EQUITY AND THE INCREASINGLY DIVERSE TERTIARY STUDENT POPULATION: CHALLENGES AND OPPORTUNITIES IN STATISTICS EDUCATION

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Professional organizations and educators are increasing their focus on equity issues for the diverse (sub)populations they serve, such as second language learners. This focus is especially important in statistics because of the importance of context in both diversity and statistics, and because of the ways in which diversity issues interact with the actual practice and teaching of statistics. Also, there are many ways in which diversity and equity can be natural vehicles for motivating or exploring particular statistical concepts and content. Recently emerging evidence suggests that students in diverse classrooms can be motivated by such examples and there have been a variety of courses that have recently been developed to do this with varying emphases and degrees of integration. The totality of efforts in this area suggests that the challenges of teaching diverse populations ultimately yield opportunities, resources, and vehicles for student learning.

FOCUS ON EQUITY FOR DIVERSE POPULATIONS

Equity has recently gained much attention within mainstream mathematics education in the US, with national organizations issuing position statements, sponsoring featured talks, supporting professional development and coming together for equity summits (Lesser, 2009b). This emphasis on equity in education is particularly important because "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" (NCTM, 2000, p. 13). Though commitments to equity and justice are reflected in the mission/history/vision statements of the American Statistical Association, some (e.g., Enyedy, Mukhopadhyay & Danish, 2006, p. 1) claim that "The statistics education community has not yet emphasized how to improve achievement of traditionally underserved and marginalized students."

However, some recent statistics education scholarship addresses how diverse specific populations and subpopulations can be served. Lesser (2009a) describes a statistical literacy course (populated mostly by Latinas) with a gender equity theme. Plank and DiPietro (2008) describe a freshman seminar course that explored statistics of the gay and lesbian population. A more diverse classroom more likely has a nontrivial proportion of students for whom the language of instruction is not their first or strongest language, and being able to engage in everyday conversation in English is not a sufficient condition for following formal academic instruction. Case study research by Lesser and Winsor (2009) of how English language learners (ELLs) encounter introductory statistics yielded themes of context and navigation among multiple registers and yielded recommendations for instructors such as increased wait time. The College Board reported that the 1.5 million college-bound students who took the SAT® in 2009 were more diverse than any group before and a quarter reported that English was not their first language at home.

Hulsizer and Woolf (2009) argue that statistical reasoning and thinking require understanding context, and because diversity is contextual, instructors must take diversity into account. They describe diversity as including race/ethnicity, gender, sexual orientation, age, disability, cross-cultural, international, socioeconomic status, language, educational level, religion, marital status, social class/caste, computer literacy, and physical appearance. Harris, Mazoué, Hamdan and Casiple (2007) add: learning styles, behaviors/attitudes/expectations of students, and degrees of (visual, auditory, motor, or cognitive) impairments.

INTERACTION OF DIVERSITY ISSUES AND STATISTICS

Smith, Reid and Petocz (2009) note that by having associations with and serving a wide variety of different disciplines, statistics has a more diverse potential clientele than many other subject areas. But even instructors who may be quite conscious about matters of diversity (e.g., Schacht, 2000) may not automatically apply this to their statistics courses. This is unfortunate because, whether acknowledged or not, diversity issues often interact with the practice of statistics. For example, Hulsizer and Woolf (2009) review how researchers seeking high internal validity (to

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make a stronger case for causality) may naturally prefer to draw participants from homogeneous, less-diverse populations (e.g., college students or white, middle-class US citizens) and assume too readily that research conducted on one population generalizes to other populations.

The decision to include other groups addresses this issue, but raises others. Pitfalls include sampling, experimenter bias, construct validity, informed consent, group definition, and impact of omission/exclusion of groups on research conclusions. Hulsizer and Woolf (2009) also discuss the diversity-related pitfall of possible sources of data non-equivalency (e.g., translation, metric, and conceptual). Such pitfalls are reinforced by professional association guidelines (CNPAAEMI, 2000) and books (e.g., Marín & Marín, 1991) addressing methods for studies on particular populations. Practical suggestions include making sure that translated surveys are independently back-translated to English to ensure the survey worked as intended on denotative, connotative and cultural levels. A different type of cultural tension is how "the mindset that more items and multiple measures will increase variance, statistical robustness, and psychometric power" yields "excessively high subject mortality among American Indian subjects." (CNPAAEMI, 2000, p. 13).

Another issue is that researchers may not realize that certain groups such as "Asian-Americans/Pacific Islanders" actually have much heterogeneity (e.g., between Chinese, Japanese, Korean, etc.) that make it unsatisfactory to be treated as a homogeneous population for certain purposes. Members within a minority group can also vary greatly with respect to level of assimilation, acculturation, academic achievement, socioeconomic status, access and points of entry into the educational system, temperament, language use, etc., and some of these variables may interact with the variables being studied. For the context of sexual minority groups, Woolf and Hulsizer (2007, p. 244) caution that "juxtaposition of identity and orientation may be socially beneficial for individuals experiencing stigma in the United States, but can create the basis for problematic research hypotheses and, certainly, sampling challenges."

Even the interpretation and reporting of statistical results are not independent of diversity awareness (CNPAAEMI, 2000). Researchers with little cultural training or sensitivity may not readily consider culture-informed alternative explanations to the data or may be unduly quick to use a "deficit model" of interpretation (i.e., implicitly viewing the majority group as the "superior standard" to which other groups must be compared). Another issue is whether the researcher's ethnicity would be deemed relevant to report and whether the researcher has taken culturally sensitive steps to access and interact with the cultural community. For example, CNPAAEMI (2000, p. 12) warns, "Not including tribal members or any American Indians in the development of the design, methodology, and information dissemination of research involving American Indian participants is a serious affront to those being studied…" and "more traditional participants may be insulted by an offer of money for their participation, which they consider a sacred gift."

Hulsizer and Woolf (2009) assert the fundamental need for students to understand ethics and the impact of diversity on research. Instructors and students should be aware of past inappropriateness in statistical work on particular populations, such as the African-Americans who suffered in the Tuskegee Syphilis Study (Jones, 1993), the Jews and others subjected to Nazi experiments, or the minority subpopulations in several countries whose forced migration, internment or genocide was facilitated by misuses of population data systems (Seltzer & Anderson, 2001). That said, Kardas and Spatz (2007) recommend that negative examples of participant consent (e.g., Tuskegee) be preceded in discussions with a positive example such as Walter Reed's research on yellow fever, which was one of the first times consent forms were used.

Whether acknowledged or not, diversity can also interact with the learning of statistics, even on a conceptually abstract level. Lesser (2009b) discusses how students' concepts of fairness may affect how readily they embrace some statistics content, such as the role of randomness (in selecting participants for surveys or experiments) or expected value. Also, a student's prior familiarity with the word "bias" in a more qualitative context of prejudice may interfere with gaining an understanding of its use in the quantitative context of parameter estimation. This lack of clarity may make it hard for a student to distinguish between disparate treatment and disparate impact, the latter of which has various associated quantitative approaches (Lesser, 2009a).

To the extent diversity emphasizes distinctiveness, it may interfere with the ability to see oneself as an arbitrary member of a population, an ability which arises in situations such as the "Birthday Problem" (where students might erroneously focus on "someone matching with *me*"

instead of "any two people match") or in situations where one's personal interest or experience or imagination gets in the way of making objective assessments of probabilities (e.g., availability heuristic, conjunction fallacy, forgotten base rates, etc., in Utts, 2005). This is not unlike what Enyedy et al. (2006) discusses in terms of students' focus on one aspect of the data (or individual, meaningful data points), which interferes with making appropriate generalizations from the data.

DIVERSITY AS VEHICLE FOR TEACHING STATISTICS

The preceding discussion notes challenges–indeed, Smith et al. (2009) cites papers that view a classroom's diverse composition as a burden or barrier to effective teaching–but there are also many ways in which diversity is a resource and a vehicle of opportunity not only in terms of the interesting applications and resources individual students bring from their backgrounds, but also in terms of general ideas and issues of diversity itself. Adapting the function classification vehicle of Lesser (2000) to data, we cannot "know" a dataset (e.g., Anscombe's quartet) from a couple of summary measures nor can we easily "summarize" a person. Tang (2009) noted that a line of fit is a better model when fitted over a "diverse" range of x values rather than values all in one clump. Such examples can both honor diversity and reinforce content.

Before doing any computations, statistics students need first to acknowledge the complexity of having clear operational definitions of variables such as ethnicity (e.g., Lesser, 2007; Blank, Dabady, & Citro, 2004). Lesser (2009a) notes that to the extent that diversity-related categories such as race and gender are socially constructed, parallels can be made to the argument of Best (2001) that statistics are socially constructed.

Students can construct basic summaries for diversity data but may not consider the possibility of computing a numerical measure of diversity beyond the trivial case of two categories. Kader & Perry (2007) develop a measure of variability for data from a categorical variable, and this has applicability to measuring, for example, ethnic diversity. Lesser (2007) notes that quantitative diversity indices have appeared in textbooks (e.g., Frankfort-Nachmias & Leon-Guerrero's index of qualitative variation) or in the media (e.g., the *USA Today* Diversity Index).

Woolf and Hulsizer (2007) explore a wide range of representative intersections, including: issues of exclusion and definition involving race/ethnicity, experimental bias involving gender, difficulty of defining and sampling the hidden population of sexual minorities, methodological design issues involving research on aging, issues of construct validity and informed consent involving people with disabilities, and issues of equivalence in cross-cultural studies.

A creative point of entry is exploring study design for detecting prejudice. Disguised-gender experiments show how adults perceive baby girls and boys differently (Eliot, 2009). A controlled experiment showed that males randomly assigned to watch a tape of positive or negative feedback were more likely to deem the deliverer of negative feedback as incompetent if the evaluator was female (Sinclair & Kunda, 2000). In a "list experiment" (e.g., Streb et al., 2008), people say how many statements on one of two lists (only one of which includes a sensitive extra item involving race, religion, gender, etc.) upset them. An Internet field experiment suggests discrimination against homosexuals on the housing market (Ahmed & Hammarstedt, 2008).

Another way to acknowledge diversity in teaching statistics is through ethnomathematics, such as cultural probability games (e.g., Toma Todo), cultural data recording tools (e.g., *quipu*), and cultural connections to the concept of randomness (Lesser, in press). Beyond a source of examples, however, cultural awareness informs one's very pedagogy. Clark (2006) put this into practice with Maori by showing discretion in public questioning, using examples from their society, acknowledging cultural influences on how students worked together, and starting with the more familiar transmission style of teaching before moving to a more independent style in the spirit of the active learning called for by ASA (2005).

EQUITY AS VEHICLE FOR TEACHING STATISTICS

Acknowledgment of diversity naturally increases awareness and interest in whether various identified groups are treated equitably. Lesser (2009a) gives several uses of published media clippings and activities to explore concepts of (gender) equity and discrimination in memorable real-world contexts such as hiring, earnings, jury selection, domestic violence, and college athletics. Frankfort-Nachmias and Leon-Guerrero (2009) is an introductory quantitative methods

text with a focus on equity issues. Rodriguez (2005) suggests examining anti-affirmative-action university admissions policies. Lesser (2007) gives further examples, framework, and emerging evidence for the motivational potential of social justice examples and followup webinars are available at *www.amstat.org/education/webinars/UsingSocialJusticeExamples.wmv* and *www.causeweb.org/webinar/teaching/2007-07/* for precollege and college teachers, respectively.

In investigating a course for pre-service teachers designed to develop understanding of equity through data-based statistical inquiry, Makar (2004) found significant correlation between their engagement with their topic and the depth of statistical evidence they used, particularly for minority students. Makar's context of using accountability data is even more relevant in today's culture of high-stakes testing mandates as statistical thinking helps interpret achievement gaps. It can be helpful for both statistical and personal growth of a student to learn how Andreescu, Gallian, Kane & Mertz (2008) found that apparent gender achievement gaps in mathematics are better explained by opportunity or environment than by ability. And interest in comparing groups is a natural vehicle to motivate discussion of aggregation pitfalls such as Simpson's Paradox (Lesser, 2001). Also, there should be awareness of what has been called the "treadmill effect"–where former ELLs' being declassified as ELLs (and the arrival of new ELLs) naturally lowers ELL category mean score even if individuals are making progress. Finally, validity and reliability of high stakes tests need to be carefully considered when ELLs take tests designed and normed for English speakers.

FURTHER THOUGHTS AND RECOMMENDATIONS

We previously noted topics where notions of diversity, bias and fairness can interact or even interfere with the learning of some statistical ideas. To progress beyond this, it is important to cultivate a classroom environment that respects students' diverse experiences and perspectives by first acknowledging the aspects of their ideas that are reasonable (at least in an everyday context), in the spirit of Cohen (2009). An additional consideration for some instructors will be how to honor diversity in situations where it is not visible, such as in online classes (Tolan, 2007).

Addressing many matters of diversity seem to fall along the lines of a very commonly encountered type of diversity–students' varied academic preparations. In the face of this type of diversity (which made Berenson (2006) feel he needed to lecture more than he intended), instructors are generally encouraged to avoid splitting their classroom into homogeneous tracks or groups, but rather to maintain the diversity of the class as a whole, and even to have this reflected in groups formed for group work. In particular, it is generally useful for each group to have three or four students, for each group to be heterogeneous with respect to statistics background and other variables, and for a reward system to be built in to encourage intragroup teamwork. Such structuring may help avoid the pitfall Berenson (2006) mentions of teaching only to the least prepared or to the most prepared.

It is important and valuable for instructors to realize the ways that diversity is more opportunity than obstacle. As Woolf and Hulsizer (2007, p. 251) state, "The methodological challenges associated with research inclusive of diverse populations and the subsequent avoidance of bias may enable students to move away from thinking of research methods as a 'canned' science." Instructors may need to take the initiative to attend workshops or read some of the references in this paper to be able to cultivate and incorporate this awareness into the classroom, given the likelihood of gaps in their own preparation: "A chapter or lesson may have been devoted…but no concrete experiences or teaching methods were provided" (Hoffert, 2009, p. 132). Also, multicultural education literature does not address diversity and equity in a discipline-specific way, especially in mathematical fields perceived as devoid of social considerations (Kitchen, 2007). It is a strong recommendation of this paper that this type of preparation for future statistics teachers should be improved.

Research recommendations include making qualitative and quantitative assessments of student motivation, attitude, anxiety, and conceptual understanding for the "good examples" of courses mentioned. It would also be worthy to study the extent, manner, and instances in which students' focus on distinctiveness (e.g., due to diversity) may affect their statistical reasoning.

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REFERENCES

Ahmed, A., & Hammarstedt, M. (2009). Detecting Discrimination against Homosexuals: Evidence from a Field Experiment on the Internet. *Economica, 76*, 588-597.

American Statistical Association (2005). Guidelines for Assessment and Instruction in Statistics Education College Report. Online: www.amstat.org/education/gaise/GAISECollege.htm.

Andreescu, T., Gallian, J. A., Kane, J. M., & Mertz, J. E. (2008). Cross-Cultural Analysis of Students with Exceptional Talent in Mathematical Problem Solving. *Notices of the American Mathematical Society*, *55*(10), 1248-1260. Online: www.ams.org/notices/200810/fea-gallian.pdf.

Berenson, M. L. (2006). Teaching Academically Diverse Groups. In A. Rossman & B. Chance (Eds.), *Proceedings of the 7th International Conference on Teaching Statistics*. Voorburg, The Netherlands: ISI. Online: www.stat.auckland.ac.nz/~iase/publications/17/3D2_BERE.pdf.

Best, J. (2001). *Damned Lies and Statistics: Untangling Numbers from the Media, Politicians, and Activists*. Berkeley, CA: University of California Press.

Blank, R. M., Dabady, M., & Citro, C. F. (2004). *Measuring Racial Discrimination*. Washington, DC: National Academies Press. Online: www.nap.edu/catalog.php?record_id=10887.

Clark, M. (2006). A First Year Statistics Programme for Indigenous and Migrant Students Arrived at by Co-operating with Local Communities and the Students Themselves. In A. Rossman & B. Chance (Eds.), *Proceedings of 7th International Conference on Teaching Statistics*. Voorburg, The Netherlands: ISI. Online: www.stat.auckland.ac.nz/~iase/publications/17/1B1_CLAR.pdf.

Cohen, D. W. (2009). Teaching Tip: Accepting that .999… = 1. *College Mathematics Journal, 40*(4), 258.

CNPAAEMI, Council of National Psychological Associations for the Advancement of Ethnic Minority Interests (2000). *Guidelines for Research in Ethnic Minority Communities*. Online: www.apa.org/pi/oema/programs/cnpaaemi_guidelines_research_emc.pdf.

Eliot, L. (2009). *Pink Brain, Blue Brain: How Small Differences Grow Into Troublesome Gaps—And What We Can Do About It*. New York: Houghton Mifflin Harcourt.

Enyedy, N., Mukhopadhyay, S., & Danish, J. (2006). At the Intersection of Statistics and Culturally Relevant Pedagogy: Potential and Potential Challenges of Learning Statistics Through Social Activism. In A. Rossman & B. Chance (Eds.), *Proceedings of 7th International Conference on Teaching Statistics*. Voorburg, The Netherlands: International Statistical Institute. Online: www.stat.auckland.ac.nz/~iase/publications/17/7A1_ENYE.pdf.

Frankfort-Nachmias, C., & Leon-Guerrero, A. (2009). *Social Statistics for a Diverse Society* (5th ed.). Thousand Oaks, CA: Sage Publications.

Harris, C. M., Mazoué, J. G., Hamdan, H., & Casiple, A. R. (2007). Designing An Online Introductory Statistics Course. In D. S. Dunn, R. A. Smith & B. C. Beins (Eds.), *Best Practices for Teaching Statistics and Research Methods in the Behavioral Sciences* (pp. 93-108). London: Lawrence Erlbaum Associates.

Hoffert, S. (2009). Mathematics: The Universal Language? *Mathematics Teacher, 103*(2), 130-9.

Hulsizer, M. R., & Woolf, L. M. (2009). *A Guide to Teaching Statistics: Innovations and Best Practices*. Chichester, United Kingdom: Wiley-Blackwell.

Jones, J. H. (1993). *Bad Blood: The Tuskegee Syphilis Experiment*. New York: Free Press.

Kader, G. D., & Perry, M. (2007). Variability for Categorical Variables. *Journal of Statistics Education, 15*(2). Online: www.amstat.org/publications/jse/v15n2/kader.html.

Kardas, E. P., & Spatz, C. (2007). Teaching Ethics in Research Methods Classes. In D. S. Dunn, R. A. Smith, & B. C. Beins (Eds.), *Best Practices for Teaching Statistics and Research Methods in the Behavioral Sciences* (pp. 159-171). Mahwah, NJ: Lawrence Erlbaum.

Kitchen, R. (2007). An Overview of Schooling in High Poverty Communities. In R. S. Kitchen, J. DePree, S. Celedón-Pattichis, & J. Brinkerhoff (Eds.), *Mathematics Education at Highly Effective Schools that Serve the Poor: Strategies for Change* (pp. 1-19). Mahwah, NJ: Lawrence Erlbaum Associates.

Lesser, L. (2000). Reunion of Broken Parts: Experiencing Diversity in Algebra. *Mathematics Teacher, 93*(1), 62-67.

Lesser, L. (2001). Representations of Reversal: An Exploration of Simpson's Paradox. In A. A. Cuoco & F. R. Curcio (Eds.), *The Roles of Representation in School Mathematics* (pp. 129-145). Reston, VA: National Council of Teachers of Mathematics.

Lesser, L. (2007). Critical Values and Transforming Data: Teaching Statistics with Social Justice. *Journal of Statistics Education, 15*(1). Online: www.amstat.org/publications/jse/v15n1/lesser.pdf.

Lesser, L. (2009a). Social Justice, Gender Equity, and Service Learning in Statistics Education: Lessons Learned from the DOE-Funded Project ACE. *Proceedings of the 2008 Joint Statistical Meetings, Section on Statistical Education*, pp. 424-431. Alexandria, VA: American Statistical Association. Online: https://www.amstat.org/membersonly/proceedings/papers/300471.pdf.

Lesser, L. (2009b). Equity, Social Justice, and the Mission of TODOS: Connections and Motivations. *Teaching for Excellence and Equity in Mathematics, 1*(1), 22-27.

Lesser, L. (in press). An Ethnomathematics Spin on Statistics Class. *NASGEm News*. Online: http://nasgem.rpi.edu/.

Lesser, L., & Winsor, M. (2009). English Language Learners in Introductory Statistics: Lessons Learned from an Exploratory Case Study of Two Pre-Service Teachers. *Statistics Education Research Journal, 8*(2), 5-32. Online: www.stat.auckland.ac.nz/~iase/serj/.

Makar, K. M. (2004). *Developing Statistical Inquiry: Prospective Secondary Math and Science Teachers' Investigations of Equity and Fairness through Analysis of Accountability Data.* Doctoral dissertation, University of Texas at Austin. Online: www.stat.auckland.ac.nz/~iase/publications/dissertations/04.Makar.Dissertation.pdf.

Marín, G., & Marín, B. V. O. (1991). *Research with Hispanic Populations* [Applied social research methods series]. Newbury Park, CA: Sage Publications.

National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

Plank, K., & DiPietro, M. (2008). Diversity-Related Content as a Gateway to Critical Thinking: A Case Study of a Freshman Seminar, Consortium for the Advancement of Undergraduate Statistics Education webinar. Online: www.causeweb.org/webinar/teaching/2008-08/.

Rodriguez, A. J. (2005). Teachers' Resistance to Ideological and Pedagogical Change: Definitions, Theoretical Framework, and Significance. In A. J. Rodriguez & R. S. Kitchen (Eds.), *Preparing Mathematics and Science Teachers for Diverse Classrooms: Promising Strategies for Transformative Pedagogy* (pp. 1-16). Mahwah, NJ: Lawrence Erlbaum Associates.

Schacht, S. P. (2000). Using a Feminist Pedagogy As a Male Teacher: The Possibilities of a Partial and Situated Perspective. *Radical Pedagogy, 2*(2), Online: http://radicalpedagogy.icaap.org/content/issue2_2/schacht.html

Seltzer, W., & Anderson, M. (2001). The Dark Side of Numbers: The Role of Population Data Systems in Human Rights Abuses. *Social Research, 68*(2), 481-513. Online: www.unc.edu/~pnc/pop/SeltzerAnderson01.pdf.

Sinclair, L., & Kunda, Z. (2000). Motivated Stereotyping of Women: She's Fine if She Praised Me but Incompetent if She Criticized Me. *Personality and Social Psychology Bulletin, 26*(11), 1329-1342.

Smith, N., Reid, A., & Petocz, P. (2009). Representations of Internationalisation in Statistics Education. *Journal of Statistics Education, 17*(1). Online: www.amstat.org/publications/jse/.

Streb, M. J., Burrell, B., Frederick, B., & Genovese, M. A. (2008). Social Desirability Effects and Support for a Female American President. *Public Opinion Quarterly, 72*(1), 76-89.

Tang, G. (2009). Rethinking Math Education: Have We Been Led Astray? Paper presented at National Council of Teachers of Mathematics regional conference, Nashville, TN.

Tolan, D. (2007). Making Visible the Invisible. *Online Classroom, 7*(7).

Utts, J. M. (2005). *Seeing Through Statistics* (3rd ed.). Belmont, CA: Thomson Brooks/Cole.

Woolf, L. M., & Hulsizer, M. R. (2007). Understanding the Mosaic of Humanity Through Research Methodology: Infusing Diversity into Research Methods Courses. In D. S. Dunn, R. A. Smith, & B. C. Beins (Eds.), *Best Practices for Teaching Statistics and Research Methods in the Behavioral Sciences* (pp. 237-256). London: Lawrence Erlbaum Associates.