Statistical literacy in adult college students

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Abstract: Currently statistics is used in society as social indicators that measure, for example crime rates, or research concerning health and medical issues, which are reported by the media. Educated citizens need to be able to understand statistics; it is assumed that adult students who graduate from college will have this ability. Knowing how important statistical literacy is, the purpose of this research was to measure statistical literacy in adult learners before and after they have completed a statistics class, or a research methods class with no prior statistics, or a research methods class with prior statistics. Participants were 110 adult students, 74 females and 37 males, 72% Caucasian, 26% African American, 1% Native American and 1% Asia/Pacific Islander; ages ranged from 18 to 40 years old (M = 21, S.D. = 3.25), with most reporting marital status as single and being full-time students. Using a quasi-experimental research design, adult students completed pre- and post-test surveys, which measured statistical literacy, based on Gal's (2004) Model of Statistical Literacy that embraced both knowledge and dispositional elements. Fisher's LSD post-hoc test results showed a statistically significant difference among class types for the knowledge elements, statistical thinking, reasoning, and literacy, but no statistically significant differences for the critical questions. Results from a MANOVA on post-test scores among class types showed no significant differences on the dispositional elements, affect, cognitive competence, difficulty and value. For beliefs, a Chi-square analysis showed that 90% of adult students in the research methods class with prior statistics believed that statistics was relevant in their lives. More importantly, further tests that examined pre- to post-test scores revealed significant differences among class types. Implications for policy include a re-examination of prerequisites for statistics courses, and requiring completion of a statistics course before a research methods course. Many teaching implications are indicated in this research; however, the most important is the use of constructivist perspectives in the classroom; accordingly, future research should examine teaching methodologies. In addition, statistical literacy needs to be examined again; however, using modifications to the model that separates statistics into its two main branches, descriptive and inferential.

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STATISTICAL LITERACY IN ADULT COLLEGE STUDENTS
A Dissertation in
Adult Education
by
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Submitted in Partial Fulfillment
of the Requirements
for the Degree of
Doctor of Education
May 2009

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CHAPTER 1: Introduction

This first chapter of this dissertation lays the foundation for this quantitative research study on statistical literacy. It describes the background of the problem, the teaching of statistics, an overview of the conceptual framework, the problem and purpose statements, hypothesis, significance of the research, the précis of the research design, assumptions and limitations of the research, the organization of the dissertation, and definitions of terms.

Background to the Problem

This section examines why it is important for higher education and adult education to place an emphasis on the teaching of statistics. In the not-so-recent past, the teaching of statistics was not considered to be important in the college curricula, and when it was taught, it was taught in the abstract—it had no application to everyday life. However, a change in mathematics and statistics education was imminent, and during the 1990s a movement toward improving statistical education began to unfold. Currently and historically, numerical data is used and produced by our political system, but unfortunately, most Americans are unable to understand the reported data. The government uses data extensively in a variety of ways to monitor the social economy. For example, poverty is measured by numbers, and through these numbers individuals may claim benefits. Crime rates are measured as an indicator of public order, divorce rates are used to examine private morality and family life, and opinion polls measure the feelings of a country on a given issue at a given time (Rose, 1991). And as shown in the past, statistics were used for political gain. Take, for example, the American Census of 1840—unbeknownst to many this Census, like others, was riddled with errors.

For example: The 1840 Census added a count of the insane and idiots, distinguished by race and mode of support, to the counts of the blind, deaf and dumb, that had been included in 1830. When the results of the Census were published in 1841, the total number of those reported as insane or feeble minded in the United States was over 17,000. More to the point, perhaps, nearly 3,000 were black, and the rate of insanity amongst free blacks was 11 times higher than that of slaves and six times higher than that of the white population. For those who opposed abolition, like U. S. Vice President John C. Calhoun, these Census figures proved that blacks were congenitally unfit for freedom. (Rose, p. 685)

But more importantly, statistical literacy is more problematic today, because most information is governed by numbers. Numbers underlie everyday decisions, from quantitatively based proposals that shape public policy in education (Steen, 2001), to decisions regarding political candidates, medicines and health, which are based on logic and quantitative information (Moreno, 2002). Many research studies concerning these health and medicine issues are reported regularly in newspapers and magazines with conflicting results, and leave many to become cynical about research in general (Utts, 2003). Also, in this age of information, much of what is reported to citizens is unregulated, unrestricted, and difficult for many to interpret. Because of the inability to understand statistical information, many individuals become either skeptical or believe anything that is printed (Rumsey, 2002). This leaves those who are not mathematically or statically literate outsiders in a society whose inability to participate in public dialogue leads to mistrusting the technocratic elite, resulting in a retreat from public issues, or possibly an aggressive opposition to change.

Especially important to the discussion on statistical literacy is the global economy we live in and the global competition that ensues. Compared to other countries, the United States is behind in mathematics education. According to the Third International Mathematics and Science Study (TIMSS), which examined 38 countries, the United States was significantly behind 14, even with 6 and doing better than 17. One reason the United States remains competitive now is due to our sheer size, which allows us to select the best for our workforce. Labor markets are minimally

regulated, giving employers the flexibility to pay based on performance, leaving no guarantees for jobs, wages or benefits (Carnevale & Desrochers, 2003).

Respectively, all citizens in society need to be able to think quantitatively, from farmers to lawyers, from consumers to manufacturers and even jurors to the accused (Moreno, 2002). In fact, as Steen (1997) warns, "an innumerate citizen today is as vulnerable as the illiterate peasant of Gutenberg's time" (p. xxvii). Most schools do not provide a bridge from arithmetic in elementary education to mathematics in high school, to the world of data and statistics. One reason for this disjuncture is the perception about statistics by the public that it is not as rigorous or prestigious as some of the mathematics courses that are in place—for example calculus, which is associated with the hard sciences of physics and engineering. But in fact, the reasoning involved in data-based statistical inference "is harder for students to grasp and explain than the comparable symbol based problems and proofs in a typical calculus course" (Steen, p. 62).

Traditionally, algebra and calculus courses have been the dominant goals of high school mathematics. These are often the standard courses students need to complete their high school diplomas, and great importance is placed on them, because of college entrance exams, such as the ACT or SAT. These exams often determine if and where high school students will go to college. However, passing the requirements to get accepted into a college does not necessarily prepare students for higher education or later employment. Many students who are accepted into college find themselves required to take remedial courses in intermediate algebra, but unfortunately, the skills that they are required to master are rarely encountered in adult life. "From school to college, mathematics follows an isolated trajectory of increasing difficulty and abstraction whose implicit purpose is to select and prepare the best mathematics students for graduate education in mathematically intensive fields" (Carnevale & Desrochers, 2003, p. 21). On the other hand, courses that promote statistical literacy could help adult learners become better prepared to function in the real world, because in the real world, "mathematical activity begins not with formulas, but with data" (Steen, 2003, p. 59). Our educational system is only beginning to promote the need to understand mathematical reasoning or quantitative reasoning.

How mathematics is being taught—and what is missing from the curricula—has been the impetus for change, and was addressed by the National Council of Teachers of Mathematics (NCTM) in the 1990s to reform teaching at all levels. The call for change— the Democratization of Mathematics—is the remedy to close the cultural, political and economic gap between those who are literate and illiterate in mathematics. It is not the dumbing down of mathematics courses, but rather making them more accessible to all students, who later become citizens in a data driven society (Carnevale & Desrochers, 2003). It also asserts mathematics is no longer a curriculum designed for the elite, as it was in the past, but as a necessary part of general education for all citizens (Moore, 1997). Data has shown education in mathematics "has always been about separation—of rich from poor, of boys from girls, of elites from plebeians…the biggest barrier to upward mobility in educational attainment" (Steen, 2004, n.p.). Moore further argues that democratization also states mathematics studies need to move away from the esoteric toward the immediately useful. Reformers in mathematics education urge: A change of culture toward the concrete, toward applications, toward ability to use mathematical concepts and tools over rigor of detail…they are responding to the pressures of democratization. This is an opportunity for statistics; as mathematical studies shift toward a more utilitarian approach, a larger place for statistics opens up. (p.124). Hence, the movement, the Democratization of Mathematics, not only places emphasis on the teaching of mathematics, but also the teaching of statistics, especially at the college level.

During some of the changes that were being implemented in mathematics education at the beginning of the Democratization of Mathematics, a concern about adults and mathematics education surfaced. While the teaching of reading and writing to adults has been a primary focus

of adult educators, the teaching of mathematics has not. Most research on the teaching of mathematics and adults has been focused on math anxiety or comparing the mathematical abilities of women to men (Rose, 1997). In adult education and literacy, quantitative skills have been viewed as a basic skill adults need to possess. However, defining the types of mathematical skills necessary to function in society have been vague. As defined by the United States National Literacy Act in 1991, adult literacy is an individual's ability to read, write and speak in English, and to compute and solve problems at levels of proficiency necessary for functioning on the job and in society, achieving one's goals and developing one's knowledge and potential. (Gal, 1997, p. 13)

From this definition it is clear that computation and problem-solving abilities are of chief concern within adult literacy; however, to specifically outline them remains a challenge. What are the "mathematics-related skills, knowledge, abilities and dispositions adults require to meet the goals of literacy and numeracy" (Gal, 1997, p. 13)? Gal informs us that this is a complicated question to answer, due to the multiple and diverse types of situations adults encounter in their daily lives "involving numbers, measurements, mathematical ideas, patterns, probabilities and events that unfold over time" (p. 13). One area where mathematical skills are interwoven with statistical literacy is the community, as it is of the utmost importance of the community to have an informed citizenship. Here, an individual, who is statistically literate, can comprehend poll results or crime figures, or promote social action by interpreting surveys that may have important environmental implications. (Gal). Others who join the discussion on adult literacy, define mathematical skills adults require to include "computational skills and number sense, statistical and probabilistic knowledge and reasoning, including data representation and interpretation of graphics" (Weist, Higgins, & Frost, 2007, p. 48). These skills are considered life skills for adults by some in that they enable individuals to assess claims, detect fallacies, evaluate risk and weigh evidence (Steen, 1997), which adults encounter in the media in their daily lives. As important as statistical literacy is, it is surprising to find that it is not included as part of the most commonly used instrument to measure adult literacy in the United States, the National Assessment of Adult Literacy (NAAL).

The NAAL is a nationally representative assessment of English literacy among American adults age 16 and older, and examined over 19,000 adults' literacy skills in the United States in 2003. This scale measures adult literacy on three literacy dimensions of adult learning, prose, document and quantitative. Prose literacy refers to skills needed to search, comprehend and use continuous texts—for example, interpreting editorials, news stories, brochures and instructional materials. Document literacy is the knowledge and skills required to search, comprehend and use non-continuous texts in various forms such as job applications, transportation schedules, or drug and food labels. Quantitative literacy embraces the skills required to perform quantitative tasks requiring an adult to identify and perform computations by using numbers embedded in text. Examples of quantitative literacy would include demonstrating the ability to balance a checkbook, compute a tip in a restaurant, or complete an order form (National Center for Education Statistics [NCES], 2006). The scale does not examine adults' ability to interpret statistical data that is presented in multiple ways and in various forms to the general population and further, it does not examine the related abilities necessary to critique various types of numerical or statistical based information (NCES, 2006). However, these measures of literacy will probably not remain stagnant, as various projects are under way to establish content standards for what adults should be able to do after completing their education (Gal, 1997).

Changes on other scales have occurred. Similar to the NAAL, the renamed Adult Literacy and Lifeskills Survey (ALL) measures adult literacy in the United States and in 20 other countries, for example in Canada and Italy. The new instrument has modified its assessment from prose, document and quantitative literacy to prose and document literacy, numeracy and problem solving. The new numeracy scale is replacing the old quantitative scale and is "designed to be

broader than the quantitative literacy scale, going beyond applying arithmetic skills to a wider range of mathematical skills such as the use of number sense, estimation and statistics" (NCES, 2006, p. 1).

Results from the ALL surveys suggest adults' numeracy skills are deficient in specific areas. In fact, 25 to 50% of American adults are unable to complete a range of …

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- ISBN: 1244092436
- ISBN-13: 9781244092433
- PUB. DATE: September 2011
- PUBLISHER: BiblioLabsII

Source: http://udini.proquest.com/view/statistical-literacy-in-adult-pqid:1883501711/
Download full version : $37.

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