UTILIZING A FLIPPED CLASSROOM FOR AN INTRODUCTORY BIOSTATISTICS COURSE

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This article describes the philosophy and methodology used to redesign an Introduction to Biostatistics course at the Boston University School of Public Health using the flipped classroom approach. The course was previously taught using a traditional lecture-based model where students learned material in class and complete homework assignments outside of class. The course was redesigned such that students are required to watch video lectures online and complete quizzes to prepare for class. During class, rather than lecture, students engage in active learning exercises including: audience response ("clicker") questions, pair and share activities, microlectures, and case studies with discussion. Formative assessments include weekly homework assignments which involved data analysis and interpretation using RStudio; summative assessments include a group project, midterm and final exam.

INTRODUCTION

With new advances in technology and ideology, the manner in which we educate students has drastically changed over the past decade (Bishop 2013). Information is being amplified at an extremely low cost allowing for new avenues of pedagogy. This combined with the massive growth in the field of public health calls for an intensive reworking of how we educate students. The Framing the Future initiative by the Association of Schools and Programs of Public Health (ASPPH) provided guidelines for rethinking the public health education which were published in the 2015 report *A Master of Public Health Degrees for the 21st Century* (ASPPH 2015). These guidelines indicate the importance of a core curriculum that teaches students the "tools of public health data collection, analysis and interpretation". The new criteria put a stronger emphasis on the content and outcomes of a public health education. With these new reforms public health educators must reconsider how we educate our students (Merzel 2017, Galway 2014).

The Introduction to Biostatistics course that we teach is a requirement for many students on the medical campus at Boston University. We assume no prior knowledge in statistics and start by teaching students the basics with types of variables and descriptive statistics and then move on to more complex material with different types of hypothesis testing being the bulk of the material. The course enrollment is typically around 70 students. The main course objectives are first to give students the background needed to interpret and critique statistical methods and results encountered in the public health literature, and second, to provide the skills needed to conduct basic statistical analyses. After articulating the objectives for this course, we carefully thought out learning activities that would help students learn the skills necessary for successful completion of the course during my course redesign.

OLD COURSE STRUCTURE

For years, Introduction to Biostatistics has been taught as a traditional lecture-based course to students in the Master's in Public Health, Nutrition, Dental and Medical schools. We provided students with PowerPoint lecture slides which we would go through in class (no preparation was required prior to class for the students). These lectures did include some active learning components including "clicker" questions and problems to be worked out by hand and interpretation of results from article abstracts. We would spend 15-30 minutes at the end of class teaching the students how to run the analyses using RStudio with practice datasets. After lecture was finished, students were then required to complete a short quiz (due four days after class) and a homework assignment (due prior to the next lecture). Quizzes consisted of seven multiple choice questions each worth ten points that involved computation and interpretation of analysis results. Once the student has completed the quiz, the student receives a score, but is not told which questions they got right or wrong. To encourage self-correction, students were allowed to take

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quizzes an infinite number of times. Students would often take the quiz until they received a perfect score. Homework assignments involved analyzing a dataset using RStudio and interpreting the results as a write up. A midterm exam (testing students on the first half of the course) and a final exam (testing students on the last half of the course) were used as summative assessments in the course.

Overall, students were very happy with the course. Teaching evaluations for the course and its instructors were often high and students commented that they enjoyed the course and found lectures to be easy to understand. Despite high course evaluations, there have been indications that the overall course objectives were not being met. The first issue is that students had poor long term retention of the material. While final exams were not cumulative, it is difficult to do well on the final exam without a solid understanding of the first half of the course. Students typically struggled with the second half of the course due to poor retention of basic concepts learned in the first half of the course. In addition, instructors of subsequent courses in which Introduction to Biostatistics was a prerequisite indicated that students seemed to have forgotten a lot of the material or not learned it very well. A second issue with the course was that students often complained that while the material in class seemed easy, they struggled to complete homework assignments. With these two major issues there appeared to be a serious flaw in the design of the course. One of the major objectives of the course is for students to be able to analyze public health data and interpret and critique the methodology and results from any public health or biomedical journal long after the course has finished.

FLIPPED CLASSROOM APPROACH

Studies have shown that a large proportion of students are not learning the critical thinking, written communication and complex reasoning skills required for their careers (Arum 2010). Evidence shows that active learning enhances learning outcomes and improves students' motivation and attitudes (Prince 2004). While the old structure of this course did have some components of active learning, it was limited to approximately 30 minutes in a 2.5 hour course; the remaining 2 hours of the course was spent lecturing to students.

Our new approach involved utilizing a flipped classroom approach. The flipped classroom model involves moving the transmission of knowledge portion of the class (lecture) to outside of the classroom; thereby allowing more time for active based learning activities during class (Loux 2016, Bishop 2013, McGraw 2015, Dove 2013, McLaughlin 2014). Students are required to watch video lectures at home prior to class and then come to class prepared to apply the learning through active learning techniques. We offloaded lecture content into self-paced online videos. The remaining class time was devoted almost entirely to active learning exercises (doing some analyses by hand, running analyses in RStudio, reading and critically evaluating abstracts in group discussions, audience response system "clickers") with minimal time spent on microlectures as necessary.

Preparing for Class

With our new approach, each student will be responsible for coming to class with a basic understanding of the material so that he or she can participate in the active learning activities. For each class students were required to watch several short (2-5 minute) videos that are prerecorded to narrated interactive learning objects (lectures) using Articulate Storyline 360. These online videos are adapted from PowerPoints slides used to teach Introduction to Biostatistics during previous semester; however, only critical concepts were emphasized in these videos. These videos are then hosted on YouTube and embedded in Articulate Storyline or Blackboard Learn (a Web-based learning management system). Students are able to access these videos at any time on any computer or any device that has access to the Internet. Students are able to pause, rewind, and fast forward through the videos and they can be viewed multiple times; thus allowing students to learn at their own pace.

Due to the fact that the flipped classroom model is a student-centered approach, if the student does not come to class prepared, the model does not work. In order to ensure that students watched the videos, we first made sure that the video length was not too long (most videos were between 2 and 5 minutes in length). In addition, to ensure that students watched the videos we embedded 10-20

quiz questions within the videos. These quiz questions contributed to the students' overall grade and were graded within Blackboard Learn.

Active learning components in class

With the lecture component of the course now designated to be done outside of class, all in-class time was devoted entirely to active learning. Active learning is generally defined as any instructional method that engages students in the learning process in the classroom (Prince M 2004, Triantafyllou 2014)). We utilized the following active learning activities in the classroom: audience response ("clicker") questions, microlectures, pair and share activities, and case studies with discussion. Audience response ("clicker") questions were used to gauge students' understanding of basic concepts that were presented in the online video lectures. Each class had approximately 5-10 multiple choice clicker questions. After being given 30 seconds to 1 minute to respond to the question, the instructor would view the responses and explain the rationale for the correct (and incorrect) answers. Microlectures were brief (no longer than 5 minutes) lectures on the material that were used as needed by the instructor. For example, if it becomes clear through the use of a "clicker" question that the majority of students are confused about a critical concept from the online video lectures, microlectures could be used to provide clarity. Classes also included rapid pair & share activities in which students were presented with a discussion question and students were asked to pair together and share ideas with one another. After discussing with their partner, certain pairs were called upon to share their ideas and the instructor and the students' peers provided feedback. Case studies were presented to students throughout lecture and called upon students to do basic hand calculations, run analyses on a dataset using RStudio and/or interpret statistical methodology and study design of journal or newspaper articles.

Assessments

To assess student understanding of the online video lectures, we embedded quiz questions within the videos that were graded on Blackboard Learn. These quizzes comprised of 10% of the students' overall grade. Homework assignments were another formative assessment used to gauge student understanding and were worth 20% of student's overall grade. Homework assignments typically consisted of students analyzing a dataset using RStudio (with a few hand calculations) and providing the interpretation of the results. Summative assessments of the students' understanding of the material included the midterm exam (covering the first half of the course) which was worth 20% of the students' grade, the final exam (covering the second half of the course) which was worth 30% of the students' grade and the group project which was worth 20% of the students' grade. The group project required students to work in groups of 3-5 students and asked them a series of research questions pertaining to a dataset. Students were required to determine the best way to analyze the data (both through hypothesis test and graphical displays), format their tables to present their analyses and write up a cohesive report of their findings. This summative assessment encourages higher-order thinking and assess students' ability to analyze, synthesize and evaluate material (Bloom's Revised Taxonomy of Learning) and consistent with the ASPPH's goal to have students learn to collect, analyze and interpret data (Krathwohl 2002, ASPPH 2015).

CONCLUSIONS AND DISCUSSION

While there seem to be many advantages to the flipped classroom approach; there are some drawbacks that make instructors hesitant to deviate from the traditional lecture approach. One major obstacle is the time spent offloading the lectures into an online video format (McGraw 2015). This is not an obstacle to be taken lightly; it takes a considerable amount of time from dedicated faculty (and possibly an instructional design team) to ensure that the video lectures are of high quality and can be accessed by students with learning disabilities as well. In addition, there may be hesitation from the students to embrace a flipped classroom approach. Initially, students may feel that they have to put in more work by watching online videos and taking quizzes to prepare for class compared to the traditional lecture approach (Wilson 2013, Triantafyllou 2014)). However, while students may put in more time preparing for class, allowing students to have more

time spent engaged in active learning during class should ultimately lead to less time spent on the homework assignments due to less confusion regarding how to approach the problems.

Providing students with online video lectures that are readily available to students and allow them the capability to watch, rewind, rewatch and skip sections of the video as best suits their needs is a huge advantage to the flipped classroom approach and really helps struggling students (McGraw 2015). With the traditional lecture based approach, if students missed a class it is very easy for them to fall behind since they may not have an opportunity to make up the missed lecture content. Also, classroom distractions that may occur during lectures are no longer an issue.

With more class time allotted to active learning activities, the flipped classroom approach offers increased student-student and student-instructor interaction (McGraw 2015, Roehl 2013). This increased interaction can allow instructors to better monitor students' progress; versus only identify struggling students after a summative assessment such as an exam. Flipped classrooms are particularly useful in fields where learning is enhanced by doing, thus allowing the students to learn essential job skills (Schwartz 2016, Howard 2017).

REFERENCES

Association of Schools and Programs of Public Health (2015). *Framing the future* http://www.aspph.org/educate/framing-the-future.

Arum, R., & Roksa, J. (2011). *Academically adrift: Limited learning on college campuses*. University of Chicago Press.

Bishop, J. L., & Verleger, M. A. (2013, June). The flipped classroom: A survey of the research. *ASEE National Conference Proceedings, Atlanta, GA*, 30(9), 1-18.

Dove, A. (2013, March). Students' perceptions of learning in a flipped statistics class. In *Society for Information Technology & Teacher Education International Conference* (pp. 393-398). Association for the Advancement of Computing in Education (AACE).

Galway, L. P., Corbett, K. K., Takaro, T. K., Tairyan, K., & Frank, E. (2014). A novel integration of online and flipped classroom instructional models in public health higher education. *BMC medical education*, *14*(1), 181.

Howard, S. W., Scharff, D. P., & Loux, T. M. (2017). Flipping Classrooms in a school of Public Health. *Frontiers in public health*, *5*.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, *41*(4), 212-218.

Loux, T. M., Varner, S. E., & VanNatta, M. (2016). Flipping an introductory biostatistics course: a case study of student attitudes and confidence. *Journal of Statistics Education*, *24*(1), 1-7.

McGraw, J. B., & Chandler, J. L. (2015). Flipping the Biostatistics Classroom, With a Twist. *The Bulletin of the Ecological Society of America*, *96*(2), 375-384.

McLaughlin, J. E., Roth, M. T., Glatt, D. M., Gharkholonarehe, N., Davidson, C. A., Griffin, L. M., ... & Mumper, R. J. (2014). The flipped classroom: a course redesign to foster learning and engagement in a health professions school. *Academic Medicine*, *89*(2), 236-243.

Merzel, C., Halkitis, P., & Healton, C. (2017). Pedagogical Scholarship in Public Health: A Call for Cultivating Learning Communities to Support Evidence-Based Education. *Public Health Reports*, *132*(6), 679-683.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of engineering education*, *93*(3), 223-231.

Roehl, A., Reddy, S. L., & Shannon, G. J. (2013). The flipped classroom: An opportunity to engage millennial students through active learning. *Journal of Family and Consumer Sciences*, *105*(2), 44.

Schwartz, T. A., Andridge, R. R., Sainani, K. L., Stangle, D. K., & Neely, M. L. (2016). Diverse Perspectives on a Flipped Biostatistics Classroom. *Journal of Statistics Education*, *24*(2), 74-84.

Triantafyllou, E., & Timcenko, O. (2014, May). Introducing a flipped classroom for a statistics course: A case study. In *EAEEIE (EAEEIE), 2014 25th Annual Conference* (pp. 5-8). IEEE.

Wilson, S. G. (2013). The flipped class: A method to address the challenges of an undergraduate statistics course. *Teaching of Psychology*, *40*(3), 193-199.