Expectations for Statistical Literacy:
A Comparison among Psychology, Business, and Public Health Professions

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Abstract: The Consortium for the Advancement of Undergraduate Statistics Education (CAUSE) and the International Statistics Project emphasize the need for statistical literacy. Definitions of literacy tend to be general statements that need to be expanded to address specific skills. This poster presented a draft survey for identifying key specific elements of literacy. The intent of the surveys will be to make comparisons of expectations held by faculty and by employers of recent graduates. The academic areas planned to be surveyed include: business, psychology, and public health. While Fulcomer et al. (2005) noted similarities in various statistics courses that cross content lines, the current effort is in identifying similarities, differences, and potentially missing elements in statistics curricula. The session was used to encourage comments on the draft instrument.

1. INTRODUCTION

Statistical literacy and the implications for teaching statistics are currently actively discussed topics in the statistical education literature. While definitions vary, there is no doubt that statisticians, statistical educators, and many other's believe statistical reasoning is important to functioning in today's world. Evidence of the importance of statistics is provided by Schield (2005) who suggests that, quite possibly, over 50% of the college graduates in the United States have taken a course in statistics.

Along with the emphasis on defining statistical literacy, several researchers have been studying the implications for statistics educators in recognition of the need to develop a literate population. We believe many would agree that developing students' statistical skills for higher level college courses and the world of work are reasonable goals for introductory statistics courses. Nevertheless, we are also amazed by how many people make negative remarks about statistics courses and say that the statistics course they took had no value for them.

2. DEFINITIONS OF STATISTICAL LITERACY

Definitions of literacy encompass not only the ability to use statistical language and concepts, but also to think critically, communicate statistical ideas, and apply statistical reasoning to novel situations. By comparing several definitions of statistical literacy, we note the emphasis on critical thinking. Gal (2002), for instance, defines statistical literacy as interpreting, critically evaluating, and communicating statistical information, data-based results, and stochastic phenomena. He also emphasizes the importance of applying statistical concepts to diverse content. Li (2005) notes that the Minister of Education of China views statistical literacy as including the following three components:

1. Familiarity with using statistical thinking to deal with problems containing data.
2. Appreciating the role statistics plays in decision making by going through the process of collecting, displaying, and analyzing data, and making reasonable decisions.
3. Being able to critically read data resources, data analyses, and summarized information.

Again, we note the inclusion of critical thinking in the Minister's definition of statistical literacy.

Wallman (1993) defines statistical literacy' as "the ability to understand and critically evaluate statistical results that permeate our daily lives--coupled with the ability to appreciate the contribution that statistical thinking can make in public and private, professional and personal decisions." Watson (1997) uses a three-tier hierarchy to examine statistical literacy with Tier 3 being the "questioning of claims." Finally, Rumsey (2002) notes the discrepancies in the many definitions and opts to use one term, statistical competence, to refer to the basic knowledge necessary for statistical reasoning and thinking. She then defines statistical citizenship to refer to the ability to function effectively in today's age of information by questioning, inquiring, probing, comparing and contrasting, explaining, and evaluating. Statistical citizenship obviously requires high order statistical reasoning and thinking. Clearly, scholars studying statistical literacy see a need to emphasize critical, questioning behavior as a part of teaching statistics. Emphatically clear is that statistical literacy involves more than calculating values and solving text book problems.

3. CONSUMERS OF STATISTICAL INFORMATION

Another notion that has appeared in the literature is the concept of the statistical consumer. For example, Gal (2003) studied the demands placed on consumers using statistical products produced by large statistical

organizations. By examining work products produced by large national and international organizations, he classified the variety of statistical products as Indicators, Press Releases, Executive Summaries and Highlights, Reports, and Aggregate Data. After examining each of the classifications, he makes the case that using the statistical products requires the activation of knowledge bases and dispositions noted in his previously published model (Gal, 2002). He concludes by claiming that even consumers of statistical information may require substantial statistical and mathematical knowledge to critically evaluate statistical products.

Isaacson (2005) provides another view of statistical consumerism by describing the development of courses focused on teaching statistical concepts from a consumer perspective. The course deemphasizes calculation while emphasizing using statistics in arguments, analyzing and interpreting statistics contained in written prose, and examining covariation and confounding. He summarizes the focus with the acronym CARE—Confounding, Assembly, Randomness, and Error with "Assembly" defined as the influence of data definition and presentation on a given piece of statistical evidence (p. 2245).

We take the position that being a consumer of statistics does not trivialize the topic. Being a good consumer requires the critical thinking skills we noted as being important to any definition of statistical literacy. We question, however, the degree to which calculations and problem solving can be minimized. Certainly complex and tedious calculations need not be covered in an introductory class, but some knowledge of calculations appears necessary. Nevertheless, in this paper we will not pursue the notion of how much calculation is needed in an introductory statistics class.

4. COGNITIVE ELEMENTS INCLUDED IN STATISTICAL LITERACY

Other researchers have pursued statistical literacy using a cognitive psychology theme in which the development of intellectual ability is the idea underlying the sequencing of topics in a statistics curriculum. Gal (2002) sees statistical literacy as focusing on interpreting and critically evaluating statistical information, data-based arguments, and stochastic phenomena. He also sees statistical literacy as resulting in an ability to discuss and communicate one's reactions to the information or argument in diverse applications. His model combines knowledge elements (literacy skill, statistical knowledge, mathematical knowledge, context knowledge, and critical questions) and dispositional elements (beliefs and attitudes, and critical stance) as the keys to developing a statistically literate population. Watson et al. (1995) report on a substantial project to enhance higher-order skills in data handling for a wide range of students. Rumsey's (2002) emphasis on being able to

"explain, decide, judge, evaluate, and make decisions about the information" shows the importance of cognitive skill in the development of statistical literacy. Isaacson (2005) provides a description of the development of an on-line statistical literacy course with a focus on critical thinking. Clearly, the development of critical statistical thinking ability has a cognitive basis.

While defining statistical literacy is challenging when approached from a relatively abstract perspective, even more variation is expected when one discusses the capabilities a statistically literate employee or student brings to the table. The aim of this paper is to propose a survey instrument that can be used as a means of evaluating statistical expectations held by employers and instructors of statistically literate workers and students.

In an attempt to identify gaps based on the students' perceived needs for their development. Harraway and Barker (2005) studied the gap between what is taught in the university and what is needed on the job by surveying recent graduates from a variety of disciplines. They asked the 977 respondents about statistical topics studied in school, which of 46 statistical techniques and methods were used in the work place, and finally, made recommendations for improving statistical training. The Harraway and Barker results show the importance of common topics such as graphing, basic hypothesis testing, ANOVA, and simple and multiple regression in the work place. They also show that some topics have limited use within the world of work. Aiken, West, and Sechrest (1990) review gaps in statistical reasoning for graduate psychology students. Interestingly, while they report adequate training in 1990 on topics that had been well developed twenty years prior to their study, they lamented the lack of coverage of topics that would have been current in 1990.

5. O*Net Use of Statistical Concepts

While the above perspectives arise from statisticians, statistically trained faculty, and statistics educators, examining the world of work from a human resource view may provide different results. O*Net is a comprehensive database of worker attributes and job characteristics that is used by organizations conducting job analysis, training, career counseling, and employment testing. O*NET aims to be the nation's primary source of occupational information. For this paper, an important characteristic is that it provides a common language for defining and describing occupations. The database contains information about knowledges, skills, abilities (KSAs), interests, general work activities, and work context.

The *O*Net Questionnaires: Generalized Work Activities* (2006) is a comprehensive list of activities designed to distinguish a wide variety of jobs and aid in developing selection tests for various jobs. What is

interesting about this *O*Net* questionnaire is the indirect approach to identifying statistical work activities. No activity is clearly identified as being statistical, yet several activities incorporate statistical ideas. For example, the "Processing Information" activity is evaluated on two scales with the questionnaire. One of the anchors for one of the scales includes the anchor "compile data for a complex scientific report." Thus, the O*Net generalized work activities do not provide a broad view means for obtaining the clear evidence about the statistical demands of the world of work, but the activities support the importance of statistical reasoning at work when examined closely.

We believe that more work can be done to evaluate the importance of statistical literacy in both the work place and in college course that follow introductory statistics. Much of the work noted above in support of statistical literacy has been provided by statisticians and statistical educators. When the *O*Net* questionnaire was examined, the emphasis on statistical thinking was not obvious. What appears to be needed are data showing the relative importance of elements of the introductory statistics course sequence.

6. Questionnaire Development

The ubiquitous introductory statistics course is taught in a variety of undergraduate and graduate programs forms the basis for the development of our instrument. We doubt that few would argue that these introductory courses promote statistical literacy. What we wish to expand upon is the relationship between what is taught and what is required by the world of work and content courses that follow introductory statistics. In line with research noted above, we also have interest in the cognitive demands associated with statistical tasks required by work and in content courses. A copy of the survey form presented in Seattle is available from the first author.

7. Reference List

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