GRADUATE STUDENTS TEACHING STATISTICS: THEIR EXPERIENCES IN COMMUNITY AND BELIEFS ABOUT TEACHING

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Graduate students teach and assist the teaching of statistics courses at post-secondary institutions across the world. The dependence on graduate students (henceforth graduate teaching assistants, or GTAs) for teaching, along with the potential for GTAs to become professors, raises questions about how GTAs learn to teach statistics, and how their beliefs about teaching may change. This paper describes the development, administration, and results of a survey designed to explore graduate students' beliefs about teaching statistics and their experiences learning in their statistics-teaching communities. The survey results (based on n=174 GTAs) suggest that GTAs' beliefs about teaching can change to become more student-centered. The relationship between beliefs and their experiences in community is less clear.

BACKGROUND

In universities across the world, graduate students teach and assist with the teaching of statistics courses in many different positions: designing and administering courses; facilitating lab or discussion sessions; grading; holding office hours; and monitoring course websites (e.g., Hoessler & Godden, 2015). For the purposes of this paper, graduate teaching assistants (GTAs) will be defined as graduate students who have been hired to be the instructor of record, or to assist the instructor of record in any way associated with teaching undergraduate or graduate courses. This definition is designed to include many different titles used in different countries such as *teaching fellows*, *teaching assistants*, *moniteurs*, and department-hired *graduate tutors*.

Recent research by Justice, Zieffler, and Garfield (2017) suggests many statistics GTAs appear to hold teaching beliefs and teaching practices that are not aligned with current recommendations for teaching statistics (e.g., GAISE, American Statistical Association Revision Committee, 2016). One way to classify teaching beliefs and practices is on a spectrum from teacher-centered to student-centered (Kember, 1997). Teacher-centered teaching focuses on transferring structured knowledge to students; student-centered teaching focuses on facilitating understanding and fostering conceptual change. In his introduction to a special section of *The American Statistician* dedicated to the topic of GTA preparation, Moore (2005) notes that "teaching as information transfer tends to leave students with an algorithmic rather than a conceptual understanding" (p. 1). A variety of professional development experiences have been created to try to cultivate student-centered teaching beliefs and practices among statistics GTAs (e.g., Rumsey, 1998; Schwab & Blankenship, 2014).

Some researchers argue that studies of teacher professional development should take into account surrounding cultures and contexts (e.g., Putnam & Borko, 2000). This approach may be particularly important for GTA professional development; GTAs appear to be particularly influenced by each other, seek information from each other first, and rate interactions with each other and with faculty as most valuable (e.g., Staton & Darling, 1989; Myers, 1994).

This paper examines results of a survey designed to explore GTAs' experiences in community, changes in their perceptions of their beliefs about teaching, and the relationship between their experiences in community and their beliefs. The perspective taken in this study is that GTAs learn to teach by participating in a community of practice (Lave & Wenger 1991) composed of experts (e.g., faculty) and novices (e.g., peers). Participation in community can take many forms; in this study five forms were examined: (1) a faculty observation of teaching with feedback; (2) visiting a shared space (e.g., office or cubicle) with other GTAs; (3) attending *required* meetings regarding teaching; (4) attending *voluntary* meetings regarding teaching; and (5) attending required meetings *with faculty present*. The research questions for this study are:

- How do GTAs participate in communities of practice related to teaching?
- T o what extent do GTAs' beliefs change?

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- To what extent are changes in beliefs related to participation in communities of practice?

METHOD

An online survey was developed and administered to graduate students in statistics departments in the United States. The 70-item instrument was divided into six sections, including a section asking about GTAs' experiences in the five aforementioned forms of participation in community and another section asking about GTAs' beliefs about teaching a face-to-face section of introductory (not calculus-based) statistics. The entire instrument and more detail about the development process are given in Justice (2017). The survey development process included two focus groups, several reviews of instrument drafts, think-aloud interviews (n=5), and a small pilot (n=2) to confirm skip logic worked properly and to estimate completion time (roughly 10 minutes).

In February, 2016, the survey was administered to graduate students across the United States. Participants were recruited via the American Statistical Association's Council of Academic Representatives (CAR), colleagues of the researcher, and colleagues of the researcher's adviser. The contacts in CAR and colleagues (all academics) were asked to forward the invitation to their graduate students. As an incentive, participants were entered into a drawing for one of five $25 Amazon.com gift cards.

All analyses were conducted using R software. Confirmatory factor analysis was conducted using the lavaan package (Rosseel, 2012). As this study was exploratory, no corrections for multiple testing were used.

RESULTS

Data were collected from 245 graduate students from 37 statistics and biostatistics departments in institutions that offer doctoral degrees in the United States. The focus of this paper is the 174 participants who responded to all questions in the beliefs topics of interest and who indicated they had been hired in their current departments to do at least one of the following teaching-related responsibilities: grade papers, hold office hours, facilitate lab or discussion sections, assist an instructor with teaching, or serve as the primary instructor for a section. About half the participants indicated they expect to teach as part of their career, and about one quarter of participants indicated they obtained a student VISA to study in the United States. Most (82%) of the sample indicated they intend to earn a PhD at their current institutions.

Statistics GTAs' Experiences in Community

Table 1 provides a summary of respondents' experiences in the five forms of participating in community. The table gives the percentage of participants who experience each form at a particular cutoff frequency. The cutoff frequencies will be used in further analysis and are where natural breaks in the data occurred that split the participants into fairly equal-sized groups. It is interesting to note that only about half of GTAs reported experiencing at least one observation with feedback from a faculty member during the entire course of their current degree programs. The rest had not experienced an observation at all in their current programs. All but about 10% of participants indicated they are required to attend required meetings regarding their teaching, however the frequency of the required meetings varied. The distribution of frequency was fairly bimodal with about 25% indicating they meet *fewer* than *once* per month and over 50% of participants estimated they meet at least once every two weeks.

Table 1
Statistics GTAs' Participation in Five Forms of Experiences in Community (n=174)

Form of Participation	Cutoff Frequency: At least as often as…	% Yes
1. Faculty observation	Once during entire experience in program	52
2. Visiting a shared office	Once per week	59
3. Attend required meetings	Once per two weeks	52
4. Participate in voluntary meetings	Once per week	49
5. Attend required meetings with	Once per two weeks, faculty attend >75%	44

faculty of time

Statistics GTAs' Beliefs and How They Change

This paper focusses on four topics regarding GTAs' beliefs. More specifically, GTAs were asked to enter numbers reflecting the following percentages: (1) the percentage of the course content about statistical inference for which students should use simulation methods (e.g., randomization tests, bootstrapping); (2) the percentage of total scores on exams and quizzes that should be based on students' explanations of their reasoning using words; (3) the percentage of class time that should be used for the instructor to present to the class (e.g. conducting demonstrations or lectures); and (4) the percentage of class time that should be used for students to communicate their ideas to each other together in small groups. For each topic the GTAs were asked to respond to two questions: the first according to their current beliefs and the second reflecting back to their beliefs prior to entering their current degree programs. Table 2 gives a summary of the results.

After visualizations suggested that appropriate conditions for a t-test were met, matched pair difference scores were tested against the hypothesis that there is no overall average change from prior to current beliefs; all four topics showed significant change in the direction of more student-centered and less teacher-centered beliefs, on average. For this study a participant indicating increased use of simulation-based methods to teach inference is interpreted to reflect more student-centered teaching beliefs despite the fact that it is entirely possible that traditional methods can be taught using very student-centered teaching methods.

Table 2
Statistics GTAs' Perceived Beliefs about Teaching Statistics: Current Beliefs, Beliefs Prior to Entering Current Degree Programs, and Difference (Current-Prior). (n=174)

Topic	Current *M (SD)*	Prior *M (SD)*	Difference *M (SD)*
1. Percentage of inference using simulation	31 (23)	17 (19)	14 (20) *
2. Percentage of exam scores based on explanations	46 (24)	36 (23)	9 (19) *
3. Percentage of class-time in lectures	59 (23)	72 (22)	–13 (20) *
4. Percentage of class-time in group work	24 (20)	16 (16)	9 (17) *

*$p<.001$

Relationships between Community Engagement and Beliefs

Confirmatory factor analysis supported the claim that the difference scores (Table 2, right-most column) draw from a single latent variable, which was interpreted to reflect the extent to which participants' beliefs had become more student-centered since entering their current degree programs (χ^2 p=.949, TLI=1.033, RMSEA=.000). Using the coefficients of the CFA model as weights, a single "change in beliefs" score was created. The score was used to explore the extent to which changes in their beliefs may be related to GTA's experiences in community.

For each of the five forms of engagement in community (Table 1) a two-sample t-test was conducted to explore differences between change score in the two groups: below or above cutoffs given in Table 1. None of the tests revealed significant differences in average change in beliefs between those who did and did not meet the cutoff frequency.

DISCUSSION

The results of this study suggest that GTAs in this sample perceive that their beliefs about teaching statistics have become more student-centered with regard to four aspects of teaching: (1) the extent to which simulation methods (e.g., randomization tests, bootstrapping) should be used; (2) the extent to which exams and quizzes should require explanations; (3) the use of lectures and (4) small group work to deliver course content. This finding is encouraging in light of research that suggests beliefs are often resistant to change (Kember, 1997). Also, in light of the fact that beliefs are often difficult to measure (Kember, 1997) the four topics used in this study may be helpful in

measuring the extent to which GTAs' beliefs are student-centered. Future work could continue to explore how such beliefs could be measured.

This study is limited by the lack of random sampling methods used; it is likely that GTAs interested in teaching were more likely to respond. Also, analysis of missing data indicates many GTAs had difficulty responding to the questions about beliefs and there may be systematic differences between those who did and did not respond. Still these results suggest that some GTAs' beliefs may be able to become more student-centered over the course of their graduate studies.

This study did not find evidence of relationships between change in beliefs and GTAs' experiences participating in community. No evidence was found to suggest GTAs who have experienced a faculty observation, who have a shared office space, or who regularly attend frequent required or voluntary weekly meetings (with or without faculty) are more likely to perceive their beliefs to become more student-centered, on average. This result is surprising considering that GTAs in other disciplines have indicated that these experiences are helpful and most influential (e.g., Myers, 1994). Perhaps these experiences have effects but a larger sample size is needed to detect them. On the other hand, the lack of significance may be an indication that the strategies previously thought to help change GTAs' beliefs are not as effective as faculty may wish; faculty may not be investing their time and financial resources wisely. Should these results hold in other studies, further research should be conducted to explore how faculty may conduct an effective observation, how GTAs can be guided to receive faculty feedback, or how weekly meetings can lead to more student-centered teaching beliefs. Perhaps it takes *more than one* faculty observation to be able to detect change. In such cases it may be appropriate to hire and train senior graduate students to conduct such observations (e.g., Schwab & Blankenship, 2014; Williams, 1991). As for common shared spaces, further research could be conducted to explore what aspects of a shared space promote healthy communities of graduate student teachers.

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