Developing Statistical Intuition Through Visualization

George Hess, Forestry Department

Background and Rationale

I teach Natural Resources Measurements (NR 300), a course in which students learn to estimate population attributes with statistical confidence. For example, they might be asked to estimate the amount of woody debris (i.e., sticks and branches on the ground) in a forest, or the number of small mammals along a greenway. Statistical confidence, or confidence interval, is the "plus-or-minus" term that provides a measure of certainty for the estimate, as in "The amount of woody debris is 500 cubic feet, plus-or-minus 50 cubic feet." In order to develop a confidence interval, one must calculate the sample variance and associated statistics.

Most students do not develop an intuitive sense of how statistical measures, such as variance, standard error, and confidence intervals, change with sample size and the variability of the population attribute they are trying to measure (e.g., delMas et al. 1999; delMas 2002). On completion of the course, most are able to carry out the calculations mechanically but few have made intuitive connections between the numbers and what they are seeing in the field. Thus, they are unable to give ready answers to questions such as "What would probably happen to your estimate and confidence interval if you took fewer samples? Or the debris were arranged differently? Or the animals started avoiding your traps? And how would you change what you're doing as a result?" Being able to answer questions like these is an important skill, because our graduates will encounter circumstances more complex than those presented in classroom laboratories.

Objective

I will implement visual, web-based simulation learning modules to help students develop a stronger intuition about how changes in the population being measured affect variance, confidence intervals, and other statistical quantities. Students will be able to make changes in simulated populations or sampling scheme and see the effects graphically.

Approach

There are a number of existing software products that attempt to address this issue (Ben-Zvi 1997; delMas et al. 1997; Garfield et al. 2002) as well as simulation packages that could be used to design a custom product (e.g., MatLab and SimuLink). I will hire a graduate student to work with me to:

- » evaluate available software and select the most appropriate product
- » obtain and install selected software
- » design learning modules to improve statistical intuition through visualization
- » modify software as needed to meet learning objectives
- » implement the learning modules during the Spring 2004 offering of my course
- » develop and administer classroom assessment instruments to evaluate the efficacy of the learning modules

» modify the learning modules as needed, based on assessment results

Evaluation

I will evaluate effectiveness through a sequence of classroom assessments.

- » Baseline assessment: Test student intuition at the beginning of the course (basic statistics is a prerequisite) using one or two well-designed questions.
- » Pre-assessment: Test student intuition after teaching the material through mini-lectures and practice problems (i.e., the way I have done for years).
- » Post-assessment: Test student intuition after using the new visualization modules.

I will consider the approach successful, if performance on the post-assessment is better than performance on pre- and baseline assessments. I expect to see little improvement from baseline to pre- assessment and marked improvement from pre to post assessment.

Dissemination

Software developed for this project can be incorporated into other natural resources / forestry courses that would benefit from improved statistical intuition. In our own department, there are several measurements courses that could benefit from this approach. I will work to publish the results (e.g., Journal of Natural Resources and Life Sciences Educations) and I will make all products available freely on the InterNet.

Budget

Item	FCTL	Forestry	Total
Graduate student stipend, 1 year	$2,000		$2,000
Software (to be determined)	$500	$500	$1,000
TOTAL	**$2,500**	**$500**	**$3,000**

Citations

Ben-Zvi, Dani. 1997. Software for Teaching Statistics. URL=www.dartmouth.edu/~chance/teaching_aids/IASE/11.Ben-Zvi.pdf, 2003 Jan 27.

DelMas, R.C. 2002. Statistical literacy, reasoning, and learning [special section]. J. Stat. Ed. URL= www.amstat.org/publications/jse/v10n3/delmas_intro.html, 2003 Jan 27.

DelMas, R.C., J. Garfield, B.L. Chance. 1999. A model of classroom research in action: developing simulation activities to improve students' statistical reasoning. J. Stat. Ed. URL=www.amstat.org/publications/jse/secure/v7n3/delmas.cfm, 2003 Jan 27.

Garfield, J., R.C. delMas and B. Chance. 2002. Tools for teaching and assessing statistical inference. URL=http://www.gen.umn.edu/faculty_staff/delmas/stat_tools/index.htm, 2003 Jan 27.