to write a thesis at the beginning of the course was significantly related to underrepresented student status. Students who were non-underrepresented were more likely to have plans to write a thesis. This relationship was moderated by gender. The significant relationship held true for male students, but not for female students. Student class year was also revealed as a significant

factor in the relationship; juniors and seniors were less likely to have plans to write a thesis. Students with plans to write a thesis were more likely to have low self-reported math skills entering the course. Financial aid status confounded the relationship between underrepresented student status and plans to write a thesis. Students who were not on financial aid were more likely to have plans to write a senior thesis.

Experience in the Course—Project-based

To understand the experience that both non-underrepresented and underrepresented students had during their semester in the multidisciplinary, project-based course, Table 4 displays students' thoughts on the level of challenge, reward, and usefulness of the course and resources offered throughout the semester.

Multivariate analyses revealed that for students who felt that they accomplished more than they expected in the course, both underrepresented student status and a student's class year were significant factors. Racially underrepresented students were more likely to report that they accomplished more than they expected in the course. This relationship is also moderated by gender. The initial relationship remained significant for female students ($p=.005$), but not for male students ($p=.239$). When accounted for in the multivariate model, student class year was independently related with juniors/seniors being less likely to agree that they accomplished more than they expected in the course.

When examining whether students felt that the multidisciplinary project-based course was more challenging than other courses they've taken, non-underrepresented students displayed a significant negative relationship, meaning underrepresented students were more likely to find this course more challenging than other courses they have taken

at Wesleyan. When individually controlling for SAT math scores, gender, high school type, financial aid status, class year (freshman/sophomore vs. junior/senior), and student math skill, SAT Math scores moderated the relationship whereby students with lower SAT Math scores were more likely to find the course challenging compared to others they had taken at Wesleyan.

Outcomes of Participation in Project-based Course

Both non-underrepresented students and underrepresented students displayed an increase in confidence in all measured areas over the course of the semester except for the students perception that they had mastered all of the course material. The highest average rates of increase were seen in students' confidence in their ability to evaluate codebooks and utilize citation software. Again, the only average decrease in confidence was displayed in student confidence that they mastered course material (average of -.44 decrease for all students). This category, in turn, saw the lowest rate of increase in student confidence. Overall confidence levels increased for over 74% of all students and for over 78% of underrepresented students. No significant differences were observed in the increase of individual confidence factors or overall confidence between underrepresented students and non-underrepresented students. In relation to underrepresented student status, students who were juniors or seniors displayed higher rates of confidence. Students who left the course with higher self-reported math skills also left the course with more overall confidence in their statistics skills.

When evaluating changes in students' feelings about the course over the semester, in relation to underrepresented student status, non-underrepresented students saw a significantly greater increase in the likelihood to think that they would enjoy taking

future statistics courses. Both groups saw decreases in agreement that they were scared by statistics and that they found it difficult to understand statistical concepts.

Both racially underrepresented students and non-underrepresented students were similarly very likely to respond that they would recommend this course to other students. Students from both groups felt that they would use the skills they learned in the course in the future. About half of both groups thought that they would use statistics in the remainder of their degree program. About half of both groups also felt that it was likely that they would enroll in another course in statistics

Both groups were highly likely to agree that they worked hard in the statistics course. At the end of the course, non-underrepresented students were more likely to agree that they liked statistics. When individually controlling for SAT Math scores, gender, high school type, financial aid status, class year (freshman/sophomore vs. junior/senior), and student math skill, the relationship between students agreeing that they like statistics at the end of the course and underrepresented student status is confounded by SAT Math scores, whereby students with lower Math SAT scores were less likely to agree that they liked statistics.

Non-underrepresented students were significantly more likely to agree that statistical skills would make them more employable compared to underrepresented students. Students agreeing that statistics would make them more employable was not confounded; gender was found to moderate the relationship, as the relationship remained significant for males, but not for female students.

Underrepresented students were more likely to agree with the statements that they had no idea what was going on in the course. The relationship between agreeing to the

statement “I have no idea what’s going on in my statistics course” and underrepresented student status held significant when accounting for gender but was again confounded by SAT Math scores.

Positive Outcome Predictors for Project-Based Students

To examine what possible factors contribute to positive outcomes for underrepresented students enrolling in the multi-disciplinary, project-based course, several variables were chosen as potential predictors. These potential predictors included: student self-reported mathematics skill, gender, high school type, financial aid status, SAT Math scores and whether or not a student thought that the course research project was challenging. These predictors were used to model the following outcomes: increase in overall confidence over the course of the semester, how much students think statistics will be used in the field they hope to be employed in after school, if the student would recommend the course to other students, if students felt that the effort in the course was worth it, if students desired to take a follow-up course on advanced statistics, if students felt that they accomplished more than they expected, and if students felt that the multidisciplinary, project-based course was more challenging, interesting, or useful that other courses that they have taken at Wesleyan.

Self reported math skill was an important predictor in multiple measured outcomes. Math skill was significantly related to how useful underrepresented students felt the multidisciplinary, project-based course was in comparison to other courses they have taken. Students who were not very skilled at math were less likely to feel that the course was more useful than other courses. It was not related to their feeling that this course was more interesting than other courses they have taken. Students who were not

very skilled in math were less likely to report that the course was worth the effort. This group of students was also less likely to report that they will use statistics in the field they wish to be employed in after school. Students with higher math skills were more likely to have an increase in overall confidence over the course of the semester.

Gender was not related to overall change in confidence among underrepresented students over the course of the semester; it did not play a significant role in any of the relationships when individually accounted for. No significant differences for underrepresented students from private vs. public high schools were found. There were also no differences by financial aid status.

Underrepresented students who did not find the course research project challenging were less likely to agree that they accomplished more than the expected in the course. SAT Math scores were negatively related to students feeling that the multidisciplinary, project-based course was more difficult than other courses they have taken at Wesleyan. SAT Math scores were positively related to students' desire to take a follow-up course on advanced statistics.

The same predictors were used to model identical outcomes for non-underrepresented students in the project-based classroom. For non-underrepresented students, math skill was a significant indicator of whether or not a student desired to take a follow-up course in statistics. Students who reported not being very skilled in mathematics were less likely to want to take a follow-up course. However, self-perceived math skill was not a significant predictor of any other positive course outcomes for this group.

High school type was shown to be a significant indicator of whether or not a student felt the effort in the course was worth it. Students who attended private high schools were less likely to think that the effort in the course was worth it. Gender, financial aid status, and SAT math scores, were not significant indicators of positive outcomes for non-underrepresented students.

Whether or not students found the research project for the course challenging was a significant indicator of whether or not a student thought that statistics would be used in the field that they hope to be employed in after school. Students who did not see the project as a challenge were more likely to see themselves employed in a related field. These students were also significantly more likely to recommend the course to other students. Those who found the research project to be challenging were more likely to agree that they accomplished more than they expected in the course. Students who felt that the research project was not very challenging also did not think that the course itself was more challenging than other courses they had taken.

Discussion

The age of "big data" has brought statistics to the forefront of conversation in education, politics, and even popular culture. This shift has also led to an understanding that traditional "silo" science methods are less effective than more innovate, collaborative methods. The shift away from the solitary researcher to collaborative team research within and across disciplines has occurred in numerous fields including the natural sciences, computing sciences, engineering, the social sciences, the learning sciences, and the humanities (Wuchty, Jones, & Uzzi, 2007). Many measured benefits have been observed in undergraduate participation in research including increased student interest in

a particular discipline, enhanced career preparation, increased skills, and gains in critical thinking and understanding (Seymour, Hunter, Laursen, & DeAntoni, 2004). As students of introductory statistics continue to change, modern statistics courses must also adapt to remain relevant to students and encourage course enrollment (Gould, 2010; Zieffler et al., 2008).

Goals of this study included 1) determining if women and underrepresented students enrolled in a multidisciplinary project-based statistics course at higher rates than a traditional introductory statistics course and 2) evaluating background characteristics, course experiences and post-course outcomes of underrepresented and non-underrepresented students in the multidisciplinary project-based course. Our findings contribute to the current ongoing discussion of modernizing statistics education, diversifying undergraduate statistics classrooms, and making statistical literacy a reality for as many people as possible (J. Garfield, delMas, & Zieffler, 2012; Handelsman et al., 2005). Previous studies have noted many positive effects of diversity experiences including greater intellectual engagement, commitment to promoting racial understanding, perspective taking, and a sense of commonality in values with students from different racial/ethnic backgrounds. These outcomes applied to all racial groups of students (Chang, 2003; Gurin, Dey, Gurin, & Hurtado, 2003).

This study examines the multidisciplinary, project-based course as one attempt to address the barriers faced in teaching statistics outlined by Svetlana and Gillian. Considering the issue of new students entering the course with a phobia of math or statistical anxiety, the course abandons the notion of developing an understanding of

broad, complex mathematical topics, and instead focuses on enabling students to answer their empirical questions and communicate a story with data.

Within the design of the course is also the expectation that students are entering from various disciplines with varying levels of experience. It is important to note that the project-based course is aimed at taking advantage of students' natural curiosity and providing a common language for approaching questions across numerous disciplines. This is achieved by asking students in the first week of class to develop their own research question from a number of large data sets representing different disciplines such as ecology, psychology, economics, planetary science and more. In addition, great care is taken to present translations of terminology and vocabulary that are used across different disciplines for similar statistical concepts (e.g. independent and dependent variables vs. predictors and outcomes vs. stimulus and response variables).

In addition to the course reducing a focus on the learning of a plethora of statistical algorithms and testing methods that will largely go unused, the method of assessing student progress is also unique. Students are encouraged to work collaboratively both on the long-term development of their data story, but also on their short-term periodic assignments that allow the students to “check-in” on the progress they have made in anything from learning the most recent coding command, to effectively interpreting statistical output. The final project consists of designing a poster that lays out the data story the student has worked on throughout the semester, and presenting their work alongside their classmates during a poster presentation symposium. The hope is that students will see that more value is placed on developing an understanding of data and

statistical analysis and being able to communicate their story, than on repetition and memorization in preparation for an exam.

Gould et al suggested expanding the meaning of data and teaching technology in order to maximize success in the contemporary classroom, and the multidisciplinary, project-based course has done that in spades. Since the course's inception, students have been able to choose one of various statistical software programs to learn throughout the semester as they develop and begin to answer their empirical question(s). Throughout the five year period covered in this study, the course has offered SAS, Stata, SPSS, and R as options for students to become proficient coders in efforts to tell their story. Students have also been welcomed to bring their own datasets into the course, whether from another lab within the university or from an independent research project a student is already involved in. This flexibility has allowed us to progressively offer more seats at the table and offer a truly customizable experience for students in the course.

With the multidisciplinary, project-based course established as meeting many criteria laid out by various researchers to improve the quality of learning in the statistics classroom, it was then important to understand what students were choosing to enroll in the course. Overall, juniors and seniors were significantly more likely than freshmen and sophomores to enroll in both the project-based and traditional statistics courses and both courses also attracted higher rates of female students compared to their representation in the larger university community. The higher representation of upperclassmen could be largely driven by the fact that most juniors and seniors had declared a major that included requirements fulfilled by one of the introductory statistics courses. Anecdotally, we have also found that seniors enrolled in statistics often described a desire to "gain new skills

for the job market." In our most recent offering of the project-based course, over 40% of students were first semester seniors. Given that participation by upperclassmen in introductory statistics courses has little chance of influencing students selection of major, and by extension, little chance of reversing the 'leaky pipeline' in which students turn away from plans to major in STEM fields (Clark Blickenstaff, 2005), more needs to be done to encourage enrollment of students in statistics courses as early as possible in their academic careers. One possible solution could be to demarcate a certain number of seats in the project-based course for first year students. Early engagement with a statistics curriculum could lead to more students taking opportunities to follow-up with additional coursework and extra-curricular involvement with data science.

Underrepresented students were more likely to enroll in the project-based course than the traditional statistics course regardless of class status and after controlling for a myriad of demographic factors. Furthermore, the interaction between SAT Math scores and underrepresented student status in predicting course enrollment demonstrated that among underrepresented students, those selecting the project-based course had significantly lower SAT Math scores than those selecting the traditional statistics course. Thus, lower mathematics achievement could not singly explain the higher rate of underrepresented students in the project-based course, but rather, suggested that math achievement may have influenced underrepresented students in making their choice.

It should be noted that because of the selective nature of Wesleyan University, where this multidisciplinary, project-based course was developed, SAT scores of both underrepresented and non-underrepresented students are quite high, with both mean and median scores well above 600. In other words, scores for the underrepresented students

in this study were not low, but instead, for those in the project-based course, just relatively lower than those of underrepresented students selecting the traditional statistics course. Notably, previous research has shown that African American and Hispanic college students with high grade point averages and SAT scores above 600 typically do not pursue STEM college majors for reasons including poor teaching in STEM courses, lack of encouragement from teachers or parents, and self-perception of their own inability to be successful in STEM majors (George, 2001).While we are not yet able to evaluate the potential impact of the project-based course in terms of future academic decision-making, the present findings suggest that a course in which students "have the opportunity to answer questions that [they] feel passionately about through independent research based on existing data", may represent a more attractive option for engaging students in the process of statistical inquiry. In conversations with students from the math and economics departments within the university, many respond with interest in undertaking a project-based approach to their work.

It appears that early recruitment practices are essential in recruiting women and underrepresented students into introductory statistics courses. This also seems to be important for students who have historically not performed as well on math related exams. Early intervention strategies must be formulated to both attract students to math-related courses, and to provide them with a welcoming experience. Much of this work is underway at Wesleyan within departments in the STEM fields, in no small part due to students within these departments seeking a better learning experience. Academic advising, productive mentoring relationships, and opportunities for students themselves to serve as mentors, can all be enhanced by early introductions to statistics.

Once the demographic characteristics that help influence enrollment in the project-based course were established, we then turned to better understand the personal background and experiences of the students as they entered the course. As expected, while statistical literacy is growing throughout the country and the world, our study found that undergraduates aren't likely to enter an introductory statistics course with experience using statistical software. Early exposure to any software can be important to increase student comfort levels with programming language. During implementation of the course we have witnessed students with experience in one statistical software have a much less stressful time picking up a new language.

Not unrelated is a student's confidence in scientific writing when they enter the course. Even enrolling in a project-based statistics course, underrepresented and non-underrepresented students were likely to feel scared by statistics. Both of these issues reflect on the role that high schools play in preparing students for college-level statistics courses. More work needs to be done at the high school level to encourage students to explore statistical inquiry and provide rewarding experiences that build confidence. This study seemed to point to a positive relationship between the number of math and statistics courses taken during high school and the level of confidence students display as they enter the multidisciplinary, project-based courses. This relationship existed outside of performance on the math portion of standardized exams.

Non-underrepresented students were more likely than underrepresented students to have four or more high school math or statistics courses, and more likely to have one or more college level math or statistics courses. Non-underrepresented students were also more likely to report doing well or very well in previous math courses, and were more

likely to identify themselves as being skilled or very skilled at mathematics. While many students come from more well-resourced private high schools, Wesleyan is also intentional in recruiting students from college-entry programs that work to better prepare students that attend public high schools. It may be interesting with a larger sample size to subset students who participate in college-prep programs from those who do not. Lack of exposure to math and statistics courses in high school and a student's early years of college certainly contributes to the identification as a 'non-math' person. This can lead to detrimental interactions with new statistical courses and heighten the sense of stereotype threat within the classroom (O'Brien & Crandall, 2003).

Students within the project-based course felt that the course research project was both challenging and rewarding, and most agreed with the pace in which the semester led up to the final presentation. Underrepresented and non-underrepresented students were most likely be interesting in taking an advanced statistics course as a follow-up when also given the options of a course on science writing, graphing, constructing a data set, and computer programming. Both groups were least likely to agree in an interest in taking science writing as a follow-up course. There may still be improvements to be made within the project-based course to make scientific writing more appealing to students.

Considering the class year of students and the relationship to their feelings of accomplishment indicated that younger students left feeling that they accomplished more. This could be connected to freshman students adjusting from high school to their first semester of college, since the course always takes place in the fall. Junior and seniors may have a better sense of both their capabilities to learn new skills and have a higher confidence in navigating the college environment to seek support and additional

resources. This relationship was confounded by whether or not students thought the project-based course was more challenging than other courses. Students who felt that the course was not as challenging were less likely to respond that they accomplished more than they expected.

An increase in nearly all measures of confidence over the semester for both underrepresented and non-underrepresents indicates that the exposure to statistical experiences during the semester of the multidisciplinary, project-based course, improved students' confidence levels, regardless of background.

For underrepresented students taking the multidisciplinary project-based course, in particular, there were a few measurable factors that played a role in successful outcomes. Self-perceived math skill was an important factor for predicting positive outcomes, and much more so than for non-underrepresented students. For non-underrepresented students, math skill only significantly predicted whether a student would want to take a follow-up course. But for underrepresented students, how they evaluated their own proficiency in math was related to every positive outcome except for one. It is important that we recognize the significance of the identification as a "non-math" or "maths-phobic" person (I. Gal, Ginsburg, Lynda. , 1994). Lower self-perception of skill even led to lower increases in confidence throughout the semester.

It is important that we realize that making a class more meaningful does not necessarily mean making a class easier. But it also does not mean making a class more difficult for the sake of 'rigor'. Overall, students who felt challenged by the research project for the course were actually more likely to say that the effort was worth it. They were also more likely to say that the effort put into the course was worth it at the end.

Limitations

During multivariate analyses, we could only include students who had all data for any given set of independent, dependent, and third variables within our model. As our survey implementation continued to advance, not all students were asked the same questions during each iteration of the course. It is also true that not all students took SAT, as some instead took the ACT. We initially sought to also include students in our multivariate models that only took the ACT, but the numbers showed to be too few. Both of these factors often meant that students who participated in earlier years of the course were excluded from multivariate analyses. We have yet to fully analyze demographic changes within the course over time; therefore, there could be enrollment patterns that would be useful to incorporate into the larger story of not only the growth of the course, but also any shift in student experiences as the course has changed.

Given that women and many students of color are not highly represented within statistics courses, it was sometimes difficult to pursue certain analyses due to limitations in statistical power. In the future, as we hope to increase the number of underrepresented students in the classroom, we will also be able to expand our abilities to evaluate their experiences in the classroom, and improve our courses overall.

Conclusion/Next Steps

The presence of in-group peer experts have shown to inoculate new students from underrepresented groups for stereotype threat. The presence of in-group experts (instructors) or peers led to the more active participation in achievement context, and higher displays of effort (Dasgupta, 2011).The opportunity to relate to expert role models and peers from demographic in-groups does matter. This study also revealed that

increasing contact with in-group peers and experts is particularly important in early years of training. It may be important in the future of the project-based course to analyze the student experience in relation to their section instructor and peer mentors within the course. Beginning in the fall of 2014, we implemented a mid-semester survey that asked students how much they relate and identify with their instructors and peer mentors, as well as how supported by each resource. In the future these findings will help shape discussion around overcoming interpersonal barriers within the classroom.

The revelation that racially underrepresented students felt that they accomplished more than they expected in the course is an important one to consider, given that these students are often excluded from the introductory statistics classroom and STEM professions. It is important for students to leave the course with a sense of accomplishment. This may be even more important for students who may initially feel as if they do not belong in the course for some reason. Increased feelings of accomplishment may also lead to a greater sense of ownership over one's learning. An important philosophical backing of the course has always been to not only give students a seat at the table, but also to provide an inclusive and productive learning environment. These factors may play a role for underrepresented students choosing to remain in the course, even though they were more likely to view the course as more difficult than other courses they have taken at Wesleyan.

It is important to consider that the majority of this study would not have been possible without the detailed, innovative course evaluation methods incorporated into the multidisciplinary project-based course curriculum. This course is serving as a premier example of the possibilities that are available to answer questions that will help us better

serve our students when we ask the right questions. Traditional teaching evaluations have not been sufficient in offering meaningful pathways to improvement to our courses in the field of Statistics or in academia at large.

It is not only important for us to make sure that we are optimally educating students who have the courage to enroll in statistics and other applied methods courses. We must also pursue outcome evaluation more thoroughly and thoughtfully. Though we believe that this inclusive and comparative approach allows students to more widely communicate across disciplines on a variety of computational issues, we also recognize that there is more to be done to enhance access to truly interdisciplinary research and thinking. We hope to achieve this in future iterations of the course through reliance on more interdisciplinary data sets (e.g. outcomes and predictor variables measured from cells to society) and through group projects drawing on the range of disciplinary backgrounds of our students.

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