Critical Values and Transforming Data: Teaching Statistics with Social Justice

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Abstract

Despite the dearth of literature specifically on teaching statistics using social justice, there is precedent in the more general realm of teaching using social justice, or even in teaching mathematics using social justice. This article offers an overview of content examples, resources, and references that can be used in the specific area of statistics education. Philosophical and pedagogical references are given, definitional issues are discussed, potential implementation challenges are addressed, and a substantial bibliography of print and electronic resources is provided.

1. Introduction

With a teacher's skillful facilitation, some datasets engage and may even transform student understanding of statistical methods or reasoning. For example, a student who encounters the famous dataset quartet of Anscombe (1973) (also in Sowey 2001) might never again choose to run a regression without first looking at a scatterplot. In a parallel spirit, some datasets from the real world may have the power to effect a lasting appreciation of or even commitment to statistics as a tool to help understand (and maybe improve) some of our society's most profound or pressing matters.

A source of such datasets that has not been fully tapped is social justice. Social justice is not a monolithic concept in theory or in practice, and trying to state and stick to a single definition with mathematics-like precision can be problematic. In his thoughtful discussion on this matter, Novak (2000, p. 11) states that the term dates back to 1840 and that "whole books and treatises have been written about social justice without ever offering a definition of it." For purposes of this paper, however, we start with the Wikipedia (2006) definition that social justice is a "philosophical definition of justice, that is, giving individuals or groups their due within society as a whole." This paper assumes this includes the idea that all people are entitled to basic human needs (e.g., adequate food, water, sanitation, shelter, health care). It will also be assumed that this includes the notion that all people deserve an equal opportunity to succeed, though this criterion is arguably harder to define or measure than the "basic needs" criterion.

This definition of social justice, however, does not necessarily require or guarantee equal outcomes. This is not a trivial distinction in light of education scholars (e.g., Allexsaht-Snider and Hart 2001; Martin 2003) who consider equity to require not just equal access and opportunity, but also equal outcomes. From the point of view of statistics, however, it seems problematic to use the phrase "equal outcomes"

without addressing issues such as how possible confounding variables may be taken into account and what thresholds or tests of statistical significance might be applied to observed deviations from equality. Other ideas that are also not automatically included in our definition (but could be explored in some types of courses) are the imposition of a significant redistribution (e.g., through various forms of taxation) of resources and specific ideas about "correcting" historical inequalities. This paper's less restrictive definition is chosen so that a broader set of educators might feel comfortable participating in this realm.

Karl Pearson called statistics "the grammar of science" (in the title of his 1892 book), but perhaps statistics could also be known as the "grammar of social justice." Tools to identify statistical group differences or patterns can help people recognize, analyze or address social inequalities. Knowing how to calculate the expected value of a "fair share" and how much statistical deviation from that might be tolerated as innocuous can offer people a benchmark in their discussions about what is "fair." And an awareness of statistical pitfalls can help people interpret or produce appropriate depictions of quantitative information.

There has recently been significant increasing interest in how statistics can better society. One of the six parts of the Mission Statement of the American Statistical Association is "Using Our Discipline to Enhance Human Welfare," which was also the theme of the 2005 Joint Statistical Meetings. Pollack and Wunderlich (2005) give the table in Appendix 1 and also detail efforts by the Committee on National Statistics' Panel on Methods for Assessing Discrimination (www.nap.edu/catalog/10887.html) to measure the outcome disparities many racial and ethnic groups in the United States continue to face in areas such as employment, income and wealth, housing, education, criminal justice, and health care. For length considerations, this article concentrates on social justice, but readers wanting some discussion of relationships between social justice and the domains of ethics and service learning may consult Lesser (2006a).

One of the first uses of the term "social justice" in statistics education occurred when Kahneman and Tversky (1982, p. 496) tested the conjunction fallacy. In their well-known experiment, 85% of the subjects ranked "Linda is a bank teller and is active in the feminist movement" as more probable than "Linda is a bank teller," given the following description: "Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student she was deeply concerned with issues of discrimination and social justice and also participated in anti-nuclear demonstrations." And perhaps this article will offer readers an opportunity to reflect upon any associations they may have about what "type" of person might or can teach statistics using social justice.

2. Teaching Statistics Using Social Justice

2.1 Scope and Aims of TSSJ

One way to move towards understanding "teaching statistics using social justice" (TSSJ) is mentally to substitute 'statistics' for 'mathematics' in the explanation of Gutstein (2003, p. 45) that

> "reading the world [in the sense of Freire] with mathematics means to use mathematics to understand relations of power, resource inequities, and disparate opportunities between different social groups and to understand explicit discrimination based on race, class, gender, language, and other differences. Further, it means to dissect and deconstruct media and other forms of representation and to use mathematics to examine these various phenomena both in one's immediate life and in the broader social world and to identify relationships and make connections between them."

Because statistics are numbers with context, the deconstruction of media should come even more readily in TSSJ, and may even be viewed as a second meaning of the book title *Seeing Through Statistics* (Utts 2005). TSSJ would also include students developing a sense of empowerment to be able to use statistics to "talk back" to or change the world.

We will define TSSJ as the teaching of statistics with nontrivial inclusion of examples related to (our previously defined version of) social justice, offering opportunities for students to reflect upon the context of these examples as they learn or apply the associated statistical content.

Analogous to the six pedagogical levels Anderson and Sungur (2002) articulate for enhancing an introductory statistics course by a "community awareness component," there are obviously various degrees of TSSJ that are possible. At the most basic level, students can be given predetermined datasets and asked to use predetermined statistical methods to analyze them. At further levels are courses which give students more and more opportunity to discuss the context, choose the social justice topic(s), and find (or even collect) the data. An instructor can choose her place on this continuum based on backgrounds, interests, available time, and the balance of goals for the particular course.

TSSJ can be viewed as a way of teaching statistics that includes the conceptual and computational proficiency goals recommended by most leading statistics educators, but also has a critical perspective that incorporates and facilitates awareness of issues of social justice and prepares students not only to be competitive workers in the economy but also engaged participants in a democracy, able to be critically reflective about the role statistics has played and can play in our society. In other words, statistics must be seen not merely as useful (for working, shopping, etc.) but also as a tool to help effect social change in the world.

TSSJ includes the course called for by the ASA (2005) in the sense that the critical thinking (in the sense of higher-order thinking, using the full span of the taxonomy of Bloom (1956)) and a fervent statistical literacy (e.g., Schield 2005a) any good course should provide is absolutely necessary for TSSJ to build upon. TSSJ can also go beyond it because, as Skovsmose (1994b, p. 58) puts it: "Democratic competencies concern evaluation and criticism of actions and proposals, and it is not obvious that an accumulation of mathematical knowledge would add up to some ethical competence." In ASA (2005), the section "Goals for Students in an Introductory Course: What it Means to be Statistically Educated" describes statistics audiences as some blend of producers and consumers. A TSSJ orientation would include viewing audiences as democratic citizens/participants, and include the additional goals of increasing student awareness of social justice issues (e.g., through datasets examined) and increasing ability to evaluate or even promote social change.

Let us examine the nature of TSSJ in very practical terms – such as the actual questions a teacher would make sure are addressed when facing a statistics media clipping or dataset. Viewing TSSJ as an augmented form of a statistical literacy course means that the questions should start with, or at least include, the seven critical components from Utts (2005, pp. 18-21): the research/funding source, the researchers who had contact with the participants, the individuals/objects studied and how they were selected, the nature of the measurements made and the setting, other differences in the groups being compared, and the size of any claimed effects. The TSSJ list, however, might also include questions such as:

1. From this particular collection, representation, or publication of data, who appears to benefit and who appears to suffer? Whose values may be implicitly represented or excluded?

2. Does this data or exploration offer a vehicle or tool that could be used to help understand or improve social conditions in our present world? (Classes may find it useful to discuss what meaning(s) they will give to "improve," of course.)

2.2 Background Literature Connections

The literature of teaching using social justice has virtually nothing specific to statistics alone, but for mathematics, there is a small, fast-growing body of work (e.g., Gutstein 2003, 2006a; Gutstein and Peterson 2005; Gau 2005), national workshop presentations (e.g., Lesser 2006c; Gray 2006), and conferences (e.g., www.radicalmath.org/conference/ and ww2.lafayette.edu/~math/Rob/MathOfSJ/). Because this article's focus is the teaching of statistics using social justice, there is no space to repeat the review of the literature of teaching mathematics for social justice. However, interested readers could start with the aforementioned work by Gutstein and later read the sources that inform his work: what Frankenstein (1983, 1989, 1997, 2005) calls 'criticalmathematics,' the ethnomathematics of D'Ambrosio (1985), the critical mathematics education philosophy of Skovsmose (1994a, 1994b), and the liberation pedagogy of Freire (1992, 1987). For that matter, readers interested in more general literature and resources on teaching using social justice may also want to consult Ayers (1998), Lee, Menkart, and Ogazawa-Rey (1998), Oakes and Lipton (2003), Bigelow, Christensen, Karp, Miner, and Peterson (1994), Bigelow, Harvey, Karp, and Miller (2001), Barton (2003), Darling-Hammond, French, and García-Lopez (2002), and the resources in the Related Websites section at the end of this article.

While space does not permit a full discussion of this, it should be briefly noted that "critical" has different meanings in different contexts. Specifically, the term critical thinking is perhaps commonly viewed as a synonym for higher-order thinking (i.e., the highest levels of the taxonomy of Bloom (1956)) or a functional or workplace literacy. However, humanities or education professors who refer to a critical approach may be invoking "critical theory" perspectives from sociology or philosophy, which includes sociocultural analysis and critique of whose interests are served, and with interests in liberation and creation of a more just world (e.g., Skovsmose (1985), Lesser and Blake (2006)). As an aside, there is a doctoral program in the field of critical pedagogy offered by the University of St. Thomas (in Minneapolis, MN). Any given instructor can have statistical literacy without having this type of critical literacy and vice-versa.

3. Specific Content Topic Examples

As points of departure, the examples in this section are intended to illustrate topics from the major areas of an introductory statistics course that can be naturally connected to social justice and references are provided for further examples. The nature of social justice is that it is perhaps more meaningful and lasting when teachers and students also seek out and discover their own examples that speak the best to their locality and lives in the present day. The author invites *JSE* readers to relay any new examples they create as well as the results of trying out this article's examples.

3.1 Operational Definitions

A key part of TSSJ is getting students to ask critical questions about operational definitions of variables, and to reflect upon whose interests the definition in use may serve. Questions that can be vehicles for this include "who counts as unemployed?" (e.g., the activity on p. 23 of Frankenstein 2005), "how should the Census be conducted?" (e.g., Utts 2005, p. 494), "how is poverty (or the poverty line) defined?" (e.g., Iceland 2005), "how is homelessness defined?" and "how is ethnicity defined?" (e.g., Evinger 1995).

The difficulty of constructing definitions has serious consequences. For example, Pollack and Wunderlich (2005, p. 45) report that "federal racial categories are not always consistent with scholarly concepts of race or with concepts held by individuals and groups, leading to difficulties in obtaining data that are comparable over time and across different surveys." This lack of consensus extends to methods of measurement as well:

> "no single approach to measuring racial discrimination allows researchers to address all the important measurement issues or to answer all of the questions of interest. In particular, it can be difficult with a single method to convincingly address the key counterfactual question –whether an observed adverse outcome for an individual (or group) would have been different had the individual (or group) been of a different race." (ibid, p. 46).

On a related note, classes can discuss quantitative indices of diversity that have appeared in the media (e.g., the *USA Today* diversity index in CHANCE News 2001) and in textbooks (e.g., the Index of Qualitative Variation in Frankfort-Nachmias and Leon-Guerrero (2000)).

Another example is "how is economic progress defined?." Steele (2005) contrasts the traditional measure of U.S. economic success (the gross domestic product, GDP) with an alternative measure called the Genuine Progress Indicator (see www.rprogress.org) that takes into account the value of factors such as pollution and unpaid childcare. Anderson and Gerber (2004) provide further perspectives. Any of these questions of definitions could be a vehicle for a rich classroom exploration or student project.

3.2 Descriptive Statistics: Choosing a Measure of Location

Average class size and "student-teacher ratio" are hot topics these days for educational institutions. Elementary and secondary schools try to meet new legislative mandates for class sizes, and research has been conducted on the effectiveness of various class sizes, such as the large-scale randomized experiment known as the STAR Project (e.g. Finn, Gerber, Achilles, and Boyd-Zaharias (2001);

www.heros-inc.org/star.htm) conducted by the state of Tennessee in the 1980s.

I have classes of university introductory statistics students form 4-person groups to discuss this simplified scenario: "In a (very small) university, each student takes one of 3 classes. The class enrollments are 3, 9, and 18. Discuss with your teammates what you would say is the 'average class size' at this school." Most groups offer the mean (10), and a few groups that recall that "average" could refer to mean or median go on to give the median (9) as well. I say, "Okay, suppose we agree on the mean -- is there more than one mean possible?" Students generally do not venture further ideas at this point. I imagine that someone with an enriched math background might respond that there are means other than the arithmetic mean (e.g., geometric, harmonic), but this hasn't happened yet.

At this point, I say, "suppose I interview each of the 30 students and ask 'how big is your class?' and then find the mean of those 30 answers -- do I get 10?" It is here that students realize for the first time that there was an unstated assumption about what unit is being averaged over. They now can articulate that they had computed their mean on a per-class basis, and that I was now leading them to realize they could have chosen to average on a per-student basis. (As an aside, it has been shown mathematically that the per-class-mean never exceeds the per-student-mean (Hemenway 1982)). Students verify that on a per-student basis, the mean is 13.8, and the median (and mode, for that matter) is 18.

While most aspects of this example thus far might be viewed as what any introductory statistics course might already include, a TSSJ approach would make sure the discussion would go beyond the general observation that measures of location for the same dataset can differ and also include reflection about why the measures might be chosen in particular ways. If a college student thought about the average class size numbers in the promotional literature she may have seen from colleges during her senior year of high school, she may see this as a consumer issue. But class size can also be an equity issue if smaller classes yield higher achievement, if minorities are more likely to end up in larger classes, and if achievement gaps can be reduced more rapidly by putting underperforming minorities in smaller classes (Nye, Hedges and Konstantopoulos (2004); Finn, et. al (2001)).

3.3 Descriptive Statistics: Graphical Summaries

Instead of scatterplots limited to well-worn consumer topics such as how flight ticket prices depend on mileage, a teacher could go (as did Gutstein (2002) with middle school students) to the College Board or FairTest websites (www.collegeboard.com; www.fairtest.org) and try to understand the (highly positive) association between mean SAT scores and family annual income. Here is more recent data from College Board (2006), with the top row giving the income bracket in thousands of dollars:

Income Bracket (in $1000s)	**0 - 10**	**10 - 20**	**20 - 30**	**30 - 40**	**40 - 50**	**50 - 60**	**60 - 70**	**70 - 80**	**80 - 100**	**100+**
Math	457	465	474	488	501	509	515	521	534	564
Verbal (Critical Reading)	429	445	462	478	493	500	505	511	523	549
Writing (section added in 2006)	427	440	454	470	483	490	496	502	514	543

Using an earlier year's data for family income and verbal SAT scores, Moore and McCabe (1989, p. 245) ask students to draw the median trace for a scatterplot.

The extent to which money may be related to education and equity issues can be explored in other ways as well. For example, mainstream media (e.g., Grissom 2005) often report how school districts with higher statewide accountability rankings tend to spend more instructional money per pupil and tend to have lower percentages of economically disadvantaged and limited English proficient students. Related issues were recently explored by Chambers, Levin, and Parrish (2006). And Spencer (2005) reports how low-income schools are less likely to have qualified teachers. On the other hand, classes may also encounter some work (e.g., Pincus and Rolph 1986; Guber 1999) that suggests that the relationship

between money spent and student standardized test score outcomes is weaker than may have been assumed.

The topic of resource distribution is important, but is not as clear-cut a topic for our definition of social justice. This is because most people would not demand or expect every single person or nation (or worker within a company) to have equal income/wealth, and yet there is no consensus on how much deviation from equality can still seem "fair." Also, on a governmental level, it is difficult to obtain consensus on how much of a nation's budget should be spent on defense, education, social services, etc. That said, students usually find it interesting and informative to construct summaries such as pie charts as a way to learn about graphing as well as about the status quo of how things are presently distributed. In other words, this topic could be implemented without controversy with the topic of descriptive statistics rather than testing particular hypotheses, and examples of explorations appear in Appendix 2 for those interested.

3.4 Expected Value

Just like any consumer product such as an extended warranty on a washing machine, health insurance premiums can be expected to cost the customer money on average (or it wouldn't be profitable for companies to offer the insurance). However, it seems health insurance is something the consumer would be much more willing (compared to an extended warranty) to buy if she can. When students are asked to discuss why this is, they will likely agree that a "worst case" scenario for health is far more severe (in human and in financial terms) than for an appliance. This is, of course, a perfect moment to make an explicit social justice connection by asking students to track down what proportion of Americans do not have health insurance. From DeNavas-Walt, Proctor, and Lee (2006), we see that 15.9% of all Americans have no health insurance and there are higher uninsured rates for certain minority groups (e.g., 32.7% of Hispanic Americans have no health insurance). On a related note, the textbook of Frankfort-Nachmias and Leon-Guerrero (2000, p. 526) offers a dataset from the 1996 General Social Survey to apply a chi-square test that shows that the condition of one's health is not independent from one's socioeconomic class.

Finally, students can apply expected value to the lottery. First students can verify that the expected winnings from a $1 ticket are generally about 50 cents. They can discuss whether it is appropriate to criticize someone for buying a lottery ticket when it is perfectly respectable to pay for other things that "lose money on average" (e.g., warranties, insurance). Students could be asked if their position would be affected by how many lottery tickets someone buys. Another critical question would be to have students investigate how revenue from a state's lottery actually correlates with how much that state budgets for education (Rubel 2005). Also, considering that social justice advocates often make critical claims that state-run lotteries make most of their money from the poor and/or less mathematically educated, there is also arguably a broad sense of activism or consciousness-raising behind efforts (e.g., Lesser 1997, 2003, 2004) to make sure teachers (and hopefully therefore their students) will be empowered to have more intuition for the probabilities and make more informed choices about whether or how to play the lottery.

3.5 Probability and Inferential Statistics

A powerful example of social justice that has been in the news recently (e.g., McAplin 2000) is use (e.g., by police) of racial profiling. McClave and Sincich (2000, p. 136) include a multi-part exercise that allows students to conclude that African-Americans were indeed "stopped more often for speeding than expected on this stretch of turnpike," based on these observations reported by *The Washington Post*: "14% of the drivers on this stretch of highway were African-Americans; 98% of the drivers were exceeding the speed limit by at least 5 mph (and, thus, subject to being stopped by the state police); of these violators, 15% of the drivers were African Americans; of the drivers stopped for speeding by the NJ state police, 35% were African American." Terrin and Kadane (1998) give a detailed accessible explanation of the statistical methodology. A classroom group project on this topic appears in Gutstein and Peterson (2005, pp. 16-18) and at www.teachersforjustice.org/c-lessons/S-math.html. While raising awareness about racial profiling itself, Gutstein's lesson is also a vehicle for students to learn how to analyze data collected from a probability simulation, how to set up their own simulation, and to examine the relationship between theoretical probabilities and empirical data. Wild and Seber (2000, pp. 301-303) use racial profiling to illustrate the standard error of a difference between proportions.

Another powerful current topic in social justice is the death penalty. Lesser and Nordenhaug (2004) explored with university students how probability might be used to assess the likelihood that no person has ever been falsely executed by United States civil authority. Students can also discuss the use of probability underlying the DNA techniques that have exonerated hundreds of people on death row. A more explicit social justice angle of fairness is to explore what roles the race of the defendant or of the murder victim play in whether the defendant is sentenced to death. Classes can track down primary source data (e.g., Radelet 1981) or, if time is limited, work through a textbook exercise (e.g., Moore and McCabe 1989, pp. 232-233), whose three-way table classifies 326 actual murder cases by the victim's race, the defendant's race, and whether the defendant was sentenced to death. By aggregating this into a two-way table, students can verify and try to explain why "A higher percent of white defendants are sentenced to death overall, but for both black and white victims a higher percent of black defendants are sentenced to death." (It's worth noting that awareness that a comparison can be an artifact of how data is aggregated is listed by NCED (2001) as essential for democracy, and would therefore be important to include in a TSSJ course.)

Did White Defendant Receive Death Penalty?	Yes	No	**Did Black Defendant Receive Death Penalty?**	Yes	No
White Murder Victim	19	132	White Murder Victim	11	52
Black Murder Victim	0	9	Black Murder Victim	6	97

For another example, Gutstein (2003) adapted a scenario on the mathematics of random drug testing from the Interactive Mathematics Program (IMP), a four-year integrated problem-based NSF-supported curriculum designated as "exemplary" by the U.S. Department of Education. Gutstein's middle school students used simulation to explore the probability that a student chosen randomly (from a school with a small percentage of drug users) who tested positive (with school administrators using a very accurate test) actually were using drugs. Lyublinskaya (2005, p. 537) conducted a mathematically-rich classroom exploration of this topic and found all of her students very engaged "because of its social aspects." It can also be discussed how statistics can assess whether "random" drug testing includes a disproportionately high percentage of minorities.

Another example is the use of statistics (e.g., the binomial model) in jury discrimination court cases, such as actual cases in the southern United States discussed in Gastwirth (1988) or a "composite" scenario in Gonick and Smith (1993, pp. 138-139): "50% of eligible citizens were African-American. On an 80-person panel of potential jurors, only four were African-American. Could this be the result of pure chance?" Gastwirth (1988) discusses the binomial model in employment opportunity cases as well, and this context has appeared in textbook exercises (e.g., Bock, Velleman, De Veaux 2007, p. 268).

Individual stories of social justice in the media can be a source of classroom calculations the next day. For example, the Associated Press (1997) reported on a Supreme Court ruling of discrimination based on 51% of Brown University's 5,722 undergraduate students being women, but only 38% of the school's 897 intercollegiate varsity athletes being women. From just this reported information, students can readily compute the value of the test statistic $z = \frac{.38 - .51}{\sqrt{.51(1-.51)/897}} = -7.8$. Classes wanting more details of how statistics were applied to this and related court cases may consult Gray (1996). Meyer (2002) discusses the statistics involved in the significant racial discrepancies reported by the media in proportions of uncounted votes in Georgia for the 2000 Presidential election. When Kitchen (1999, p. 321) asked his pre-service high school teachers to look at each day's local newspaper over a two-month period to examine what types of articles incorporate statistics, they found the most common theme in the articles was race or ethnicity (a frequent component of social justice explorations) and that "the more relevant that the data were to the students, the more willing that they were to analyze the data" (p. 321).

4. Identifying Datasets for TSSJ

Because much of a basic TSSJ can be launched by the datasets students summarize or analyze, it is

important to be able to identify and gather examples, and this is indeed one of this article's primary goals. Most of the examples in this article come from daily newspapers or mainstream statistics textbooks on the author's shelf (e.g., Moore and McCabe 1989; McClave and Sincich 2000; Wild and Seber 2000). An example of a social sciences statistics textbook with a sustained focus on social issues for its examples is Frankfort-Nachmias and Leon-Guerrero (2005).

Other datasets can come from major online repositories in statistics education. For example, in the *Journal of Statistics Education* Data Archive (www.amstat.org/publications/jse/jse_data_archive.html), datasets that could be used for TSSJ include: "Simpson's Paradox: An Example from a Longitudinal Study in South Africa," "The Statistics of Poverty and Inequality," and "Getting What You Pay For: The Debate Over Equity in Public School Expenditures." From the CHANCE Project Datasets (www.dartmouth.edu/%7Echance/teaching_aids/data.html), we could use "Human Development Report." And in the Dataset and Story Library (lib.stat.cmu.edu/DASL/), datasets that could be used for TSSJ include: "Refusals in Mortgage Lending," "Wages and Hours," and "US Crime."

In addition to finding social justice examples from statistics sites, teachers may also find statistics examples from social justice education sites, most notably www.radicalmath.org, which has student and teacher versions of statistics curriculum units. Other sites include www.tolerance.org/teach/activities/ and www.teachersforjustice.org/database.html.

This focus on social justice ideas can also apply to the choice of data that students collect themselves. For example, students could sample advertisements from Saturday morning children's television to estimate what percentage is for not-so-healthy products such as high-sugar foods. Peterson (2005, p. 139) notes that these kinds of advertisements are against the law in Sweden, and offers several followup questions for discussion.

Instructors needing suggestions for periodicals likely to include social justice examples might find useful suggestions from colleagues, Burant (2004), or Gutstein and Peterson (2005). The latter offers an annotated bibliography of print and electronic resources and organizations, and many can be used in a statistics course.

On a further note, Kenschaft (2002) has written a liberal arts mathematics textbook with a sustained focus on global survival issues. Six of its nine chapters overlap with material in an introductory statistics course. While most of its focus is on the environment, there are examples that have a more explicit social justice connection, such as inequalities in CEO/worker wages and inequalities in life expectancy. Also, it should be noted that environmental issues may at times be social justice issues. "Environmental racism" is said to occur when race is the most significant variable associated with the location of commercial hazardous waste sites, etc. Miller (2005) gives an activity to explore this using the U.S. Environmental Protection Agency website: www.epa.gov/enviro/wme.

5. Benefits and Emerging Supporting Evidence

Finding what motivates students is an important challenge in statistics education. As stated in the College Guidelines for Assessment and Instruction in Statistics Education (ASA 2005, pp. 2-3): "Most take statistics earlier in their lives, increasingly often in high school; few are drawn to statistics by immediate practical need; and there is great variety in their levels of quantitative sophistication. As a result, today's teachers face challenges of motivation and exposition that are substantially greater than those of a half-century ago."

In TSSJ classrooms, students are analyzing real data on issues that may be more likely to have immediate relevance and importance to their lives than most textbook scenarios. The author conjectures that students are unlikely to leave a TSSJ course viewing statistics as a disconnected collection of theorems and plug-and-chug recipes. As Rouncefield (1995) asserts, "[S]tudents can ask real questions about real-life situations. These in turn raise ethical and moral questions, which motivate students' learning, making the subject matter more relevant and interesting." Students may feel profoundly empowered by gaining the ability to draft a petition or letter that includes statistical analysis/reasoning on a social justice issue that they deem relevant to their own lives or neighborhoods, whether or not they actually send such a letter to a public official or newspaper editor. Tate (2005) reports about a predominantly African-American

middle-school class that used data to make an argument to get their city government to address the high concentration of liquor stores in their neighborhood.

There is an emerging body of evidence that suggests that social justice examples support student engagement. Gutstein (2003) informally found far more student engagement when his middle-school students made a scatterplot of SAT scores and family income than when they made a (much more conventional "real-world") scatterplot of heights of children and same-sex parent. A randomized experiment conducted by Lesser (2006b) showed that college introductory statistics students (N = 160) on the first day of class rated an example with this social justice context (SAT and family income) significantly (p-value = .05) more interesting than one with a conventional consumer paradigm (house price and family income). The interpretation of this particular quantitative finding from "Likert" scale data was supported by qualitative analysis of narrative data collected at the same time in which students gave written explanations for their ratings. After several passes through a subset of the data, twelve categories emerged to use for coding the narrative responses. After classifying each student response with one or more of these categories, the author then had a mathematics education colleague independently (after discussing the definitions of the coding categories) do the same to ensure the reliability of the coding. There was 92% agreement between the two independent codings. However, it will take further investigation to see whether and how this result extends to a larger set of social justice examples. Makar (2004) investigated a course for preservice teachers designed to develop understanding of equity through data-based statistical inquiry. Makar found a significant correlation between prospective teachers' degree of engagement with their topic of inquiry and the depth of statistical evidence they used, particularly for minority students.

6. Implementation Considerations

6.1 Time

One can argue that the same statistics topics can still be covered, but just with some substitutions in the datasets used. If entire statistics courses can be taught using examples from baseball (Albert 2003) or playing cards (Knapp 1996), then it does not seem unreasonable to consider that social justice could serve as a worthy theme or vehicle. Presumably instructors are already in the habit of spending at least some amount of time discussing the context of a dataset (statistics are "numbers with a context," reminds Moore 1992, p. 15) before jumping into computations -- whether or not the dataset had anything to do with social justice. For instructors using or moving to a more reform way of teaching anyway (e.g., ASA (2005) recommendations such as statistical literacy, real data, technology, conceptual understanding, active learning, group work, student-centered discussion, higher-order/conceptual thinking, projects, writing assignments, etc.), social justice could be a natural, community-building vehicle for this. Instructors wishing to incorporate deeper engagement with the social justice issues themselves will need to think very carefully about how to do this without unduly sacrificing class contact hours devoted to coverage of statistics topics. Such challenges, however, are not at all unique to TSSJ and are currently being addressed in various ways by, for example, instructors incorporating service learning (see Hadlock 2005). And, on a positive note, something done even just in a small dose can still be the thing that is most memorable or transformative from a course.

6.2 Working in Environments without Precedent for TSSJ

An educator in sympathy with the aims of teaching using social justice may be concerned about being perceived as unduly radical, political or off-task by supervisors or students. These concerns may be allayed by using one or more of these strategies:

1. Make TSSJ assignments optional (at least initially) or simply one of several options for a required project or paper.

2. Explain how the course supports ASA (2005) recommendations and your institution's policies (e.g., most institutions already have statements or policies opposing sexism and racism, supporting multiculturalism and character education, etc.), and cite some of the emerging evidence (see Section 5) of student interest and engagement.

3. Use a variety of datasets from mainstream mass media, textbooks, or government publications/websites.

4. Use less loaded language: the word "inequality" is more matter-of-fact and less emotionally-loaded than "inequity" (even though the latter can be a secondary meaning of the former); likewise, referring to an "underrepresented group" is more matter-of-fact than referring to an "oppressed and marginalized group." Instructors may even find that examples are more smoothly received if they use words such as "equity" or "ethics" rather than "social justice." People who consider themselves well-meaning and well-informed may not always agree on when something is "sexist" or "racist," but should be able at least to agree on whether things are "equal" or "proportional." As a comment from Vatter (2006) suggests, it is possible that well-intentioned advocates for social justice may unintentionally limit their audience by using language targeted to those "who already share that perspective." Just as our statistics knowledge may be received more effectively by students when we "pull back" a bit from a mode of lecture and give them an active role in uncovering the material, it may be the case that questions of social justice are more inviting when we err on the side of understatement in our language and allow students the opportunity to uncover or declare instances of apparent injustice themselves.

5. Communicate that statistics faculty and students need not have a particular ideology to explore data relevant to questions of social justice. Philosophically speaking, Novak (2000, p. 13) asserts that the virtue of social justice is "ideologically neutral. It is as open to people on the left as on the right or in the center." Those who might be quick to dismiss social justice as not being a sufficiently neutral topic may wish to reflect upon the question asked by Long Island University Professor Kesson: "Why is there an assumption that people who wish to bring real world social justice issues into the math curriculum are any more 'ideological' than teachers who teach from a math textbook in which the word problems feature product placement for Nike shoes, Barbie dolls, or Cocoa Frosted flakes? Both approaches claim that their goal is 'relevance'. While the former might actually get students to think about housing patterns or the incidence of asthma in their neighborhoods, the other seems geared to encourage mindless consumption. Now isn't that just a tad ideological?" Kesson (2007).

   In any case, once students gain tools of statistical reasoning from any collection of examples, nothing can stop them from applying them to any topic they encounter or seek. Sociologist Joel Best (2002, p. 5), in discussing some criticism he received for including in his book *Damned Lies and Statistics* some examples of bad statistics used by feminists, notes that "once you give your students a set of critical tools to evaluate statistics, the sad thing is they are not going to apply those tools only to the statistics that are produced by the tobacco industry; they're going to notice when other people, people that you may like, produce bad statistics." Best (2001, p. B7) maintains that "bad statistics come from conservatives on the political right and liberals on the left, from wealthy corporations and powerful government agencies, and from advocates of the poor and the powerless."

6. Form an informal network within your institution – perhaps others will try some of the ideas as well, so then you won't be the "only one." Also, it can be very helpful to attend conferences and workshops on this topic and the networking and dialogue can continue even afterwards (e.g., mathofsj.blogspot.com/).

6.3 Detachment

There sometimes appears to be an assumption or perception that a teacher of statistics must maintain a certain kind of detachment that goes beyond the demarcation of Lee (2006). It may be hard to visualize many statisticians at the front of a classroom saying anything as strong or stronger than Pollack and Wunderlich (2005, p. 45): "Although many factors may contribute to such disparities [in outcomes among racial and ethnic groups, with respect to employment, housing, education, criminal justice, health, etc.], their size and extent suggest that various forms of discriminatory treatment persist in U.S. society." However, Rouncefield (1995) declares: "Just as the teacher of history or literature would not avoid moral issues in her lessons, the statistics teacher likewise should not avoid them." After all, if "[statistics'] real contribution to society is primarily moral, not technical" (Vardeman and Morris (2003, p. 21)), then this could arguably apply to the teaching of statistics as well.

Bigelow and Peterson (2002, p. 5) make an important distinction that may inform one's perspective in those moments when social justice matters arise in a statistics class:

> "The teacher who takes pride in never revealing his or her 'opinions' to students models for them moral apathy…. We would never urge that teachers shelter their students from views that they find repugnant. Indeed, the way to develop critical global literacy is only through direct engagement with diverse ideas. Nor is it ever appropriate for teachers to hand students worked-out opinions without equipping students to develop their own analyses of important issues…. We see a distinct difference between a biased curriculum and a *partisan* one [emphasis added]. Teaching is biased when it ignores multiple perspectives and does not allow interrogation of its own assumptions and propositions. Partisan teaching, on the other hand, invites diversity of opinion, but does not lose sight of the aim of the curriculum: to alert students to global injustice, to seek explanations, and to encourage activism."

To identify a way that has the best chance of efficiently getting all sides of an issue to be drawn out by the students themselves, it may be worth exploring the use of the pedagogical technique called guided controversy (e.g. Dresner and Blatner 2006), in which students are randomly assigned to play roles of various stakeholder groups when they write or discuss a scenario.

A different type of detachment in academic settings occurs when faculty in multiple departments separately assume they may delegate teaching critical thinking, social justice, or any other interdisciplinary theme or skill to some unidentified "other department." The result of this, of course, is often that no one does it. This abdication is particularly unfortunate in light of the fact that education itself is one of the focus areas of social justice. The landmark first Standards document of NCTM (1989, p. 4) asserts "The social injustices of past schooling practices can no longer be tolerated." For example, public schools in heavily-minority neighborhoods appear to be less likely to have teachers who are highly qualified or certified in the subject they are assigned to teach (Peske and Haycock 2006; Spencer 2005; King 2006).

The very skills of data analysis, data interpretation, and questioning of assumptions that statisticians teach make them as strong a candidate as any to take significant ownership or leadership in this area. Statistics teachers can play an important role in reconciling seemingly contradictory statistics that can occur even if both sources appear to be honest and competent (e.g., Section 8.3 in Kenschaft 2002 or the "tax cut" example of Schield (2005b)). Statistics teachers are among the best qualified to articulate conclusions requiring nuance such as Connor and Kadane (2001, p. 22): "Thus the result of the analysis, although strongly indicating the possibility of steering, remains somewhat ambiguous about whether racial steering occurred." And as Williams and Joseph (1993, p. 204) conclude: "When discussing racism, all views are not equal; those which are supported by reasoned, statistical, and mathematical arguments are more equal than those which are not."

6.4 Pedagogy

As discussed in Section 6.1, a basic version of TSSJ can be quite compatible with the pedagogy and broader use of assessment called for by ASA (2005). Faculty that have the appropriate support, time, and interest for their classes (especially terminal classes with more flexible requirements on topic coverage) to engage with social justice in a more critical, integrated, and sustained manner with their students may find it useful to consult Williams and Joseph (1993) and some of the background references in Section 2.2 such as Gutstein (2006a), since there is not space in this article to address all of the real challenges that can come with teaching from what Ernest (1991) calls a public educator ideology. For example, Gutstein (2003) describes the effort and care that must be taken to ensure that core mathematics/statistics content goals are not "bumped off" by incorporating a significant ongoing social justice component. Also, if one course goal is to prepare students for more active democratic participation in society, it may be more effective if some element of that occurs within the class itself, where students feel part of a shared classroom community in which multiple perspectives and critiques are heard. Another question is whether analysis will be confined to the relative safety of historical datasets or whether data from present-day issues will be examined or collected.

7. Further Thoughts

In Section 1, we mentioned that one of the six parts of the ASA Mission Statement is "use our discipline to enhance human welfare," but there are also other places the ASA has made statements that would support this orientation. In describing its Vision, Mission and History, the ASA (www.amstat.org/about/index.cfm?fuseaction=vision) describes its founders as having "demonstrated early a commitment to statistical science in service to public welfare" and includes "the examination of social issues such as the homeless and the poor" as one of the vital areas to which its members now apply their expertise. Engaged by the meaningfulness of the topics, students may find themselves wanting to be more meaningfully engaged with our subject (statistics) and with our world. In short, teaching using social justice can help make our subject matter matter.

Appendix 1: Table from Pollack and Wunderlich (2005)

Potential Source Points for Discrimination	within Labor Markets	within Education	within Housing or Mortgage Lending	within Criminal Justice	within Health Care
…in Access	Hiring; interviewing	Acceptance into college; financial aid	Steering; mortgage redlining	Police behaviors; arrests	Access to care; insurance
…in Treatment	Wages; evaluation	Track placement; grades/evaluations; special education placement	Loan pricing	Police treatment; quality of legal representation	Quality of care; price
...in Movement through the Domain	Promotion; layoffs; rehiring	Promotion/graduation; retention	Resale value; wealth accumulation	Parole; sentencing	Referrals

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Appendix 2: Resource Distribution Examples

One of the most common social justice topics is the distribution of resources or wealth in the world and within the United States, and there are several striking hands-on ways to introduce or illustrate this topic (e.g., Kellogg 2005; Hersh and Peterson 2005; Langyel 2005; Falk and Lann 2006; Smith 2002). This topic lends itself to be useful in the early part of a statistics course, when data needs to be summarized. For example, side-by-side pie charts can be constructed – one showing the percentage of the world's population each continent has and one showing the percentage of the world's wealth (or food resources, energy consumption, etc.) each continent has. Distribution of food resources can be a particularly powerful topic, considering that many presently die of starvation each year when there is enough food to feed everyone if it were redistributed.

Also, redistribution can make a memorable intuitive connection to the concept of the mean, as explained by Williams and Joseph (1993, p. 187):

> The notion of equal shares and, hence, of redistribution is one which is fundamental to the concept of average. The redistribution of income [totaling 100 pence] in the South African example played out by twenty-two students yields an overall average of about 5p per student. If each of the [4] 'whites' with 16p retains 5p and the remaining 11p are redistributed among [the 18] 'blacks' [who started with 2p each], this provides an effective representation of the

> concept of averaging. We have also, in the process of calculating the overall average, introduced the new idea of a frequency distribution and the method of calculating 'weighted' averages.

A more open-ended example is the large dataset provided by Rouncefield (1995), who allowed students to examine several variables on a judgment sample of 97 nations and generate their own hypotheses and summaries about life expectancy, wealth, population growth, etc. Apparently taking into account sociopolitical similarity not just geographical proximity, Rouncefield (1995) groups the 97 nations into 6 groups of countries for comparison purposes. She does note that the groupings are "somewhat arbitrary" and teachers or students could certainly easily consult her reference sources (*The Annual Register* and the *UNESCO Demographic Year Book*) and choose their own set of nations and country groupings. Kenschaft (2002) includes and continually refers to the World Population Data Sheet (WPDS), which includes a rich collection of demographic data for the world's nations. A more recent WPDS is available from the Population Reference Bureau (see Related Websites).

A common introductory text topic is a cumulative frequency distribution. Textbooks such as Lapin (1987, p. 27) explain: "The ordinate (vertical height) of a plotted point represents the cumulative frequency for values less than the abscissa (the horizontal scale value). Such a curve is called an ogive." A specific example of this type of graph is to consider the Lorenz curve (e.g., Shan and Bailey 1991, p. 182), which graphs the % (y) of the total wealth (or income, if you prefer) the poorest x% of households have. Plotting the quintile points will be enough for exploration and discussion. In one extreme, one person has all the resources and all others have none ($y = 100$ for $x = 100$; $y = 0$ for $x < 100$). In the other extreme, the line $y = x$ would represent perfectly equal distribution of wealth/resources. Students can discuss why the Lorenz curve must be increasing, convex, and not above the line $y = x$.

If any people's amounts of wealth differ (as will virtually always be the case), the Lorenz curve falls below line of equality. This leads to a numerical measure (not the only one, but the most commonly used) of the "amount of inequality" called the Gini ratio, which is the area between the Lorenz curve and the "$y = x$ line of equality" divided by the total triangular area under the line of equality. This ratio is used in U.S. Government publications such as DeNavas-Walt, Proctor and Lee (2006), which reports a Gini index of 0.469 for United States household incomes in 2005. We note that Temkin (1993) discusses how various philosophical aspects of income inequality are captured by a variety of numerical approaches, including these statistical measures: range, relative mean deviation, the variance, coefficient of variation, standard deviation of the logarithms, the Gini coefficient, and Atkinson's measure. Gastwirth (1988) offers further discussion that includes connections to measures of monopoly power.

Students can be asked to track down the Gini index for other countries (industrialized and nonindustrialized) and interpret how it compares with the United States. Students may discover trends such as that the U.S. as a whole has high levels of both wealth and inequality (especially the top quintile versus the rest) compared to other countries. Students might also look up Gini index values for the United States over the years to see how inequalities have been growing. Students might discuss (as economists do) possible relationships between inequality and capitalist market growth/efficiency. Inequalities within a company have also been explored (e.g., Sikka and Wearing 2000), as has the growing ratio of CEO pay to average worker pay (e.g., 262 in the U.S. in 2005, reported by Schroeder (2006)), as has the extent to which rich nations fall short of their Official Development Assistance aid targets of 0.7% of GNP.

As an aside, the idea of using the line $y = x$ as a benchmark is not unheard of in a first-year statistics course. For example, to see if two data sets come from populations with a common distribution, we see if the points formed from the quantiles of the datasets lie roughly on the line $y = x$ (e.g., Moore and McCabe 1989, p. 65). Another example is to assess how well calibrated people are by how closely the ordered pairs (actual result, person's prediction or answer) are to the line $y = x$. An example appears in Utts (2005, p. 329).

Students can also explore if wealth distributions are more unequal within or between ethnic groups. Wilson (2004) reports that the wealthiest 25% of Hispanic and black households own 93% of the total wealth in each group and typical (i.e., median) Hispanic and black households in the U.S. have less than 10% of the wealth typical Anglo households have.

For mathematics enrichment, students can explore the algebraic relationships that can impact the summary

statistics. In particular, simple algebra can verify that even if all salaries rise at the same percentage rate, the dollars gap between any two people would simply increase at that rate, too. It can be further shown that if a rich person's salary is R times that of a poor person, the rich-poor gap would not grow only under the unlikely scenario that the poor person's salary increases at a rate R times that of the rich person's. This not only continues the inequality among classes, it also increases the earning gap, and perhaps also the Gini index. This might lead to a discussion of how this may or may not apply to efforts to close the gap of students' standardized test achievement between different racial backgrounds.

One final example in this topic is welfare, which Gutstein (2006b) allowed preservice elementary teachers to understand through discussing this problem involving a hospital setup, paraphrased:

> Dr. Wauzeka strode to the podium and addressed the crowd: "Do you know that right now 90% of all the patients in the hospital are here for long term stays of 1 year!!??" Dr. Sarah Rubinstein rose from the back of the room to counter her: "But Dr. Wauzeka, about 85% of the people who stay in our hospital are there for stays of about 1 week." Either create a dataset that satisfies both statements or prove informally that at least one doctor is lying and show which one.

Gutstein's solution was to consider a 10-bed hospital in which 9 of them each have one patient for the entire year, and the tenth bed has a different patient each week. Therefore, most of the year's patients (52/61 = 85%) are short-term stayers, but at any moment, 90% of the patients in the hospital are long-term stayers. This example gives students the opportunity to consider that most people ever on welfare could be "short-term" to get back on their feet, but at any moment in time, it would appear that most had been on it years. A related paper is at www.census.gov/prod/2/pop/p70/p70-55.pdf.

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Selected Website Resources

Census Bureau of the U.S.: www.census.gov

Constitutional Rights Foundation: www.crf-usa.org

Data Center (Impact Research for Social Justice): www.datacenter.org/

Educators for Social Responsibility: www.esrnational.org

Gapminder: gapminder.org

Harper's Index: www.harpers.org/HarpersIndex.html

Human Development Report: hdr.undp.org/statistics/

Human Rights Data Analysis Group: www.hrdag.org/

Institute for Democracy in Education: www.ohiou.edu/ide/

Mathematics of Social Justice monograph: www.math.umt.edu/TMME/Monograph1/

Mathematics of Social Justice workshop: ww2.lafayette.edu/~math/Rob/MathOfSJ/

Millenium Development Goals Indicators: millenniumindicators.un.org/unsd/mdg/

National Association of Multicultural Education: www.nameorg.org

National Coalition of Education Activists: www.teachingforchange.org

National Priorities Project: www.nationalpriorities.org

National Service-Learning Cooperative Clearinghouse: www.servicelearning.org

Population Reference Bureau: www.prb.org

Racial Profiling Data Collection Resource Center: www.racialprofilinganalysis.neu.edu

Radical Math: www.radicalmath.org

Radical Statistics Group: www.radstats.org.uk

Rethinking Schools: www.rethinkingschools.org

Social Statistics Section of ASA papers from JSM:
www.amstat.org/sections/ssoc/SSS_Human_Rights_Papers.pdf

Southern Poverty Law Center: www.teachingtolerance.org

Statistical Abstract of the United States: www.census.gov/compendia/statab/

Statistical Literacy Project: www.statlit.org

Statistics from U.S. Federal Agencies: www.fedstats.gov

UNESCO (United Nations Educational, Scientific and Cultural Organization): www.uis.unesco.org

United for a Fair Economy: www.faireconomy.org

World Bank: worldbank.org

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