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What to Do When the Lab Closes? Managing an Interdisciplinary, Undergraduate Research Capstone Course During a Global Pandemic

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Introduction

The Agricultural and Medical Biotechnology (ABT) program at the University of Kentucky's College of Agriculture, Food and Environment is a genetics-based, research-intensive, interdisciplinary program that consistently produces undergraduate scholars prepared for careers in research, medicine, and other health-related industries. The program enrolls approximately 250 students and is administered around a liberal philosophy of interdisciplinarity, with undergraduates encouraged to build their own individualized curricula centered on foundational courses in biology, chemistry, and genetics. This student-centric approach, combined with an array of faculty research foci, results in a diverse student body engaging in scholarship that ranges from human neurobiology to plant rhizosphere metagenomics. A hallmark of the ABT program is a required capstone independent research experience, which is scaffolded after courses focused on identifying areas of research interests, formulating independent research projects, understanding the scientific method in practice, and conducting hypothesis-driven research and presenting it in technical writing and oral formats. Since this independent research experience is predominantly laboratory-based, campus closures and social distancing requirements that occurred during the eighth week of the 16-week spring semester disrupted the pace of investigation and threatened the scholarship and, in some cases, graduation of many students. Despite interruptions to the research and academic enterprise, the faculty and students utilized several approaches to salvage their research experiences. These examples may offer strategies for similar programs to utilize as academia adapts to the institutional changes initiated in response to the COVID-19 pandemic.

Program Description Prior to COVID-19

ABT 395/399: Independent Study in Biotechnology is the required capstone research experience course in the ABT program. Students enrolled in the

course have generally completed courses on how to write and present in the sciences, and they have identified a mentor for their independent research project. Often, students take this course after completing other research experiences through work-study programs, federal REU (Research Experiences for Undergraduate) programs, and volunteer internships. Because students undertake diverse projects from several different disciplines (e.g., medicine, dentistry, pharmacy, and agriculture), the course is decentralized, with 50% of assessment weight dependent on mentor feedback of the student's research performance and adherence to course guidelines and submission timelines. The four essential requirements are: 1) Verification of an ABT program-approved research proposal or learning contract; 2) Completion of the approved research activities under the supervision of a faculty mentor; 3) Submission of a 12-page written report, which follows the format of a scientific manuscript (i.e., abstract, introduction, methods, results, discussion) and contains revisions of content developed in previous scaffolded classes and; 4) Presentation of a 12-15 minute oral report. The oral presentation is the most important component of the course (other than conducting the research itself) and is presented during a 1-2 day public symposium comprised of student speakers. Community-wide participation by students, faculty, and laboratory members enables scientific discourse via robust discussions during the symposium. The faculty assess individual presentations based on a holistic rubric, which is used to inform course assessment scores and recognize the best overall presentation for a named award at the conclusion of the symposium.

Changes Made Due to COVID-19

The mid-semester timing of COVID-19 laboratory closures and other disruptions—including transitioning to online-only delivery of classes at the University of Kentucky—generated several unique challenges for students and their faculty mentors. The first (and simplest) change made was to move the oral presentation symposium online through Zoom (the preferred platform for the University of Kentucky), while retaining the original class schedule and assessment strategy. Several classwide and individual practice sessions were conducted to ensure student ease with use of technology and giving presentations remotely. The most important assessment faculty needed to make was whether students would be in a reasonable position to complete their written and oral presentation requirements by the semester's end. Because most student-led research effectively ended in the middle of the semester, students fell into four different groups based on the status of their planned research: 1) Completed research and data analysis; 2) Able to complete remaining research and/or data analysis remotely; 3) Almost complete research, but lacking final pieces of data; 4) Insufficient data to make a reasonable written/oral presentation.

Each group of students was advised differently in order to either complete their research remotely or finalize their incomplete projects for presentation in a scientifically sound manner. Students who were not in their last semester were given the option to defer presentations to subsequent semesters by receiving an incomplete grade. Twenty-eight percent of students chose this option.

Students who had completed their research or could finish remotely worked with their research mentors and course coordinator to prepare, review, and finalize reports remotely. In this regard, access to on-campus computational infrastructure and programs were critical for projects that involved bioinformatics or specialized data analyses. In one unique case, a student was able to continue and complete their wet-research project (behavioral analyses of a common insect utilizing straightforward techniques, inexpensive equipment, and biohazard-free materials) at home. Students who completed a majority of their research but lacked essential hypotheses-testing data were advised to present a theoretical discourse on what possible outcomes or types of data would have proven/disproven their initial hypotheses. Such reports started strong and were empirically grounded but concluded with what the data could have revealed if complete. Though unavoidably disappointing, one positive outcome of such cases is that several motivated students hope to complete their promising but unfinished research projects once laboratory access and research is restored.

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The biggest challenge was helping students that needed to complete the course in order to graduate but whose research projects could not be completed remotely. Such students fell in two categories. The first group consisted of students who had only conducted a small fraction of their projects and demonstrated an aptitude for their work by producing results but lacked the time and practice to be truly familiar with the nuances of their research. Faculty mentors and course coordinators worked with such students to bring their preliminary data to a reasonable conclusion. These students were primarily assessed on the demonstrated understanding of their overall research, thoroughness of their discussion, and critical analyses of different anticipated outcomes. Audience queries focused primarily on broader impacts of the research. The second group was students who had not meaningfully initiated their projects and lacked any data. Normally, these students would have received an "Incomplete" and would be required to complete course requirements in the summer session in order to graduate on time. Such students (a minor percentage of the class) were asked to develop and present a proposed project pertaining to their research mentor's field of research. Presentations were assessed for depth of literature review, scientific merit of the hypothesis, and thoroughness of experimental design.

Challenges Faced or Problem-solving Techniques Employed

Based on official university policies, which mandated programs exhibit the utmost flexibility and creativity to help students finish the semester, the most important challenge became balancing course policy liberalizations with maintaining as much scientific and methodological rigor as possible, to ensure that all students received a consistent and valuable experience. To this end,

any questionable situation was assessed in the student's favor. Many students experienced connectivity issues or had difficulties consistently engaging with their course work due to their rural location and/or complex living conditions. While these cases were frequently challenging during the remainder of the semester, all of the students were able to prioritize and complete their course requirements adequately, though it should be noted that a small minority of the students stopped responding to faculty intervention after the transition to distance learning. These situations persisted despite significant contact efforts from the university, college, and course-associated faculty. In these cases, students were awarded an Incomplete while attempts to reach them continue.

COVID-19 disrupted the pace of research for the mentors, as well, despite exceptions granted for agricultural and medically relevant projects that were deemed essential. Some mentors experienced impactful changes to their programs and had to judiciously manage their time while trying to maintain the productivity of their labs. Some mentors were unable to devote sufficient attention to their undergraduate mentees during the final stages of presentation development due to adjustments to teaching/research/extension activities. For these students, program faculty interceded and assisted in the mentor's stead.

Looking Ahead

If undergraduate students are allowed to reengage with research during the fall semester (which current statements from university administration indicate), then the Independent Study in Biotechnology course will ensure all participating students and their mentors have fallback plans based on the likely scenarios for a fall semester. Currently, the University of Kentucky has publicized three different potential schedules: Normal, hybrid (some combination of online and in-person), and fully online. Since the impact of the hybrid and online-only approaches on laboratory and experiential education classes is still unclear, the course faculty are encouraging all propsective students and mentors to identify projects with obvious and attainable endpoints or research that can be conducted or analyzed remotely. Examples include: bioinformatic analyses, imaging scans, chromatography scans, existing datasets from previous projects, and virtual experiences in wet-lab research through various platforms such as JoVE (https://www.jove.com/). Furthermore, the course assessment strategy will change to include more digital interaction (i.e., checking in) between students and program faculty to ensure that the pace of research is satisfactory and that institutional policies (which may change week to week) are not unduly impacting the research experience.

Conclusion

The required Independent Study in Biotechnology course is an important discerning element of the Agricultural and Medical Biotechnology program at the University of Kentucky. Because this course is critical to ensuring students are ready to enter the workforce upon graduation, the program will continue to provide training in different aspects of the research enterprise. As faculty operate under the reasonable assumption of inevitable COVID-19-related disruptions in the future, program leadership will

continue to explore additional novel avenues of providing enriching undergraduate research experiences. It is important for academic programs and individual enrichment courses to develop reasonable adaptive strategies that best achieve student learning objectives while maintaining the rigor of their offerings. ■