IMPACT OF NON-COGNITIVE INTERVENTIONS ON THE PERFORMANCE OF WOMEN, MINORITY AND INTERNATIONAL STUDENTS IN INTRODUCTORY STATISTICS

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Psychosocial interventions have been shown to be effective in reducing the impact of stereotype threat in a number of educational environments. Students from under-represented groups (e.g. women, minority, international) can experience negative non-cognitive factors that influence their attitude towards statistics and impact their academic achievement. In this study, students in a large introductory statistics course were presented with two interventions before exams – a values affirmation exercise, and a video featuring teaching assistants. The Survey of Attitudes Towards Statistics (SATS) along with demographic questions, was distributed the first week of class. A SATS post-survey was distributed the last week. Survey results and course grade data are used to evaluate the impact of the interventions and the overall academic success of the students.

BACKGROUND

Significant academic research has been devoted to understanding the nuances behind the underrepresentation of women and minorities in science, technology, engineering, and mathematics (STEM) fields. This underrepresentation has been attributed to external factors such as classroom environments that inhibit the comfort and participation levels of these groups, culminating in reduced confidence levels in quantitative ability (Maher & Thompson, 2001). It has also been ascribed to "attitudinal components" like affect, cognitive competence, and value, which have been found to have statistically significant relationships with academic achievement (Ramirez, Schau & Emmioğlu, 2012).

Garfield, Hogg and Whittinghill (2002) state that one of the major outcomes statistical educators should stress is having their students attain a positive attitude toward the discipline. In terms of the impact of student demographics on these attitudes, a number of studies have looked at the effect of gender on these measures. Several of the studies that were conducted outside the United States reported gender-based discrepancies in attitudinal measures in statistics courses with male students reporting higher positive scores in all four attitudinal categories (Bechrakisa et al, 2011; Coetzee & van der Merwe, 2010; Mahmud & Zainol, 2008; Tempelaar, Schim van der Loeff, Gijselaers, & Nijhuis, 2011; Verhoeven, 2009, 2011). Van Es and Weaver (2018) researched racial and gender differences in attitudinal scores in a U.S. university. They found significantly lower average scores for female students in affect, cognitive competency and subject difficulty, but no significant differences between races (White, Black or African American, Latino, Asian and Other). In general, there has been less research into the impact of racial/ethnicity on student attitudes and achievement in statistics education, although some work has been done on students with English as a second language (Lesser, 2009).

Racial disparity in achievement goals has often been studied through the lens of stereotype threat (Steele, 2011). The idea of a stereotype threat hypothesizes that "members of minority groups underperform academically because of unconscious fears of living up to negative group stereotypes" (Masey and Fischer, 2005). Whereas this hypothesis had initially been validated only in small experimental studies, Masey and Fischer tested it on a sample of 4,000 students at 28 colleges and universities, accounting for a large number of factors like demographics, stereotype constructs, socioeconomic status, academic preparation, racial-ethnic identifiers, etc. They found that internalization and externalization of stereotypes lead to a dis-identification with academic success and a performance burden for Black and Latino students, resulting in lower grade achievement. Similar studies highlighted the role of stereotypes in formulating identification issues for female students in quantitative and STEM fields (Cheryan, Plaut, Davirs & Steele, 2009).

Physical and psychological environments can play a role in perpetuating stereotype threats. Subtle interventions that affect student psychology can lead to large and lasting positive effects,

especially for people of color, due to recursive feedback loops that promote non-reinforcement of stereotypes and dynamic interactions with other factors within the school environment (Garcia & Cohen, 2012). For example, in a stereotyped domain like mathematics performance, simply placing high-achieving women in an environment in which men outnumber them can cause women to experience performance deficits, with the performance deficits increasing as the relative number of males increase (Inzlicht & Ben-Zeev, 2000). The gender of the professor has a powerful impact on female students' performance in math and science courses, the likelihood of them taking additional math or science courses, and on female graduation rates in these disciplines, while little such effect is observed among male students (Carrell, Page & West, 2010).

Various methods have been tested in order to study how deploying interventions can mitigate stereotype threat effects. Ambady, Paik, Steele, Smith & Mitchell (2004) tested for the effect of gender priming and individuation manipulation. Other intervention methods to alleviate the effect of stereotype threats include practices like self-affirmation, where targeted timely interventions, e.g., having students reaffirm their sense of personal adequacy or "self-integrity" through a brief in-class writing assignment significantly improved the grades of African American students and reduced the racial achievement gap by 40% (Cohen, Garcia, Purdie-Vaughns, Apfel & Brzustoski, 2009). In another study, male-female performance discrepancies were found to be lower and women's modal grades were found to be elevated when students in the treatment group received an affirmation condition, and were asked to write about their most important values from a list including relationships, learning, gaining knowledge, etc. (Miyake, et al., 2010). Interestingly, the benefits were observed to be the strongest for women who had initially suggested that men do better than women in physics classes.

Interventions have also drawn attention to the role of attitudes that women and minorities harbor towards certain fields and their approach toward intelligence itself. Forbes & Schmader (2010) suggest that positive attitudes are causally linked with better performance, and these attitudes can motivate stigmatized individuals to engage with threatening domains by reorienting their stereotypes. In their study, women who were retrained to have a more positive attitude towards math had more motivation. They found that by retraining the stereotype into associating their gender with higher performance in mathematics, women experienced increased performance levels within a stereotype threatening context. In a similar vein, Aronson, Friend & Good (2002) observed that viewing intelligence as malleable produced "greater enjoyment of the academic process, greater academic achievement, and obtained higher GPAs" for African-American students, and to some extent, for White students.

These studies indicate that social-psychological interventions have the potential to make powerful impacts where stereotype threats surrounding women and minorities are common, especially in fields where they are underrepresented. Furthermore, their effects are enduring, because they target subjective experiences in school by using subtle yet persuasive methods to convey psychological ideas. These interventions also benefit from incorporating contextual information, thus producing "long-lasting gains in achievement in multiple studies" (Yeager & Walton, 2011). As Yeager & Walton note, "If scaled up in appropriate ways, social-psychological interventions have the potential to contribute, in conjunction with other reforms, to the solution of endemic problems in education."

INTERVENTIONS

The Dyson School of Applied Economics and Management at Cornell University offers an Introductory Statistics class each fall. The course enrolls approximately 240 students. The instructor is a female with a Ph.D. in Statistics and over 25 years of teaching experience. Students in 2017 were given an assignment in the first week of class to complete a survey consisting of questions from the Survey of Attitudes Toward Statistics (Schau et al. 1995) as well as additional demographic questions. While a number of survey instruments are available to measure student attitude, SATS has been the most extensively studied. Through composite questions, it measures four dimensions – Affect, Cognitive Competence, Value and Difficulty. Questions in the Affect category measure how students feel about statistics. The Cognitive Competence category measures how students perceive their own intellectual abilities and how well they think these abilities apply to statistics. The Value category gauges their view on the utility of statistics education. The

Difficulty category relates to student perception of the complexity of the subject. The post SATS survey data was collected the last week of class.

Introductory Statistics has two exams and a final test along with other learning assessments. Two days before the first exam students were prompted to take an on-line values affirmation activity (Appendix A). Richard Paselk of Humbolt State University adapted it from prompts developed by Geoffrey Cohen (Stanford) and Akira Miyake (University of Colorado). Before the second exam they were shown a video (https://vimeo.com/257796724/d66f85c5c9) prepared by the instructor and teaching assistants. The course teaching assistants (who were all former students) were asked to discuss their experiences when they took the class, which were not all high-performancel from the beginning. They also gave tips on how they succeeded in mastering the content. The intent was implicitly to promote a growth mindset as proposed by Dweck, Chiu, and Hong (1995) and studied as an intervention to stereotype threat by Aronson, Fried, and Good (2002).

RESULTS

The sample size of students participating in the study was 201. Forty nine percent of the participants identified as female, fifty-one percent as male. The majority of the students identified as white (40%). The non-white students listed their race or ethnicity as: Asian (23%), Black (15%), or Latino (10%). The remaining students self-identified as Multiple Race, Multiple Ethnicity, or Other. For the purposes of this study they were combined into the "Other" category. Ten percent of the students submitted that they were "International Students". Ninety-three percent of the students participated in the values affirmation intervention, while only 42% viewed the video. The latter was shown at the beginning of lecture in the class preceding the exam. The number of students arriving slightly late, or not attending class that day possibly influenced the lower participation rate.

A MANOVA model was performed using the differences between the four post-subscore dimensions and the pre-subscore dimensions (Affect, Cognitive Competency, Value and Difficulty) as the dependent variables. Sex, Race, Values Affirmation (Yes/No for participation), Video (Yes/No for viewing), International (Yes/No) were the independent factors. Initial screening verified that that the data was appropriate for the basic assumptions of this model.

The results showed a significant difference overall in the positive direction ($p = 0.037$) for the Cognitive subscores of those students who did the values affirmation. Their mean increase was 1.04 points ($s = .93$), versus a mean decrease of 0.25 points ($s = 1.01$) for those who did not participate in the exercise. Meanwhile there was a significant difference ($p = 0.027$) between the sexes in terms of their Values subscores: women saw an average increase of 0.285 points ($s = .80$) while men saw an average increase of 0.05 points ($s = 1.02$). The most significant factor ($p = 0.003$) was the interaction of student nationality with video viewing for the Value subscore difference. International students who viewed the video saw an average increase in this score of 0.73 points ($s = 0.74$), while those who did not averaged a decrease in the Value subscore of 0.30 points ($s = 1.03$). These results suggest that having students participate in the values affirmation exercise impacted all students by increasing their perception of their own intellectual abilities, which could increase their confidence in doing well in the course. Additionally, the interventions seem to have the highest impact on women and international student in terms of influencing views on the utility of learning statistical methods. No racial effects were found to be significant.

Students were asked to rate their level of confidence in terms of their ability to "master introductory statistics material" on a one to six scale (one being 'not at all confident' and six being 'very confident') in the pre and post SATS survey. Female students who both viewed the video and did the values assessment showed a significant difference based on a multinomial test ($p < 0.001$) among the proportions selecting each category. The biggest differences for female students in the pre versus post SATS surveys were that none of them in the post-test said they had little or no confidence, whereas the percentage who were very confident jumped from 23% to 39%. While other factors could explain this change, it is important to note that there were not similar significant changes for the male students. There was also no such significant change in the confidence levels for the minority or international students.

Two analyses were prepared to evaluate the possible influence of the specific interventions on the exams given immediately afterwards. Student scores on the first exam were used as the independent variable in a test investigating the impact of the values assessment (Yes/No for participation), along with Race, Gender, International, and associated interactions. There was no significant difference found between the grades overall for students who did and did not participate in the values assessment (p = 0.689). The only significant factor was Race (p < 0.001), with a Tukey pairwise comparison showing that Asian students scored highest, while Black and Latino students achieved lower scores.

The video was shown the day before the second exam. Those test scores were compared for students who did or did not see the video, along with the aforementioned demographic variables. In this case there was a significant difference between the scores of those students with respect to viewing the video (p = 0.019). The students who saw the video had mean test scores of 89.28 (s = 13), while those who did not had a mean score of 84.96 (s = 15). Again, there was a significant difference between the scores based on race (p = .001), with Asian students scoring higher than Latino or Black students. It should be noted that when cumulative overall grades for the entire semester were analyzed, the only variable that was significant was Race (p <.001), with a similar pattern showing up in the pairwise comparisons.

CONCLUSION

The use of interventions in introductory statistics courses as a means to increase student confidence and academic achievement shows some promising, while conflicting, results. The video of testimonials from teaching assistant seemed to have the most influence on test scores. It also impacted the international students in terms of increasing their attitudinal evaluation of the Value of learning statistics. This "you can do better too" message appears to give students the indication that they can improve even if they initially perform below their expectations. The strategy, based on the pioneering work of Dweck (2006) on growth mindset, deserves further study.

While the values assessment exercise did not have a significant effect on student grades, it did impact some of the attitudinal measures, such as the Cognitive Competency subscore. There was also an increase in the Value component for women. More research needs to be done in this area.

Disappointingly, neither of these interventions made a significant difference in the assessment scores for minority students, which continue to be lower than other racial groups. A comparison was done with the scores from the previous offering of the course, and while there was a slight increase in the final averages of Black and Latino students in 2017 (p = .098), it was not significant. More work on interventions that address stereotype threat for this particular group of students, as well as deeper research into the causes of this achievement gap, are required.

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APPENDIX: VALUES AFFIRMATION EXERCISE

Year:
International Student (y/n/prefer not to answer)
If yes, which country are you from?

Circle the two or three values *most* important to you
• creativity
• community/relationships with family and friends
• political views
• independence
• learning and gaining knowledge
• money, wealth or status
• your social/cultural/racial identify
• honesty or integrity
• helping others
• achievement in athletics, education, or career
• connection with nature/the environment _
• athleticism, fitness
• spirituality or religion
• sense of humor/having fun

Based on your responses above, please do the following:
First, look at the values you picked as most important to you.
Next, think about times when these values were important to you.
Finally, describe in a few sentences why these values are important to you

On a scale of 1 – 5 where 1 is highly disagree and 5 is highly agree, rate the following statements:
1. These values have influenced my life.
2. In general, I try to live up to this value these values.
3. These values are an important part of who I am.
4. I care about these values.