Moving a Flipped Class Online To Teach Python to Biomedical Ph.D. Students during COVID-19 and Beyond

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INTRODUCTION

Quantitative skills are an essential element of modern biomedical graduate education. Classical, -omics, and “big data” approaches require that students appropriately and reproducibly manage, analyze, and share data (1). One challenge of teaching these skills is effectively combining basic computer science instruction and biologically relevant examples. Incorporating this instruction into existing curricula is even more challenging. A boot camp-style approach has been successful but requires nearly total dedication of faculty and student time over multiple days (2). Inserting quantitative training into existing core courses provides a brief exposure to programming languages and their typical uses in biology, but the time required to teach these skills competes with other course goals. Consultation by dedicated staff can successfully support students’ just-in-time data analysis needs but does not support long-term skill development and is not easily scaled.

Online courses provide a highly scalable alternative. Many teach the basics of coding for biology and, because they are free-standing and largely asynchronous, can be easily integrated into existing training programs. However, the value of large asynchronous online courses remains limited by low completion rates, a lack of direct access to instructors, and a one-size-fits-all approach to the content (3). To take advantage of the flexibility of free-standing asynchronous courses while addressing some of their potential

shortcomings, we adapted the HarvardX online course *Using Python for Research* into a flipped class by adding in-person small group problem-solving sessions facilitated by an instructor and teaching assistants. While successful, this in-person flipped model became impossible when COVID-19 forced all courses online in March 2020. Here, we report on our experience developing this flipped class and migrating it to a fully remote environment. We propose this as an easily deployable approach for teaching quantitative methods across a variety of institutions, programs, and learning environments.

PROCEDURE

Overview

HarvardX’s “Using Python for Research” is a self-paced, 5-week online course that combines video lectures and Jupyter Notebook-based (4) homework assignments to teach basic applications of Python to the organization and analysis of research data (5). We hypothesized that a “flipped course” structure (where students primarily use class time to solve sample problems and most lecture materials are viewed outside of class) would improve student motivation while supporting formative assessment and peer learning. To accomplish this, we added five 3-h in-person problem-solving sessions between the video modules. After a brief introduction of the day’s problems and an overview of any relevant new functions, students used this time to work on problem set questions in groups of approximately three, each turning in their own Jupyter notebook after class (Fig. 1). In addition, these meetings provided opportunities to connect course content to students’ research interests in formal and informal ways, which has been demonstrated to improve retention of skills-based instruction (6). All students demonstrated the competence in Python required to complete the assignments, and their self-assessed confidence in Python increased by an average of 1.7/5 points (Fig. 2, hybrid). Students also rated both the problem-solving

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FIG 1. Course workflow: what our students do before, during, and after class.

sessions and work with their classmates as favorably contributing to their learning (see Appendix S2 in the supplemental material).

Adapting to an all-online format

Following the shift to remote learning in March 2020, we attempted to replicate the benefits of the flipped model in an all-online format, with the group problem-solving sessions held via Zoom. We launched this new iteration of the course in May 2020 (Fig. 2, remote). The small in-class working groups were replaced by breakout rooms, while the teaching assistants (TAs) and Course Director remained in the main room

to be available for student questions. Groups used the built-in features of Zoom to request instructor help. An empty breakout room was available so individual students could get one-on-one assistance without disrupting the rest of their group.

Assignments

The problem set assignments from the HarvardX *Using Python for Research* course are very amenable to this flipped format. Each is written within a Jupyter Notebook, which interactively combines live code, text, and images. They are also formatted as a series of smaller problems that students solve to answer a bigger question. This incremental approach

FIG 2. Reported confidence with Python before and after the course with 1 = not confident at all and 5 = completely confident. We did not observe significant differences in confidence gains between the two sessions (Mann-Whitney $U = 119$, $n_1 = 15$, $n_2 = 18$, $P = 0.5478$ [two-tailed]). Student 11 from the hybrid session reported a score of 5 for both “before” and “after.” Student ID numbers correspond to students that completed the course evaluation (15/17 in the hybrid session and 18/20 in the remote session). G1-G2 students are in their first 2 years of a Ph.D. program and are still completing required coursework. G3+ students are primarily engaged in thesis research.

and the additional hints provided by the embedded text and pictures offered students more freedom to troubleshoot and work through problems in their groups before seeking help from the instructors. This encouraged independent- and peer-learning before instructor intervention. The day after each session, students submitted their own solved Jupyter Notebook, which allowed instructors to assess students' individual progress. Office hours were available for anyone requiring help outside of the problem-solving session (Fig. 1).

Creating groups

In the in-person iteration of the course, groups were created randomly at the beginning of each class and varied each week. This strategy maximized students' opportunities to work with new colleagues. When fully online, groups with the most varied levels of programming experience struggled initially, potentially because of barriers to instructor access and greater reliance on peer-learning. After the first week, students had the choice between joining a "fast" or a "steady" group, which allowed them to work together more effectively and for TAs to respond to groups' needs more efficiently. Students were free to switch between fast and steady groups at any point in the course.

Tailoring the course to student interests

The course content was tailored to student interest in two ways. First, live sessions used the case studies from the HarvardX course that were most relevant for our students. Other instructors might match different cases to their students' needs, or even create their own. Second, students completed pre- and postcourse reflection exercises. Before the course, participants identified a computational goal the course would help them achieve. On the last day of the course, students reflected on whether they had reached their original goals. If not, they worked with the primary instructor to design a strategy to achieve them after the course. Example responses are provided in Appendix S2 in the supplemental material (see Text S1). Unlike in a fully asynchronous course where informal interactions with the instructor are rare, students could informally ask instructors how course content related to their specific thesis research.

CONCLUSIONS

We found a flipped version of a previously existing online course was an effective and efficient way to insert quantitative training into our biomedical Ph.D. curriculum. The high-quality lecture videos and multistep problem sets contained within the HarvardX course *Using Python for Research* meant relatively little content development or instructional resources were required. When the COVID-19

crisis required us to adapt our flipped course to an all-remote environment, the model was robust to these changes. Student feedback showed increased confidence using Python in data analysis regardless of format (Fig. 2) and course completion remained at 100%. All students also agreed that the course would benefit their scientific and professional development (see Appendix S2). In the all-remote course, we recorded a slight increase in how helpful students rated their peers (see Appendix S2) and noticed that group dynamics became more important. It is possible that the lack of a physically present instructor made students more reliant on their groups for problem-solving support, which encouraged peer learning and made appropriate matching within groups more important. Adding remote problem-solving sessions into asynchronous online courses appears to be a scalable tool for skills-based graduate training.

SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

TEXT S1, DOCX file, 0.4 MB.

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