VARIABILITY IN THE TEACHING OF STATISTICAL LITERACY: A CASE OF PEDAGOGICAL DISSONANCE?

Rossi A. Hassad
Mercy College
New York, USA

Statistics education is a fast evolving discipline, and major advances have been made over the past two decades regarding reform of the introductory statistics course. There is now growing consensus that the introductory statistics course should seek to develop statistical literacy. The objective of this pilot study was to explore and describe self-reports of course learning outcomes and assessment strategies, as well as the extent to which instructors of introductory statistics at the college level emphasize statistical literacy. The results revealed that for a considerable proportion of instructors, what they think they are teaching is at variance with what and how they teach. If this gap is not addressed, it will quite likely result in students not being adequately prepared in statistical literacy, as well as misrepresentation of the type and quality of instruction. This gap or conflict between what instructors think they do and what they actually do, can be viewed as pedagogical dissonance, which can be attributed to a multiplicity of factors, addressed herein.

INTRODUCTION

Statistics education is a fast-evolving discipline, and major advances have been made over the past two decades, particularly with regard to reforming the introductory statistics course at the tertiary level (Forbes, 2014; Tishkovskaya & Lancaster, 2012; Everson, Zieffler, & Garfield, 2008). Reform has sought to address content, pedagogy, integration of technology, and assessment, toward making the first or introductory course more practical, applied and meaningful. In this regard, the constructivist (rather than the behaviorist) views and philosophy of teaching and learning have been the primary models and theories informing this change and dialogue (Hassad, 2011, 2013). There is now widespread consensus among instructors that the introductory statistics course should seek to develop statistical literacy (Forbes, 2014; Woodard & McGowan, 2012), which is increasingly becoming a required competency for most college and university majors, given the emphasis on evidence-based practice, and the realization that for most students, the introductory course will be their only formal education in statistics.

While there is no universal definition of statistical literacy, there is general recognition that it reflects conceptual understanding, including transferable knowledge and skills (Lane-Getaz, 2013), for which there are effective and evidence-based instructional strategies. Indeed, this approach represents an important shift in instruction, which has progressed on a continuum, with an initial emphasis on modification of course pedagogy, followed by changes in content and material, then infusion and integration of technology, to the point where it is now widely supported that the quality of learning (including what and how students learn) is directly related to, and driven by our assessment approach (Garfield et al., 2008). The critical role of assessment in the teaching and learning process is made clear by Resnick (as cited in Wiggins, 1990) who noted that: "*What we assess is what we value. We get what we assess, and if we don't assess it, we wouldn't get it*". Statistics educators vary in academic preparation and teaching philosophy; and they teach across disciplines. Therefore, it is reasonable to expect heterogeneity in terms of understanding and delivery of the course curriculum, and this could be problematic if their approach is incongruent with the intended outcomes of reform-based teaching of the introductory course.

OBJECTIVE

The objective of this pilot study was to explore and describe self-reports of course learning outcomes and assessment strategies, as well as the extent to which instructors of introductory statistics at the college level emphasize statistical literacy.

In: M.A. Sorto (Ed.), *Advances in statistics education: developments, experiences and assessments. Proceedings of the Satellite conference of the International Association for Statistical Education (IASE),* July 2015, Rio de Janeiro, Brazil. iase-web.org/Conference_Proceedings.php

CONCEPTUAL FRAMEWORK

At the core of effective instruction is assessment, and this has been a guiding principle of statistics education reform from its inception (Cobb, 1992; Hubbard, 1997), and indeed, reform in the wider academic setting. In other words, the desired learning outcomes should inform the instructional process; and in this context, the desired outcome is statistical literacy, and not merely knowledge of mathematical procedures and algorithms. Accordingly, what we value as learning outcomes should guide the content or materials we select, the pedagogical strategies used, integration of technology, and above all, the assessment methods. In the reform context, the assessments used must reflect and measure outcomes for statistical literacy, thinking and reasoning (Pearl et al., 2012). Statistical literacy is generally defined as the ability to interpret and critically evaluate statistical information and data-based arguments, and discuss opinions regarding such statistical information (Gal, 2000), outcomes that are consistent with the constructivist philosophy of education. How statistical literacy is understood and operationalized by instructors can vary by academic discipline, as well as by personal and contextual factors.

METHODOLOGY

In the Spring of 2015 a pilot cross-sectional study of statistics educators was conducted via the following:

1. ALLSTAT@JISCMAIL.AC.UK - A UK-based worldwide email broadcast system for the statistical community.
2. TEACHING-STATISTICS@JISCMAIL.AC.UK - A UK-based worldwide email broadcast system, concerned with the initial learning and teaching of statistics.
3. SRMSNET@LISTSERV.UMD.EDU - A mailing list of the Survey Research Methods Section of the ASA (American Statistical Association).
4. EDSTAT-L@LISTS.PSU.EDU - An email forum devoted to discussion of topics related to the teaching and learning of statistics at the college level.

The link to a brief questionnaire (designed via "Google docs") was circulated. The questionnaire ascertained information from instructors about the introductory statistics course; whether or not they emphasized statistical literacy, their course objectives or outcomes, assessment methods, as well as duration of teaching, highest earned academic degree, and the discipline in which they taught. All data were analyzed using SPSS (version 22) along with an online sorting and text analysis software for the open-ended responses. The interpretation of the qualitative data was guided by the TISS (Teaching of Introductory Statistics Scale; Appendix I, Hassad 2011), and was performed by two instructors who independently rated the narratives. The inter-rater reliability was initially 83%, and following discussion of the discrepancies, there was complete (100%) agreement. The TISS is a two-dimensional, ten-item teaching-practice scale. The two teaching dimensions (or subscales) are characterized as constructivist (reform-oriented, student-centered, and active learning) and behaviorist (traditional, instructor-centered, and passive learning).

RESULTS

There were 30 respondents in this survey, all of whom were engaged in the teaching of introductory statistics at the tertiary or college level. Almost all (80%) reported possessing a doctoral degree with a mean duration of teaching of 19 years (SD = 15 years, Median = 12 years, and Range = 49 years). The modal teaching discipline was social sciences (n = 7), followed by mathematics (n = 5) and statistics (n = 4). The other disciplines represented were business, education, engineering, and health sciences; a few were classified as multidisciplinary.

Of the 26 instructors who responded to the question: "*Do you specifically address statistical literacy in your introductory statistics course"*, 20 (77%) indicated "Yes" and the remainder "No". Content and thematic analysis of the open-ended responses (or narratives) to the following two questions was performed.

1. Briefly tell us how you have assessed or plan to assess the primary learning objectives or outcomes of your introductory statistics course.

2. What are/were the primary learning objectives or outcomes of your introductory statistics course?

Based on the extracted themes (Tables 3 and 4), and guided by the TISS (Teaching of Introductory Statistics Scale; Hassad 2011), each respondent's instructional approach was characterized as either more or less consistent with a focus on statistical literacy, specifically authentic assessment (question 1 above), and either more consistent with the constructivist or behaviorist philosophy (question 2 above).

Of the 18 instructors who reported specifically addressing statistical literacy in their introductory statistics course (Table 1), 7 (39%) were characterized as not focusing on statistical literacy, based on the narrative provided for their assessment approach. Also, 2 of the 6 instructors who reported not addressing statistical literacy, were oppositely characterized, that is, their assessment approach was determined to be consistent with a focus on statistical literacy. A similar trend was observed for the reported course objectives (Table 2); of the 11 who reported emphasizing statistical literacy, 5 (46%) were characterized as constructivist, and the other 6 (54%) as behaviorist. A comparable distribution was noted for the 4 instructors who reported not focusing on statistical literacy.

Table 1: Association between Respondents' Reports of Emphasizing Statistical Literacy and the Researcher's Characterization* of their Reported Assessment Approach (Narrative) N = 24

Do you specifically address statistical literacy in your introductory statistics course?	Reported Assessment (Narrative) Reflects a Focus on Statistical Literacy*		
Response	**Yes**	**No**	**Total**
Yes	11	7	18
No	2	4	6

*As determined by the Researcher, using the TISS (Teaching of Introductory Statistics Scale; Hassad 2011)

Table 2: Association between Respondents' Reports of Emphasizing Statistical Literacy and the Researcher's Characterization* of their Reported Course Objectives (Narrative) N = 15

Do you specifically address statistical literacy in your introductory statistics course?	Characterization of Reported Course Objectives*		
Response	**Constructivist**	**Behaviorist**	**Total**
Yes	5	6	11
No	2	2	4

*As determined by the Researcher, using the TISS (Teaching of Introductory Statistics Scale; Hassad 2011)

Constructivist: Reform-based, student-centered, and active learning
Behaviorist: Traditional, instructor-centered, and passive learning

Table 3: Classification of the Themes Extracted from the Reported Assessment Strategies (Narrative)

More consistent with Statistical Literacy	**Less consistent with Statistical Literacy**
Projects, collecting data, research design	Probability calculations
Oral and written data presentations	Textbook exercises
Computer assignments, take-home and open-book exams	Multiple choice exams
Focus on variation	Formulas

Table 4: Classification of the Themes Extracted from the Reported Course Objectives (Narrative)

More consistent with Constructivist Pedagogy	**More consistent with Behaviorist Pedagogy**
Design and conduct of experiments, ethical issues	Probability terms, rules and theory
Concepts of probability, distributions and sampling, think statistically	The central limit theorem, simulations, permutation tests
Research skills, exploratory data analysis,	Hand/manual calculations; descriptive statistics,

critically analyze research methodology	hypothesis tests
Skills in computing and statistical analysis, use of techniques	Calculate classical and empirical probabilities
Apply quantitative research techniques, formulate and solve problems	Knowledge of calculator functions
Teach concepts not formula, perform basic statistical analyses with SPSS	Algebra, calculus, mathematical models, formulae

DISCUSSION

This small pilot cross-sectional study identified a relatively high level of reports by instructors regarding emphasizing statistical literacy in their introductory course. While this is encouraging, it must be noted that 3 of the 4 online forums in which this questionnaire was circulated are dedicated to the discussion of improvements in statistics education, including quantitative and statistical literacy. Hence this finding should be expected, but cannot be generalized, given the small and convenience sample used. Also, it cannot be assumed that the membership these discussion forums represents the population of instructors of introductory statistics. Furthermore, these are cross-sectional data (obtained at one point in time), and may not provide a meaningful and sustained profile of teaching. Additionally, the qualitative approach used by the researcher to evaluate the narratives could have resulted in mischaracterization, albeit this may have been mitigated by having both narratives (course objectives and assessment approach) rated by two instructors; with an initial inter-rater reliability of 83%, and complete (100%) agreement following discussion of the discrepancies.

That said, there seems to be a major disconnect between the instructors' self-reports (of emphasizing statistical literacy), and the researcher's characterization of their instructional approach based on the narratives provided for course objectives and assessment methods. In other words, for a considerable proportion of instructors, what they think they are teaching seems to be at variance with what and how they teach. If this gap is not addressed, it will quite likely result in students not being adequately prepared in statistical literacy, as well as biased estimates of the extent to which statistical literacy is being facilitated; not to mention, a misrepresentation of the type and quality of instruction.

This gap or conflict between what instructors think they do and what they actually do, can be viewed as pedagogical dissonance, which can be attributed to a multiplicity of factors and explanations, including the following.

1. A definition of statistical literacy was not provided to the participants, and therefore, their responses may be reflective of their perception and understanding of this construct, which may not be consistent with the definition intended, when used in the statistics education reform context.
2. Due to social desirability bias, some instructors may have intentionally misrepresented their instructional approach, by indicating that they emphasize statistical literacy, so as to be considered more favorably, in this context.
3. A lack of awareness and understanding by instructors of what constitutes the teaching of statistical literacy may have resulted in mischaracterization of their teaching and hence inaccurate self-reports.

While it is generally understood that statistical literacy is primarily a function of constructivist teaching (rather than the behaviorist approach), it is recognized that there is no clear constructivist-behaviorist dichotomy, but rather a continuum of pedagogical mixing. In other words, the instructional approach typically reflects a combination of constructivist and behaviorist strategies, weighted based largely on contextual factors.

Of note is the observation that this sample was predominantly senior faculty rather than early career instructors. Indeed, this study cannot conclude that senior faculty are more likely to engage in the teaching of, and discussions about statistical literacy, however, focusing on statistical literacy is still relatively innovative, and may be met with resistance by those who are lacking in perceived self-efficacy and behavioral control, in this regard. The reform approach, that

is, emphasizing statistical literacy represents a major paradigm shift, and senior (job-secured) faculty may be more comfortable in changing the status quo.

The gap, conflict, or pedagogical dissonance reported in this study may be reduced through carefully designed professional development programs with attention to course content, pedagogy, integration of technology, and assessment methods. Faculty mentoring, coaching, and team-teaching with ongoing support are necessary and critical for meaningful and sustained change in instructional approach. Finally, if statistical literacy is to become central to the teaching and learning of introductory statistics, then it must be viewed as a language with its own form, structure and vocabulary; and manuals and audio-visuals of an entire introductory course should be developed and made available to the teaching community, as models for teaching. Finally, large scale and more scientific research is needed to better explore the construct of pedagogical dissonance, and its implications for teaching and learning. In this regard, it would be wise to focus initially on qualitative methods such as focus group discussions, in-depth interviews, and classroom observations.

ACKNOWLEDGEMENTS

Special thanks to the administration of Mercy College for supporting my participation in the IASE Satellite Meeting, and to my wonderful students from Mercy College (CNSL 673), Hunter College (PSYCH 350), and NYU (APSTA-UE 1085) for their superb feedback.

REFERENCES

Cobb, G. (1992). Teaching Statistics. In *Heeding the Call for Change: Suggestions for Curricular Action*, ed. L. Steen, MAA Notes, No. 22.

Everson, M., Zieffler, A., & Garfield, J. (2008). Implementing new reform guidelines in teaching introductory college statistics courses. *Teaching Statistics*, *30*(3), 66-70.

Forbes, S. (2014). The coming of age of statistics education in New Zealand, and its influence internationally. *Journal of Statistics Education, 22*(2).

Gal, I. (ed.), (2000), Adult Numeracy Development: Theory, Research, Practice, Cresskill, NJ:Hampton Press.

Garfield, J. B., Ben-Zvi, D., Chance, B., Medina, E., Roseth, C., & Zieffler, A. (2008). Assessment in Statistics Education. In *Developing Students' Statistical Reasoning* (pp. 65-89). Springer Netherlands.

Hassad, R. A. (2013). Faculty Attitude towards Technology-Assisted Instruction for Introductory Statistics in the Context of Educational Reform. *Technology Innovations in Statistics Education*, 7(2).

Hassad, R. A. (2011). Constructivist and Behaviorist Approaches: Development and Initial Evaluation of a Teaching Practice Scale for Introductory Statistics at the College Level. *Numeracy, 4*(2), 7.

Hubbard, R. (1997). Assessment and the process of learning statistics. *Journal of Statistics Education, 5*(1), 1-8.

Lane-Getaz, S. J. (2013). Development of a reliable measure of students' inferential reasoning ability. *Statistics Education Research Journal (SERJ), 12*(1), 20-47.

Pearl, D.K., Garfield, J.B., delMas, R., Groth, R.E., Kaplan, J.J., McGowan, H., and Lee, H.S. (2012). Connecting Research to Practice in a Culture of Assessment for Introductory College level Statistics.

Tishkovskaya, S., & Lancaster, G. A. (2012). Statistical education in the 21st century: a review of challenges, teaching innovations and strategies for reform. *Journal of Statistics Education, 20*(2), 1-55.

Woodard, R., & McGowan, H. (2012). Redesigning a Large Introductory Course to Incorporate the GAISE Guidelines. *Journal of Statistics Education, 20*(3), n3.

Wiggins, G. (1990). Toward assessment worthy of the liberal arts: The truth may make you free, but the test may keep you imprisoned. *Proceedings of 5th AAHE Conference on Assessment in Higher Education* (pp.17-31), June 1990, Washington D.C.

APPENDIX I

TISS - Teaching of Introductory Statistics Scale (Hassad, 2011)

Teaching Practice Items	Never	Rarely	Sometimes	Usually	Always
(1) I emphasize rules and formulas as a basis for subsequent learning. **B**	5	4	3	2	1
(2) I integrate statistics with other subjects. **C**	1	2	3	4	5
(3) Students use a computer program to explore and analyze data. **C**	1	2	3	4	5
(4) I assign homework primarily from the textbook. **B**	5	4	3	2	1
(5) Critiquing of research articles is a core learning activity. **C**	1	2	3	4	5
(6)The mathematical underpinning of each statistical test is emphasized. **B**	5	4	3	2	1
(7) I use real-life data for class demonstrations and assignments. **C**	1	2	3	4	5
(8) I require that students adhere to procedures in the textbook. **B**	5	4	3	2	1
(9) Assessment includes written reports of data analysis. **C**	1	2	3	4	5
(10) I assign drill and practice exercises (mathematical) for each topic. **B**	5	4	3	2	1

(B) Behaviorist subscale items. These **i**tems must be reverse-coded (as shown here) for the overall teaching practice score, so that higher values indicate more favorable levels of reform-oriented (concept-based or constructivist) practice. **(C) Constructivist subscale items.**