First-Year Seminars as a venue for Course-based Undergraduate Research Experiences: a preliminary report

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ABSTRACT

Hands-on research provides insight into the process of science and has been linked to increased retention of students in STEM disciplines. While large research universities can provide valuable undergraduate research experiences in laboratories, most cannot accommodate all of the students seeking research apprenticeships. Course-based undergraduate research experiences (CUREs) offer a scalable solution to this problem by facilitating faculty-mentored student research on novel problems through the structure of unit-bearing classes. Yet, implementation of CUREs de novo in large-enrollment introductory courses can be challenging at both institutional and individual instructional levels. We investigated whether First-Year Seminars (FYS), small credit-bearing classes targeted at freshman and transfer students, which are common in large universities, could provide a venue for CUREs. We found that in association with taking these courses, students reported attitudinal gains linked to STEM persistence and that the FYS-CURE participant body demographically represented the campus undergraduate population. Here, we describe the successful implementation of twenty-four CUREs spanning a diverse range of topics through the FYS program at a large research institution.

Keywords: Course-based Undergraduate Research Experience, CURE, First-Year Seminar, Freshman Seminar, Transfer Seminar, Biology Education Research, Undergraduate Research

Introduction

Participation in Undergraduate Research Experiences (UREs) is associated with increased persistence and improved academic performance of students in science, technology, engineering, and mathematics (STEM) disciplines (National Academies of Sciences, 2017). Additionally, UREs have been shown to promote students' sense of project ownership, self-efficacy and scientific identity (Seymour et al., 2004). These benefits arguably have the greatest impact on students from traditionally disadvantaged backgrounds, and URE participation has been linked to improved STEM retention in minority populations (Barlow & Villarejo, 2004; Gregerman et al., 1998). However, the typical one-on-one mentorship structure of traditional UREs limits the scalability of these opportunities.

Course-based UREs (CUREs) provide a larger number of students access to authentic research, as advocated by educational reform reports such as Vision and Change: A Call to Action (Brewer & Smith, 2011) and the President's Council of Advisors on Science and Technology (Holdren et al., 2010). Within the CURE course structure, elements of traditional UREs are incorporated for experiential authenticity. These features include: use of scientific practices, collaboration, iteration, discovery and broadly relevant work (Auchincloss et al., 2014), which not only reflect the nature of science, but also directly relate to improvements in metrics relating to these attributes (Bascom-Slack et al., 2012; Corwin et al., 2018; Hanauer et al., 2016). A growing body of evidence suggests that participation in CUREs provides benefits comparable to those of UREs (Brownell et al., 2015; Brownell & Kloser, 2015; Brownell et al., 2012; Rodenbusch et al., 2016). Additionally, CUREs benefit instructors – with the most frequently reported outcome being "CUREs facilitate the integration of research and teaching" (Shortlidge et al., 2016) – and institutions, by improving graduation rates and retention in STEM majors for students of all backgrounds (Rodenbusch et al., 2016). However, despite their many benefits, converting already established lab courses to CUREs remains challenging for institutions, requiring new equipment, curricular reorganization and significant time commitment from faculty.

First-year seminar (FYS) programs provide a course format that is an ideal venue for the development of CUREs because they freely allow faculty instructors to design courses according to their own interests, research and teaching philosophy. Studies show FYS programs are associated with increased student retention and improved academic outcomes (Jenkins-Guarnieri et al., 2015; Schnell & Doetkott, 2003; Tampke & Durodoye, 2013). Nationally, FYS are widely implemented; results from a 2008 national survey suggest that 84% of responding colleges and universities offered some kind of FYS program (Tobolowsky, 2008). At UCD, FYSs have a 19-student enrollment cap, consistent with national trends (Tobolowsky, 2008). Due to the national implementation and the non-issue of departmental buy-in, the paradigm of developing CUREs in a FYS program format is readily transferable to other institutions and has the potential for widespread scalability. Cross-disciplinary projects are also facilitated with its flexible design; thus, providing the benefits of traditional UREs and hands-on research to students across and outside of STEM disciplines.

In this study, we piloted a series of CUREs within the framework of a FYS program at a large research university. We evaluated the effects of the FYS-CURE format on students' researcher identity and self-efficacy in science, since previous research suggested that these metrics are associated with persistence in STEM fields (Hanauer et al., 2016; Robnett et al., 2015). We describe the rollout, successes and challenges of our pilot study and highlight details that may inform launching FYS-CUREs at similar institutions.

Methods

Summary of FYS program at UC Davis

First-Year Seminars at the University of California Davis (UCD) are not departmentally housed and are supported directly by the Office of the Chancellor and Provost, with a faculty director reporting to the Vice Provost and Dean of Undergraduate Education. The program is reviewed regularly by the Special Academic Program committee of the Academic Senate Undergraduate Council. UCD FYS have their own course codes, have been part of the curriculum since 1978, and are purely elective courses that can be letter or Pass/No-Pass graded for 1 or 2 units. Students are limited to one FYS per ten-week quarter, and students with first year status (including transfer students) are given priority registration.

FYS-CUREs structure and administration

FYS based CUREs (FYS-CUREs) were offered as 2-unit, letter-graded courses, meeting for two consecutive hours each week for 10 weeks. FYS-CUREs were co-taught by faculty as instructors of record, with graduate students or postdoctoral fellows, and staff as part of the instructional teams. Enrollment in FYS-CUREs was managed on a first come, first served basis, and seats were initially reserved for both freshmen and incoming transfer students. All lab notebooks were maintained as live documents on Google Drive and course materials were posted on the university online course management system. An end-of-term project was assigned, which aggregated, organized, and distributed the data collected in class to contribute to the collaborating PI's research mission. While the inter-course elements were minimally coordinated, all sections used the same Pre- Post-survey and included the same learning goals in their syllabi (Appendix 1). Between spring 2016 and spring 2018, 20 biology-related CUREs were piloted through the FYS program (Table 1).

Teaching structure and support

FYS-CUREs were supported centrally by the FYS program's academic coordinator responsible for experiential FYS, who has training in CURE pedagogy and instruction. The academic coordinator provided administrative and academic course support, including ensuring the availability of required space and laboratory equipment, ordering supplies, coordinating best practices across CUREs, and in some instances serving as a co-instructor. Faculty were offered individual training and guidance in the design and assessment of new CUREs. Instructors were encouraged to use student-centered teaching techniques such as backward course design and active learning strategies to further promote the success of FYS-CUREs (Cooper et al., 2017). Learning Assistants, students from a previous FYS-CURE and/or undergraduate researchers in the faculty instructor's laboratory, were provided internship units for their work as part of the instructional team.

Student assessments

During the 2016-17 and 2017-18 academic years, the FYS-CURE program offered 20 biology-related seminars; students in all but one of these classes were surveyed on the first and last days of the quarter. We used the previously described 2015 Robnett et al. instrument to measure Scientific Self-Efficacy and Identity as a Scientist, Factors 2 and 3 respectively. Factor 3 Identity items were modified by replacing the terms "science" and "scientist" with "research" and "researcher" (Robnett et al., 2015), resulting from a desire for a more representative survey to compare with future non-STEM CUREs. We matched student Pre- and Post- survey responses using unique identifiers developed by the students, omitting unmatched responses from the sample set, with 182

Table 1. Timeline and titles of FYS-CUREs offered between spring 2016 and spring of 2018.

	Fall	Winter	Spring	Summer
2015-16			(1) Hands on Experience with Big Data In Biology	
2016-17	(2) Investigating Antibiotic Resistance in Koala Poop*	(3) Hands-On Engineering of Genetic Systems*	(4) Birds, Bugs and Bioacoustics: Using Sounds To Evaluate Composition of Biological Communities* (5) Hands-On Engineering of Genetic Systems* (6) Making a Mutant – Build* (7) Investigating the Regulation of the Coq Super Complex* (8) Investigating a Schizophrenia-Linked Gene and Its Role in Neural Development*	(9) Making a Mutant – Test
2017-18	(10) Hands-On Engineering of Genetic Systems* (11) Making a Mutant – Test* (12, 13) The Nectar Microbiome - For the Birds and the Bees (2 sections) *	(14) Biotechnology at the Intersection of Plants, Chemistry and Biomanufacturing* (15) Hands-On Engineering of Genetic Systems* (16) Molecular Binding Interactions of Organic Molecules for Drug Discovery* (17) Part Of Your Microbial World - Isolate and Identify Bacteria Living Near You*	(18) Hands-On Engineering of Genetic Systems* (19) Molecular Binding Interactions of Organic Molecules for Drug Discovery* (20) The Nectar Microbiome - For the Birds and the Bees *	

* FYS-CUREs surveyed using the Robnett et al., 2015 instrument, as reported on in Student Assessment section.

paired responses for the final analysis. The differences in individual item responses and section averages Pre- and Post- were evaluated by the Wilcoxon sign rank test. P-value interpretation was adjusted by the Bonferroni correction and statistical significance was defined by p-value < 0.01. To obtain further insight into the student experience, we also analyzed student end-of-term reflections. While reflections were common among FYS-CUREs as part of course assignments, each instructor's format for these writings differed and reflection prompts were not consistent across courses. Thus, for the purpose of this initial report we focused our evaluation of reflections on one course. Combined demographic information about course participants was obtained from the university registrar and compared to the composition of the University's student body.

Results

<u>The road to FYS-CUREs</u>

The first two CUREs offered through the UCD FYS program had few infrastructure resources available and were taught in a dismantled teaching laboratory space. The success and popularity of these two initial offerings led to a partnership with a campus bio-makerspace, which doubles as a molecular biology teaching lab. Makerspaces are collaborative work environments that facilitate and support making, learning and exploring, through cost effective access to equipment and expert staffing (Barrett et al., 2015). The Molecular Prototyping and BioInnovation Laboratory (MPBIL) provided increased flexibility and resources for the offering of this course series (Yao et al., 2017), expanding the program to accommodate five FYS-CUREs in spring 2017. By spring 2017, 20 biology-focused FYS-CUREs had been offered at UC Davis. One of the goals of implementing CUREs through the FYS program was

Table 2. Summary of student demographic data: FYS-CUREs (spring 2016 – spring 2018) and spring 2017 campus student body.

	N	STEM %	Female (%)	Transfer (%)	URM (%)	Limited Income (%)	First-generation (%)
FYS-CUREs	288	90	69	23	19	36	39
Campus body	26,588	54	60	25	25	29	42

to allow for a diversity of research topics within and across quarters. The range of research projects can be seen in the courses listed in Table 1.

The 20 offerings were highly appealing, as students filled all of the seats in nearly all FYS-CUREs by the start of the quarter. A second goal was to make the research experiences accessible to a diverse range of students; the FYS-CURE student participant population closely matched the composition of the campus population at large with the exceptions of being female-gender and STEM-major biased (Table 2).

Attitudinal survey results

We analyzed matched Pre- Post- survey results in response to Researcher Identity and Scientific Self-Efficacy Likert-scale statements (Figure 1) from the 2016-17 and 2017-18 academic years.

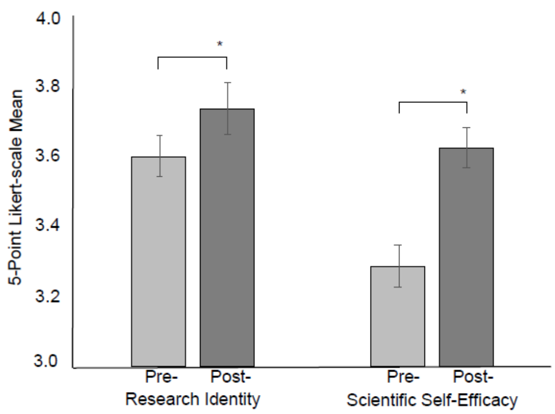

Fig 1. Students self-report gains in their self-identification as a researcher and scientific self-efficacy. Data collected during fall 2016, winter 2017 and spring 2017. N = 182, Wilcoxon signed rank test. Error bars represent SEM. *p-values < 0.01. Students reported on five point Likert scale, with 1 representing strong disagreement and 5 representing strong agreement. Y-axis only partially displayed.

We observed significant gains in self-reported researcher identify (6% increase, p-value < 0.01) and belief in their ability to do science (10% increase, p-value < 0.007) (Figure 1). Examination of the individual items in the Researcher Identity section showed that the biggest effects corresponded to the statement "I am a researcher". In the Scientific Self-Efficacy section, the student-reported gains were statistically significant in five of the six statements, with the largest changes corresponding to the statement regarding technical, field-specific skills acquired (Table 3).

Representative quotes from student feedback

We aggregated students' final reflective writing assignment from the spring 2017 Making-a-Mutant FYS-CURE (Table 4).

In summary, students reported a sense of belonging in science, instructor approachability, the importance of collaboration, and better understanding of the research process. Students reported enjoyment of the class, citing that it was personal, hands-on, and clarifying for career-related trajectories.

Co-instructional models of teaching

FYS-CURE students anecdotally benefited from the approachability of co-instructors, as well as the expertise and contact with faculty. Furthermore, graduate student co-instructors informally reported their own experiential gains through involvement in the development and teaching of FYS-CUREs. Thus, courses could provide a venue for graduate student training in inquiry-based pedagogical strategies and course design. A blog post published on the Eisen Lab website describes benefits and the primary feasibility hurdles from an instructor's perspective (Coil, 2016).

Student-generated research progress

UC Davis FYS-CUREs offered to date did not generate publishable research data, with the lone exception of a Genome Announcement publication generated by the first FYS CURE, made possible by a very time-consuming and ultimately unsustainable, back-stage instructor effort (Vater et al., 2016). Data from these FYS-CUREs has in several cases however, resulted in "research leads." For example, students accomplished the research goal of identifying microbial isolates from koala feces with a phenotype of interest relevant to the greater project (Dahlhausen et al., 2018).

Discussion

While the benefits of undergraduate research are well documented and CUREs offer curricular models that integrate these experiences into existing demonstration labs, implementing these changes de novo may be a complex and lengthy process. An

Table 3. Summary of survey items means Pre and Post course participation with comparative statistics (N = 182) for instruments (A) Research Identity and (B) Scientific Self-Efficacy. Survey response options consisted of five-point Likert-scales with (A) agreement statements and (B) confidence statements.

(A)

	In general, being a researcher is an important part of my self-image	Being a researcher is an important reflection of who I am	I feel like I belong in my field (i.e. science, arts)	I have a strong sense of belonging to the community of researchers	I am a researcher
Pre-	3.59	3.49	4.27	3.40	3.24
Post-	3.74	3.64	4.28	3.54	3.48
Percent Increase	4%	4%	0%	4%	8%
p-value	0.023	0.031	0.99	0.029	3.8E-04**

(B)

	Relate results and explanation s to the work of others	Generate a research question to answer	Use field-specific (i.e. scientific) literature to guide research	Create explanations for the results of a study	Develop theories (integrate results from multiple studies)	Use field-specific (i.e. Scientific) language and terminology	Use technical field-specific skills
Pre-	3.53	3.28	3.21	3.36	3.24	3.21	3.15
Post-	3.69	3.65	3.67	3.64	3.54	3.54	3.67
Percent Increase	4%	11%	14%	8%	9%	10%	17%
p-value	0.08	3.17E-06**	1.01E-7	4.36E-04**	9.15E-05**	1.48E-04**	8.13E-05**

** Bonferroni-corrected significant p-values, p-value < 0.01.

Table 4. Final student reflections from spring 2017 FYS-CURE: Making a Mutant (N = 16). Representative student quotes were pulled from reflections to the prompt: "... What's your take-away from this class? In five years, what do you hope you remember?"

Theme	Representative Quotes	
Networking	I found myself multiple times explaining to my friends in the dorms or in the Dining Commons what I was doing in this class	I think that this class has, first of all, taught me how meaningful it is to communicate with teachers
Clarification on Career	The biggest takeaway I had from this class was its impact on me deciding what kind of career I wanted to go after. Now after the fact, I can honestly say that I HATE lab work, and it is not something I want to be doing for the rest of my life, at least not that alone.	You took us to a lab (in the UC Davis Genome Center) and seeing that lab gave me goosebumps. I felt so emotional because I realized that was the environment I wanted to be in for the rest of my life.
Favorite class	This class was the most personal and hands on experience I've gotten in college so far	This class by far is my favorite class as of my freshmen year!
Nature of research	Research takes repetition and that mistakes happen and things don't always work the first time.	I got to learn a lot about how scientists do science in the real world rather than just memorizing concepts about math and chemistry
Feeling comfortable asking for help	It was my first time being part of an actual research with a group of students who were around my year. It was refreshing to know that I could ask them for help	The first day of the class I was honestly really scared that I was the only one in the course who didn't understand/felt overwhelmed by the ideas/biological concepts we were discussing. Yet, I took it day by day, asked many questions, and things started to make sense
Sense of belonging in science	It made me feel like I had contributed to the process.	I do feel a stronger sense of belonging within the scientific research field

alternative to a complete overhaul of existing demonstration labs is the implementation of CUREs through the First-Year or Freshman Seminar format, allowing institutions to pilot and test these new types of courses while enhancing student learning.

Student self-reported attitudinal gains and reflections

Gains in Researcher Identity and Scientific Self-Efficacy survey item responses have been proposed as indicators for persistence in STEM as evaluated through the SEA-Phage program (Hanauer et al., 2016). In our study, we observed gains in these attributes upon course completion, which suggests that participation in FYS-CUREs could translate to increases in propensity for STEM persistence. Longitudinal studies following students who participated in FYS-CUREs will be needed to confirm this possibility. The first-year seminar format allowed for a series of independent and wide-ranging variety of courses. Thus, we argue that this FYS-CURE format and not necessarily their specific content, contributed to student attitudinal gains, as we observed aggregate attitudinal gains across the courses.

Hurdles to broader implementation

Despite the documented benefits of CUREs, there are remaining challenges in implementing CUREs on a larger scale within the FYS context. Although a systematic study was not conducted, the three major obstacles that we noted anecdotally were: (1) limited faculty incentives to teach FYS generally, (2) limited research progress during the course, and (3) the essential need for a dedicated program coordinator. A fundamental challenge for the sustainment of FYS-CUREs are the limited faculty incentives to teach them. Since these courses do not typically count toward the required teaching loads set by UC Davis departments, faculty may be unable to justify allocating the time that these courses require. In addition, junior faculty may be very hesitant to take on teaching that doesn't "count" towards tenure. However, some departments have explored a model where "X" number of FYS count toward one course equivalent in the instructor's normal teaching load. While the UC Davis FYS program contributes a $3,000 academic enrichment fund to incentivize faculty teaching the courses, the sum can be insufficient to cover the large expenses incurred by research programs in certain disciplines (i.e. graduate student support, new equipment, expensive reagents). This amount of discretionary money is highly valued by faculty of the humanities and social science disciplines, whose research programs are not contingent on large grants. This highlights an opportunity to target FYS-CURE recruitment efforts to faculty from these disciplines. It should be noted that within the biology discipline, FYS-CUREs taking advantage of the varied environs around the Davis campus and the traditional institutional strengths in animal behavior and field research in this study provided examples of successful, lower-overhead FYS-CURE opportunities. Another issue, which is linked to faculty buy-in, is that these FYS-CUREs very rarely produced publishable research data to date. The program is still in its early days, so we don't yet know how many publications might eventually result from research leads seeded in the FYS-CURE model, or if grants will be awarded that benefitted from preliminary data generated (at least in part) in FYS-CUREs. Lastly, the design, implementation, and coordination of these new and ever-evolving classes – especially when several are run concurrently – requires dedicated central administrative assistance from someone other than the instructors, which necessitates monetary support as well as the identification of qualified and knowledgeable personnel. These challenges have limited the number of FYS-CUREs that our institution can offer to approximately five per term or about fifteen per academic year at present, as we continue to work with faculty and campus administration to creatively expand this unique CURE venue.

Conclusion

Despite their limitations, through these courses, our institution was able to provide authentic research experiences to over 280 students who otherwise would have not engaged in research. These students by and large also represented the rich diversity of the undergraduate student body at UC Davis. Thus, even at this relatively small scale, the implementation of CUREs in the First Year Seminar Program has contributed to UC Davis's goal of providing all interested students with research opportunities. Furthermore, the initial results from implementing FYS-CUREs can be used by institutions to seek additional funding and motivate significant curricular re-designs. However, in its current format, the UC Davis FYS program arguably best serves as an incubator; novelty, exploration, and nimbleness are its intrinsic values. The program is frequently and successfully used to pilot new courses, which are then adopted by a department with the means to scale the course to reach a significant number of students. The highly popular UC Davis course: The Design of Coffee, which enrolls over 1500 students annually, was born from a small Honors Program seminar, the UC Davis FYS sister program. It is conceivable that this might be the ideal outcome of the FYS-CURE project, freeing the FYS program to continue to incubate new, fledgling CUREs and optimize them for implementation at scale by campus departments.

Further research

Future studies will investigate the relationships between student participation in the UC Davis FYS-CUREs and time to graduation and retention in STEM disciplines. In these studies, it will be important to employ methods that control for attributes associated with student academic performance. Additionally, it is of interest to compare outcomes between more intensive (i.e. year-long) CUREs and the quarter-long, 20-hour, FYS-CURE experiences described here. More colloquially, we seek to ask, "is this enough?" Do FYS-CUREs have a causal, measurable impact on student success? And can FYS-CUREs function as a gateway to more intensive, longer term, traditional research experiences? While our preliminary findings show positive associations between participation in FYS-CUREs and known indicators of student persistence in STEM, further research is needed to assess the long-term impact of these "bite-sized" research experiences.

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Appendix 1. FYS-CURE Preliminary Development Guide

This resource is distributed to faculty who are interested in teaching an FYS-CURE and frames initial FYS-CURE course development consultation meetings. It employs a goal-oriented, backward design format and is written with an informal, user-friendly tone.

Background: The FYS-CURE initiative

The First-Year Seminar program is hosting a new series of Course-based Undergraduate Research Experiences (CUREs). CUREs provide a scalable means to increase the reach of traditional, faculty-mentored undergraduate research experiences. CUREs recruit a class of students to address an issue that is of real interest to the scientific or academic community. Students are encouraged to register for these classes upon arriving at UC Davis. CUREs must include the five critical elements that distinguish them from inquiry based or traditional lab courses: **(1) use of scientific practices, (2) discovery, (3) broadly relevant work, (4) collaboration, (5) iteration**. CURE syllabi will be assessed by a committee of peers to verify all essential criteria are met.

Research goal and course project mission

Each CUREs research goals will be specific to the instructor. Consider these points to identify appropriate research projects and outcomes

- What data do you want to collect and/or analyze?
- How is this data broadly relevant to the scientific community?
- Think about research goals in terms of milestones, not finite ends. What milestone might you be able to achieve in a 10 week quarter?
- How would the milestones you achieve in this(these) class(es) be aggregated towards your overarching research goal? To aggregate, would you need more of the same data in future classes or would you need a series of classes to conduct downstream experiments?

FYS-CURE universal student learning goals

The FYS-CURE program has established the following learning goals but you are encouraged to think critically about this set and you may identify other outcomes of interest.

- Students will actively/hands-on participate in research **project that is broadly relevant** and/or important to the scientific and/or academic community.
- Students will practice c**ollaboration, iteration, creativity, and failure,** through the tasks/assignments associated with the course
- Students will report gains in their understanding of the **process of research**
- Students will be exposed to **field-specific practices**/techniques TBD by course content
- Students will **believe** more strongly in their **capability to do research**
- Students will more strongly **identify as a researcher**

Key CURE elements

Explain how you will meet the five criteria that set CUREs apart from other classes

Element	Description
Scientific Practices	This one is typically readily represented in the lab activities, protocols and workflows
Discovery	This is different from inquiry-based teaching where the instructor knows the “answer”. In discovery, results are not pre-determined.
Broadly relevant	This is addressed in your research question and its importance to the scientific community.
Collaboration	Consider activities that ask students to use each other and others in the field as resources.
Iteration	While challenging to build this into a 20 hour course, this is critical for students authentic research experience

Scheduling

You have 20 hours with your students in class/lab.

Plan your schedule with your research goals in mind. Consider your 10 week schedule, and start at the end (week 10), with your final milestone and work backwards, filling in the weeks with research activities. You should consider your protocols and what can be accomplished in 2 hour blocks. For wet-lab classes, consider when you can put your samples on hold (i.e. in the freezer), these become natural end points. Be sure to build in **at least one week of wiggle room** and/or sessions to repeat “failed” experiments. Remember opportunities for Iteration is a key component of these courses.

Example of ten-week FYS-CURE class schedule with assignments (Koala Microbiome, fall 2016)

Week	Lab Activity	Assignments
1	Plate koala feces on agar media	Pre-class survey, research system and course overview
2	Pipetting 101, dilution streaking	Pre-Lab: System intro activity with Google Scholar search
3	DNA extractions	Pre-Lab: Video on Qiagen DNA extraction kit
4	PCR set-up	Pre-Lab: PCR video with emphasis on +/- Controls
5	Gel electrophoresis, PCR clean-up, PCR product quantification	Literature review (term project) assigned
6	Generate consensus 16S rRNA sequences and BLAST	Pre-Lab: BLAST video and SeqTrace program download
7	Generate phylogenetic trees to identify taxa	Lecture on phylogenetic trees, library research instruction
8	Setup antibiotic susceptibility tests	Literature review outlines
9	Measure antibiotic susceptibility	Pre-Lab: antibiotic mechanisms, Literature review draft 1
10	Wiggle room	Exit-survey, literature review final draft, post-class reflection

**depending on the day and time that you run your class you may only have 9 weeks, you’ll have to check this in terms of planning purposes*

**While it may be nerve wracking to not have a plan for one or two of the weeks, be assured you can find something to do to fill the session! We encourage conversations about how to get undergraduate research experience, what graduate school in the sciences is like, you can work on a side project, or do mundane lab work like make media/buffers/reagents for future classes - this is all part of the research experience. These activities are fair game and encouraged to include this in the course.*

Assignments

What **term project** or major assignment(s) would you like the students to complete by the end of the quarter? What skills do you want them to develop? What information would be helpful for you to assess the course and if your student learning goals were met? Recommended assignments might include: **Presentation** on results, **literature review**, **protocol** draft/revision/additions.

What **regular assignments** will you have the students do? And why (what goals are they addressing)? It is highly recommended that students keep a Lab Notebook, reporting on background, methods, results, and discussion, and which also includes a reflection section. We also recommend that students do weekly Pre-class Activities - to prep them for the concepts covered in class.