RETHINKING THE INTERSECTION OF STATISTICS EDUCATION AND SOCIAL JUSTICE

Lisa L Poling[1] and Nirmala Naresh[2]
[1]Appalachian State University, USA
[2]Miami University, USA
polingll@appstate.edu

Critical consumers of data are able to think and reason about statistics and use statistical tools to better explore and understand issues that are significant to their immediate community, the larger society, and the broader world. Promoting statistical knowledge by understanding and investigating social issues that create disparities provides an entry point for an individual to take the first step in making positive change and engaging in equitable practices (Gutstein, 2006a). Drawing from the research domains of statistics and social justice we designed a statistics learning module for prospective teachers to help them emerge as critical and caring consumers of data. The amalgamation of statistics and social justice issues created a sustainable learning environment where data were interpreted and analyzed in a meaningful way.

INTRODUCTION

In today's world, data is omnipresent and individuals receive, consume, and interpret data in different ways. An individual awestruck by data seldom questions statistics and places a blind trust in what it may convey; on the other end of this diagonal is a cynical consumer who dismisses any statistical findings and conclusions. In between the two lie the naïve consumer and the critical consumer (Best, 2001). A naïve consumer, because of a limited and superficial understanding of data and related ideas is unable to question or critique statistical information whereas a critical consumer is able to ask questions and discern information about data, its collection and analysis methods, and conclusions that are warranted by data (GAISE, 2007; Best, 2001).

Garfield and Ben-Zvi (2008) note that in the realm of statistics, "context provides meaning for the numbers and data cannot be meaningfully analyzed without paying careful consideration to their context" (p. 8). Gutstein (2006a) asserts that mathematics can be utilized to promote both social justice and mathematical goals in a classroom. He notes that an important conviction of the social justice pedagogy is that teachers as well as students are a part of the solution to injustice. In line with this approach, we use of the lens of statistics to promote the goals of social justice and that of statistics pedagogy.

BACKGROUND

In the teacher education context, this highlights the need to pose questions that will lead both prospective and in-service teachers to investigate social issues with a critical eye, so that inequities become apparent and ideas for change discussed. In a social justice model, students must recognize that their world is active, complicated, and can be transformed based upon action. According to Ball, Goffney and Bass (2005), "instead of seeing mathematics [or statistics] as culturally neutral, politically irrelevant, and mainly a matter of innate ability, we see it as a critical lever for social and educational progress" (Moses & Cobb Jr. 2001, p.2) if taught in ways that make use of its special resources" (pp. 2-3). Mathematics education is an appropriate and powerful tool to transform oppressive ideology and promote self-awareness and self-sustaining behaviors. In this paper, we describe how we used the application of statistics in conjunction with social justice to negotiate teachers' understanding of statistical ideas and their perceptions of the role of social justice in a mathematics classroom.

In merging the research domains of statistics and social justice to design a course in statistics, special features of mathematics were enacted. In particular, we hoped to help teachers emerge and grow as critical and caring consumers of data as such. Individuals are not only able to think and reason about statistics, but are able to use statistical tools to better explore and understand issues that are significant to their immediate community, the larger society, and the broader world.

In K. Makar, B. de Sousa, & R. Gould (Eds.), *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics (ICOTS9, July, 2014), Flagstaff, Arizona, USA.* Voorburg, The Netherlands: International Statistical Institute. iase-web.org

METHODS

Course Setting and Description

The geographical setting for this study is a large mid-western university in the United States. The study setting is a course in probability and statistics offered to in-service middle school and secondary school teachers. This course is one of several content courses offered for in-service teachers enrolled in a Master of Arts in Teaching (MAT) program in mathematics. This course was offered during the summer term to accommodate teachers' schedules. This 3-credit hour course (approximately 38 contact hours) was taught over three-weeks; course participants met for approximately three hours a day, five days a week. While both authors were involved in the planning of the course, the second author taught the course to a group of eleven teacher-participants.

The course focused on two key components of teacher knowledge, content and pedagogy. The guidelines for assessment and instruction in statistics education (GAISE, 2007), the Common Core State Standards for Mathematics (CCSSI, 2010) were consulted in deriving the overall course goals. The identified course goals were to help participants a) understand and engage in statistical thinking and thereby deepen their content and pedagogical knowledge of statistics and b) understand the statistics (and the potential it holds) to explore social justice issues and thereby emerge and grow as critical and caring consumers of data. Two key resources were used for this course - *Workshop Statistics: Discovery with Data* (Rossman & Chance, 2012) and *Rethinking Mathematics* (Gutstein & Peterson, 2013)

Course Activities

Course activities were structured in adherence to the following principles: Engage in statistical problem solving using real data, "focus on the process of statistical investigation in each setting" (Rossman & Chance, 2012, p. 4), and consider statistics a means of promoting change. Activity-based learning was emphasized and course participants engaged in content, pedagogical, and curricular explorations to accomplish the course goals. The focus of the content explorations was to better understand what it means to understand and reason about statistical concepts. Pedagogical explorations were focused on identifying methods for developing students' understanding and reasoning about these concepts, and curricular investigations required teacher-participants to identify and develop tasks that will foster a deeper and richer understanding of statistics and social justice issues. Course assignments included lab explorations, problem-solving activities, reading and reflecting on course readings, leading a class discussion, and completing a course project.

Technological aids such as a TI 83 calculator, Fathom software, and Excel were used during content exploration sessions. Participants completed problem sets that focused on statistical concepts including sampling methods, study design, data displays, descriptive statistics, random variables, correlation, regression and probability. Real data derived from multiple sources (e.g., World Factbook, www.gapminder.org, and world population statistics) were used to investigate many of these concepts. Concurrently, participants read and reflected on chapters from *Rethinking Mathematics* (e.g., Home Buying While Brown or Black, Sweatshop Accounting, Math, Maps, and Misrepresentation) to generate and foster critical reflection on the use of statistics to explore social justice issues.

RESULTS

Course Artifacts: Project Assignment

Teacher-participants completed a course project that required them to develop a statistical lesson that could be taught to students in grades 7-12. Teachers were encouraged to connect statistical concepts to understand relations of power, resources inequities and disparate opportunities between different social groups. The following sub tasks were assigned.

Task 1. Reflect on the course readings and propose a definition of social justice that makes the most sense to you as a citizen of this world.

Task 2. Identify potential data sources that relate to your social justice theme. Identify sources of data that are most useful in exploring key statistical concepts.
Task 3. Identify at least three key statistical concepts that are central to the lesson.
Task 4. Develop a class activity. Include procedures for implementing the activity. Discuss one or more approaches to solving the problem. Include screenshots (or written work) from key steps of the problem solution. In your lesson plan, pay attention to the following questions.
  - Describe why the chosen activity is appropriate for the chosen grade level?
  - What connections to other mathematical topics / subjects could be made?
  - Establish specific connections to the GAISE guidelines and the CCSS-M standards.

At the end of the first week of classes, teachers completed a course project outline that included responses to the first three tasks. After receiving feedback from their instructor, they incorporated suggested changes and developed the intended activity. During the last day of classes, they enacted their activity with their peers. Examples of teacher-developed activities include *Pay inequity in the workplaces*, *Racial disparities and graduation rates*, *Racial and wealth divide*, *Disproportionate distribution of a city budget*, and *A comparison of two school districts budget allocations*. Here we provide a brief outline of one such activity. A more comprehensive report could be located at http://tinyurl.com/course-project-sample-artifact

- *Title*: Pay inequity in the workplaces.
- *Definition of Social Justice*: A society with social justice believes in equal opportunities and equal rights for all of its citizens. People are not discriminated against or restricted due to their gender, race, nationality, economic status or anything other factors. All different groups in society have the sense that they are valued, safe and important.
- *Data Sources*
  - http://www.americanprogress.org/issues/labor/news/2012/04/16/11391/the-top-10-facts-about-the-wage-gap/
  - http://www.census.gov/prod/2011pubs/p60-239.pdf
- *Key statistical concepts*: Representing and comparing data distributions, interpreting categorical and quantitative data, modeling linear association, measuring the strength of association between two quantitative variables.
- *Lesson Outline*: This activity is designed for the 8th grade classroom, but could be adapted to fit other grades as well. This lesson uses data about income gaps between genders and covers topics such as percent of change, linear equations, data analysis, scatter plots and trend lines, and the measures of center and dispersion.

Course Artifacts: Gapminder Explorations

Gapminder is a free online data visualization software (www.gapminder.org) that allows a user to investigate and interpret data compiled from various international sources (e.g., UNICEF, World Bank, WHO). An exploration of the Gapminder tool and analyses of related graphs enabled participants to uncover, understand and question their perceptions about various nations and the issues facing the world. Prior to the Gapminder content explorations, the entire class watched a TED talk presented by Hans Rosling (2007), titled "Debunking myths about the third world". Teachers were asked to reflect on the content of the talk. Teachers were then introduced to the Gapminder sorting game (www.gapminder.org/GapminderMedia/GapPDFs/GapminderSort/GapminderSort.pdf,), to help them further probe their beliefs and perceptions of the developed and the developing nations of the world.

As a next step, teachers were asked to explore the Gapminder World Graph and understand the features of the graph. In particular, they were asked to attend to and understand the available options for choosing scales (linear or logarithmic), indicators (e.g., life expectancy, infant mortality) and categorizations (e.g., income, religion) to generate graphical displays. The following open-ended task was assigned to facilitate this process.

- Examples of some questions that students have explored using world statistics depicted in the Gapminder interactive software.
    - How do social and political changes affect literacy rates in West Africa?
    - What government changes affect the health and wealth of Iran and China?
    - How have major natural disasters affected the countries of Venezuela and Bangladesh in terms of their political and economic stability as well as their overall development?
- Propose a question (and possible sub-questions) that could be addressed through an analyses and interpretation of data using the Gapminder software.
- Respond to your question(s) - Describe how you analyzed the data using the Gapminder software. Include all evidence that was used to arrive at this response.

Some examples of teacher-generated Gapminder questions are listed here. A more detailed report can be located at http://tinyurl.com/gapminder-sample-artifact

- How did the Vietnam War affect life expectancy in the countries involved in the war? Look at the Life Expectancy Graphs over time for Vietnam, Cambodia, China, Taiwan and the United States from 1940 to 2012. Describe any trends that you notice.
- How does the expenditure per student at the primary level affect math achievement in the 8th grade? Compare the following countries: United States and Japan.
- Look at the Cell Phones per 100 People data on Gapminder for the year 2011. Find the mean, median and standard deviation for all of the countries that provided data. Find the z-score for the United States. Why would some countries have more than 100 phones per 100 people?

DISCUSSION

Relevant mathematics instruction can help to promote the knowledge practicing teachers need as they evolve in education and engage in society. Ball, Goffney, and Bass (2005) state that mathematics, if taught in a manner that recognizes and uses its special features, becomes a critical component for social and educational development.

As our society continues to become more diverse in race, culture, ethnicity, class, and sexual orientation the educational systems we have in place must also revise their purpose and their context. Promoting teachers' statistical knowledge by investigating social issues that create disparities provides an entry point for the individual to take the first step in making positive change and engaging in equitable practices (Gutstein, 2006b).

REFERENCES

Ball, D. L., Goffney, I. M., & Bass, H. (2005). The role of mathematics instruction in building a socially just and diverse democracy. *The Mathematics Educator,15*, 2-6.

Best, J. (2001). *Damned lies and statistics*. Berkeley/Los Angeles: University of California Press.

Common Core State Standards Initiative (CCSSI) (2010). *Common Core State Standards for Mathematics.* Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers.

Garfield, J. B., & Ben-Zvi, D. (2008). Learning to reason about data. In J. B. Garfield & D. Ben-Zvi (Eds.), *Developing students' statistical reasoning* (pp.123-142). Springer Publishers.

GAISE (2007). Guidelines for assessment and instruction in statistics education: A curriculum framework for preK-12 statistics education. Alexandria, VA: American Statistical Association.

Gutstein, E. (2006a). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. New York: Routledge, Taylor & Francis Group.

Gutstein, E. (2006b). "The real world as we have seen it": Latino/a parents' voice on teaching mathematics for social justice. *Mathematical Thinking and Learning, 8*(3), 331-358.

Gutstein, E., & Peterson, B. (2013). *Rethinking mathematics*: *Teaching social justice by the numbers*. www.rethinkingschools.org.

Moses, R., & Cobb Jr., C. E. (2001). *Radical equations: Math literacy and civil rights*. Boston, MA: Beacon Press.

Rosling, H. (2006, February). *Hans Rosling: The best stats you've ever seen* [Audio podcast] http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html

Rossman, A.J., & Chance, B. L. (2012). *Workshop statistics: Discovery with data* (4th ed). Wiley.