Reflection on Training, Experience, and Introductory Statistics: A Mini-Survey of Tertiary Level Statistics Instructors

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Abstract

Instructors of statistics who teach non-statistics majors possess varied academic backgrounds, and hence it is reasonable to expect variability in their subject content knowledge, and pedagogical approach. The aim of this study was to determine the specific course(s) that contributed mostly to instructors' understanding and use of statistics, as a first step toward understanding their cognitive style and pedagogical approach. An exploratory mini email survey was conducted via ALLSTAT and SRMSNET listservs. Courses reported were described as advanced or graduate level only, and classified as application-based, math, multivariate, probability, and research. The majority of the respondents 9 (56%) attributed their understanding of statistics to either an application-based or research course, and of those, 7 (44%) reported negative feelings about their introductory/first statistics courses. Notwithstanding the methodological limitations of this small study, these findings are plausible, and underscore the importance of discipline-specific applications (authentic activities), and constructivist pedagogy toward facilitating statistical thinking and literacy. Large-scale research is needed to determine the effect of instructors' academic training and professional preparation on their knowledge, conceptions, attitudes, and pedagogical practices in the context of teaching statistics, in particular, introductory courses.

Keywords: Statistics, Teaching, Learning, Introductory, Reform, Constructivist

1. Introduction

Instructors who teach statistics (especially introductory courses) to non-statistics majors possess diverse academic backgrounds, including psychology, behavioral sciences, education, sociology, mathematics, engineering science, biostatistics, statistics (mathematical and applied), epidemiology, economics, and public health. This heterogeneity in training and preparation is likely to equip them with varying degrees of knowledge and skills in statistics (content knowledge), which raises the following questions. How does this knowledge base translate into pedagogical content knowledge (Shulman, 1987), teaching, and student performance? Also, which specific course or other exposure from their training or practice most of all facilitated their understanding of statistics, and how does this relate to their cognitive style (Martinsen & Kaufmann, 1999; Lovett & Greenhouse, 2000) and pedagogical approach?

These questions are relevant to effective teaching and learning, as instructors may be inclined to teach the way they learned (Rusley, 2003). And this can be counterproductive when there is a mismatch of learning styles (Kolb, 1984; Fielding, 1994), which is not recognized and addressed by the instructor. This is particularly relevant to statistical methods, which have underlying concepts and assumptions that may be viewed as difficult and counterintuitive (such as aspects of probability theory and hypothesis testing).

The statistics education literature is abound with best practices for facilitating quantitative reasoning (Lovett & Greenhouse, 2000). These strategies are primarily the product of reform efforts, and have become the focus of professional development and continuing education programs for instructors. A major project in this regard was STATS: Statistical Thinking with Active Teaching Strategies (Rossman, 1996-1999) which conducted workshops for mathematicians who teach statistics but have little formal training in the subject. The target audience for these workshops has been expanded to include "instructors of the introductory course; those developing statistics concentrations, minors and majors; and mathematics education faculty who conduct pre-service training" (Pearl & Short, 2005).

Not adequately addressed in these training programs is the diversity of learning styles and learning strategies among students, which is the primary challenge to implementing effective pedagogy. For example, algorithmic learners are inclined to initially show resistance to reform-based teaching which emphasizes conceptual thinking and understanding, rather than mathematical underpinnings, and procedural knowledge. This barrier must be resolved before meaningful and deep learning can occur. When an empirically effective teaching method is not compatible with the student's learning style, compensatory pedagogy becomes necessary. That is, the instructor will have to adjust in order to facilitate the student to voluntary adopt a learning strategy that is conducive to meaningful learning (Weinstein & Mayer, 1986; McKeachie et al., 1985). Instructors should begin by explaining the rationale for their teaching tools and methods, and the specific benefits to their students.

If this approach is not adopted, we may lose many potential educators and practitioners. They will fail or drop the course, and go on to either change their academic major or not complete their degree. Also, there are those students who may have had an unpleasant experience with the course, struggled and managed to pass, but are discouraged from taking another statistics course, or engaging in the discipline. Moreover, statistics is fast becoming a graduation requirement for most majors, and especially in psychology, it is regarded by some academics as "the single most important course in terms of admittance into graduate schools" (Alder & Vollick, 2000). This obviously contributes to the high level of anxiety and concern that some students generally associate with statistics.

Toward promoting meaningful learning, the technique of concept mapping (Novak, 1991; Verkoeijen et al., 2002) is considered effective and efficient. It is favorable to a broad spectrum of cognitive styles, and enables students to identify, integrate, and apply course concepts (Jonassen, 1996). Concept maps are primarily semantic networks expressing the interrelationship among concepts within a domain of information. The exercise of creating this map helps students to make connections between theory and practice, and build on existing knowledge. Consequently, students become motivated and empowered, resulting in deep learning, as well as appreciation for the pedagogical strategies. Furthermore, construction of these concept maps (by students) allows the instructor to assess understanding and diagnose misunderstanding. Indeed, the key implication here is that the instructor should be conversant with pedagogy, as well as learning theories and their applications, however, this is more the exception rather than the norm.

Besides focusing on teaching methodology, introductory statistics courses with central and unifying themes such as "variability" (Moore, 1997), "prediction" (McLean, 2000), "data management", and "decision-making" (Hassad, 2002) have been suggested as effective for facilitating statistical thinking and literacy (Wild & Pfannkuch, 1999; Chance, 2002). Toward this end, the epidemiological model has been posited as a practical framework for designing introductory statistics courses to achieve quantitative reasoning (Stroup et al., 2004). This framework is generally defined as "the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems" (Last, 1995). This is especially applicable to the evidence-based disciplines (such as health and behavioral sciences). Other than promoting statistical literacy among students, these strategies, and methods can guide the training and re-training of faculty via graduate programs, as well as professional development workshops.

2. Objective

The primary objective of this exploratory mini-survey was to ascertain from instructors and practitioners of statistics the specific course(s) or other exposure which contributed mostly to their understanding and application of statistics.

3. Methodology

In January 2005, an exploratory mini email survey was conducted via ALLSTAT and SMRSNET. Two broad open-ended questions were asked, and permission was obtained from respondents to make the results available publicly, in summary form.

(1) Which course(s) or other exposure contributed mostly to your understanding and application of statistics?

(2) Do you recall when you first said any of the following? ("aha" experiences)

- Oh, I see, this is how it works!
- It's all coming together and making sense!
- I got it!
- This is so cool!
- I like this!

4. Results

Sixteen (16) responses (some quite detailed and informative) were received and analyzed. Respondents were either college/university instructors of statistics or practicing statisticians/data analysts with teaching experience. All courses reported were described as **advanced** or **graduate** level only, and based on thematic analysis were classified as follows:

Table 1. Type of course which instructors reported as being most instrumental to their understanding of statistics

Course Description	**Number**
Application-based*	7
Research	2
Multivariate	2
Probability	2
Math	3
Total	**16**

*The following were reported, and classified as application-based (statistics) courses: **Actuarial Science, Biometry, Business, Ecology, Economics, Psychology, Thesis, Dissertation, and SPSS. A few respondents listed multiple courses.**

The seven (7) respondents who reported "application-based" courses, expressed negative feelings (see below) about their introductory and earlier statistics courses. The other respondents did not comment on such courses.

- "My introduction to statistics was an incomprehensible course…."
- It "wash[ed] over me like a wave".
- "I didn't even catch the nuance between the two [standard error and standard deviation]. I just used them interchangeably."
- "The limit was the actual calculations since no computers were available…."
- "I didn't think the course was that interesting…"
- "Grueling"
- I "didn't really learn data analysis…."
- "Statistics was just another math course. I never saw the problem solving promise of the field."

5. Discussion

The majority of the instructors/practitioners 9 (56%) attributed their understanding of statistics to either an advanced or graduate level application-based or research course (Table 1). Of these, 7 (44%) reported or implied that their introductory statistics course was not helpful, as it was too math-oriented, and not practical. This profile seems to characterize instructors who are predisposed to active teaching and learning strategies (such as cooperative and problem-based learning, including hands-on data production, analysis, and presentation, as well as use of computers, discussions, and project-based assignments). On the other hand, respondents who reported math, probability and multivariate courses, as being most instrumental in their learning, may possess varied cognitive styles and pedagogical approaches, as these courses can be viewed as stimuli for different types of learning, understanding and reasoning. In particular, multivariate statistics (which explores multiple factors as determinants of an outcome), albeit mathematically intensive, is more consistent (than mere mathematics and probability) with real-world phenomena. Accordingly, it can be argued that multivariate statistics is akin to application-based courses, and is more likely to lead to conceptual understanding and deep learning. Multivariate statistical methods can facilitate understanding of concepts such as the biopsychosocial framework of disease (Engel, 1980), and multiple causality, which are the predominant models in the health and behavioral sciences.

It would be worthwhile to find out what type of understanding and reasoning was engendered by each course classification (Table 1), and the resulting pedagogical approach and student performance. In this regard, the learning context as well as cumulative learning (rather than a discrete course) must be considered. Specifically, application courses designed to promote higher-order thinking usually require pre-requisite knowledge and skills from introductory/first courses.

The delayed appreciation and understanding of statistics is disconcerting. For all respondents, this came with advanced or graduate level courses only (and not the introductory courses). Addressing this concern has been a focus of the introductory statistics education reform movement for more than a decade (Garfield et al., 2002). Despite the achievements, much remains to be done. The reform movement needs to be more visible and authoritative. A clear and well-defined mission is needed. And yes, we must expand and reorient our resources to support redoubling of our efforts in a more systematic and evidence-based manner.

Above all, these findings underscore the importance of discipline-specific and authentic learning activities (Rossman, 1997; Engel, 2002; Reeves et al., 2002) in facilitating statistical thinking and literacy. In this regard, the constructivist pedagogy continues to prove effective and attractive (Vygotsky, 1978; Garfield, 1993; Verkoeijen et al., 2002; Seipel & Apigian, 2005). It will serve instructors well if they become conversant with active learning strategies, as well as their theoretical underpinnings, particularly the educational and psychological dimensions.

Furthermore, the introductory statistics course ought to be an inviting experience for students. We must continue to improve this course so that students will emerge with useful and transferable knowledge and skills. Keep the material **R**elevant, **I**nteresting, and **S**imple, and be **K**ind (RISK) so that students can meaningfully experience the concepts rather than be victims of passive or mechanical learning. "Kind" in this context also refers to recognizing that some students may have negative feelings toward statistics, which may inhibit learning, if not appropriately addressed.

Instructors of introductory statistics (especially in the health and behavioral sciences) should consider using the epidemiological model to guide course development. This framework encompasses the themes of variability, prediction, data management, and decision-making with reference to real-world data, as well as salient and universal issues (health). This approach situates statistics in an applied context, and encourages students to conceptualize statistics as a structured and logical process of collecting, organizing, analyzing, interpreting, and presenting data, based on specific objectives, for the purpose of decision-making (Hassad, 2002). Moreover, attention to health-related data and an authentic context tends to provide motivation for students to explore and discover the meaning and interrelationship of variables and constructs.

Notwithstanding the methodological limitations of this mini-survey (sample size, design, recall bias, external validity etc.) these observations are plausible, and should be further explored with a larger and more scientific study (with attention to personal, socio-demographic, and contextual factors). Also, large-scale research is needed to determine the effect of instructors' academic training and professional preparation on their knowledge, attitudes, conceptions, and pedagogical practices in the context of teaching statistics, in particular, the introductory and basic courses for non-statistics majors.

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References

Alder, A.G., & Vollick, D. (2000). Undergraduate statistics in psychology: a survey of Canadian Institutions. Canadian Psychology, 41, 149-151.

ALLSTAT is a UK-based worldwide e-mail broadcast system for the statistical community, operated by LTSN Statistics.

Chance, B. L. (2002). Components of Statistical Thinking and Implications for Instruction and Assessment. Journal of Statistics Education [Online], 10(3). www.amstat.org/publications/jse/v10n3/chance.html

Engel, J. (2002). Activity-based statistics, computer simulation and formal mathematics. In: B. Phillips (Ed), Proceedings of 5th International Conference of Teaching Statistics, July 2002, Durban, South Africa.

Engel, G.L. (1980). The clinical application of the biopsychosocial model. American Journal of Psychiatry 137, 535-544.

Fielding, M. (1994). Valuing difference in teachers and learners: building on Kolb's learning styles to develop a language of teaching and learning. The Curriculum Journal 5(3):393-417.

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)

Garfield, J., Hogg, B., Schau, C., & Whittinghill, D. (2002). First courses in statistical science: The status of educational reform efforts. Journal of Statistics Education, 10, (2), JSE 2002 .

Hassad, R.A. (2002), "Link and Think - A Model for Enhancing the Teaching and Learning of Statistics in the Behavioral Sciences," 2002 Proceedings of the American Statistical Association, Statistics Education Section [CD-ROM], Alexandria, VA: American Statistical Association.

Jonassen, D. H. (1996). Computers in the Classroom: Mindtools for Critical Thinking. Englewood Cliffs, NJ: Prentice Hall.

Kolb, D.A. (1984). Experiential learning: experience as the source of learning and development. Englewood Cliffs, New Jersey: Prentice-Hall.

Last, J.M. (1995) A dictionary of epidemiology. (3rd ed.). New York, Oxford University Press.

Lovett, M. C., & Greenhouse, J. B. (2000). Applying cognitive theory to statistics instruction. The American Statistician, 54, 196-206.

Martinsen, O., & Kaufmann, G. (1999). Cognitive style and creativity. In M. A. Runco, & S. R. Pritzker (Eds.), Encyclopedia of creativity (Vol. I, pp. 273-282). NY: Academic Press.

McKeachie, W. J., Pintrich, P. R., & Lin, Y.G. (1985). Teaching learning strategies. Educational Psychologist, 20(3), 153-160.

McLean, A.L. (2000). The predictive approach to teaching statistics. Journal of Statistics Education [Online], 8(3).

Moore, D. S. (1997). New Pedagogy and New Content: The Case of Statistics, International Statistical Review, 65, 123-165.

Novak, J.D. (1991). Clarify with concept maps: A tool for students and teachers alike. The Science Teacher, 58 (7), 45-49.

Pearl, D., & Short, T. (2005). USCOTS E-NEWS: Vol. 1 (2), November, 2005.

Reeves, T.C., Herrington, J., & Oliver, R. (2002). Authentic activities and online learning. In A. Goody, J. Herrington & M. Northcote (Eds), Quality Conversations: Research and Development in Higher Education, Volume 25 (pp. 562-567). Jamison, ACT: HERDSA.

Rossman, A. (1997): Workshop statistics. Discovery with data. Springer: New York.

Rossman, A. and Short, T. (1996-1999). *STATS:* "Statistical Thinking with Active Teaching Strategies" workshops - NSF DUE/UFE Program, Award #9554621, 1996-1999.

Rusley, J. (2003). A look at science education at the university. The Catalyst (Brown University).

Seipel, S., & Apigian, C. (2005). Perfectionism in Students: Implications in the Instruction of Statistics. Journal of Statistics Education Volume 13, Number 2. www.amstat.org/publications/jse/v13n2/seipel.html

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57 (1), 1-22.

SMRSNET is a dedicated mailing list of the ASA (American Statistical Association, Survey Research Methods Section).

Stroup, D.F., Goodman, R.A., Cordell, R. & Scheaffer. R. (2004) Teaching Statistical Principles Using Epidemiology: Measuring the Health of Populations. The American Statistician. pp. 77-84(8).

Verkoeijen, P. P. J. L., Imbos, Tj., van de Wiel, M. W. J., Berger, M. P. F., & Schmidt, H. G. (2002). Assessing Knowledge Structures in a Constructive Learning Environment. Journal of Statistics Education [Online], 10(2). www.amstat.org/publications/jse/v10n2/verkoeijen.html

Vygotsky, L. S. (1978), Mind in Society, Cambridge: Harvard University Press.

Weinstein, C. E., & Mayer, R. E. (1986) "The Teaching of learning strategies." In M. Wittrock (Ed.), Handbook of research on teaching, pp. 315-327. New York: Macmillan.

Wild, C. J., & Pfannkuch, M. (1999). Statistical Thinking in Empirical Enquiry. International Statistical Review, 67, 223-265.