

During the 2015/2016 academic year, a group of Berkeley faculty developed, piloted, and refined an introductory course in data science: *Foundations of Data Science*. This course emerged from conversations within the university’s Data Sciences Education Rapid Action Team as a first step toward a more holistic approach to data science education on campus. *Foundations of Data Science* was initially cross-listed between the computer science and statistics departments, and eventually became cross-listed by the School of Information as well. Key stakeholders in the assessment team included two members of the Data Sciences Education Rapid Action Team, administrative leadership of the computer science and statistics departments, instructors of the *Foundations of Data Science* course, a Data Science Fellow from the Berkeley Institute of Data Science (BIDS), a team of undergraduate researchers focused on the course’s “student experience,” and myself: the Graduate Student Assessment Fellow.

As the abundance of key stakeholders suggests, the *Foundations of Data Science* course was one part of a larger, long-term approach to data science education on campus. As the Graduate Student Assessment Fellow, I was singularly focused on the *Foundations of Data Science* course and its ability to fulfill its programmatic, educational, and institutional goals. My primary points of contact were: (1) a senior member of the Data Sciences Education Rapid Action Team who operated as a high-level manager of this and other data science initiatives, (2) a Data Science Fellow from BIDS who organized undergraduate researchers studying additional aspects of the *Foundations of Data Science* course, and (3) the primary course instructor for the Spring 2016 semester. I communicated with each of these stakeholders on a regular basis through e-mail as well as in-person meetings. Much of our face-to-face interaction occurred during the Fall 2015 semester as we determined the confines of our project and the methods of our analysis.

Because the *Foundations of Data Science* course was offered for the first time ever in the Fall 2015 semester, and because this introductory course was envisioned as the underpinning of a new approach to data science education on campus, our group of stakeholders was keenly interested in applying rigorous assessment methods to the course from the start. Not only did faculty want to ensure that students were effectively learning course material, they also wanted to learn the extent to which the *Foundations of Data Science* course would overlap with existing introductory courses in computer science and statistics. One motivation to develop this course was an observation that many Berkeley undergraduates have a desire to use data science tools in their disciplinary contexts, but may not be adequately prepared for or suited to existing introductory courses in computer science and statistics. Our stakeholders particularly wanted to assess whether an introduction to “data science” specifically would better serve these students who were unlikely to major in either computer science or statistics. Our stakeholders also wanted to know whether a “data science” approach to teaching data manipulation and statistics concepts could serve as an acceptable – or even preferred – method for introducing students to these skills compared to existing methods in computer science and statistics.

The intended audience for our assessment work was twofold. First, and most immediately, the instructors of *Foundations of Data Science* received close-to-real-time feedback about how their course was addressing different learning goals and how well students were mastering different aspects of the course material. Second, members of the Data Sciences Education Rapid Action Team received information that suggested how the *Foundations of*

Data Science course could best fit into a wider programmatic landscape. Our assessment findings will inform future iterations of this particular course (through improving course-level curricular and pedagogic choices) as well as the development of a larger, more comprehensive undergraduate data science curriculum.¹

During early conversations with our stakeholder group in the Fall 2015 semester, we developed several high-level guiding questions for our assessment work. The first was: “What do we *want* students to be learning in this [*Foundations of Data Science*] course?” The second was: “What are students *actually* learning in this course?” The third was: “How does this course and its content relate to other curricula on campus? What role(s) does it play?”

After several months of discussions, I developed a general idea of how different stakeholders approached these questions. With the first pilot of the course already underway in Fall 2015, I chose to focus on an assessment plan that could be designed before the end of 2015 that would be implemented throughout the Spring 2016 semester. Near the end of the Fall 2015 semester, I initiated an e-mail conversation with the soon-to-be primary instructor for the course.² I wrote a rough draft of several possible student learning objectives for the course based on my previous conversations with our key stakeholders. We then conducted an in-person meeting to edit, adjust, and finalize this list of student learning objectives. In the end, we settled on twelve distinct objectives that would guide my assessment work throughout the Spring 2016 semester. These objectives can be found as an appendix to this document.

During the Spring 2016 semester, I regularly assessed students’ learning in the *Foundations of Data Science* course using the “Statistics” tool on gradescope.³ This tool, currently still in beta, allows instructors to “tag” individual questions or parts of questions on assignments, projects, or exams with key words. In my case, I tagged questions with the various student learning objectives they addressed. Then, after each assignment, project, or exam was graded, I collected the resulting information about how students performed on different objectives. This process also allowed me to analyze which student learning objectives were included in each assignment, project, or exam. To be concrete: for each assignment I recorded the number of assigned points related to each of the twelve student learning objectives and students’ average performance on these objectives.

Throughout the semester, I relayed my findings to both the primary course instructor and a stakeholder from the Data Sciences Education Rapid Action Team. I highlighted areas of strength, such as the course’s ability to strengthen students coding abilities; as well as areas where further adjustment may be warranted, such as the course’s relatively weak focus on prediction. I reported my findings in table form, allowing for easy visual interpretation of patterns. An example of one such table is included as an appendix to this document.

My assessment findings will likely spark further conversation among the instructors of

¹The 4.0-credit *Foundations of Data Science* course was offered concurrently with several 2.0-credit “connector courses” designed to apply the skills developed in the *Foundations* course to disciplinary contexts. This was just one of several ideas suggested by the Data Sciences Education Rapid Action Team in a January 2015 report. Over several years, a much more robust data science education landscape has been envisioned.

²*Foundations of Data Science* is a team-taught course, but the primary instructors in the Fall and Spring semesters were different individuals.

³The *Foundations of Data Science* course utilized <https://gradescope.com/> to grade all assignments. This tool, founded by Berkeley alumni, allows for efficient and anonymous grading.

the *Foundations of Data Science* course, as well as among the rest of our stakeholder group. At the time of this report, the Spring 2016 semester is just coming to a close. As such, significant follow-up conversations about the future of this course and its role in the campus data science curriculum have yet to take place. However, I expect my findings will prompt a number of specific actions.

First, I expect instructors of the course to both revise its student learning objectives and adjust its curriculum to come into better alignment. For instance, since few if any questions throughout the semester addressed prediction accuracy, I expect that the learning objective focused on assessing prediction accuracy will be eliminated or rolled into a more generally conceived objective around making predictions. In another case, I expect the concept of formal hypothesis testing to be introduced earlier in future semesters.

Second, I expect members of the Data Sciences Education Rapid Action Team to use my findings as the basis for comparisons of *Foundations of Data Science* to other introductory courses on campus in computer science and statistics. This sort of activity will allow for an informed and impartial way to determine those cases when this new course satisfies similar requirements as another course, and those cases when it does not.

Third, I hope my work has demonstrated proof-of-concept of a low-effort way to effectively assess student learning throughout a semester. In future years, I hope graduate student instructors for the course will continue such assessment activities to ensure that course updates are having their intended effects on student learning.

This project offers several tips and strategies for instructors or program administrators interested in pursuing a similar project in the future. First, and most importantly, effective and early communication between stakeholders is critical. Second, the person/team engaged in the assessment work should be given the most extensive access to student work as is possible and reasonable. In my case, being able to operate directly within the course grading website allowed me to do my work without imposing on the instructors' time. It also allows for even more finely-tuned analyses at the student level. Third, digital grading platforms such as gradescope can be used to do the analytical "heavy lifting." In large classes such as *Foundations of Data Science* (ca. 400 students), an assessment project of this magnitude would be infeasible without a digital grading platform.

Appendix 1: Student Learning Objectives for *Foundations of Data Science*

Upon completion of CS/STAT/INFO C8, students should be able to:

1. Write correct small programs that manipulate and combine data sets and carry out iterative procedures.
2. Extend a program with multiple functions so that it runs correctly with additional functionality.
3. Calculate specified statistics of a given dataset.
4. Identify the sources of randomness in an experiment.
5. Formulate a null hypothesis that relates to a given question, which can be assessed using a statistical test.
6. Carry out statistical analyses including computing confidence intervals and performing hypothesis tests in a variety of data settings.
7. Given the result of a statistical analysis from the course, form correct conclusions about a question based on its meaning.
8. Given a question and an analysis, explain whether the analysis addresses the question and how the analysis could change and still address the question.
9. Articulate the benefits and limits of computing technology for analyzing data and answering questions.
10. Correctly generate and interpret histograms, bar charts, and box plots.
11. Correctly make predictions using regression and classification techniques.
12. Assess the accuracy and variability of a prediction.

Appendix 2: Sample Assessment Data (following page)

