Findings from a Survey of Statistics and Biostatistics Instructors in the Health Sciences Who Teach Using an Online or Flipped Format

Todd A. Schwartz, Elizabeth Ajazi, and Jane Monaco

Department of Biostatistics, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC

ABSTRACT
Online and flipped courses are becoming more commonly found across disciplines, including in (bio)-statistics. The literature contains many case studies of instructors reporting on their use of these formats. However, a gap exists in regard to a systematic study of instructors’ implementation of, attitudes on, and recommendations for online or flipped courses in (bio)statistics. We conducted a survey to elicit such responses, and we report here on n = 24 instructors who teach (bio)statistics in the health sciences. These instructors’ courses are described, as well as results summarized for their responses on various aspects of these courses, ranging from the technology they use to whether they would recommend various approaches to teaching colleagues. These findings should be useful in providing a snapshot of the current use of these formats in teaching (bio)statistics in the health sciences, as well as informing other similar instructors who may be considering their own implementation of one of these formats.

Introduction
Teaching online classes (with or without a residential component) and using a “flipped” (sometimes referred to as “hybrid” or “blended”) classroom (where the lecture content is viewed by students outside the class period, and time in the classroom is instead spent applying active learning techniques) are increasingly popular trends among instructors across disciplines. Both students and faculty have reported success in flipping the classroom (Critz and Knight 2013). Online classes allow instructors to incorporate new content using available technology; notably, this is useful in (bio)statistics courses when teaching data analysis, for example (Everson and Garfield 2008). The use of online and flipped formats has been reported in the literature in many different disciplines, such as computer programming and veterinary professional skills (Moffett and Mill 2014; Mok 2014). This trend is also apparent in the health sciences, including nursing, physics, and epidemiology (Critz and Knight 2013; Tune 2013; Moraros et al. 2015; Howard et al. 2017), as well as in (bio)statistics (Keeler and Steinhorst 1995; Samsa et al. 2012; Wilson 2013; Schwartz 2014; Winquist and Carlson 2014; Gundlach et al. 2015; Peterson 2015; Loux et al. 2016; McLaughlin and Kang 2017).

In medical science, course evaluations have shown that the enhanced active learning in a flipped class resulted in positive strides in learning outcomes (Howard et al. 2017). Incorporating a flipped format in public health resulted in a higher course evaluation compared to a historical, traditionally based course, with students citing the “positive learning experience” afforded by this format (Galway et al. 2014). Students also have reported higher self-perceived knowledge, although student examination scores were similar when compared to traditionally structured classes (Galway et al. 2014). However, other studies have shown improved grades overall in a small group discussion-based class when compared to a large lecture-based class (Ferreri and O’Connor 2013) and a higher percentage of students in “cooperative learning” classes completing the course (Keeler and Steinhorst 1995). Students in an online section have also been shown to have better academic performance than students in a lecture-based section of the same statistics course (Dutton and Dutton 2017).

The literature supports that students engage to a greater degree in courses that do not rely exclusively on the traditional lecture. Incorporation of real-life examples and experiences is an effective way for students to build knowledge by using statistical thinking (Snee 1993). This approach has been shown to be successful in a PhD-level nursing students’ statistics class by emphasizing student-centered learning and students’ preparation for class (Schwartz 2014). A flipped classroom may also improve students’ comprehension of course content (McLaughlin and Kang 2017).

Students may be able to retain the information for longer periods of time compared to the traditional classroom, especially for statistics classes, as shown by Winquist and Carlson (2014); they conducted a study of students 1 year after completing a statistics course in which students were tested about their knowledge of the same statistics course (Dutton and Dutton 2017).

CONTACT Todd A. Schwartz Todd_Schwartz@unc.edu Department of Biostatistics, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7420.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The moral rights of the named author(s) have been asserted.
Despite the many advantages reported for online and flipped classroom formats, various limitations have also been described. Several authors have noted the increased preparation time for creating, administering and managing such a class (Howard et al. 2017). In particular, the initial time commitment necessary to create an online or flipped course can be substantial. In addition to this considerable initial amount of time, the overall level of organization required is high (Schwartz 2014). Some students in online classes claim to prefer face-to-face lectures due to the challenging learning environment for students who often procrastinate (Mills and Dheeraj 2017).

While we have cited studies showing benefits of online and flipped classrooms, the literature is mainly comprised of “case studies” of instructors’ experiences in implementing these approaches. To our knowledge, a gap exists in the current literature wherein no data have been reported from a cross-sectional sample of (bio)statistics instructors using online or flipped approaches. Our goal in conducting this research is to address this gap by providing a more comprehensive view of the current state of these approaches through surveying (bio)statistics instructors to obtain information on their implementation of and attitudes on the various features of these courses, as well as on time commitment, effectiveness, and technological aspects for the flipped and online classrooms.

**Methods**

We developed a survey designed to capture responses from instructors of (bio)statistics regarding their experiences in using the online or flipped formats. We asked a variety of questions, including items to describe their years of experience in teaching overall, as well as specifically using these formats. We also requested information about characteristics of their students and the nature of the courses they had taught during the 2016–2017 academic year. After ascertaining this general information, and in order to focus on a specific course that they taught using an online or flipped format, we instructed the respondents to select only one course for which they had used prerecorded lectures. Further clarification for those teaching more than one such course was to choose the course most recently taught and which used prerecorded lectures to the greatest extent. Additional items inquired about their attitudes toward various aspects of the online and flipped formats, such as the time commitment and whether they would recommend such approaches to other instructors.

The survey was implemented via Qualtrics and was distributed in an online format to (bio)statistics instructors. The intended audience was targeted through soliciting voluntary responses from members of the American Statistical Association’s (ASA) online communities for two relevant specialties: the Statistics Education section and the Teaching Statistics in the Health Sciences section. A message was sent to these members with a brief description of our study and a hypertext link to the Qualtrics study. At the time of the survey administration (May 2017), 1087 members were listed in the Statistics Education section’s online community, and 573 members were listed in the Teaching Statistics in the Health Sciences section. We were unable to ascertain how many members may be members of both online communities and therefore would have received duplicate requests; however, we expect that such instructors would only complete the survey once. Introductory questions inquired about the nature of the courses that these instructors taught, and their responses helped us to ensure that our sample was indeed comprised of instructors using an online or flipped format to teach (bio)statistics.

Data were collected anonymously with no personal identifiers other than the information on the nature of the courses taught. The data were exported from Qualtrics and imported into SAS for data management and analysis. Means and standard deviations were calculated and reported for continuous variables. Categorical variables were described through frequencies and percentages. No formal hypothesis testing was conducted. The Institutional Review Board at the University of North Carolina at Chapel Hill approved this study.

**Results**

A sample of 46 instructors who teach at least one (bio)statistics course using prerecorded lectures provided usable responses. For the purposes of this manuscript with a special emphasis on teaching statistics in the health sciences, the results of a subgroup (n = 24) of these respondents are reported here from instructors who identified their course as being taught to students who are majoring in health sciences (such as in a School of Public Health or to Nursing graduate students). For comparison purposes, information is also provided for the instructors (n = 21) who identified their course as being taught to students who are majoring in other programs; one instructor could not be classified into either group and has been excluded from these findings.

General descriptives for these instructors are given in Table 1. This sample of instructors in the health sciences (n = 24) had a mean of 11.3 years of teaching experience; these instructors had taught using an online or flipped format for an average of nearly 5 years. Notably, these instructors do not exclusively teach using an online or flipped format, as half also report teaching using a traditional format during the 2016–2017 academic year. Three-quarters of these instructors taught online or flipped courses to graduate students, and 37.5% were teaching in these formats to undergraduate students. These instructors taught online or flipped classes of varied sizes, with one-third indicating they taught online or flipped classes of less than 20 students, over half teaching online or flipped classes of between 20 and 49 students, one-quarter teaching online or flipped classes of 50–99 students, and less than 10% teaching online or flipped class sizes of at least 100 students. Three-quarters of these instructors taught online or flipped courses at an introductory (bio)statistics level, while one-third taught an online or flipped second-level (bio)statistics course. Three instructors (12.5%) indicated they were teaching a specialty topic in (bio)statistics in an online or flipped format; these were identified as epidemiology, graduate-level biostatistics, and intermediate-level statistics (reading the literature).

When restricting attention to the single course that the instructors identified as their focus for the remainder of the survey, instructors’ responses are summarized in Table 2. More than half (58.3%) of these courses are characterized as
A variety of class activities were included in these (bio)statistics courses. As shown in Table 2, the most common activities reported by instructors are data analysis using software, lectures, and software demonstrations (all at 70.8%), followed by having students complete worksheets or problems from workbooks and group projects (both at 41.7%). Small group discussions (37.5%) were also commonly used.

When asked about technology used for their prerecordings, the (bio)statistics instructors most commonly reported using Camtasia (58.3%). Other technology was used, but to a much lower extent in this sample, with Captivate being reported with the next highest frequency at 16.7%. On a scale of 1–5, with 1 being unfavorable and 5 being favorable, the instructors who reported using Camtasia recommended its use to other instructors (mean of 4.1 [SD 1.4]). They also gave high ratings to that technology in terms of ease of use (mean of 4.0 [1.2]), as well as its compatibility across different platforms and devices (mean of 4.2 [1.0]); its cost was rated at a mean of 3.7 [1.3].

Instructors’ attitudes toward the online or flipped format were rated on a variety of issues using a scale of 1–5, with 1 being much worse than a traditional format, 3 being about the same as a traditional format, and 5 being much better than a traditional format, and are summarized in Figure 1. Instructors in our sample reported that the instructor time commitment (mean of 2.8 [0.9]), as well as their students’ (2.8 [0.7]), are, on average, slightly worse than for a traditional format. However, means indicating more favorable attitudes for the online or flipped format were reported for the items on students achieving the desired learning outcomes (3.5 [1.0]), as well as students’ satisfaction (3.8 [1.1]) and engagement (3.6 [1.1]). The item addressing student resistance to using the online or flipped format was, on average, about the same as for a traditional format, with a mean of 3.0 (0.7).

Instructors were asked how highly they would recommend various techniques to teaching colleagues on a scale of 1–5, with 1 strongly recommending against, 3 neither recommending for nor against, and 5 strongly recommending for. Figure 2 reflects these (bio)statistics instructors’ attitudes, with favorable recommendations given to the use of video recordings as an effective tool (mean of 4.2 [0.7]) and the use of active learning techniques as an effective strategy (4.6 [0.7]). However, the use of a fully online course as being effective was nearly neutral (mean 3.2 [1.0]) and was lower than recommendations for a partially online course with an in-class component (4.0 [0.7]) or for a flipped format (4.0 [0.9]).

In Figure 3, instructors’ opinions regarding various factors of the recording software are presented; these are rated on a scale of 1–5, with 1 being least important and 5 being most important. Factors with the highest means include the availability and institutional support of the software (4.5 [0.8]) as well as the ability to produce recordings in a format appropriate for the students’ use (4.5 [0.7]). Ease of use (4.2 [0.9]) and the ability to edit the video (4.2 [0.9])

Table 2 also presents information regarding the nature of the prerecorded lectures. About two-thirds (64%) of instructors use recordings that they created themselves, although over one-quarter (28%) use their own recordings as well as recordings created by others, such as those available via YouTube or Khan Academy. Over three-quarters (79.2%) of instructors report using recordings that are comprised of using slides, such as PowerPoint, plus the instructor’s narration as the audio. Nearly 40% (37.5%) of the instructors use screen capture technology that will record their writing so the students can view annotations and sketches. Lower percentages of instructors use the prerecordings to demonstrate the use of statistical software or to deliver a lecture.

### Table 1. Descriptive statistics for the responding (bio)statistics instructors in the health sciences (n = 24) regarding their teaching experience, compared to other majors (n = 21).

|                      | Health Sciences (n = 24) | Other majors (n = 21) |
|----------------------|-------------------------|----------------------|
| **Years of experience teaching** | **Mean (SD) or n (%)** | **Mean (SD) or n (%)** |
| (bio)statistics (using any format), including the 2016–2017 academic year | 11.3 (9.1) | 14.5 (9.8) |
| Total years teaching using an online or flipped format, including the 2016–2017 academic year | 4.9 (3.2) | 4.2 (3.5) |
| Instructors teaching at least 1 (bio)statistics course in the 2016–2017 academic year that would be best described as: | | |
| Traditional | 12 (50.0%) | 13 (61.9%) |
| Flipped with in-class component | 10 (41.7%) | 13 (61.9%) |
| Completely online | 15 (62.5%) | 11 (52.4%) |
| Partially online and partially in-class | 3 (12.5%) | 5 (23.8%) |
| Instructors teaching at least 1 online or flipped course in the 2016–2017 academic year to: | | |
| High school students | 0 (0.0%) | 0.0 (0.0%) |
| Undergraduate students | 9 (37.5%) | 16 (76.2%) |
| Graduate students | 18 (75.0%) | 6 (28.6%) |
| Instructors teaching at least 1 online or flipped course in the 2016–2017 academic year in class sizes that would be best described as: | | |
| <20 students | 8 (33.3%) | 6 (28.6%) |
| 20–49 students | 14 (58.3%) | 16 (76.2%) |
| 50–99 students | 6 (25.0%) | 3 (14.3%) |
| >100 students | 2 (8.3%) | 3 (14.3%) |
| Instructors teaching at least 1 online or flipped course in the 2016–2017 academic year that would be best described as: | | |
| Introductory Statistics | 18 (75.0%) | 16 (76.2%) |
| Second-Level Statistics | 8 (33.3%) | 3 (14.3%) |
| Specialty Topic | 3 (12.5%) | 3 (14.3%) |
| Other | 0 (0.0%) | 3 (14.3%) |

*Respondents could select all that apply.*

completely online, and over a quarter (29.2%) used the flipped format. Instructors tend not to be novices to teaching these particular online or flipped courses, with a mean of 3.5 years of using that format. Three-quarters of these classes are aimed at graduate students with most in the <20 (29.2%) or 20–49 (45.8%) student class size. Almost 80% of these courses were at an introductory statistics level, and a variety of meeting schedules were represented.

Instructors were asked how highly they would recommend various techniques to teaching colleagues on a scale of 1–5, with 1 strongly recommending against, 3 neither recommending for nor against, and 5 strongly recommending for. Figure 2 reflects these (bio)statistics instructors’ attitudes, with favorable recommendations given to the use of video recordings as an effective tool (mean of 4.2 [0.7]) and the use of active learning techniques as an effective strategy (4.6 [0.7]). However, the use of a fully online course as being effective was nearly neutral (mean 3.2 [1.0]) and was lower than recommendations for a partially online course with an in-class component (4.0 [0.7]) or for a flipped format (4.0 [0.9]).

In Figure 3, instructors’ opinions regarding various factors of the recording software are presented; these are rated on a scale of 1–5, with 1 being least important and 5 being most important. Factors with the highest means include the availability and institutional support of the software (4.5 [0.8]) as well as the ability to produce recordings in a format appropriate for the students’ use (4.5 [0.7]). Ease of use (4.2 [0.9]) and the ability to edit the video (4.2 [0.9])...
Table 2. Descriptive statistics for the responding (bio)statistics instructors in the Health Sciences ($n = 24$) regarding their selected online/flipped course for which their survey responses will focus, compared to other majors ($n = 21$).

|                          | Health Sciences majors ($n = 24$) | Other majors ($n = 21$) |
|--------------------------|-----------------------------------|------------------------|
|                          | Mean (SD) or $n$ (%)               | Mean (SD) or $n$ (%)    |
| The format of this course is best described as: |          |                        |
| Completely Online         | 14 (58.3%)                        | 8 (38.1%)              |
| Flipped with In-Class Component | 7 (29.2%)                         | 10 (47.6%)             |
| Partially Online and Partially In-Class | 3 (12.5%)                        | 3 (14.3%)              |
| Years using this format for this (bio)statistics course, including the 2016–17 academic year | 3.5 (2.2) | 3.2 (2.3) |
| This (bio)statistics class is primarily taken by: |                    |                        |
| Graduate students         | 18 (75.0%)                        | 5 (23.8%)              |
| Undergraduate students    | 5 (20.8%)                         | 16 (76.2%)             |
| Physicians                | 1 (4.2%)                          | 0 (0.0%)               |
| This (bio)statistics class is primarily taken by: |                    |                        |
| Majoring in (Bio)statistics | 0 (0.0%)                       | 3 (14.3%)              |
| Minor in (Bio)statistics  | 0 (0.0%)                          | 1 (4.4%)               |
| Majoring in Health Sciences (such as in a School of Public Health) | 24 (100.0%) | 0 (0.0%) |
| Majoring in other programs | 0 (0.0%)                        | 17 (81.0%)             |
| This (bio)statistics class size is best described as: |          |                        |
| < 20 students             | 7 (29.2%)                         | 4 (19.1%)              |
| 20-49 students            | 11 (45.8%)                        | 10 (47.6%)             |
| 50-99 students            | 4 (16.7%)                         | 3 (14.3%)              |
| ≥ 100 students            | 2 (8.3%)                          | 4 (19.1%)              |
| This (bio)statistics course’s meeting schedule is best described as: |          |                        |
| Online format (no set meeting schedule) | 15 (62.5%) | 7 (33.3%) |
| 1 day per week           | 4 (16.7%)                         | 2 (9.5%)               |
| 2 days per week          | 3 (12.5%)                         | 7 (33.3%)              |
| 3 days per week          | 1 (4.2%)                          | 3 (14.3%)              |
| Other                    | 1 (4.2%)                          | 2 (9.5%)               |
| The duration of each class for this (bio)statistics course (in minutes), where applicable |        |                        |
| Sources of the prerecordings: |                    |                        |
| I exclusively use recordings that I created myself | 15 (62.5%) | 12 (57.1%) |
| I use recordings that I created myself, as well as those created by others | 6 (25.0%) | 6 (28.6%) |
| I only use recordings that were created by others | 1 (4.2%) | 2 (9.5%) |
| Other                    | 2 (8.3%)                          | 1 (4.8%)               |
| Sources of the prerecorded lectures created by someone else?** |          |                        |
| Other online resources (such as Khan Academy or YouTube) | 4 (16.7%) | 5 (23.8%) |
| Previous Instructor of this course/Co-instructor | 2 (8.3%) | 4 (19.1%) |
| Textbook publisher       | 1 (4.2%)                          | 3 (14.3%)              |
| Nature of the prerecorded lectures** |          |                        |
| Narration over a screen capture of slides (such as PowerPoint) | 19 (79.2%) | 17 (81.0%) |
| Screen capture that included the ability to see your handwriting | 9 (37.5%) | 12 (57.1%) |
| A video-recording of the instructor delivering a lecture | 3 (12.5%) | 7 (33.3%) |
| Software demonstration   | 3 (12.5%)                         | 4 (17.4%)              |
| Other                    | 3 (12.5%)                         | 4 (19.1%)              |
| Activities includes during class time** |          |                        |
| Data analysis using software | 17 (70.8%) | 18 (85.7%) |

Table 2. (Continued)

|                          | Health Sciences majors ($n = 24$) | Other majors ($n = 21$) |
|--------------------------|-----------------------------------|------------------------|
| Lectures                 | 17 (70.8%)                        | 13 (61.9%)             |
| Software demonstration   | 17 (70.8%)                        | 14 (66.7%)             |
| Worksheet/workbook type problems | 10 (41.7%)                        | 14 (66.7%)             |
| Small group discussions  | 10 (41.7%)                        | 9 (42.9%)              |
| Hand calculation problems | 9 (37.5%)                         | 13 (61.9%)             |
| Group projects           | 7 (31.8%)                         | 7 (33.3%)              |
| Group presentations      | 7 (29.2%)                         | 4 (19.1%)              |
| Online quizzes/readiness tests | 6 (25.0%)                        | 3 (12.5%)              |
| Experiments (Data generation/collection) | 3 (12.5%) | 5 (23.8%) |
| Clicker questions/interactive polls | 1 (4.2%) | 1 (4.8%) |
| Other                    | 2 (12.5%)                         | 1 (4.4%)               |

*If the course was completely online (with no classroom sessions), respondents were instructed to enter zero, and these responses were excluded from this calculation. These means are based on $n = 10$ and $n = 14$, respectively, for those teaching health sciences majors and other majors.

**Respondents could select all that apply.

were also rated highly by these instructors. Cost was rated as being less important (2.7 [1.4]) by the instructors in this sample.

**Discussion**

This survey addressed a wide range of issues for online of flipped (bio)statistics courses being taught to students in the health sciences. While the findings reported here provide a useful snapshot of these courses’ characteristics, they also provide information that can guide instructors of (bio)statistics teaching in the health sciences who may already be using these formats or who are considering using them.

Instructors in this sample are experienced teachers and have experience teaching using the online or flipped formats, despite their more innovative nature. These instructors also tend to continue to teach some courses using a traditional format. These formats were used in a wide range of settings, including different class sizes, levels of education, majors, topics, and meeting schedules. While this survey did not include any high school courses, this result is likely due to the approach in recruiting volunteers to participate, rather than reflecting whether these formats would be appropriate for teaching at that level.

We also note there is not a sole correct approach to teaching (bio)statistics using an online or flipped format, as has been previously reported in Schwartz et al. (2016). Instructors report differing sources of their prerecorded lectures, though most produce their own content. The nature of their prerecorded lectures and the in-class activities vary as well, presumably tailored to their students’ specific needs. This provides the instructor with flexibility to help maximize their students’ learning during the course.

Although instructors in our sample noted the increased demands on both the instructor and the students in these formats relative to a traditional lecture-based format, they indicated that student resistance was neither better nor worse, on average. However, when comparing to the traditional format,
the value of these approaches seems to lie in the better student achievement of the desired learning outcomes, as well as better student engagement and higher student satisfaction under the online or flipped formats.

Importantly, the majority of instructors in our sample reported they would recommend these methods to their teaching colleagues. The item most strongly endorsed was active learning as an effective instructional tool. These instructors also endorsed the use of prerecorded lectures, followed by the flipped classroom and a partially online course with an in-class component. The use of a fully online course, with no in-class component, was nearly neutral (i.e., neither recommended for nor against), on average.

In rating the importance of various factors when selecting technology for their prerecordings, instructors considered the usability of the format for their students, as well as their institution’s resources (i.e., availability and support), as being most important. Ease of use and ability to edit the video were also considered to be important. Cost was found to be the least important factor when making this decision. We also note that most respondents teaching in this sample stated that they use Camtasia for recording lectures, and the cost of Camtasia was rated favorably, though less favorably than its ease of use and compatibility. These respondents would tend to recommend the use of Camtasia to other instructors.

Some barriers to implementing an online or flipped course were noted by instructors in our sample, namely the time commitment required for both instructors and students. While we did not explicitly ask for this information, our expectation would be that after the course was initially developed and the prerecordings completed, instructors might benefit from somewhat decreased course-related demands on their time in subsequent course offerings. The reluctance of students to embrace these formats may be perceived as a challenge, as students may have never experienced these formats and could be hesitant to try something new. However, in this study, this perception was not reported by the instructors, on average. Consistent with the literature, students’ engagement in, and satisfaction with, the online or flipped course was rated as better than for a traditional format, on average. A sample of open-ended comments from the instructors in our sample regarding the online and flipped formats, both favorable and unfavorable, are included in Listing 1.

Notably, these results are consistent with several of the American Statistical Association’s Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report recommendations (GAISE College Report ASA Revision Committee 2016). In particular, our data support the importance of “foster(ing) active learning,” as evidenced by the item regarding “the use of in-class activities (i.e., active learning) as an effective instructional tool” being favorably endorsed by the respondents teaching in the health sciences. Furthermore, the “use (of) technology to explore concepts and analyze data” is supported, as the flipped and online formats necessarily involve technology to some degree. Finally, these formats and their use of active
learning could facilitate “teach(ing) statistics as an investigative process of problem-solving and decision-making.”

While the information gained from this survey among (bio)statistics instructors in the health sciences is novel and valuable, there are some limitations of this study, including the relatively small sample size ($n = 24$) available. While this sample size may seem small, relative to the total membership of the two ASA sections, the total number of instructors who teach in an online or flipped format to students in the health sciences is not known. While anecdotal evidence suggests that the use of these formats is increasing, the number or percentage of bio/statistics instructors who teach using these formats in the health sciences is unclear. The low response rate may indicate that the use of these formats is anecdotal evidence suggests that the use of these formats is

The biggest issue I've had to deal with in teaching online is students who don't have the motivation needed for self-directed learning. This has been the most effective innovation to my teaching in all the years I've been teaching.

### References

Critz, C. M., and Knight, D. (2013), "Using the Flipped Classroom in Graduate Nursing Education," *Nurse Educator*, 5, 38, 210–213.

Dutton, J., and Dutton, M. (2017), "Characteristics and Performance of Students in an Online Section of Business Statistics," *Journal of Statistics Education*, 13, 1–26.

Eversen, M. G., and Garfield, J. (2008), “An Innovative Approach to Teaching Online Statistics Courses,” *Technology Innovations in Statistics Education*, 2, 1–18.

Ferrer, S. P., and O'Connor, S. K. (2017), "Redesign of a Large Lecture Course Into a Small-Group Learning Course," *American Journal of Pharmaceutical Education*, 77, 1–9.

GAISE College Report ASA Revision Committee (2017), "Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report 2016." Retrieved May 25, 2018 from http://www.amstat.org/asa/files/pdfs/GAISE/GaiseCollege_Full.pdf.

Galway, L. P., Corbett, K. K., Takaro, T. K., Tairyan, K., and Frank, E. (2014), "A Novel Integration of Online and Flipped Classroom Instructional Models in Public Health Higher Education," *BMC Medical Education*, 14, 1–9.

Gundlach, E., Richards, K. A. R., Nelson, D., and Levesque-Bristol, C. (2015), "A Comparison of Student Attitudes, Statistical Reasoning, Performance, and Perceptions for Web-augmented, Fully Online, and Flipped Sections of a Statistical Literacy Class," *Journal of Statistics Education*, 23, 1–33.

Howard, S. W., Scharff, D. P., and Loux, T. M. (2017), "Flipping Classrooms in a School of Public Health," *Frontiers in Public Health*, 5, 1–7.

Keeler, C. M., and Steinhorst, R. K. (1995), "Using Small Groups to Promote Active Learning in the Introductory Statistics Course: A Report from the Field," *Journal of Statistics Education*, 3, 1–9.

Loux, T. M., Varner, S. E., and VanNatta, M. (2016), "Flipping an Introductory Biostatistics Course: A Case Study of Student Attitudes and Confidence," *Journal of Statistics Education*, 24, 1–7.

McLaughlin, J. E., and Kang, I. (2017), "A Flipped Classroom Model for a Biostatistics Short Course," *Statistics Education Research Journal*, 16, 441–453.

Mills, J. D., and Dheeraj, R. (2017), "Teaching Statistics Online: A Decade’s Review of the Literature About What Works," *Journal of Statistics Education*, 19, 1–28.

Moffett, J., and Mill, A. C. (2014), "Evaluation of the Flipped Classroom Approach in a Veterinary Professional Skills Course," *Advances in Medical Education and Practice*, 5, 415–425.

Mok, H. N. (2014), "Teaching Tip: The Flipped Classroom," *Journal of Information Systems Education*, 25, 7–11.

Moraras, J., Islam, A., Yu, S., Banow, R., and Shindelka, B. (2015), "Flipping for Success: Evaluating the Effectiveness of a Novel Teaching Approach in a Graduate Level Setting," *BMC Medical Education*, 15, 1–10.

Peterson, D. J. (2015), "The Flipped Classroom Improves Student Achievement and Course Satisfaction in a Statistics Course: A Quasi-Experimental Study," *Teaching of Psychology*, 43, 10–15.

Samsa, G. P., Thomas, L., Lee, L. S., and Neal, E. M. (2012), "An Active Learning Approach to Teach Advanced Multi-Predictor Modeling Concepts to Clinicians," *Journal of Statistics Education*, 20, 1–34.

Schwartz, T. A. (2014), "Flipping the Statistics Classroom in Nursing Education," *Journal of Nursing Education*, 53, 199–206.

Schwartz, T. A., Andridge, R. R., Sainani, K. L., Stangl, D. K., and Neely, M. L. (2016), "Diverse Perspectives on a Flipped Biostatistics Classroom," *Journal of Statistics Education*, 24, 74–84.

Snee, R. (1993), "What’s Missing in Statistical Education?" *The American Statistician*, 47, 149–154.

Tune, J. D. (2013), "Flipped Classroom Model Improves Graduate Student Performance in Cardiovascular, Respiratory, and Renal Physiology," *Advances in Physiology Education*, 37, 316–320.

Wilson, S. G. (2013), "The Flipped Class: A Method to Address the Challenges of an Undergraduate Statistics Course," *Teaching of Psychology*, 40, 193–199.

Winquist, J. R., and Carlson, K. A. (2014), "Flipped Statistics Class Results: Better Performance Than Lecture Over One Year Later," *Journal of Statistics Education*, 22, 1–10.

### Listing 1. Selected instructor comments.

- I have mixed feelings about (teaching online). There are certainly some advantages, mainly allowing flexibility in terms of time and location to deliver and receive content. Yet, I feel it's very impersonal.
- My MPH students performed much better in the partially flipped format than my previous students had done in the traditional lecture format.
- Students like having videos and materials they can do (sic) on their own time.
- The flipped classes don't do so well because [students] rarely review the material before the class time and it ends up where I go over the statistics lectures fast in our 1 hour per session week.
- We assessed the flipped approach and were not able to detect a difference in performance compared to a traditional approach. However, it helped the weakest students and we were able to reduce the failure rate in the course.