Minor Adventures in Flipped Classrooms, Team-based Learning, and other Pedagogical Buzzwords

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ABSTRACT

This paper describes elements introduced into a combined undergraduate/graduate data visualization course in order to make it more active and engaging. These elements include pre-class readings, interactive quizzes, reading reflections, and team-based activities.

1 INTRODUCTION

For many years, I had been teaching a rather standard data visualization course to a mixed class of graduate students and advanced undergraduates. This course combined lectures on core topics in visualization, student presentation of seminal and recent papers, individual assignments on visualization design and algorithm implementation, and a multi-phase group project for a client with real data and goals. It was a well-received course with an organization that had been honed over time, but some course elements worked better than others. Students tended to enjoy the in-class critiques of good and bad visualization examples that their classmates had found, but drift off during paper presentatations by their peers. As the typical class size grew from 15 to 23 to 28 to 40, the number of student paper presentations had become rather unwieldy, especially since students had done two presentations each, giving them a chance to apply feedback about their first presentation in order to improve performance in their second presentation. Lectures were generally well-received, but the growing class size made it difficult for them to be truly interactive. The multi-phase group project for a client was the heart of the course, both in terms of time required and the resulting sense of accomplishment.

After a year spent developing a new CS0 course around team-based learning concepts, I decided to bring some of those concepts to the data visualization course to increase student engagement as enrollments continued to grow. In order to accomplish this, I replaced most of the lecture and paper presentation time with interactive quizzes, small group discussions, and small group exercises. The revision was a lot of work and the resulting class that was more fun to teach. This paper primarily discusses in-class elements of the course, glossing over other assignments and the term project.

2 CONTEXT AND GOALS

This course redesign started from a reasonably successful and well-received course. It wasn't broken, but I felt that it could be better. My overall goal was to increase engagement in the class despite the growing class size. In order to do this, I concentrated on improving the least interactive elements of the course: lecture on core topics by the instructor and presentations of paper summaries by students. Course topics, assignments, and project structure were largely unchanged.

In order to increase engagement, I drew upon concepts from Team-based Learning (TBL) [3]. In classical TBL, students engage in identical individual and team quizzes, group exercises with randomly-assigned persistent groups, and group projects with student assessment of the contributions of teammates. I adapted quizzes to be only individual, but with embedded question-by-question discussion of answers. Group exercises used new random groups for each exercise, while the term project used persistent groups based on topic of interest. Since my approach did not adhere rigorously to the TBL framework, it might be more accurate to call it tBL (with a small 't'). Drawing from the TBL framework, I organized the course into a relatively small set of units, starting each unit with a quiz. The units were: Foundations, Metric Display, Design and Evaluation, Pattern and Shape, and Visual Analytics.

Course syllabus, schedule, lecture notes, and assignments are available from the course webpage [5]. Other materials are available by request.

3 INNOVATIVE COURSE ELEMENTS

New course elements replaced most of the in-class lecture and student paper presentation time with more interactive alternatives. Additionally, some out-of-class assignments were supplemented with online reflections to engage other students. The overarching theme of these course modifications was to increase positive interactions between the professor and students, as well to increase interactions among students, both in the context of increasing class sizes.

3.1 Pre-class Readings and Interactive Quizzes

In the traditional version of this course, I had assembled a set of readings that covered most of the topics I wanted to cover. I summarized some of these readings in lecture, with other lectures covering topics not really represented in the readings. In order to have a more integrated foundation in the readings, I switched to the textbook that matched my approach most closely, Colin Ware's Information Visualization: Perception for Design [6]. Instead of repeating the content of the textbook in lecture, my goal was to entice students to complete the readings before class and use class time to clear up concepts they didn't understand from the readings. For each unit, the assigned reading was about three chapters of the textbook.

Each unit opened with an interactive quiz of about ten multiple-choice questions administered through Piazza [4]. Students would enter their answers using a laptop or phone and see the distributions of the answers of their classmates. In questions where there was a variety of answers (most of them), students with different answers would make a case why theirs was the correct answer. I would join in to explain the correct answer and clear up any lingering misconceptions. Generally the interactive quiz and resulting discussion would take an entire 75 minute class period. On some topics, students requested traditional lectures to expand on the readings and I complied.

Each student's original answers were graded for correctness, but the quiz component was a relatively small part of the overall grade (ten percent). The goal was to motivate students to do the reading, but to limit their anxiety about being quizzed on new material.

3.2 Reading and Assignment Reflections

For each unit, along with the final week on Hot Topics and Research Challenges, I also assigned a group of three to six research

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papers. For each set of papers, students were asked to reflect on one paper or respond to the reflection of another student using the Piazza discussion board. This helped ensure that students did the reading and gave shyer students a less threatening venue to share their thoughts and engage in discussion. Generally students would post their own reflection, but a significant minority would respond to the post of another, sparking little flurries of online discussion. I would comment on reflections that I felt were particularly thoughtful and offered private feedback to students who requested it. At the end of the semester, students were asked to pick the two posts of which they were most proud and turn them in to be graded.

Reflections also became part of one individual assignment. The Visualization Construction assignment was composed of three phases: finding a interesting data set online, reviewing two tools that could be used to visualize such data, and creating a set of three visualizations exploring different options and settings. After the first two phases, students posted their reflections on Piazza. Extra points were given for the discovery of unique data or tools. In later phases, other students were free to use the data or tools discovered and reviewed by others, with students who were sources for data or tools receiving extra credit. Visualizations produced in phase three were presented to the class in a speed format.

3.3 Small Group Discussions

For three sets of papers (Metric Display, Design and Evaluation, and Shape and Pattern Display), student were randomly assigned to small groups to discuss the papers and decide which they thought was most valuable. Once groups converged on their favorites, they voted their preferences using colored cards. A cross-group debate of utility then ensued.

For the Design and Evaluation papers, students also gathered in their term project teams to discuss which paper described an approach that seemed most valuable to their particular project. Since projects varied widely in type, these preferences were more even more varied. Once again, discussion ensued, this time allowing students to glimpse how different approaches might be more or less valuable in different situations.

3.4 Small Group Exercises

Five group exercises gave students the opportunity to work together to accomplish goals, mostly with a team other than their term project team. Group sizes ranged from two to five, depending on the nature of the exercise. Each exercise and the corresponding sharing and discussion filled one or two 75 minute class periods.

3.4.1 Gapminder Exploration

Pairs of students shared a laptop to use Gapminder [2] to explore data about countries and US states. Based on their explorations of available information, they were asked to rate the following places to live: Maryland, New Mexico, Spain, Mississippi, Iowa, Norway, Cuba, Serbia. Groups compared and defended their rankings, mostly exposing differences in the variables used to form rankings.

3.4.2 Client Interview Exercise

Students prepared for upcoming interviews with the clients for their term projects in random groups of approximately four. One person was the Client; one the Interviewer; one the Coach; and the last the Evaluator. For each scenario, the Client received a scenario description, the Interviewer would spend about five minutes eliciting goals and data characteristics from the Client, the Coach would make real-time suggestions to the Interviewer about how to proceed, and the Evaluator would observe and fill out a performance rubric. Evaluators (and potentially other players) then shared their observations with the class. Players then switch roles and repeat with another scenario. Interviews became noticeably smoother and more effective with each successive round of practice.

3.4.3 Color Exercise

Groups of four to five students using a single computer to explore the effects of using different color scales on a map of synthetic data using the colorbrewer system [1]. Each group was asked to design an effective color scheme for five different scenarios:

1. Design a color scheme to display patterns in preferences for favorite ice cream flavor (from a list of fifteen possibilities). Your audience is a group of marketing managers who are particularly interested in places where preference changes in order to develop strategies for co-marketing ice cream toppings.

2. Design a color sequence that shows as much detail as possible about patterns in consumer spending, where high values show places where people spend more than they make and low values show people living below their means. This visualization will be used in financial literacy classes for high school students.

3. Design a color scheme that shows accumulations of toxic waste in that county to be used in a presentation to policymakers on how to allocate cleanup funds.

4. Design a color sequence that allows you to easily distinguish every color in the random section of the map (the lower left)? If you have a ten-class map, you should be able to see clearly ten unique colors.

5. Within each large band of color on the map, there is one polygon filled with each map color (outliers). For example, if you have a seven-class map, there will be six outliers per band, demonstrating the appearance of all map colors with each as a surrounding color. Can you see each outlier clearly? Do all pairs of outliers in the band look different? If not, perhaps you should choose a different scheme or fewer classes.

Groups presented their schemes to the class and justified why they had made good choices.

3.4.4 Metric Display Exercise

Groups of four to five randomly assigned students collaborated to design a visual representation 4X4 grid of multivariate data observations, where each grid point contained values for high temperature (in degrees F), low temperature (in degrees F), sunniness (from 0 to 100 percent), and wind speed (in mph). While the sample data was 4X4, designs were supposed to be suitable to densities up to 100X100. The goals were to help viewers answer the questions:

1. How do highs and lows of temperature vary across the area?

2. Where would you recommend holding an outdoor activity that benefits from sunny skies, warm temperatures, and low winds?

3. Are sunniness and wind speed correlated (either positively or negatively)?

Each group collaborated to design their representation, document their design process and choices, prepare a figure explaining their design, prepare a sample display element with given variable values, and visualize the 4X4 grid of observations. Visualizations were produced using a large collection of art supplies to allow groups to create their designs and immediately mock them up.

After designs and visualizations were complete, groups were randomly assigned into a direct elimination bracket. Designs went head to head in pairwise competition, with the two groups each presenting the features and strengths of their design and the rest of the class voting on a winner. Winners advanced to the next round of competition. Eventually, a grand champion emerged.

3.4.5 User Study Exercise

In groups of about six, students collaborated to design a simple use study to determine which of two provided visualizations of the same data was better. For each visualization, groups received an explanation of the mappings used, an example image, and a test image. Each group answered the these questions about their design:

1. What are the different conditions for subject trials?
2. Which visualization(s) will you show to each subject?
3. How will you assign subjects to conditions or trial orders?
4. What questions will you ask subjects?
5. What data will you collect?
6. How do you intend to analyze the data collected?

Students then tried to pilot their user study using four test subjects from another group. This process tended to turn up aspects of user study procedure that groups had not anticipated.

4 RESULTS

Converting my standard lecture-based visualization class to this interactive format took way more time than I expected (less than starting a course from scratch, but way more than a standard refresh of an existing course). Particular time sinks were the creation of interactive quizzes, the crafting of in-class discussions, the design of in-class exercises, and participation in the Piazza reflections and discussions. I haven't taught the course in this format a second time, but I'm hoping that much of that effort can be recycled. Beyond the time required, each in-class exercise felt a bit like a tight-rope act without a net. I never quite knew what would go wrong. Mostly it was that the exercise took much longer than I expected it to take.

On interactive quiz and exercise days, the energy in the classroom was almost palpable. These classes were noisy, unruly, and fun. Student end-of-semester feedback was almost universally positive. A very few students would have preferred to have been passive participants in a more traditional lecture class.

I had fun. My students had fun. I'm looking forward to doing this again.

REFERENCES

[1] C. Brewer. Colorbrewer. `http://www.colorbrewer2.org`.

[2] Gapminder. Gapminder website. `http://www.gapminder.org`.

[3] L. K. Michaelsen, A. B. Knight, and L. D. Fink. *Team-based learning: A transformative use of small groups*. Greenwood publishing group, 2002.

[4] Piazza. Piazza website. `http://www.piazza.com`.

[5] P. Rheingans. CMSC 436/636 course website. `http://www.cs.umbc.edu/~rheingan/636/index.html`, 2013.

[6] C. Ware. *Information Visualization: Perception for Design*. Morgan Kaufmann Publishers, third edition, 2012.