

INTRODUCTORY STATISTICS INSTRUCTORS' PRACTICES AND BELIEFS REGARDING TECHNOLOGY AND PEDAGOGY

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The development of technology tools has created many possibilities for the introductory statistics classroom, but student learning outcomes may be influenced by how instructors use technology in their teaching. The Statistics Teaching Inventory (STI) was developed to assess introductory statistics instructors' practices and beliefs as part of an NSF-funded project (e-ATLAS, DUE 1044812 & 1043141), to evaluate the effect of reform efforts in statistics education. The STI was administered to a national sample of teachers of introductory statistics courses across various disciplines in U.S. colleges and universities. Results from a preliminary sample of 96 instructors will be presented, and the relationship between technology use and pedagogical practices will be explored.

BACKGROUND

The use of technology in statistics education continues to have an increasing impact on how statistics is taught (Chance, Ben-Zvi, Garfield, & Medina, 2007). Not only do computer tools make it quicker and easier to perform calculations, but they also allow students to interactively explore statistical concepts. However, just because software includes features to help students visualize statistical concepts, it does not mean that instructors will fully utilize these features to build students' conceptual understanding. Therefore, it is important to consider how teachers use software in statistics learning environments and how these uses are related to their pedagogical practices.

Various research studies in education at the primary and secondary level have found that teachers who use more student-centered pedagogical practices also tend to be more likely to use technology as a learning tool (e.g. Becker & Ravitz, 1999; Rakes, Fields, & Cox, 2006). In these studies, student-centered practices are described as focusing on student inquiry and discovery of ideas, using classroom activities such as discussion and collaborative learning. These practices stand in contrast to teacher-centered practices, which commonly involve greater use of lecturing by the teacher as the authority, who delivers content to students.

In statistics education, calls for reform such as the Guidelines for Assessment and Instruction in Statistics Education (GAISE; ASA, 2005), have recommended a greater use of active learning and a larger emphasis on conceptual understanding, together with the use of technology to analyze data and to develop understanding of statistical concepts. Recently, introductory statistics curricula have emerged that combine conceptual technology tools with active learning to teach concepts related to inference via computer simulation. Statistics educators who have designed and used such curricula (e.g. Tintle, Topliff, Vanderstoep, Holmes and Swanson, 2012; Garfield, delMas, & Zieffler, 2012) have reported positive student learning outcomes, especially regarding reasoning about statistical inference.

This study uses data from a random sample of tertiary-level introductory statistics instructors in the United States to examine the question: Do instructors who differ in the extent to which they use student-centered teaching practices also differ in their use of technology to teach concepts, and if so, how? Recommendations for statistics education such as those presented in GAISE suggest that use of active learning and technology to teach concepts go hand-in-hand. The data from this study can be used to provide insight into whether instructors using student-centered practices tend to make greater use of technology to teach concepts.

INSTRUMENT AND METHODS

The current version of the *Statistics Teaching Inventory* (STI), modified from a previous version described in Zieffler, Park, Garfield, delMas, and Bjornsdottir (2012), was developed as part of the NSF-funded e-ATLAS project (DUE-1044812 & 1043141). This project seeks to evaluate the effects of calls for reform in statistics education. Four separate forms of the STI were developed

for each of four different types of instructors: (1) sole instructors of a face-to-face course; (2) instructors who teach a face-to-face course where class time is divided between a large lecture and a smaller recitation/lab section; (3) instructors who teach a course 100% online; and (4) instructors who teach a course that is a mixture between face-to-face and online (hybrid). The STI has between 63 and 67 items, depending on the form. It is divided into seven major sections: *pedagogy*, *curricular emphasis*, *technology*, *assessment*, *beliefs*, *course characteristics*, and *additional information*. Approximately 10% of the items vary between the four forms.

The STI was piloted with nine introductory statistics instructors who provided feedback that was used to initially revise the instrument. The instrument was then piloted using statistics instructors who were randomly sampled from 150 institutions of higher education in the U.S. Of the 97 respondents, 62 were sole instructors of a face-to-face course, 10 were instructors of a course that included lecture and lab sections, 19 were online instructors, and 6 were hybrid instructors. For more details on the instrument development and administration, see Fry (2014). One instructor’s responses were eliminated from the analysis due to missing data.

RESULTS

Classifying Instructors According to Their Pedagogical Practices

Instructors were classified according to the extent to which they reported the use of student-centered practices in their pedagogy. Five items from the *pedagogy* section of the STI (see Table 1) were used to conduct an Exploratory Factor Analysis (EFA) to identify a scale that places instructors on a continuum from student-centered to teacher-centered pedagogical practices.

*Table 1. Responses of n = 97 instructors to:
Consider a student who was fully engaged in your course. To what extent do you think that student would agree or disagree with the following statements about this course?*

	Strongly Disagree	Disagree	Agree	Strongly Agree
a) The content was presented mostly through the instructor’s lectures (or video/audio/reading materials). ^a	2 (2%)	4 (4%)	46 (47%)	45 (46%)
b) The instructor (and/or TA) asked challenging questions that made me think. ^b	0 (0%)	4 (4%)	66 (69%)	26 (27%)
c) The course frequently required students to work together.	17 (18%)	39 (40%)	30 (31%)	11 (11%)
d) The content was presented mostly through activities.	12 (12%)	64 (66%)	17 (18%)	4 (4%)
e) This course encouraged students to discover ideas on their own.	7 (7%)	35 (36%)	49 (51%)	6 (6%)

^a Item (a) was asked in different ways depending on which of the four forms of the survey the instructor completed. For full details, see Fry (2014).

^b One instructor failed to answer item (b), so statistics for this item include n = 96 instructors.

Since items (b) through (e) represent practices which are considered more student-centered, while (a) represents a more teacher-centered practice, item (a) was reverse-coded so that higher factor scores represented a greater use of student-centered practices. A scree plot revealed that one factor accounted for most of the explained variance, so factor scores were computed for each of the respondents based on extracting only the first factor. For more details on the factor analysis, see Fry (2014).

Comparing Instructors on Their Use of Technology

The vast majority (91%) of the respondents indicated that they use technology other than hand calculators in their course. The mean factor score for the 87 instructors who use technology was 0.01, while that for the nine who do not use technology was -0.08. Additional analyses (see

Fry, 2014) suggested no significant difference in pedagogy factor scores based on whether or not instructors use technology. However, given the small number of instructors who do not use technology, it is difficult to compare the groups.

Data on instructors’ use of technology specifically for the purpose of teaching concepts was also examined. The group of items in Table 1, which asks instructors about what a hypothetical engaged student would say about the course, also includes item (f) which read: *This course often used technology (e.g. web applets, statistical software) to help students understand concepts.* Instructors indicated the extent to which that student would agree or disagree.

The mean factor score for those instructors who agreed with this statement was 0.04, compared to a score of -0.18 for those who disagreed. There is not compelling evidence that pedagogy factor scores differ between instructors who often use technology to teach concepts and instructors who do not (see Figure 1). Although the two instructors with the lowest factor scores are in the “Disagree” group and the nine instructors with the highest factor scores are in the “Agree” group, there does not appear to be a large difference in the distribution of scores between the two groups.

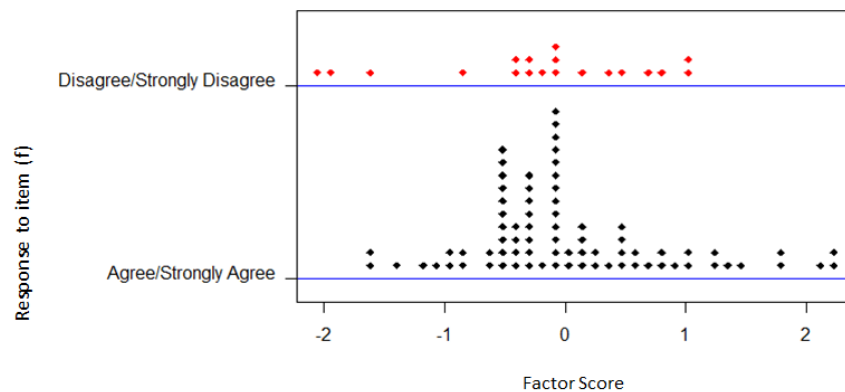


Figure 1. Pedagogy factor scores for instructors based on how they believe a student would respond to the statement: *This course often used technology to help students understand concepts.*

Another item in the *technology* section of the STI asked: *What percentage of time that students spend using technology is designed to be spent understanding statistical concepts?* Instructors responded by using a slider to select a percentage between 0 and 100. The correlation between the responses to this item and the pedagogy factor scores was -.05 ($p = .63$), suggesting no relationship between percent of time using technology to understand concepts and the extent to which instructors use student-centered practices.

Since the factor analysis did not reveal any relationship between pedagogy and technology use, individual correlations between the pedagogy and technology items were also obtained (see Table 2). The item from the *technology* section did not correlate very well with any of the pedagogy items. However, correlations with the technology-related item from the *pedagogy* section suggest that using fewer lectures, using more teamwork, and emphasizing student discovery of concepts are moderately positively correlated with the use of technology to teach concepts.

Table 2. Correlations between technology and pedagogy items

Item	Polychoric correlation with the item: This course often used technology to teach concepts	Polyserial correlation with the item: What percentage of time that students spend using technology is designed to be spent understanding statistical concepts?
a. Deliver content through lectures(reverse-coded)	.32	.11
b. Ask challenging questions	.10	-.01
c. Use teamwork	.26	-.11
d. Use activities	.09	-.05
e. Students discover concepts	.30	.08

DISCUSSION

Education research and recommendations from the statistics education community suggest that teaching in student-centered ways and using technology to teach concepts go hand-in-hand. However, data from the *Statistics Teaching Inventory* does not provide compelling evidence that instructors who use more student-centered teaching practices are also more likely to use technology to teach concepts.

One possible reason for this lack of association is that instructors interpreted the technology-related questions in different ways. Technology can be used to teach concepts in many different ways depending on the classroom environment. For example, an instructor may teach a concept using a technology demonstration during lecture, or may instead have students discover concepts using technology in an activity. Another problem may be related to how instructors indicated the percentage of time that students use technology designed to learn concepts on the STI. For example, one instructor may have included the time that students spend reasoning about statistical output from a data analysis package, while another instructor may have included only the time that students spent exploring concepts such as probability and sampling using online applets. For future uses of the STI, it would be beneficial to conduct cognitive interviews with pilot participants to determine how items are being interpreted. It would also be helpful to conduct additional validation through course observations.

Additional items are needed to determine the extent to which instructors use student-centered pedagogical practices. On the current instrument, only five items were helpful in classifying instructors. For one of these items, 96% of instructors answered “Agree” or “Strongly Agree”, so this item did not contribute much information to help place instructors on a continuum from student-centered to teacher-centered.

In summary, results from this study show little to no relationship between use of student-centered pedagogical practices and use of technology to teach concepts. This suggests that technology can be used to teach concepts in both student-centered, active learning environments and teacher-centered environments that make wider use of lectures. Also, further revision and validation of the *Statistics Teaching Inventory* may provide a better insight into possible associations between pedagogy and technology use.

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