Link and Think – a model for enhancing the teaching and learning of statistics in the behavioral sciences (the power of a definition)

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Abstract

Statistics is generally classified as a difficult course. In this regard, promoting an active learning environment is a popular instructional strategy. However, there is much evidence in the literature of a literal and simplistic interpretation of "active learning environment". This report describes an approach to facilitating introductory statistics. The model embodies constructivism, the integrated curriculum approach and outcomes-based assessment. Statistics is promoted as data management, and is defined as: a structured and logical process of collecting, organizing, analyzing, interpreting and presenting data, based on specific objectives, for the purpose of decision-making. This model provides a logical framework that reflects real world applications. In particular, it has the potential to offer appropriate stimuli for cognitive effort, resulting in learning that is meaningful rather than rote.

Key words: psychology, constructivism, teaching, learning, statistics)

Introduction

This case study report is based on my teaching experience as an assistant professor of statistics in psychology at Mercy College and Hunter College, New York. This model must be viewed as a work in progress

A review of articles published in the Journal of Statistical Education (1993 –2002)[1] and presentations from the International Conferences on Teaching Statistics (ICOTS 1982-2002)[2] shows an abundance of information on:

- challenges to teaching introductory statistics
- fear, anxiety and failure associated with introductory statistics
- preparation of students (pre-requisites)
- the use of technology/computers in the teaching of introductory statistics, and
- best practices models for teaching selected topics in introductory statistics.

However, there exists a dearth of information on:

- a comprehensive model for teaching introductory statistics (behavioral sciences)
- evaluation of teaching methodologies
- empirical basis of teaching methodologies
- faculty preparation, and
- needs assessment for statistics education in general, and introductory statistics in particular.

Objective

My objective is to develop a simple model that will de-emphasize formulae, calculations and examinations, and promote reasoning (thinking) by making links with real life activities that truly define the subject and which almost all students can identify with. Above all, I first seek to facilitate the student to appreciate (other than for credits) the rationale for studying statistics.

Teaching Methodology

I usually elicit from students on the first day (focus group style):

- their feelings about the subject
- their expectations of me and the course, and
- their perceptions of the role of statistics in their lives.

The following are common themes from the responses over the past two years:

- I am afraid of math, numbers, calculations, formulae and computers
- I am going to fail this course
- do you give make up exams (extra credit)?
- not sure how statistics will help except to get my degree
- use examples to explain
- do not overwhelm us with notes
- it helps to understand information

In general, my approach to teaching is guided by a definition and the core functions of statistics **(see flow diagram)**, and was formulated based on the theory of constructivism[3]. This concept evolved from the works of John Dewey, Jean Piaget and L. S. Vygotsky who characterized learning as "experiencing the material".[4]

Constructivism in general and its application in the teaching of statistics purport that students construct new knowledge and meaning by linking and relating new experience and information to previous knowledge.[5-6] In this regard the emphasis is on creating active learning environments[7] with stimuli for cognitive effort leading to learning that is meaningful rather than rote.

Consistent with this theory, course content and development have focused on the integrated curriculum approach (problem-based learning) as plausible in facilitating statistical reasoning. It has been reported that knowledge is recalled more easily, retained longer, and more readily applied when the process of learning reflects the real world applications of knowledge and skills. (Boyle 1999)[8]. This

approach has also been characterized as cognitive apprenticeship.[9]

An integral part of this methodology is student assessment, the importance of which is underscored in the words of the psychologist Lauren Resnick (quoted in Wiggins 1992, p. 152[10]), "we get what we assess, and if we don't assess it, we won't get it." Essentially the form of assessment determines not only what material students learn but also more importantly how they go about learning it.

As a focus for this approach, David Moore, a pioneer in the field of statistics education, has long recommended that "for statistical reasoning, the student must recognize the omnipresence of variation and learn how this variation is quantified and explained."[11]

The specific elements of my methodology are:

- a practical definition of statistics
- outlining the development of statistics as a discipline
- promoting statistics as data management
- cooperative learning (small-group exercises) . Garfield (1993)[12]
- the integrated curriculum approach/problem-based learning (linking within and between course concepts to reflect real-life research scenarios and solutions)
- teaching statistics as a language (includes vocabulary building to facilitate practical report writing to allow for decision-making)
- attention to data quality (reliability and validity)
- outcomes-based assessment[13] (1) statistical analysis in the context of research including exploratory data analysis based on class-generated and other real-life data (2) reading articles from peer-reviewed journals and commenting on the statistical methods, results and their interpretation, and (4) discussing statistics and research reported in the popular press, and
- faculty evaluation (1)routine course evaluation (2) faculty peer observation, and (3) informal student feedback.

Operationalization of the Methodology

I usually begin with a carefully crafted definition of statistics, which is the sole focus of the introductory session and is promoted as a general framework for the entire course.

The Definition

Statistics can be viewed as data management, and defined as a structured and logical process of collecting, organizing, analyzing, interpreting and presenting data, based on specific objectives for the purpose of decision-making.

To facilitate understanding of this definition, the following is provided:

Explanation

Structured	defined steps or activities
Logical	in an order that is natural and makes sense
Process	set of related activities (collect -> organize-> analyze -> interpret-> present)
Specific Objectives	allows for identifying and defining the variable(s) of interest and to characterize the analysis: univariate, bivariate or multivariate
Decision-making	facilitates students to focus on and appreciate the need for optimum quality data, given that critical decisions will be based on the findings. Reliability and validity are addressed.

At this stage, the term **VARIABILITY** is introduced, and it is emphasized that the presence of variability in data makes statistics possible, and that in general, we seek to:

- identify and measure it (variability)
- explain it, and
- model it (to predict).

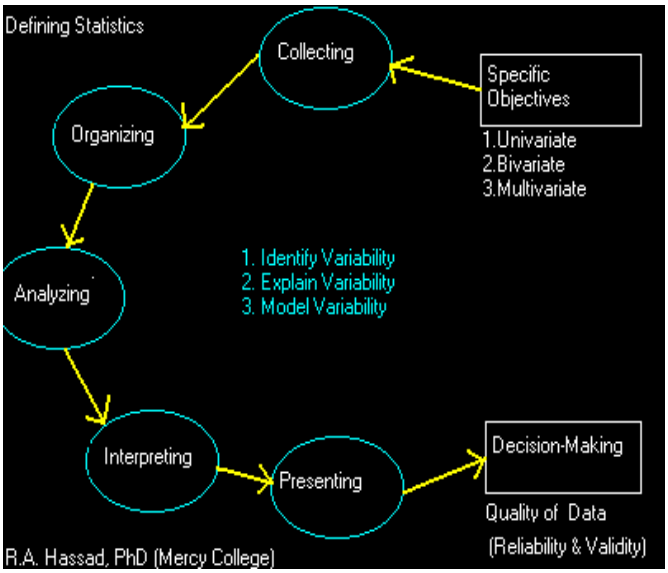
The focus then shifts to **DATA**, which is introduced as numerical (continuous & discrete) and categorical (nominal and ordinal). Using a pun which most students recognize, I then mention that not all data behave the same way, some are normal and others non-normal or skewed (graphical sketches are shown). Therefore, the behavior of data together with the objective of the exercise will demand that the data be treated differently, hence the need for different statistical tests.

Each statistical analysis (descriptive and inferential) is explained in accordance with the definition, in the context of research, and is generally detailed as follows:

1. state the objective of the analysis
2. identify the variable(s)
3. if applicable, orient the variables with respect to independent (explanatory) and dependent (outcome)
4. define the variable(s) especially to identify the type of data to be collected/analyzed including the specific level of measurement
5. characterize the analysis (univariate, bivariate, multivariate)
6. select the appropriate statistical test
7. perform the test
8. interpret the results in conjunction with the objective, and
9. write a practical report to allow for decision-making.

With respect to the actual statistical test, emphasis is given to its conceptual framework (logic) rather than mathematical calculations. All analyses are usually performed with a statistical software package (SPSS)[14] from which appropriate tables and graphs are also generated for report writing and presentation. I have observed that having generated the SPSS output, students generally find it easier to follow and understand the formulae and calculations.

Flow Diagram of Definition/Model



Results (qualitative outcomes)

- Almost all students have described the course as practical and challenging. In particular, there was overwhelming support for the following features of the methodology:

  1. presents course content in an organized manner
  2. makes good use of examples and illustrations to clarify concepts
  3. interprets difficult and abstract ideas, and
  4. stimulates thinking.

- In general, students became empowered, evidenced by greater interaction and participation in learning activities along with enthusiasm about the course.

- There was evidence of considerable learning (articulation, integration and application of concepts).

- This teaching methodology has been rated "excellent" by faculty peer observers and students.

- This model stimulated great interest in research. Students and their professors reported tremendous benefits from this course (pre-requisite) when students progressed to experimental psychology.

Conclusion & Recommendations

Providing a comprehensive, practical and meaningful definition of statistics in the introductory lecture can promote greater understanding of and appreciation for the subject, and dissipate fear and anxiety generally manifested by students of introductory statistics in the behavioral sciences. This definition provides a logical framework that reflects real world applications. In particular, it has the potential to offer appropriate stimuli for cognitive effort, resulting in learning that is meaningful rather than rote.

Student anxiety and fear must be given critical consideration in the teaching of introductory statistics, especially in the social and behavioral sciences, which traditionally are literature-based rather than data-oriented. "The affective domain of learning is sometimes left to chance."[15] Ramsden (1992)[16] states that any anxiety students have about a subject will affect their learning style. He subsequently notes that it is possible for the same student to exhibit deep, surface, or strategic learning styles within the same subject.[17]

The model used herein is consistent with the theory of constructivism, which application to the teaching of introductory statistics is not without controversy[18]. However, given the plausibility of this concept and the widespread success of its application in other disciplines, any heterogeneity in outcome may be attributed to a lack of consistency in operationalizing the concept.

Specifically, there is much evidence in the literature of a literal and simplistic interpretation of "active learning environment" to mean mere proliferation of and emphasis on computers (primarily for simulations) rather than the integration of this technology into practical activities and exercises which can provide stimuli for cognitive effort and hence a meaningful learning experience. Such an approach attaches more importance to technology rather than pedagogy. In this regard, it must also be noted that the computer has the potential to exacerbate fear and anxiety especially with our changing and non-traditional student bodies.

DelMas, Garfield and Chance (1998)[19], in their paper on understanding sampling distributions, posit that the computer may detract from learning through cognitive overload. Specifically, they noted that, "while software can provide the means for a rich classroom experience, computer simulations alone do not guarantee conceptual change." This position was reinforced in a 1999 conference presentation,[20] which commented on the ambiguity about the effect of computer technology on both the communicative style of the instructor and the learning process of the students. The author concluded that computer-assisted instruction is beneficial to the student when the instructor's role is perceived as an integral part of the process (facilitator) rather than a mere adjunct to the process. A subsequent conference presentation[21] reported that computers negatively affected class management.

In summary, this model emphasizes holistic[22] statistics. In this regard, statistics is detailed as a tool of research and addressed in that context, with the associated

methodological and data quality issues that must be considered for effective decision-making. There is need to enhance pedagogy (faculty preparation) in order to effectively integrate technology into the introductory statistics curriculum and promote meaningful learning. At the very minimum, let's listen to our students, they can help us to shape a successful teaching and learning experience.

Finally, further evaluation of this teaching methodology is encouraged.

List of References

[1] http://www.amstat.org/publications/jse/

[2] http://www.swin.edu.au/maths/iase/english.html

[3] Von Glasersfeld, E. (1987). Learning as a constructive activity. In C, Janvier (Ed.) *Problems of representation in the teaching and learning of mathematics*. Hillsdale, NJ: Lawrence Erlbaum Associates, 3-17.

[4] Steinhorst, R. K. and Keeler, C. M., Developing Material for Introductory Statistics Courses from a Conceptual, Active Learning Viewpoint ; *Journal of Statistics Education* v.3, n.3 (1995).

[5] Cobb, P. (1994), "Where is the Mind? Constructivist and Sociocultural Perspectives on Mathematical Development," *Educational Researcher*, 23, 13-20.

[6] Von Glasersfeld, E. (1987), "Learning as a Constructive Activity," in *Problems of Representation in the Teaching and Learning of Mathematics*, Hillsdale, NJ: Lawrence Erlbaum Associates, 3-17.

[7] Garfield, J. (1993), "Teaching Statistics Using Small-Group Cooperative Learning," *Journal of Statistics Education* [Online], 1(1). (http://www.amstat.org/publications/jse/v1n1/garfield.html)

[8] Boyle, C. R., A Problem-Based Learning Approach to Teaching Biostatistics; *Journal of Statistics Education* v.7, n.1 (1999)

[9] Singer, J. and Willett, J. (1993), ``Lessons We Can Learn from Recent Research on Teaching: It's Not Just the Form, It's the Authenticity," paper presented at the 1993 Joint Statistical Meetings, San Francisco, CA.

[10] Wiggins , G. (1992), "Toward Assessment Worthy of the Liberal Arts," in *Heeding the Call for Change*, ed. Lynn Steen, MAA Notes No. 22, Washington: Mathematical Association of America.

[11] Moore, D. S. (1990), "Uncertainty," in *On the Shoulders of Giants: New Approaches to Numeracy*, ed. L. A. Steen, Washington: National Academy Press, pp. 95-137.

[12] Garfield, J. B. (1993), "Teaching Statistics Using Small-Group Cooperative Learning," *Journal of Statistics Education* [Online], 1(1). (www.amstat.org/publications/jse/v1n1/garfield.html)

[13] Wiggins, G. P. (1993), *Assessing Student Performance*, San Francisco, CA: Jossey-Bass.

[14] SPSS, Inc. Statistical Package for the Social Sciences.

[15] Gal , I. & Ginsburg, L., The Role of Beliefs and Attitudes in Learning Statistics: Towards an Assessment Framework; *Journal of Statistics Education* v.2, n.2 (1994).

[16] Ramsden, P. (1992), *Learning to Teach in Higher Education*, New York: Routledge.

[17] Prosser, M. (1994), "Student Learning," presentation to the Statistics Education Workshop, Melbourne.

[18] P. P. J. L. Verkoeijen, Tj. Imbos, M. W. J. van de Wiel, M. P. F. Berger, and H. G. Schmidt *Volume 10, Number 2 (July 2002): Journal of Statistics Education.*

[19] delMas, R. C., Garfield, J. B., & Chance, B. L. (1998). Exploring the role of computer simulations in developing understanding of sampling distributions. Paper presented in the AERA Annual Meeting. Montreal.

[20] Schenone-Stevens, M. Carla. Reflections from the Classroom on the effects of Computer-Assisted Instruction on the Teaching-learning process; paper presented at the Annual meeting of the National Communication Association (85th, Chicago, IL, November 4-7, 1999).

[21] http://www.swin.edu.au/maths/iase/english.html (6th International Conference on Teaching of Statistics ICOTS-6).

[22] Kettering, Jon R., Shaping Statistics For Success in the 21st Century; (Presidential Address); *Journal of the American Statistical Association;* Volume 92, Number 440, December 1997. http://www.argreenhouse.com/papers/jkettenr/jsm97addr.shtml