**Race, Sex, and their Influences on Introductory Statistics Education**

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**Abstract**

Students in a Cornell University Introductory Statistics class were given the Survey of Attitudes Towards Statistics or SATS (Schau et al 1995). Additional questions requesting demographic information and expected final course grade were added. Responses were analyzed to investigate possible differences between sexes and racial/ethnic groups. The findings showed that female students rated their own statistical abilities significantly lower than their male counterparts. This confidence gap was reflected in students' affect, cognitive competency, and subject difficulty scores as well as their expected final course grade. When expected and achieved grades were compared, both male and female students overestimated their score, but female students did so to a lesser extent. No differences in confidence in statistical ability were found between racial/ethnic groups. However, significant differences between racial groups were found when comparing student's expected and actual grades. These results suggest that educators should focus on differences between sexes when planning ways to improve students' self-confidence. They should also focus on implementing strategies for minority students to achieve their expected final course grade.

## 1. Introduction

While there have been increases in the representation of women and minorities in science, technology, engineering, and mathematics (STEM) these groups are still largely marginalized in quantitative fields. This underrepresentation has been attributed to classroom environments in which women and minorities don't feel comfortable enough to actively participate in class (Maher & Thompson 2001). These groups then do not have confidence in their own quantitative abilities and choose not to pursue careers in a STEM field. The differences between male and female students in attitudes toward mathematics widens as students age (Hyde et al. 2006). By the time students reach university there is a large confidence gap between male and female students. The purpose of this study is to investigate the role that sex and race play in attitudes towards learning statistics, and in student performance expectations. It is critically important to understand these differences in order to determine the best ways to intervene so that all students feel equally comfortable in statistics classrooms.

## 2. Review of the Literature

The effect of gender on performance in introductory statistics classes has been reviewed with variable results (Haley, Johnson and Keunnen 2007; Scheaffer and Stasny 2004; Alldredge and Brown 2006). While a study of gender differences in performance in introductory business statistics showed females tend to achieve higher scores than male students (Johnson and Keunnen 2006), and that students taught by a professor of the same gender do significantly better, these results do not address the attitudinal or confidence differences between genders.

There has been less research about racial differences in terms of attitudes towards statistics. As Wagler and Lesser (2011) noted, "Students from diverse cultural or language backgrounds may not always

respond in the same way to traditional statistics classroom instruction." But the focus has been largely centered on the impact of language, specifically English as a second language (Lesser 2009;Ware 2004).

Verhoeven and Tempelaar (2014) focused on cultural diversity in statistics education using Hofstede's research on cultural dimensions (Hofstede 1986). They observed patterns among different cultural regions. For example, Dutch and Scandinavian students demonstrated high scores in affect, while Confucian students were lowers in most of their attitudes. Their final conclusion stated that "strong patterns become visible that deserve our undivided research attention in the near future." Mvududu (2003) examined differences in attitudes of students from samples of American and Zimbabwean students. They also noted that "cross-cultural comparisons have the potential to generate new insights into statistical pedagogy and the role non-cognitive socio cultural variables play in teaching statistics to college-age students." While these studies provided insights into cultural differences from a nationality standpoint, less work had been done in the area of gender and racial influences on success in introductory statistics class among students in the US.

In addition to comparing demographic impact, it is crucial to consider what instructors can do to improve students' attitude toward statistics and their ability to demonstrate subject knowledge. Research shows simple social-psychological interventions in education can have a profound impact. Walton and Cohen performed work in 2007 in which they studied the impact of one-hour sessions aimed to help African American students improve their sense of social belonging. These sessions resulted in increased GPAs and reduced the African American-White GPA gap by half. Another study performed by Cohen et al. (2009) aimed to curb stereotype threat by having college physics students write down values that were personally important to them. A second group was kept as a control and was asked to write down attributes that were generally important, but not necessarily important to them. As a result of the intervention, the GPAs of female students in the treatment group increased by 0.33 points. Both of these interventions were designed to make students more comfortable in the classroom and increase their confidence, thus showing the influence of simple interventions.

These studies show that social-psychological interventions have the potential to make powerful impacts in the classroom. Understanding students' differences in perceptions towards statistics will allow educators to develop targeted interventions and teaching strategies that improve students' attitudes toward the subject.

## 3. Methods

### 3.1 Survey

The survey consisted of questions from the Survey of Attitudes Toward Statistics (SATS) as well as nine other questions added for the purpose of this study. Survey questions from the SATS were divided into four dimensions for scoring - affect, cognitive competence, value, and difficulty. Questions in the affect category aimed to measure how students feel about statistics. The cognitive competence category measured how students perceived their own intellectual abilities and how well they thought these abilities applied to statistics. The value category gauged the utility of statistics. The difficulty category measured student perception of the difficulty of the subject.

Questions addressing the different categories were varied, and responses were on a 1 (strongly disagree) to 7 (strongly agree) scale. Higher cumulative scores in all of these categories indicated a more positive attitude towards statistics. Scores were calculated for each student in each dimension. Additional questions were added requesting demographic information and the final grade they expected to receive in the course. The full list of questions can be found in Appendix 1.

One change was made to the survey over the course of the study. In the 2014 survey, students were asked to identify themselves. This enabled a comparison between the students' expected and actual earned final grades.

### 3.2 Setting and Survey Participants

Students enrolled in the introductory statistics class offered by Cornell University's Dyson School of Applied Economics and Management participated in this study. The course consists of three 50-minute lectures per week and one two-hour discussion section per week. The instructor is a female with a Ph.D. in Statistics and over 25 years of experience teaching introductory classes. All students enrolled in the course during the Fall 2012, 2013, and 2014 semesters were given the survey at the beginning of the semester. A total of 611 students responded. Students in the course came from a variety of disciplines and academic backgrounds, although they are predominately Business Management majors. The class is a requirement for a number of majors and many students in the course did not come into the class with a strong interest in the subject. The majority of students were freshman or sophomores.

Table 1 contains the demographic information of the students that participated in the survey. The sex balance was approximately equal with 51.1% female students and 48.9% male students. A disproportionate percent of the class, 49.3%, identified as White. The next largest racial group was Asian at 19.8%. The "Other" category includes students that are Pacific Islander, Native American and multi-racial.

**Table 1.** Demographic Information

| Race | Male | Female | Total |
|---|---|---|---|
| Asian | 6.71% | 13.09% | 19.80% |
| African American | 5.89% | 5.24% | 11.13% |
| Latino | 6.38% | 3.76% | 10.15% |
| White | 24.71% | 24.55% | 49.26% |
| Other | 5.24% | 4.42% | 9.66% |
| Total | 48.93% | 51.06% | 100% |

## 4. Analysis of Data

### 4.1 Analysis of SATS Questions

Several significant differences between sexes were found. Male and female students' scores differed in the categories related to confidence. There were significant differences in male and female scores for the affect ($p = 0.0001$), cognitive competence ($p = 0.0004$), and difficulty ($p = 0.0047$) categories. Differences in these categories indicate that male and female students have different levels of faith in their own statistical abilities (table 2). It is also important to note that there was not a significant difference in scores in the value category, which suggests that male and female students find statistics similarly important.

**Table 2**. Mean Scores for Male and Female Students by Dimension

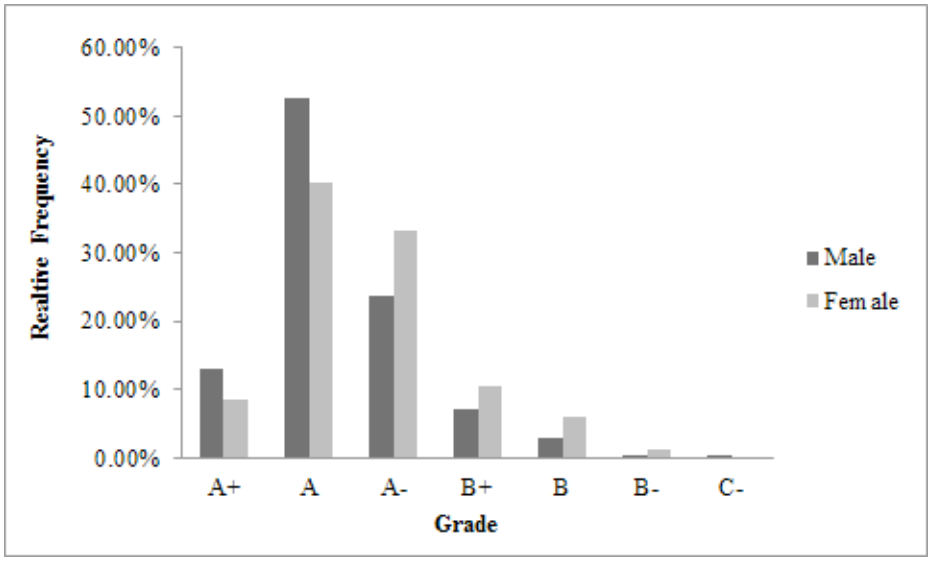
| Category | Male | Female | p - Value |
|---|---|---|---|
| Affect | 28.95 | 26.98 | 0.0001 |
| Cognitive Competence | 31.79 | 29.74 | 0.0004 |
| Difficulty | 27.93 | 26.90 | 0.0047 |
| Value | 49.93 | 50.79 | 0.1169 |

The mean scores from the four dimensions were also tested for significant differences between racial/ethnic groups. No significant differences were found in any of the categories. It is important to highlight that minority and white students had a similar degree of confidence in their abilities in statistics and felt similarly about the value of the subject. A two-way factorial test showed no significant interaction between sex and race for any of the dimensions (Appendix 2).

### 4.2 Analysis of Supplemental Questions

One of the questions added to the SATS survey asked students to anticipate their final grade for the course (again, this survey is given in the first week of the class when no assignments or exams have occurred yet). The majority of male students expected to receive an A or A+ in the course while the majority of female students expected to receive an A or A- (Figure 1). The expected grades were converted to a GPA scale and a two-sample t test found a significant difference in expected grades between the sexes ($p = 0.0002$). The average grade male students expected was 3.88 while the average grade female students expected was 3.78. A comparison of the actual grades received by the students at the end of the semester showed no significant difference between the sexes ($p > 0.05$). This result reveals that female students tend to be less confident in their abilities, although their final course grades are not lower than the male students.

**Figure 1**: Expected Grade by Sex




Student names were attached to the 2014 survey to allow for comparison of anticipated and achieved final grades. Among both male and female students, there was a significant difference between expected and received grades (males and females: $p < 0.0001$). The differences between expected and actual grades were then compared between males and females. Though both groups overestimated their grades on

average, male students did so to a significantly larger degree than female students ($p = 0.0026$). The average difference between expected grades and actual grades was 0.74 GPA points for males while it was 0.43 GPA points for females. While students tended to overestimate their grades, some underestimated themselves and predicted that they would receive a lower grade than they actually did. The degree to which some students underestimated themselves also varied by sex. The minimum by which male students underestimated their grade was 0.3 GPA points while the minimum by which female students underestimate their grade was 1 GPA point.

The difference between the grades students expected to receive and their actual course grades were compared for each racial group. For all races except Asian there was a significant difference between expected and actual grades (Table 3). Students that identify as African American, Latino, White, and Other all clearly believe they can earn higher grades than they actually received. The degree to which students' expected grades and actual grades differed also varied by race. On average, this difference was the largest for Latino students with those students receiving an average grade 0.85 GPA points lower than expected. The second largest average difference was for African American students who received mean grades 0.82 GPA points lower than they expected.

**Table 3**. Actual vs. Expected Grade by Race

| Race | Average Expected Grade | Average Actual Grade | P -Value |
|---|---|---|---|
| Asian | 3.99 | 3.82 | 0.1107 |
| African American | 3.81 | 2.99 | $p < 0.0001$ |
| Latino | 3.78 | 2.93 | 0.0007 |
| White | 3.79 | 3.22 | $p < 0.0001$ |
| Other | 3.70 | 2.95 | 0.0007 |

## 5. Discussion and Educational Implications

### 5.1 Discussion of Survey Results

It is important to carefully consider the setting of this study when examining the results. It was performed at Cornell University, a highly selective institution that draws top students from around the world. The fact that even at this elite institution female students felt less confident in statistics than male students shows the systemic nature of the problem. Though female students felt less confident in statistics than male students, they did not perform any differently. There was no significant difference between the grades the two sexes received at the end of the semester. When professors first introduce students to statistics they should take time to make sure students understand what the subject entails. Many come in believing it will be just like any other math class and students that have felt uncomfortable in math carry this attitude into the statistics classroom. This misconception is particularly damaging for female students that have gone through their foundational education believing they are inferior to their male counterparts. Interestingly, there was no interaction between race and sex showing that differences in attitudes towards statistics can be attributed solely to sex.

Students from all but one racial group underperformed their expectations as measured by the difference between the grade they expected to receive and the one they actually received. The cause of this issue is unclear - perhaps some students expect statistics to be easier than it is, or they think an introductory class implies a less challenging course. When grouped by race, the largest difference between expected and actual grades occurred for Latino students whose grades were lower by 0.85 GPA points on average. This

divergence corresponds to nearly an entire letter grade of difference. Whatever the root of this discrepancy, steps should be taken to ensure students are achieving their full potential.

### 5.2 Student Focus Group Discussion

After the results of the survey were analyzed, two focus groups were held to better understand why some female students feel less confident than male students and why students perform below their initial expectations. One group consisted of 12 female students and the other group consisted of 11 male students. These sessions were two months into the course, before the students received their final grades. The purpose of these sessions was to delve deeper into the reasoning behind some of the student responses.

Students were asked how they determined their expected grade. There was a striking difference between male and female students' answers. Male students said that they wrote down what grade they wanted to get but not necessarily the one they thought they would get. Many of them saw it as a goal setting exercise and wanted to establish a high standard for them. Female students based their expected grade on previous grades they received in quantitative classes. Students were also asked how they would rate their ability in quantitative subjects in comparison with the average Cornell student. All of the male students said their abilities were average or above with none rating themselves below average. The majority of female students rated their abilities as average with a few students rating themselves above average and a few below average. Students were then asked if they planned to take additional quantitative courses (beyond those required by their major). The majorities of the male group said they had taken or plan to take quantitative courses beyond their basic requirements, while the majority of female students said they would not take these courses. Finally, students were asked about the way the course was designed and how it was taught. All of them believed that it was well run and did not have any structural issues with the class.

The results of the focus group illustrate the different ways male and female students think about their abilities in quantitative subjects. Male students' confident answers were consistent with the findings from the survey and show that they set high goals for themselves. Female students' answers were more realistic and their expected grades tended to be closer to their achieved grades. Most of them saw their abilities as average and few expressed a strong desire to further their education in quantitative fields.

### 5.3 Interventions and Strategies for Improvement

One promising strategy for improving students' confidence in statistics is showing students testimonials of teaching assistants and former students who struggled with the course material but ultimately earned a good grade in the course. An "it gets better" message could give students hope that they could improve their grade even if they performed below their initial expectations. Students in the focus group responded positively to this suggestion. Subsequently, a short video was made asking course teaching assistants (former students from previous years) to discuss their experiences when they took the class, which were not all exceptional from the beginning. They also gave tips on how they succeeded in mastering the content.

Another strategy would be to have students write down their strengths in the subject before they take exams. Reflecting on the aspects of statistics they feel they are strong in could give them more confidence and allow them to better perform. Students in the focus group responded fairly positively to this suggestion. While some of them did not think it would affect them, others said it might have a positive subconscious effect. Both the video and this proposed intervention would be piloted in subsequent offerings of the course and their effects documented.

Appendix

*Appendix 1: Survey Questions*

Affect

1. I will like statistics.
2. I will feel insecure when I have to do statistics problems.
3. I will get frustrated going over statistics tests in class.
4. I will be under stress during statistics class.
5. I will enjoy taking statistics courses.
6. I am scared by statistics.

Cognitive Competence

1. I will have trouble understanding statistics because of how I think.
2. I will have no idea of what's going on in this statistics course.
3. I will make a lot of math errors in statistics.
4. I can learn statistics.
5. I will understand statistics equations.
6. I will find it difficult to understand statistical concepts.

Value

1. Statistics is worthless.
2. Statistics should be a required part of my professional training.
3. Statistical skills will make me more employable.
4. Statistics is not useful to the typical professional.
5. Statistical thinking is not applicable in my life outside my job.
6. I use statistics in my everyday life.
7. Statistics conclusions are rarely presented in everyday life.
8. I will have no application for statistics in my profession.
9. Statistics is irrelevant in my life.

Difficulty

1. Statistics formulas are easy to understand.
2. Statistics is a complicated subject.
3. Statistics is a subject quickly learned by most people.
4. Learning statistics requires a great deal of discipline.

Additional Questions

1. What is your race?
2. What is your sex?
3. What grade do you expect to receive in this class?

*Appendix 2: ANOVA results*

**Affect Responses**

| Source | DF | SS | MS | F- Value | P- Value |
|---|---|---|---|---|---|
| Sex | 1 | 517.9 | 517.920 | 14.77 | 0.0001 |
| Race | 4 | 196.4 | 49.088 | 1.40 | 0.2325 |
| Sex * Race | 4 | 95.2 | 23.808 | 0.68 | 0.6067 |
| Error | 601 | 21072.2 | 35.062 | | |
| Total | 610 | 22009.2 | | | |

**Cognitive Competence Responses**

| Source | DF | SS | MS | F- Value | P- Value |
|---|---|---|---|---|---|
| Sex | 1 | 390.6 | 390.621 | 12.81 | 0.0004 |
| Race | 4 | 206.6 | 51.650 | 1.69 | 0.1498 |
| Sex * Race | 4 | 32.3 | 8.087 | 0.27 | 0.9003 |
| Error | 601 | 18329.3 | 30.498 | | |
| Total | 610 | 19235.2 | | | |

**Value Responses**

| Source | DF | SS | MS | F- Value | P- Value |
|---|---|---|---|---|---|
| Sex | 1 | 109.0 | 109.001 | 2.47 | 0.1169 |
| Race | 4 | 156.0 | 38.996 | 0.88 | 0.4743 |
| Sex * Race | 4 | 223.2 | 55.802 | 1.26 | 0.2836 |
| Error | 601 | 26572.0 | 44.213 | | |
| Total | 610 | 27034.6 | | | |

**Difficulty Responses**

| Source | DF | SS | MS | F- Value | P- Value |
|---|---|---|---|---|---|
| Sex | 1 | 173.8 | 173.755 | 8.06 | 0.0047 |
| Race | 4 | 140.7 | 35.185 | 1.63 | 0.1645 |
| Sex * Race | 4 | 11.5 | 2.882 | 0.13 | 0.9699 |
| Error | 601 | 12954.3 | 21.555 | | |
| Total | 610 | 13280.4 | | | |

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