DEVELOPMENT AND IMPLEMENTATION OF IN-CLASS ACTIVITIES IN A LARGE INTRODUCTORY STATISTICS CLASSROOM

Eugenia Yu
Department of Statistics
University of British Columbia, Vancouver BC, Canada V6T 1Z4
eugenia@stat.ubc.ca

The use of in-class activities has many benefits to learning, including increased student engagement, better critical thinking skills and improved classroom dynamics. However, conducting activities in large classes can be very challenging due to difficulty in monitoring student participation and progress, lecture hall being unconducive to group work and other logistical issues. In this paper, we address such challenges by discussing strategies in developing in-class activities that facilitate group discussions and providing suggestions on the logistics of implementation in large classes. We will describe our experience in transitioning from traditional lecture-based to partially flipped classroom teaching in a large introductory course. We also present a sample activity and its implementation plan with teaching assistant support and use of clicker technology.

INTRODUCTION

Over the past few decades, active learning such as using in-class activities in lecture has become an increasingly popular and recommended approach to teaching. This teaching approach has demonstrated not only academic but also social and psychological benefits [see, for example, Faust & Paulson (1998), Tishkovskaya & Lancaster (2012)]. While many instructors recognize these benefits, they tend to resort to traditional lecture format when teaching large classes, possibly due to their fear of negative reaction from students and loss of control of the class. There are also other challenges in teaching in a large classroom such as the lack of student participation and engagement, and reduced opportunities for instructors to provide feedback to individual students. In fact, if carefully planned and executed, in-class activities coupled with formative assessments can help address these challenges while giving both instructors and students a meaningful and enjoyable teaching-learning experience.

In this paper, we will focus on in-class activities where students work together in small groups to complete a task or achieve a common goal, which is also referred to as collaborative learning (Garfield, 1993). We will discuss strategies for developing and implementing such activities in a large classroom setting. We will also share our experience in incorporating in-class activities in one of our large introductory courses. A sample activity and our implementation plan will be given in the end.

DEVELOPMENT OF ACTIVITIES

Regardless of the types of in-class activities, good activities share some common desirable features. An activity should have clear instructions and learning goals, be self-contained and consist of an overview at the beginning and debriefing at the end [see, for example, GAISE (2016), Yazedjian & Kolkhorst (2007)]. It is also suggested to revolve activities around students' interests. Particular to collaborative learning activities, they should require all group members to be involved and held accountable for their contributions to an end goal, both individually and as a group (Garfield, 1993). Furthermore, class size should be taken into consideration when developing activities. Unlike in small classes where it is feasible to run complex activities, Carbone (1998) recommended instructors teaching large classes to keep group activities simple and short, and intersperse them with segments of lecture which will maintain the momentum of the lecture and keep students interested. Carbone also pointed out that most of the negative experiences encountered by instructors and students in an active learning classroom stem from poor planning and preparation of the activities. For example, activity purpose and instructions not being communicated clearly to students will likely lead to confusion; if there is no assessment or no end product to be expected, students may become resistant to participate.

Expanding on the above recommendations, here we provide some ideas and examples for developing activities to be used in a large introductory statistics class.

Using Pre-Activity to Communicate Purpose of Activity and Prime Students for Upcoming Tasks

While instructors can provide learning goals and instructions on paper worksheets or overhead slides during class time, given the large number of students, it can take some time for the whole class to get ready to start their task. One may consider developing a pre-activity worksheet which contains learning goals and some simple tasks for students to complete individually before class. This not only informs students on what to expect in the upcoming activity but also allows more efficient use of class time. As well, students enrolled in an introductory course tend to have very diverse backgrounds, so completing pre-activity tasks can help bring students to the same level of knowledge before the activity. For example, for an activity on hypothesis testing, a pre-activity may provide a scenario and include questions that ask students to identify the population and parameter of interest. During lecture, students can be asked to work together to perform a hypothesis test on the parameter of interest that they already identified.

Promoting Involvement of Individual Members

In order to ensure all members are involved, one can create tasks that require each member to contribute to only part of a final result, after which members build the final answer together. The individual tasks can be kept simple and easy to accomplish. For example, an activity on confidence intervals may require one student to compute the sample mean from a set of observations and another student compute the sample standard deviation. Students then put their pieces together to compute the confidence interval. As another example, an activity on studying sampling distribution of the mean can have each member obtain a few random samples from a given population and calculate the means of the repeated samples. Afterward, members work together to construct a histogram of their sample means.

Promoting Discussion among Group Members

At the beginning of the semester, most students in a large class do not know each other and may feel intimidated to begin conversation and work in groups. It is a good idea to develop activities that use student-collected data or scenarios that pertain to students' lives. Students are more ready to dive into discussion when they have common interests and experiences that they can relate to. In regards to tasks within an activity, one can include more conceptual questions that encourage synthesis, comparison and contrast. For example, in an activity on sampling variability and sampling techniques, instructors can select multiple simple random samples of students from class, collect data on student ownership of a certain type of mobile device and compute the sample proportion of ownership from each sample. Group members can then be asked to compare the sample proportion values (this helps introduce or reinforce the concept on sampling variability). There can also be a question asking group members to discuss alternative ways of selecting random samples of students from class.

Individual and Group Accountability

For large classes, it is more practical to make use of technology such as classroom response system (clicker) in monitoring student participation and progress, as well as for assessment purposes. If a pre-activity is used, instructors can ask students to individually answer a few readiness check questions before the start of an activity. One can also devise pre and post clicker questions where the pre question is answered individually, followed by group discussion and then the post question. Students are generally curious to find out how their answers compare with others', so this pre and post question structure helps increase student engagement in discussion. As well, through discussion, students are able to receive feedback on their understanding of course concepts from their peers. At the end of the activity, instructors may request students to turn in some form of evidence of participation such as the completed activity worksheet.

IMPLEMENTATION OF ACTIVITIES

Large class size does present some challenges to conducting in-class activities, but using the right strategies and making adjustments according to the course structure, learning environments and the physical setup of the lecture room will allow one to achieve successful implementation. GAISE (2016) provided recommendations for implementing active learning in general in various learning environments including face-to-face, flipped and distance learning classes. We will discuss strategies specific to running group activities in a large lecture hall setting.

Forming Groups and Seating Arrangement

Perhaps the biggest concerns most instructors have are choosing the right group size and forming groups. Carbone (1998) recommended group size of 2 to 3 for a large classroom with fixed chairs which helps keep the noise level down and ease communication between group members (with linear or triangular seating arrangement). Garfield (1993) discussed using formal and informal groups. Below we describe and propose some strategies in implementing the two types of groups depending on the course structure and the lecture room configuration.

- Formal groups refer to groups of students who work with the same students for a long period of time or even throughout the semester. Many introductory courses have a separate computer lab component. If the lab portion of the course is mandatory and involves group work, there may already be fixed lab groups and one can use the same groupings in lecture. Alternatively, instructors may form groups by random assignment or by balancing certain characteristics such as major or gender. Seating arrangement for formal groups will require some planning – if the lecture hall has a regular shape, it may be easy to make seating plans in advance. Seating arrangements may also be determined during class time [see, for example, Magel (1998), Yazedjian & Kolkhorst (2007)]. One may consider doing seat rotation at some point during the semester so that students are not restricted to the same seat all the time.

- In situations where formal groups are not practical, one can simply use informal groups, e.g., having students turn to their neighbours and pair up. Groups can be formed very quickly and students can start the activity right away. One possible downside of informal groups is that students who know each other tend to sit together and they usually have similar education background and interest level. This will not be as beneficial as having group members with more diverse backgrounds who can borrow strengths from each other in solving problems. However, this is possibly the most manageable way of forming groups in a large classroom setting.

Conducting Activities on a Regular Basis

We would advise that instructors make in-class activities a regular part of the lecture. This not only sets the expectation for class participation, but also allows students to know each other early on in the semester and develop the habit of working together. Initially it may take longer to set things up and get students started, but students will get used to the routine quickly after a few activities and things will run smoothly for the rest of the course. The level of resistance students may have toward group work will likely diminish as the semester progresses (Yazedjian & Kolkhorst, 2007).

Making Use of Technology for Data Collection and Formative Assessments

A large class size lends itself to the opportunity of obtaining sufficient data observations from the class for data analysis or for illustrating certain statistical concepts such as sampling distributions. One can use clicker or an online survey tool for collecting data to be used in an activity. In order to monitor progress and guide students through completing an activity, we recommend interspersing milestone questions throughout the activity and have students submit their responses using clicker. This way, students are able to receive immediate feedback from the instructor. If many students stumble on a particular part in an activity, instructors can address the problem immediately before students move on to the next part.

Making Use of Teaching Assistant (TA) Support

Teaching assistants can provide valuable support to both instructors and students in a large classroom. They can circulate the classroom and answer questions students may have while working on the activity. As students tend to be shy about asking questions, TA's are advised to act proactively, checking with individual groups on their progress, listening to students' discussions and providing guidance if needed. TA's can also help with other logistics such as distributing activity sheets and enforcing group work. In addition to assisting in class, TA's can provide instructors with feedback on students' performance and difficulties that students encountered during the activity. Such feedback will be useful for improving activities for future iterations.

TRANSITIONING FROM TRADITIONAL LECTURE TO PARTIALLY FLIPPED CLASSROOM APPROACH

Background

In University of British Columbia (UBC), three introductory statistics courses are regularly offered by the Department of Statistics. They have different target audience groups (science, non-science and applied science). Here we will describe our transition from traditional lecture to a partially flipped classroom in the introductory course for science majors. In this course, the students come from a wide range of disciplines and have very different mathematics backgrounds. In recent years, the annual enrolment is about 1200, with approximately 1000 students enrolled in the winter session (September to April) and 150 in the summer session (May to August). The class size in a lecture section during the winter session ranges from 250 to 350. The course had been traditional lecture-based, with three 50-minute lectures weekly for a total of 13 weeks during the winter session, and three 110-minute lectures weekly for a total of 6 weeks during the summer session. There are also weekly mandatory computer labs which involve students working in groups of four on data analysis.

Transition in Teaching Approach

Since the 2007 Fall semester (September to December 2007), the teaching team started using clicker in lecture, but there were no regular in-class activities until the author piloted a partially flipped teaching approach in Summer 2016.

The Summer 2016 class had 143 students and the classroom was a tiered lecture theatre with configuration convenient for forming groups of three (the lecture room has tiered benches where the left and right sections each have 3-seat benches and the middle section has 8-seat benches, which allows groups of 3 to be easily formed.) However, since the lab groups were of size 4, we did not implement the lab groups in the lecture and simply let students form their own groups of 3. In a typical activity, students worked together to solve a few problems on topics that were recently taught. For some activities, students were required to complete a pre-activity or pre-reading. Activities were administered at least twice a week and each took an average of 30 to 40 minutes to complete. As a result, most lectures had both presentation of material by the instructor as well as an in-class activity.

After this initial experience, the author continued with this partially flipped approach in the 2016 Fall semester. The author taught one of the two lecture sections, each with approximately 350 students. The instructor of the other lecture section also conducted the same set of activities. For both sections, the lecture was held in a tiered lecture hall. Since a typical lab group consisted of students from both lecture sections, it was not possible to use the same groupings within an individual lecture section. As well, the lecture hall has a somewhat irregular shape, so we adopted informal groups. In regards to the activities themselves, we split some of the activities used in the summer semester into smaller parts in order to fit them within a 50-minute lecture. Activities were given equally frequently as in the summer, i.e., at least twice every week.

For both semesters, 2 to 3 teaching assistants provided support during every activity. We gave milestone clicker questions as well as ones that target misconceptions. With these we were able to track student progress and provide students with feedback on their understanding of the course material. We observed that students were highly engaged. The course evaluations revealed that overall, students enjoyed doing in-class activities which they found useful to their learning.

SAMPLE ACTIVITY

We will present the *Understanding Confidence Intervals for the Mean* activity which we used in our introductory course. It was adapted from a similar activity developed out of the UBC Introductory Statistics Flexible Learning Project (https://skylight.science.ubc.ca/projects/isfl). The author is a key member of the project and participated in the development of various in-class activities. This particular activity aims to introduce ideas about confidence intervals for a mean by doing a simulation study on a real data set collected from the class. There are three specific learning goals: (1) explain why confidence intervals vary from sample to sample, (2) recognize that a confidence interval could contain or miss the true mean, and (3) recognize that the confidence level indicates the proportion we would expect confidence intervals to contain the true mean.

Data Collection

The activity uses student-collected data. We proposed three variables of interest, including height, amount of monthly rent, and number of Facebook friends. Instructors can choose other variables that interest students. Data are to be collected before class using an online survey form. Instructors then paste a clean data table of one of the variables into a pre-activity sheet. One may consider giving a small incentive for participation in the online survey so as to maximize the response rate. For the purpose of this activity, in order to investigate the proportion of confidence intervals that contain the true mean value, we will need to know the true mean value. This in turns requires that we treat students who have submitted data instead of all students registered in the course as the population of interest. This subtlety shall be addressed in class.

Pre-Activity

The activity uses a pre-activity which is to be completed before class. The pre-activity provides an introduction and learning goals of the activity. Students are asked to complete the following tasks: identify the population and parameter of interest, generate a set of random numbers from an online website and then use the selected numbers to obtain a random sample (of size 10, say) from the data table (population data), and finally, compute a 95% confidence interval for the population mean using their own sample.

Activity Conducted During Lecture

The in-class portion of the activity consists of the following steps:

1. At start of the activity, the instructor shall first ask a few readiness check clicker questions. These questions can ask about the population, the parameter and the mathematical expression of the confidence interval constructed. Students are to answer these questions on their own.

2. To achieve the first learning goal, students are asked to answer the following pre-question individually, then discuss their answers with their group members and answer the same question again (post-question):

    Without looking, how do you think your confidence interval (CI) compares to the one obtained by the person beside you?
        A. The two CIs have the same center and same width.
        B. The two CIs have the same center but different widths.
        C. The two CIs have different centers but the same width.
        D. The two CIs have different centers and different widths.

3. To achieve the second and the third learning goals, the instructor is to first poll data from the individual students' confidence intervals – the instructor will provide the population mean value and ask students to indicate via clicker as to whether their confidence intervals include the population mean value. The clicker results will give the empirical proportion of inclusion. Afterward, students are asked to discuss the following with their group members:

    - What would be the theoretical proportion of confidence intervals that contain the true mean?
    - Compare the theoretical proportion and the proportion obtained in class. Are they the same or different? Why do you think that is the case?

4. Finally, the instructor can wrap up the activity by asking students to reflect on what they have learned in this activity and voluntarily report their answers to the rest of the class.

The in-class portion of the activity takes approximately 30 minutes. In regards to TA support, one can arrange a few TA's to distribute activity sheets, circulate the lecture room, check on student progress and answer students' questions.

Common Misconceptions

While the majority of students recognize that different samples result in different sample mean values and hence different centers of the confidence intervals, many of them thought the confidence intervals have the same width. In our case where the population standard deviation is unknown, the width would depend on the sample standard deviation which also varies from sample to sample. The pre/post question structure would allow students to confront this misconception. When we conducted this activity in our class, students did quite poorly in the pre-question. After group discussion, the performance to the post-question improved, with responses converging toward the correct answer. More specifically, during the Summer 2016 and Fall 2016 semesters, among a total of 420 students who responded, 47% and 69% of them answered the pre and post questions correctly, respectively.

With a class size similar to that of our introductory course (350 students), we would expect the empirical proportion of confidence intervals that include the true mean to be relatively close to the confidence level. To our surprise, when we conducted the activity for the first time, the empirical proportion of inclusion was much lower than the theoretical proportion, which is beyond the reasonable doubt of sampling variability. In order to investigate this discrepancy, we collected the pre-activity sheets and examined students' computation of the confidence intervals. We noticed that quite a number of students used the wrong critical value and/or misused the population size as the sample size in their computation. This resulted in a narrower confidence interval and hence an empirical proportion lower than what would have been expected. In light of this finding, we created a clicker question that addresses these two misconceptions in the confidence interval construction and gave it as a readiness check question at start of the in-class activity. We would recommend instructors to take these misconceptions into account when explaining the discrepancy between the theoretical and empirical proportions of inclusion.

CONCLUSION

We believe that with detailed planning ahead of time, one can develop effective in-class activities and implement them successfully in a large classroom setting. The initial effort needed in the development and implementation can be significant, but most activities can be re-used in future iterations of the course or easily adapted for use in other similar courses. It will be a lost opportunity if we do not engage students actively in the learning process which is more beneficial than them solely passively receiving knowledge from the teacher.

REFERENCES

Carbone, E. (1998). *Teaching Large Classes: Tools and Strategies*. Thousand Oaks: SAGE Publications.

Faust, J. L., Paulson, D. R. (1998). Active Learning in the College Classroom. *Journal on Excellence in College Teaching, 9*(2), 3-24.

GAISE group (2016). *Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report.* http://www.amstat.org/asa/files/pdfs/GAISE/GaiseCollege_Full.pdf

Garfield, J. (1993). Teaching Statistics Using Small-Group Cooperative Learning. *Journal of Statistics Education*, *1*(1). http://ww2.amstat.org/publications/jse/v1n1/garfield.html

Magel, R. C. (1998). Using Cooperative Learning in a Large Introductory Statistics Class. *Journal of Statistics Education, 6*(3). http://www.amstat.org/publications/jse/v6n3/magel.html

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). http://ww2.amstat.org/publications/jse/v20n2/tishkovskaya.pdf

Yazedjian, A., Kolkhorst, B. B. (2007). Implementing Small-Group Activities in Large Lecture Classes. *College Teaching, 55*(4), 164-169.