

Social Justice, Gender Equity, and Service Learning in Statistics Education: Lessons Learned from the DOE-funded Project ACE (ACtion for Equity)

Lawrence M. Lesser¹

¹The University of Texas at El Paso, 500 W. University Avenue, El Paso, TX 79968

Abstract

Equity, service learning, and social justice are powerful vehicles for motivating students to take statistics seriously and also for empowering citizens with the statistical literacy needed to be able to speak out more intelligently against injustices they may uncover. This paper begins by outlining key references from the recent, rapidly emerging literature on these topics in statistics education. A major grant on the author's campus dealing with gender equity in the context of STEM (science, technology, engineering, and mathematics) fields yielded a natural vehicle to implement many aspects of these themes in a redesigned introductory statistics course for pre-service elementary and middle school teachers. After describing the grant, the student population, and features of the course, this paper presents the results of a quantitative pretest-posttest survey as well as representative narrative data such as artifacts (e.g., student reflection papers) and a peer observation. Further connections and reflections are made and situated in the literature.

Key Words: Ethics, equity, gender, gender equity, service learning, social justice, statistics education.

1. Background

In the last few years, there has been a critical mass of scholarship within statistics education on the topics of equity, social justice, and service learning. These areas are also arguably highly related to recent themes of the Joint Statistical Meetings (JSM), such as “Communicating Statistics: Speaking Out and Reaching Out” in 2008 and “Using Our Discipline to Enhance Human Welfare” in 2005.

The integration of ethics into statistics teaching has recently been supported by a major paper by Lesser and Nordenhaug (2004), a JSM luncheon roundtable session by Mary Gray (in 2005), and a topic contributed papers session (“Teaching Ethics in Statistics Class”) at JSM 2008 organized by Paul Velleman, who also gave an ethics-related invited plenary talk (Velleman 2008) at the 2007 United States Conference on Teaching Statistics. Several textbooks now have data ethics chapters (e.g., Utts 2005, Moore & Notz 2006) or case study exercises (e.g., Pelosi and Sandifer, 2003) that describe real-life challenges and ask “What do you do now? OK, what do you *really* do now?” And statistics educators doing research in their classroom must address potential issues of ethics raised by Holcomb (2002) or Nolen and Vander Putten (2007).

The branch of ethics known as distributive ethics relates to the area of social justice, and in 2007, there was the first major paper connecting social justice teaching to statistics education (Lesser 2007a) as well as an archived webinar (Lesser 2007b). The area of service learning also experienced a critical mass of attention in statistics education in 2007 with a trio of papers in the July issue of *Journal of Statistics Education*. Due to space constraints, this paper will not start from scratch with definitions of ethics, equity, social justice and service learning, but background, references, interconnections and implementation tips can be found in the aforementioned sources and Lesser (2006a, 2008).

While the domains of ethics, equity, social justice, and service learning all are worthy in of themselves, they can also each serve as a vehicle to meet objectives of a standard statistics course. For example, ideas from philosophical ethics can motivate students to engage with concepts such as expected value, distributions, and methodology for collecting data from human participants. Equity ideas and equity data motivate students to engage with proportional reasoning, hypothesis testing, expected value, etc. Service learning, by its nature, goes beyond community service by involving a two-way exchange of benefits so that students make (and reflect deeply on) connections with content and application.

These domains have tremendous potential to motivate students and examples of emerging supporting evidence of this are cited in Lesser (2007a). Another reason why this area is too important to be viewed as marginal or optional is that students' concepts of fairness (shaped by their own sense of justice and ethics, of course) affect how they encounter standard content. Lesser (2008) discusses examples of student beliefs that may interfere with embracing the use of random selection of survey participants or with embracing the use of random assignment of experimental treatments.

2. Innovation

2.1 Population

The themes of this paper are quite relevant to the population of the author's university and surrounding community. The university is a mid-sized doctoral research intensive university on the US-México border. The university is located in a county that is one of the poorest counties in the United States and 10% of the university's students commute across the border from a high-poverty city in México. Many of the university's students are first-generation students – the first in their family ever to attend or graduate from college—and most teacher graduates will continue to live in the community when they begin their jobs.

The university's student population is 56% female, 60% full-time, 74% Hispanic. In fall 2007, the author taught two sections totaling 52 students and the percentage that was female was even higher (79%), which is not unusual for classes composed exclusively of preservice elementary and middle school teachers. In an anonymous post-survey of the students at the end of the course, 100% of the ($N = 43$) respondents said the class was a requirement, not an elective, and they reported that their interest in the subject prior to this course had been low: 9.3% said high, 27.9% said average, 53.5% said low, and 9.3% were unsure. Clearly, this is a population of students who do not arrive with a strong love for mathematics or statistics, but because they will be teaching so many students in future generations, it is extremely important to find a way to make the subject meaningful and motivating to them. The grant about to be described offered a vehicle to do this.

2.2 Project Action for Equity (ACE)

Project ACE (“Action for Equity”) is a \$885,000 four-year grant funded by the U.S. Department of Education's Women's Educational Equity Act program and its Principal Investigator is the Dean of the College of Education at the author's university. The author's involvement with this grant is associated with the latter half of the grant's four years (October 2005 – May 2009). The project included ten university faculty teaching in multiple departments redesigning a wide range of courses, including: bilingual/ESL education, mathematics, statistics, physical science, critical pedagogy, and multicultural education. Project ACE offered participating faculty multiple workshops, webinars, seminars, articles, and other opportunities for professional development on relevant issues, including the implementation of service learning, gender issues in the classroom, and gender/equity issues in the STEM (science, technology, engineering, and mathematics) fields. The grant's goals include the following:

- increase access to higher education for girls, women, and underrepresented minorities
- raise awareness about opportunities in STEM careers for young women
- engage future/current teachers in planning, implementation and evaluation of community service learning activities that will enhance educational equity and solve community problems

The first bullet is particularly important in light of the observation by NCTM (2000, p. 13) that “students who are not native speakers of English, students with disabilities, females, and many nonwhite students have traditionally been far more likely than their counterparts in other demographic groups to be the victims of low expectations.” Changing the culture of expectations is important in light of findings that show that any apparent gender achievement gaps are explained more by opportunity or culture than by ability (e.g., Begley 2008).

2.3 Description of the Revised Course

The introductory statistics course uses a statistics literacy approach, and the material covered includes chapters 1-11 and 16 of Utts (2005), which spans descriptive statistics, probability, line of fit, and critiquing statistics in the media. The syllabus is available via the author's homepage. The equity focus was supported by examples brought in by the instructor, by a webpage of resources the instructor launched and maintained (www.math.utep.edu/Faculty/lesser/equity.html), and by bringing in data that connected to the students' community (e.g., Romero & Yellen, 2004). This connected, active approach was reinforced by a pedagogy that went beyond lecture-only mode to include nontrivial frequency of collaborative learning (including quizzes and projects) and authentic assessment (the final project). Connections were also modeled to children's literature with books that included statistics about equity, such as Smith (2002).

To raise awareness about STEM careers, the instructor discussed his STEM work as statistician outside academia such as the second Writing Project of Chapter 6 of a major math-for-liberal-arts textbook (COMAP, 2009) and the "thinking like a statistician" described in Lesser (2006b). The instructor also modeled his work as a statistics education researcher by having students participate in a short study and then discuss the process of consent, design, and debriefing.

Because this course was for future teachers, connections were also made to national (e.g., ASA 2005, NCTM 2000, NCTM 2006) and state standards and state teacher certification tests. Also, the use of technology (TI-73/84+ graphing calculator, Excel spreadsheets, Internet applets and websites) and manipulatives (quincunx, spinners, dice, cards, coins, etc.) were modeled or facilitated and students had time in a lab where which they each had hands-on experience and training on Excel.

Instead of a final exam, there was a final project. So that students would not feel forced into any one endeavor such as service learning, and so that students would experience a greater investment by being able to choose a project most meaningful to them, three options were offered for the project. The options were intended to be roughly equivalent in terms of time involved (and students reported that this amount of time was more than they would have spent studying for an in-class written final exam!) and in terms of the length of the oral presentation and accompanying written paper.

One project option was a data collection and analysis, whose design and topic had to be approved by the instructor before data collection could begin. This requirement not only kept students from trying anything unrealistic or inappropriate, but also modeled for them the process of approval all researchers have to go through collecting data from human subjects. The investigation had to involve at least two categorical and at least two measurement variables. The paper, while not lengthy, required the usual sections of a research paper: background, methodology, results, discussion, limitations, references, etc. The design of this option was informed by literature such as Short and Pigeon (1998), Halvorsen and Moore (2005), and Roberts (1992). As preservice teachers, students were also asked to make connections with projects of students in the grade levels they would teach (e.g., <http://www.amstat.org/education/index.cfm?fuseaction=poster1>).

A second project option was a detailed, mostly-original lesson plan which uses data, models the research investigation process, and aligns with relevant state and national standards. The lesson also needs to state performance objectives, specific content misconceptions that may arise (and how they will be addressed), accommodations for learners at each level of the state's English language proficiency standards, accommodations for students with diverse learning styles or learning disabilities, assessment, etc.

A third project option was a 20-hour service learning experience, coordinated and documented by the university's Center for Civic Engagement (CCE), which has been facilitating engagement in service learning and related activities in the local community since 1998. The instructor met with CCE staff and identified the particular project (Junior Achievement) from ten available options that would most readily allow for connections with the course objectives. The CCE then provided orientation, training and preparation for students to make five presentations to a local public school classroom using or adapting materials supplied by Junior Achievement (<http://www.ja.org>). The student then needed to write a reflection paper on this important "early field experience." CCE had the following generic set of questions designed to facilitate ongoing reflection for all participating students:

- What did you enjoy most about that experience?
- What did you enjoy least about that experience?
- Did the experience today teach you something new about yourself? If so, what?
- What would you do or expect differently the next time you do this? Why?

The instructor, however, expanded the preceding four questions into the following set of more tailored questions to guide students' reflections after each day of the service learning experience:

- What did you experience today?
- What did you enjoy most about that experience and why?
- What did you enjoy least about that experience and why?
- Did the experience today teach you something new about yourself (e.g., as an underrepresented person, as a learner, as a future teacher, as a citizen, etc.)? If so, what?
- Did the experience today teach you something about how data or statistical thinking can relate to (or improve) the world or to the lives of people in this region? If so, what?
- Did the experience today teach you something about the way you may talk or teach about data when you are a classroom teacher? If so, what?
- What would you do or expect differently the next time you do this? Why?

Statistics about women's lives in their community (e.g., Romero and Yellen, 2004) provided a powerful vehicle to reflect upon issues of gender and gender equity while applying their emerging knowledge of statistical tools and concepts. Other examples of gender-related statistical explorations were found by searching for the word "gender" within www.causeweb.org/resources. One item that turned up from the search was a project (http://www.ssdan.net/chip/modules/new/rowell_gender.pdf) by Sinclair Community College sociology instructor Kathy Rowell in which students went through these steps:

- State independent and dependent variables
- State null and alternative hypotheses
- Make cross-tabulation from data to examine hypothesis
- Now, "control for education" (< HS, HS, some college, college degree)
- Now, "control for occupation" (blue collar jobs, service jobs, white collar jobs, etc.)
- What other factors might account for earning differences?
- How much of 'gender gap' in earnings appears to be due to gender discrimination?

Such explorations were given further grounding and relevance by looking at related articles that appeared in actual mass media. For example, a news blurb from the author's city's newspaper (April 24, 2007, p. 3A) cited a study by the American Association of University Women Educational Foundation that found that "Women make only 80% of the salaries their male peers do one year after college" and that "10 years after college, women earn only 69% of what men earn. Even after taking into account hours, occupation, parenthood and other factors known to affect earnings, the study found that one-quarter of the pay gap remains unexplained." Critical thinking about stories in the newspaper is already an embedded theme of the author's statistical literacy course (and chapter 2 of the textbook: Utts, 2005), so it was just a matter of making sure some of the news articles included a focus on gender equity.

Another gender equity topic example selected from the news media involved Title IX of the Education Amendments of 1972 (prohibiting sex-based discrimination in education programs receiving Federal funding), including a *USA Today* article (Upton 2007) about which data to use and an Associated Press (1997) report on a Supreme Court ruling of discrimination based on women being 51% of Brown University's 5,722 undergraduates, but only 38% of its 897 intercollegiate varsity athletes. That sentence is enough to generate a z-score of -7.8 (Lesser 2007). More details of how statistics were applied to such court cases are in Gray (1996).

The course (e.g., chapter 11 of the textbook) includes the situation of Simpson's paradox, which basically is the pitfall that the direction of a comparison can actually change when categories are combined. This pitfall is considered as essential to citizenship (NCED 2001) and can readily involve a gender context (e.g., Lesser, 2001), but is not well known and understood by the general public.

Students also had the opportunity to discuss how statistical language helps clarify certain concepts of discrimination. For example, consider the distinction between the bias/bigotry of an individual versus institutional/systemic discrimination. This is not unlike how the word bias in a statistics book may be discussed in terms of a “biased survey question” that a biased individual may write (e.g., Utts 2005, p. 38), versus a matter-of-fact description of a measurement process that consistently misestimates a parameter in the same direction (Utts 2005, p. 49). This, in turn, helps us distinguish between disparate treatment (treating similarly-situated people differently on the basis of gender) versus disparate impact (where a facially neutral criterion such as a ‘minimum height requirement’ would have a disparate impact on one gender). Then, we discuss some of the quantitative approaches that have been used (e.g., Gray 1996) to describe when there is disparate impact, including ‘inexorable zero’ (minimal or no presence of minority group), difference in percentages, the 4/5 rule (e.g., promoting 30% of the women and 40% of the men would be a violation because $30/40 < 4/5$) and statistical significance (e.g., when gender means or proportions differ by 2 or 3 standard deviations).

Another activity found at www.causeweb.org was a scenario posed by James J. Higgins (of Kansas State) in which a company will hire 14 people by choosing at random from a large pool with equal numbers of equally qualified men and women. Students are then asked how likely is hiring 7 men and 7 women, and what is the smallest deviation from this balance that would raise a red flag for discrimination? This, of course, is a great motivator for the binomial distribution. This can be then followed up with actual jury discrimination scenarios such as the juror selection in the 1969 federal trial in Boston of Dr. Benjamin Spock, in which a first-stage panel of 350 people had only 102 women (though 53% of the eligible jurors were women) and the next stage that selected 100 of these 350 people included only nine women. (e.g., <http://www.stat.ucla.edu/cases/>).

3. Results

In light of the low interest level students entered the class with (as mentioned in Section 2.1), it was especially gratifying that the majority of the students rated the instructor as “excellent” – the highest of the five rating categories in the anonymous end-of-semester course evaluations. The single most commonly mentioned feature of the course in the narrative section of the course evaluations was the project -- 21 students mentioned this, and all 21 comments were favorable.

While general student satisfaction is valuable, it is more important to ask what they have learned. Using the same Likert scale (with these four levels: very knowledgeable, knowledgeable, not very knowledgeable, no knowledge) as the overall Project ACE pre-test/post-test survey (on Project ACE goals, but not tailored to a particular course) designed by the external project evaluator, the instructor asked students to rate their level of knowledge (and provide an accompanying explanation for their rating) about using concepts and tools from mathematics/statistics to explore concepts of gender equity. Students were assured that the instructor would not see these surveys until the course was over and grades turned in. Over the duration of the course, the percentage of students who rated themselves knowledgeable or very knowledgeable about using concepts and tools from mathematics/statistics to explore concepts of gender equity rose from 27.8% to 91.7% (for the 36 matched pairs, 1-tailed $p = 1.64 \times 10^{-8}$). Next time, it would be interesting to have a more detailed breakdown of student confidence in their critical thinking and in the impact that persists one or two semesters after the course, in the spirit of Bower et al. (2007).

Given that the themes of the course were infused only occasionally (and are certainly not a dominant focus of the textbook, which has virtually no examples directly related to social justice or gender equity, with the possible minor exceptions of a p. 164 bar graph of what fraction of each gender is in the labor force, a p. 193 case study on gendered views on ideal weight, or a p.113 gender-based Oklahoma law on drinking), it was interesting to see how the themes emerged in their culminating projects. Roughly half (49.0%) of the students chose the data collection/analysis option, while roughly one-third (35.3%) chose the lesson plan, and the rest (15.7%) chose the service learning option. Possible explanations of why service learning was chosen less often are: (1) it required a commitment earlier in the semester to begin the orientation and training; (2) it was less flexible in terms of scheduling and transportation requirements than the other options; and (3) it was less familiar to the students. Support for the third interpretation includes the fact that at the meeting when final projects were presented, many students made comments to the effect of if

they had known how neat the service learning would be, they would have signed up for it. Roughly half of all the projects were related to at least one of the course themes, including all eight of the service learning projects, at least one of the lesson plans (“The Holocaust with a Statistical Approach”), and several of the data collection/analysis projects (“Gender Influences in Career Choices”, “Gender Equity in Engineering”, “Gender Bias in Education,” “Does Education Affect Your Political Interest”). This level of engagement with the theme would be even higher by taking into account projects whose main focus was something other than equity, but which made it a point to break down responses by gender.

During the scheduled final meeting time, students presented their projects for the whole class. An independent observation by a research associate yielded these comments (Vallès 2007): “frankly, I was impressed with what many of them knew how to do. I don’t remember my one and only STAT course being that fun or creative. Had it been, I probably would have pursued more course work in that area....Your students, mostly Hispanic females, have been introduced to a subject area that is generally one that is considered ‘difficult’ or ‘boring’ to some. You have taken the subject, as many of your students stated, and helped them to understand the importance of it and the need for it in our communities, moreover, you have assisted your students in coming to understand that, yes, they can do it!!....”

In addition to experiencing success in connecting with the basic statistics content of the course, several students also had powerful experiences in the classroom that reaffirmed their desire to want to become a teacher and, more generally, to serve. One student whose service learning work was in a kindergarten class had an “aha” moment when she noticed many of the students drawing the same animals and realized that she could spontaneously incorporate bar graphs into the lesson to display and discuss the choices students were making. This same student also said in her reflection paper: “Throughout this experience I learned a lot about myself and how much I so truly can’t wait to have my own classroom. If I had any doubts before about being a teacher I don’t have any anymore....This program taught me how important it is to work in my community and that is why I became a volunteer in the school. I don’t volunteer with this same class but I work with one of the special education classes and every time one of the students from this class sees me in the hallways, they always say ‘Hi teacher!’ and it just makes my day.”

4. Further Discussion

In light of other recent research, it may not be surprising that this redesigned course would have a strong impact on pre-service teachers, particularly those who chose the service learning option. In particular, Kirtman (2008) conducted a qualitative research study in which pre-service teachers taught math and science to at-risk upper elementary students and this yielded multiple sources of data involving the pre-service teachers: self-reflections, surveys, and class discussions. Because it was an after-school program, the teachers were not bound by their cooperating teacher’s curriculum and had the freedom to teach in a more innovative manner. Kirtman found that the reflection yielded by their service learning experience led to those pre-service teachers gaining more understanding and more confidence in their ability to teach students in an innovative and meaningful way that can lead to higher student achievement.

In the instructor’s own reflections about the project presentations, there was the perception of a culture of community in the class that was unusually strong “for a math class.” There was also a sense of pleasant surprise by how skilled and poised students were in making their presentations (usually accompanied by PowerPoint slides) and how even some of the students who were “quiet” throughout regular class meetings were able to express a great deal of critical thinking and meaningful insight and reflection. Therefore, in the next iteration of the course, the instructor made it a point to include more opportunities for student communication (e.g., mini-presentations and writing assignments) in addition to and well before the final project presentation. Such additional assignments, of course, can be natural vehicles to bring in an explicit reflection or focus on a gender equity matter where statistics is needed to understand or explore the issue.

There are many degrees possible for integration of gender equity with statistics. At one end of the spectrum is a regular statistics course with a couple of token datasets relevant to gender equity thrown in. At another end of the spectrum is a course where almost every single vehicle, writing assignment, and major example comes from gender equity with ample time set aside for discussion and “processing,” not

unlike the course described in Plank and DiPietro (2008). The course described here is obviously somewhere in between and there were many moments in which the author was keenly aware of the potential for further connections that time simply did not allow to be developed. For example, the university's Women's Resource Center sponsored an event (www.takebackthenight.org) which could have yielded an opportunity to examine statistics (e.g., <http://www.abanet.org/domviol/statistics.html>) and data-reporting issues involving domestic violence. On a more abstract level, the Utts (2005) textbook (especially the early chapters) encourages critical thinking about reported study results that reinforces the idea that, as Best (2002) says, statistics are “socially constructed,” and there are many parallels to the extent to which aspects of gender are socially constructed as well (e.g., Lorber 1994, Butler 1990). A further potential to tap is exploring what it means to take a feminist approach to STEM content (e.g., Burton 1995). It would also be interesting to see the difference between supplementing a textbook with outside examples (e.g., Lesser 2007) and using a textbook that is already more thematically focused on justice or equity issues (e.g., Frankfort-Nachmias & Leon-Guerrero, 2005). In any case, the author's own awareness and commitment involving gender issues was certainly increased by Project ACE and even led to his being appointed as an Advisory Board member of his university's Women's Studies Program.

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