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Introduction

What is the purpose of this guide?

This guide is meant to demonstrate how iBiology’s online course “Planning Your Scientific Journey” (PYSJ) can be used in multiple settings to assist you when teaching multiple research skills such as developing a scientific question, planning, executing a research plan and getting feedback from a mentor on research plans. Here we will give you examples of how to use the whole course, as well as pieces of the course and materials associated with this course, to effectively convey important concepts and strategies involved in navigating advanced science training. We also provide a comprehensive list of course components and resources for your convenience.

Here are some examples of how the course can be useful in training your students or mentees:

1. To give inexperienced trainees or future trainees an idea of what doing research looks like in the real world.
2. To help trainees develop and refine an impactful and feasible scientific question they can pursue during their training.
3. To help trainees develop a plan to execute their experiments and accomplish their scientific and professional goals.
4. To help trainees communicate and work effectively with their mentor about their research projects.

Who is this guide for?

This guide is intended for educators and mentors who teach or train undergraduate, graduate students and postdocs in life science research. Examples include:

- Scientific mentors at all levels, from principal investigators supervising research trainees in the lab, to postdocs or graduate students training mentees on how to navigate their advanced science training experience.
- Faculty and administrators who are planning curricula around developing a scientific question, research planning and mentor relations for their training programs.
- Faculty and administrators who are looking for content to supplement their professional development training program.
- Faculty and administrators who teach introductory research classes at either the undergraduate or graduate level.
Our Course

Course Description:

"Planning Your Scientific Journey" (PYSJ) is a free 6-week online course designed to help guide participants through navigating their advanced science training. The course was designed so that individual course students (undergraduates, graduate students, and/or postdocs) could take the course on their own, without it necessarily being part of official training at their institutions. However, integrating the course into training (either in part or whole) will allow for expanded peer learning and mentoring.

In the online course, instruction is led by a diverse group of leading scientists, such as Nobel Laureates, accomplished faculty, and junior scientists, who think about different aspects of scientific training in deep and meaningful ways. Engaging videos, along with reflective exercises, offer concrete tools and practical advice to help participants navigate the most challenging aspects of developing and planning a research project as well as working effectively and efficiently within their research environment.

**Syllabus:** The course syllabus can be found [here](#).

**Format:** The course is composed of videos, text, relevant journal articles, forum discussion questions, and open response assessments. The majority of the instructional materials are contained within the videos and text.

As participants go through the modules, they are prompted to apply what they are learning to their own research through a series of self-reflective exercises. The goal of these exercises is to probe their thinking as they design a research project. Their responses from these exercises are accessible through a printable document titled “My Research Plan.”

This course is self-paced so participants can register and access all course materials at their leisure. We estimate participants will spend 1 to 3 hours on the course per week. This includes time spent watching videos, reading text, doing assessments, and engaging in the forum.

**Grading Policy (for self-paced course hosted on edX):** This is a pass/fail course, and participants’ grades are based solely on the completion of the open response assessments. They will receive an iBiology Courses Certificate if they complete at least 50% of the assessments. Assessment fields are defined as any text input box that appears under the “Assessment” heading within the course. Each required assessment is numbered (e.g., “Q1,” “Q2,”) to help them keep track as they take the course. Each assessment field has equal weight so there will be no difference in the penalty for assessment fields they leave incomplete. That being said, we highly recommend that they endeavor to complete as many assessment fields as possible in order to get the most out of the course.
Course Goals:

Here is a high-level description of what participants learn in this course:

- How to pick and refine a scientific question that will be of interest to the participant, impactful to the scientific community and feasible within their individual timeline.
- How to effectively set accomplishable short and long term goals within their research project.
- How to use those goals to create a detailed and comprehensive plan for answering their scientific question and accomplishing their goals.
- How to effectively seek feedback on their research project and the plan they have created from their colleagues and mentors.

Participant Takeaways:

Here is what participants will take away from this course:

- A concrete three-step process for picking a scientific question.
- A framework for evaluating their chosen scientific question.
- A list of tips and strategies for seeking feedback on their scientific question and research plan as well as maintaining a growth mindset throughout this process.
- A detailed plan for their research that they can discuss with a mentor (their “My Research Plan”).
- An agenda for a meeting with a mentor to discuss their Research Plan.

At the end of this course, participants will have a comprehensive understanding of how to think more effectively through the steps they should take to establish a scientific question, plan experiments that will help answer that question and seek feedback on their question and plan.

Learning Objectives:

Module 1: Develop a Framework

Lesson 1: Find Your Niche

At the end of this lesson, you will be able to...

- Understand that diversity is how good science gets done, and that your unique background, skill set, and way of thinking -- your individuality -- bring value to the scientific enterprise.
- Recognize the importance in choosing scientific projects that are interesting, motivating, and appropriately challenging for yourself.
- Articulate/list your scientific interests and skill set, so that you can use this to guide the development of your research question and experimental approaches.

Lesson 2: A Process to Develop a Research Project

At the end of this lesson, you will be able to...
• Articulate your process for developing a research project, and if you don’t have a process, develop one based on what you learn from the course and the course community.
• Identify and compile a list of resources, including publications and people to talk to, that will help refine your ideas in developing a scientific question and/or identify a set of experiments to address a particular question.

Module 2: Identify a Scientific Question

Lesson 3: Criterion to Evaluate Your Scientific Question, Part 1

At the end of this lesson, you will be able to...
• Explain why learning to ask a good scientific question is a key outcome of your training and an important transferable skill for your next career stage.
• Articulate the features of “good” scientific questions, so you can develop an interesting and implementable project.
• Describe a scientific question(s) that you will evaluate in lessons 3 & 4 so that by the end of lesson 4, you will have an analysis of the merits and pitfalls of a research project.
• Explain the potential impact in answering your scientific question.
• Understand the definition of a hypothesis and its role in answering a scientific question.
• Define a hypothesis for your scientific question, if applicable, so you can use it to guide your ideas for an experimental approach.

Module 3: Evaluate Your Experimental Approach

Lesson 4: Criterion to Evaluate Your Scientific Question, Part 2

At the end of this lesson, you will be able to...
• Define an experimental approach to your scientific question.
• Determine the feasibility of your experimental approach based on a variety of factors, including your skill set and available local resources.
• Describe how your research interests align with your scientific question and experimental approach.
• Identify the strengths and possible shortcomings of your project in order to weigh the decision of committing to it or taking a new direction.

Module 4: Plan Your Research

Lesson 5: Direct Your Scientific Journey With a Plan

At the end of this lesson, you will be able to...
• Summarize why making a plan has been shown to increase the likelihood of personal success.
• Recognize that planning is a skill that can be developed over time.
• Define what an Individual Development Plan (IDP) is, and why it is a useful tool for making progress as a scientist.
• Understand why self-assessment and reflection are critical to building a useful plan for yourself.
• Formulate short-term goals for your research project, so that you have a vision of what to do in the next 3 months.
• Formulate long-term goals for your research project, so that you have identified what you wish to accomplish over this coming year.
• Identify the skills (scientific/technical, professional) you want to develop based on your project, training requirements, and personal goals over the next year.

Module 5: Bring Your Plan to Life

Lesson 6: Bring Your Plan to Life

At the end of this lesson, you will be able to...

• Explain the concept of SMART (specific, measurable, action-oriented, realistic, and time-bound) goals so that your plan will be implementable and achievable.
• Create SMART goals for your research project and for the skills you would like to develop this year.
• Explain the framework for developing a skill (learn, practice, and feedback) so that you can attain greater mastery of your desired skills.
• Describe how you will keep yourself accountable so that you can achieve your goals.
• Understand the importance of getting feedback to improve your plan.
• Understand why a plan needs to be evaluated and modified on a regular basis in order to accommodate changing circumstances, evolving interests, etc.

Module 6: Develop a Growth Mindset and Seek Feedback

Lesson 7: Anticipate Success, Embrace Failure

At the end of this lesson, you will be able to...

• Set realistic expectations for your scientific journey, keeping in mind that science is a non-linear process and can move in fits and starts.
• Reframe the concept of “failure,” understanding that failure in science is not intrinsically bad, but rather it is often a part of the process of tackling interesting and challenging problems.
• Recognize that a flexible scientific mindset is necessary in order to be able to adapt to the inevitable conceptual and experimental setbacks.
• Develop a cognitive framework in which setbacks are identified as learning experiences and can lead to new and unexpected discoveries (i.e., “growth mindset”).
• Express the importance of talking with peers and mentors as a way to get support and build resilience.
• Identify individuals who might be able to help you overcome technical or conceptual barriers.

Lesson 8: Prepare for a Meeting With Your Mentor

At the end of this lesson, you will be able to...

• Prepare for the meeting with your mentor by drafting an agenda, reviewing your “My Research Plan,” and preparing any documents that you would like to share with your mentor related to your plan.
• Understand a few strategies on how to have a productive meeting with your mentor.
• Show a mentor your “My Research Plan,” a compilation of assessments from the entire course.
• (If you haven’t already) schedule a meeting with your mentor to discuss your “My Research Plan” so that your mentor will become familiar with your plan and give feedback.
Course Outcomes:

When we first released the Planning your Scientific Journey online course in 2017, we did so in a hosted format where there was a start/end date, and content was released weekly for a six-week period. During this hosted run, we were able to gather information regarding how well we were able to satisfy our course goals.

We had three main questions relating to our course goals as a team. First, would participants find the “My Research Plan” they built during the course a useful tool going forward in their research and would they actually refer back to and use that plan after the course concluded? Second, would the participants seek feedback on their plan from their colleagues and mentors specifically? Finally, did participants find the course as a whole useful for planning/navigating their scientific journey or training?

Participants found the “My Research Plan” tool helpful and continued to use the tools they developed in the course after the course was complete.

To address the first question, in our post-course survey, we asked “How helpful were the following course components to your learning?” and when asked to rate the “My Research Plan” tool participants responded:

<table>
<thead>
<tr>
<th>Not Helpful</th>
<th>Slightly Helpful</th>
<th>Moderately Helpful</th>
<th>Very Helpful</th>
<th>Extremely Helpful</th>
<th>NA</th>
<th>Total # of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;My Research Plan&quot;</td>
<td>0.72%</td>
<td>3.60%</td>
<td>17.99%</td>
<td>36.69%</td>
<td>33.81%</td>
<td>7.19%</td>
</tr>
</tbody>
</table>

These data demonstrate that out of 139 total responses, 88.49% of respondents found the tool at least moderately helpful with only 1 respondent who did not find the tool helpful.

In addition to our post-course, we sent a “follow-up survey” two months after the course completed to evaluate if they had used any of the skills or tools they developed during the course. In that survey, we asked: “Have you implemented any aspect of the research plan you created during the course?” Participants responded:

<table>
<thead>
<tr>
<th>Answer</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>59.78%</td>
</tr>
<tr>
<td>No</td>
<td>3.26%</td>
</tr>
<tr>
<td>No, but I plan to</td>
<td>28.26%</td>
</tr>
<tr>
<td>N/A</td>
<td>8.70%</td>
</tr>
</tbody>
</table>
These data demonstrate that nearly 60% of respondents had implemented some portion of the plan that they created during the course and nearly 30% had not but planned to, with under 4% responding that they hadn’t and did not necessarily plan to.

Taken together this demonstrates that on the whole the “My Research Plan” tool was useful to participants during as well as after the course.

**Significantly more than half of our participants either have or plan to meet with their mentor about the plan they created during the course.**

To address the second question, in our post-course survey we asked: “Have you scheduled a meeting with your mentor to discuss your Research Plan?” Participants responded:

<table>
<thead>
<tr>
<th>Answer</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>52.17%</td>
</tr>
<tr>
<td>No</td>
<td>34.06%</td>
</tr>
<tr>
<td>N/A</td>
<td>13.77%</td>
</tr>
</tbody>
</table>

These data demonstrate that over half of the participants had scheduled a meeting with their mentors to discuss the plan they created during the course.

In our follow-up survey, we wanted to determine how many of the respondents had actually had met with their mentors during the two months since they finished the course so we asked: “Have you met with your mentor to discuss your My Research Plan or related topics in the course?”. Participants responded:

<table>
<thead>
<tr>
<th>Answer</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>48.78%</td>
</tr>
<tr>
<td>No</td>
<td>14.63%</td>
</tr>
<tr>
<td>No, but I plan to</td>
<td>28.05%</td>
</tr>
<tr>
<td>N/A</td>
<td>8.54%</td>
</tr>
</tbody>
</table>
This demonstrates that almost half of respondents actually did meet with their mentors to discuss their research plan they created during the course, more than a quarter of respondents stated they had not but they plan to and only slightly under 15% of respondents stated that they had not with no explicit plan to do so.

These data taken together suggest that a significant portion of those who responded to our surveys either plan to or have met with their mentors to discuss the plan that they created during the course.

The vast majority of participants were satisfied with the course as a whole and would recommend it to a friend or colleague.

Finally, we wanted to determine how useful the course as a whole was to participants in planning/navigating their scientific journey. To this end we asked participants “How would you rate your overall satisfaction with the course” and participants responded:

<table>
<thead>
<tr>
<th>Answer</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very satisfied</td>
<td>53.85%</td>
</tr>
<tr>
<td>Satisfied</td>
<td>38.46%</td>
</tr>
<tr>
<td>Neutral (neither satisfied nor dissatisfied)</td>
<td>6.29%</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>1.40%</td>
</tr>
<tr>
<td>Very dissatisfied</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total # of Responses</td>
<td>134</td>
</tr>
</tbody>
</table>

These data demonstrate that 92.3% of all learners were at least satisfied with the course and over half of our participants were “very satisfied” as well as nobody responding as “very dissatisfied”.

In addition, we asked “How likely would it be that you would recommend this course to a friend or colleague?” and calculated a Net Promoter Score from their responses. Our course received an NPS of +51 placing us in the “excellent” range (according to Questionpro.com). We had:

- 57% of participants scored as promoters (they would recommend the course to another)
37% of participants scored as passive
6% of participants scored as detractors (they would not recommend the course to another)

If you would like more information regarding our course outcomes, please feel free to contact us at courses@ibiology.com.

Where to Find Course Materials

The online version of this Educator Guide for PYSJ can be found at https://courses.ibiology.org/educator_resources/PYSJ. This site provides access to all videos, video transcripts, infographics, assessments, discussion prompts, and templates used in the course. The videos can be downloaded in high and low resolution, with and without closed captioning. For convenience, we have also included this table of resources at the end of this document.

The self-paced version of the course can be found here on iBiology Course’s platform: https://courses.ibiology.org/courses/course-v1:iBiology+iBio1+2018/about. We encourage all educators to log in and view the content of the course within the context of the online platform.

We have also created a YouTube playlist with all of the course videos, which can be found here: https://www.youtube.com/playlist?list=PL5zi65Byv2hiQMMRS9PCR2v8w5ZIkcc4o

Model Examples

In this section, we provide a small set of examples for how to use our course materials, either whole or in part, to teach advanced research skills and planning. We anticipate that there are many ways to use the course materials which are not covered here. And, we plan to expand this list as we develop more models or are given models from colleagues. (We love to hear how our work is being used and will consider including any models of those who are willing to share with us and the public.)

However you might use the content in person, we suggest using techniques that increase the interaction of students. Although the stand-alone course is a great resource for training needs, evidence exists (Garrison, D.R. & Kanuka, H. The Internet and Higher Education 7, 95-105 (2004), Means, B., Toyama, Y., Murphy, R. & Baki, M. Teachers College Record. 115, 1-47 (2013)) that deeper learning occurs when online courses such as this one are paired with in-person discussions between peers and facilitators. The following are some evidence-based active learning techniques that you can use during your in-person sessions. In these techniques, we provide some ideas of questions that can be asked of the participants, but we also recommend using the assessment and discussion questions from the course (see table of links and downloads).
1. **Short writing sessions such as the “Minute Paper”:** During the discussion, ask participants to take out a blank sheet of paper and a pen. Then, state a topic or concept you would like them to think more deeply about or give context to. For example, “We have been discussing planning so far this week. List all the times that you have or haven’t planned well in your research or have seen planning succeed or fail in the research being conducted around you. You’ve got two minutes to make your list.”

2. **Whole-Group Discussion:** Develop a list of questions that you would like participants to discuss as a whole group. These questions should be designed to stimulate conversation between participants or just get participants talking about the topics presented that week in the course. For example “What struck you as something new or exciting that you learned this week? Or “A template for making goals was presented in the course this week. What similarities or differences did this template have to your current goal setting strategy?”

3. **Think-Pair-Share:** Present a question or concept that was discussed in the course that week and have participants reflect on it silently for a minute or two (they can write things down to organize their thoughts). Then have them pair up and compare their thoughts and synthesize a joint consensus on the question or concept.

4. **Peer Review:** Pick an assessment or two that participants worked on in the course that week and ask them to print it out and bring it to the discussion section. Then ask participants to pair up and exchange their printed assessments with their partner. Next, each student gives critical feedback, corrects mistakes in content and provides any other feedback that they feel might be useful for their partner’s assessment for 5-10 min. Finally, they give their partner’s assessment back to them, and each of them talks through the feedback they provided.

5. **Brainstorming:** Introduce a topic or problem discussed in the module you are discussing and ask for student input. Give participants a minute to write down their ideas. Then, ask for volunteers to present their ideas and record them on a chalkboard, whiteboard or digital screen to talk through each idea presented with the whole group.

6. **Case Studies:** Use real-life stories from your lab or a colleague’s lab (or the case studies from the course) to illustrate a certain concept, topic or question in the module you are discussing. Then ask participants to break into small groups and discuss how the story/stories you presented exemplify or differ from the concept, topic or question you are focusing on.

7. **Jigsaw Discussion:** You can take a general topic and divide it into smaller, interrelated pieces like a jigsaw puzzle. Then break the discussion section into groups in which each member of the group is assigned to read and become an expert on a different sub-topic. After each member has become an expert on their piece of the puzzle, they teach the other team members about that piece. For example, if the topic you are discussing is "SMART goal setting" and you have 5 people in the group, one person would take on "specificity," one would take on “measurable,” one would take on "action-oriented," another would take on "realistic," and the last one would take on "time-bound." Each would learn as much as they can about their assigned sub-topic in the time allotted and then they would come back together and teach the others in the group about what they learned about their element of a SMART goal.

8. **Clarification Pauses:** If giving a recap of what was covered in the module you are discussing this week, make sure to take small breaks in your recap to allow participants to think about what is being presented or remember when/how this topic was covered in the course. This is especially important when defining a key concept, presenting information that you believe will be central to this week’s
discussion or once you have stated an activity that you are planning to do during this week's session. Once you have paused, ask if anyone needs clarification.

For more information on how to design your teaching and how to incorporate the best evidence-based practices, we recommend the Vanderbilt University Center for Teaching and their extensive list of Teaching Guides. We also recommend reviewing these online courses offered by the Center for the Integration of Research, Teaching and Learning.

Example: Using the whole PYSJ course as part of an official training course

Many graduate programs have, or are building, one or more courses on foundational competencies essential to the mastery of a Ph.D. Many of these courses are a semester or quarter in length, and begin the first semester/quarter that students enter graduate training. This course work is often done at the same time as their laboratory rotations in possible mentors' labs.

The “Planning Your Scientific Journey” course can be an official addition to a formal course to help ensure that important concepts are being applied by the students to their own research as they learn them. One of the key features of PYSJ is that all of the assessments in the course urge the student to use their own research (or research of interest) to answer them. (Note, we believe this blended model presented could help address NIGMS T32 training grant objectives:

- “A broad understanding across biomedical disciplines and the skills to independently acquire the knowledge needed to advance their chosen field
- The ability to think critically, independently and to identify important biomedical research questions and approaches that push forward the boundaries of their areas of study
- A strong foundation in scientific reasoning, rigorous research design, experimental methods, quantitative approaches, as well as data analysis and interpretation
- The ability to work effectively in teams with colleagues from a variety of cultural and scientific backgrounds, and to promote inclusive and supportive scientific research environments
- The knowledge, professional skills and experiences required to identify and transition into careers in the biomedical research workforce (i.e., the breadth of careers that sustain biomedical research in areas that are relevant to the NIH mission)."

And that integrating in this way helps ensure that “instruction strategies are sufficiently well integrated into the overall curriculum” (see PAR-17-341.).

Integrating PYSJ into an in-person course

The full PYSJ course is typically done in about 6 weeks). In this schedule, students typically do about 1-3 hours of work a week for PYSJ. If your in-person course is less than 6 weeks long this model will be difficult, and we suggest using portions of the PYSJ content as opposed to the whole course (see the developing a scientific question section, below).
To integrate the course we suggest comparing the “Planning Your Scientific Journey” syllabus and learning objectives with your own course syllabus and learning objectives. Align the “Planning Your Scientific Journey” course with the course plan for the in-person training course and determine the following:

1. When will students be required to start and end the “Planning Your Scientific Journey” course?
   a. Suggestion: Make the start and end of PYSJ roughly match the beginning and end of the formal in-person course. This could mean progressing more slowly through PYSJ than the typical online schedule.

2. Will the students do all the assessments in PYSJ as homework?
   a. Suggestion: Have the students complete all the assessments in the course to create a “My Research Plan” document. The assessments can be answered in the course platform and printed out from there. To complete the assessments the students could use:
      i. Their current or past rotation project scientific questions/hypothesis (recommended).
      ii. A scientific question that is currently being studied by another in their lab (or a lab of their choice at their institution) if they have not chosen a question for their own project yet or have not joined a lab.
      iii. A scientific question from a paper or research project that they find particularly compelling, or is being used in the in-person course or another course they are taking.
      iv. A theoretical question that they are interested in (if they have not joined a lab yet)

3. How will “Planning Your Scientific Journey” be referenced and utilized in the in-person classes?
   a. Suggestion: For each of the 6 modules spend 30-45 minutes of in-class time referring to PYSJ and doing PYSJ-related activities. For example:
      i. Choose a video from a PYSJ module to show in class (~5 minutes).
      ii. Using an evidence-based teaching technique (see examples listed above), discuss the main points of the video and related concepts (10-20 minutes).
      iii. Refer to one or two related assessment questions from PYSJ. Have students work on them in class and then share with a classmate or the whole group (10-20 minutes).

4. How will students show that they have completed the PYSJ course?
   a. Suggestion: As part of their grade, they should hand in a completed “My Research Plan” document to the instructor. Each student’s “My Research Plan” can be downloaded and printed from the iBiology Courses platform. Depending on the desires of the instructor, these research plans can be simply pass/fail (i.e., passing grade if the student has shown a real effort to address the assessments) or graded relative to the learning objectives of PYSJ or the in-person course.
   b. Students can also hand in the earned iBiology Courses certificate of completion for the PYSJ course. However, note that a certificate is earned when PYSJ students have completed 50% of the assessments in the course. You may wish for a more stringent completion percentage.

5. How will you assess whether the PYSJ course content has worked for your learners?
   a. Suggestion: In-person or online surveys can be a good way to assess efficacy. For more detailed information on evaluation, please contact us at courses@ibiology.org (we plan to add more to this section of the Educator Guide in the future). We also suggest investigating the CIRTL Program Resource Collection (free login required). For PYSJ we have a number of metrics that we assess through online surveys, and here are several that we suggest:
i. Pre- and post-course knowledge gain assessments: ask questions pre- and post-course that refer to specific learning objectives or competencies in the course.

ii. Overall course satisfaction.

iii. Perceived impact on preparation for scientific endeavors.

iv. A change in some action or behavior (e.g., use of the “My Research Plan” in their project, talking to their advisor about their plan, improved efficiency in the lab...)

Determining these 5 elements will allow for the PYSJ course to be effectively integrated into the in-person course and support the broader learning objectives of the overall graduate training. If this doesn’t quite match your training program, you could also imagine using the PYSJ course in the following ways:

- As pre-work for a workshop or training series on project design, choosing a scientific question, experimental planning, setting goals or any combination of these.
- Schedule weekly (or bi-weekly) meetings/discussion sessions (or learning communities) with those who are taking the course in your lab, department or institution. During these meetings center the discussion that occurs around the material that was covered in a single module, i.e., discuss module 1 during the first week’s meeting, module 2 during the second week, etc.

For a deeper dive into an example of how to use an online course in in-person training, we suggest the following reference: Bruff, D., Fisher, D., McEwen, K., & Smith, B. (2012). Wrapping a MOOC: Student perceptions of an experiment in blended learning. Journal of Online Learning and Teaching, 9(2).

Example: Using PYSJ as part of a rotation project

As we mentioned above, this course is a great resource for training graduate students who do not have much experience working in a lab and, therefore, can be used as a resource for training rotation students in your lab or program. Our course covers many of the strategies and activities that many rotation students are asked to learn or perform during their rotations (see learning objectives for full course topics).

We also strongly advocate for the laboratory mentor/supervisor to be an integral part of teaching the finer points of picking a project/scientific question, planning the students’ research and helping them seek feedback. Because of this, we present here one model of formally integrating PYSJ into one of the mandatory first-year laboratory rotations (assuming that they are at least 6 weeks in length).

The overall idea is to require the graduate student to go through the online PYSJ course under the guidance of their rotation mentor, using their rotation project/scientific question to answer the assessments. The graduate student and mentor would meet regularly (preferably weekly) to go over the PYSJ assessments and course concepts.

Side Note: First Year Fellowship Applications

Often during the first quarter/semester of first year graduate students in the US, students also work on developing and submitting fellowship applications (say to NSF). As the goal of Planning Your Scientific Journey is to develop a research question and plan, and often, though not always, the fellowship is related to the
Rotation project under work, using the PYSJ course content could additionally help students through the process of fellowship applications.

**Possible Meeting Structure: Weekly Meetings**

Rotation student and research mentor (advisor and/or lab mentor) meet each week to iteratively develop a research plan for the rotation project.

<table>
<thead>
<tr>
<th>Week</th>
<th>Meeting Goals</th>
<th>Student Instructions</th>
<th>Mentor Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Discuss/list the students scientific interests and skill sets, so that they can use this to guide the development of their research question and experimental approaches in their “My Research Plan”.</td>
<td>Complete Module 1 of PYSJ. Come to this meeting with an understanding of the different research projects in the lab as well as your possible research interests and your general scientific interests. To prepare, talk to more senior individuals in the lab in order to learn more about the research projects and to get a reading list of key publications; read those key publications.</td>
<td>Ask the student what their research interests are and how they think those interests align with the different projects in your lab. Work together to identify what they are most interested in and how they might be able to fill a role or add to one of the existing projects in your lab that align with the student’s scientific/research interests.</td>
</tr>
<tr>
<td>2</td>
<td>Review, evaluate, and iterate Module 2 assessments. Establish what question they will be answering during their rotation project.</td>
<td>Before this meeting, complete Module 2 of PYSJ. Make sure to apply all assessments in Module 2 (and all future Module 2 assessments) to your rotation project experiment. Bring your responses and any related questions to the meeting. Come up with a draft scientific question you would like to answer during your rotation based on the discussion with your mentor from your last meeting and the answers to the assessments in module 2.</td>
<td>Discuss the feasibility, impact, and logistics of the student’s draft question. Help them refine that question so that the final question you both agree on can be answered (or at least have made significant progress toward answering) within the timeframe of the rotation and significantly contributes to the main goal of the project.</td>
</tr>
<tr>
<td>3</td>
<td>Review, evaluate, and iterate Module 3 assessments.</td>
<td>Before this meeting, complete Module 3 of PYSJ and outline an experimental</td>
<td>Discuss the outlined experimental approach the student has generated. Help</td>
</tr>
<tr>
<td></td>
<td>Approach that will bring you closer to answering the scientific question you and your mentor established during last week’s meeting. Bring your Module 3 responses and any related questions to the meeting.</td>
<td>them refine and round out that experimental approach so that it aligns with the question you both have established for them and is feasible to complete in the given timeline.</td>
<td></td>
</tr>
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<td>---</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>Review, evaluate, and iterate Module 4 assessment</td>
<td>Before this meeting, complete Module 4 of PYSJ. Formulate 2-3 short-term goals for your research project that you think you can accomplish during your rotation project. Formulate 2-3 long-term goals for your research project, so that you have identified what you wish to accomplish once you have joined a lab. Identify the skill(s) (scientific/technical, professional) you would like to learn during your rotation project. Bring your Module 4 responses and any related questions to the meeting.</td>
<td>Discuss and refine the short and long-term goals they have identified to help them establish if these goals are feasible as well as if the short-term goals will help them on the road to achieving their long-term goals. Discuss the feasibility of developing the skills they have identified that they would like to learn during the rotation project as well as a basic plan for how they can start on the path to learning those skills.</td>
</tr>
<tr>
<td>5</td>
<td>Review, evaluate, and iterate Module 5 assessments</td>
<td>Before this meeting, complete Module 5 of PYSJ. Make the short-term goals you discussed with your mentor during last week’s meeting SMART and draft an accountability plan. Bring your Module 5 responses, protocol notes, and any related questions into the meeting.</td>
<td>Discuss and improve/refine the students short-term goals now that they are SMART. Discuss and refine their draft accountability plan. Establish a plan for how the student can receive constructive feedback from you and your senior lab members while they execute their experimental plan.</td>
</tr>
<tr>
<td>6</td>
<td>Wrap-up and evaluation. This meeting is to allow both the student and mentor to discuss and evaluate how the</td>
<td>Before this meeting, finish any PYSJ course assessments that haven’t yet been finished and attend to any work that your mentor has asked to be addressed.</td>
<td>Prior to the meeting jot down notes of the students strengths and weaknesses in relation to concepts covered in the course. Discuss your evaluation with the student,</td>
</tr>
</tbody>
</table>
We recognize that some projects move more quickly than others and that some students are more advanced than others. We recommend that the mentor adjust and tweak the above schedule to reflect the realities of the scientific work, while at the same time ensuring that the student makes it through the concepts of the entire course.

We also know that not every laboratory advisor will be able to meet with the graduate student weekly. We recommend that there be an additional mentor identified (staff scientist, graduate student or postdoc in the lab) that can be readily available to join and continue the weekly meetings when the lab head is unavailable.

Assessing the curriculum:

We recommend that both the mentor and student assess the utility and fit of the PYSJ curriculum when it is used. For more detailed information on evaluation, please contact us courses@ibiology.org (we plan to add more to this section of the Educator Guide in the future). We also suggest investigating the CIRTL Program Resource Collection (free login required). For PYSJ we have a number of metrics that we assess through online surveys, and here are several that we suggest:

6. Pre- and post-course knowledge gain assessments: ask questions pre- and post-course that refer to specific learning objectives in the course.
7. Overall course satisfaction.
8. Perceived impact on preparation for scientific endeavors.
9. A change in some action or behavior (e.g., creating or refining a scientific question that is of interest to the trainee, impactful, practical, and answerable; improved ability plan their research, and start to or refine their ability to solicit feedback on their scientific question and/or plan).

Example: Using PYSJ as part of a learning community

While our course is designed to be successful as a strictly online experience, there is significant evidence that pairing an online course like ours with an in-person learning community can increase deep learning as well as

| training progressed through the rotation as well as how they can maintain a growth mindset/deal with failure and/or setbacks throughout their future research experiences. | Formulate an assessment of your strengths and weaknesses in relation to the concepts of the course and performing research in general. | including a discussion of what the student believes are their strengths and weaknesses. Identify actions that the student can do to build and improve their skills. In addition, think of some strategies you or your colleagues have used to maintain a growth mindset/deal with failure and/or setbacks that you can share with the student. |
increase course engagement and completion rates. Therefore, pairing the course with an in-person (or virtual) learning community may help you satisfy your individual program or participant goals.

These learning communities can range from the formal (as part of a professional development certificate program) to the informal (getting coffee together and talking about course concepts) and while your goals in this range of situations may be different a general structure for these community meetings can be applied in most situations. We recommend that the communities meet each week for 60-90 minutes and that each one of these meetings covers a single week of course materials. We recommend that participants work through the course materials that will be covered in each meeting during the previous week so that they are prepared to discuss the relevant materials during the meeting. Finally, we suggest that these meetings have a formal or informal “facilitator” who guides the discussion, leads activities and in general keeps the group on topic.

**Side Note: Qualifying Exams**

One time period in a graduate student’s career for which this learning community might be particularly useful is in the months leading up to doctoral qualifying exams. Typically, students are required to develop, write and defend a doctoral research proposal as part of qualifying for doctoral candidacy. Since PYSJ is directly focused on the question of building a good research question and corresponding research plan, it is particularly geared towards helping students at this important stage in their graduate career. Building a learning community for graduate students who are about to go through the candidacy process could be incredibly helpful for their progress through training.

Here is an example template for how to schedule your learning community meetings as well as a few example activities you could incorporate during each week’s meeting:

<table>
<thead>
<tr>
<th>Meeting Logistics</th>
<th>Suggested Activities</th>
<th>Facilitator Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meeting #: 1</strong></td>
<td></td>
<td>Activity #1 Warm Up (~10-15 minutes):</td>
</tr>
<tr>
<td><strong>Course Content Discussed:</strong> Week 1</td>
<td>Activity Learning Goals:</td>
<td>Activity #1 Warm Up:</td>
</tr>
<tr>
<td><strong>Length:</strong> 60-90 minutes</td>
<td>By the end of this activity participants should be able to:</td>
<td>Sometimes asking participants to share personal motivations can make them feel uncomfortable, especially in a group where participants are not very familiar with each other. So make sure to be sensitive to this and do not pressure the group to share if they don’t want to.</td>
</tr>
<tr>
<td><strong>Location:</strong> Provide a location for in-person meeting or link for joining virtual meeting.</td>
<td>- Articulate their reasons for participating in the learning community as well as what they would like to get out of the course.</td>
<td>The facilitator can sometimes break the ice by sharing their motivations for</td>
</tr>
<tr>
<td><strong>Participant pre-meeting work:</strong> View all content and complete all assessments in week 1 of the course.</td>
<td>- Be more familiar with the facilitator, the other participants and their motivations for taking the course as well as what their peers would like to get out of the course.</td>
<td></td>
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<tr>
<td></td>
<td>Before the meeting ask participants to do a short pre-meeting assignment in which they think about</td>
<td></td>
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</table>

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Facilitator responsibilities: Review all content and assessments in week 1 of the course. They may also want to complete the assessments to be able to use them as examples for other participants.

Outline discussion questions/activities that they would like participants to engage with during the meeting.

Distribute any additional pre-work they would like participants to complete at least a week before the meeting.

the main reasons they are taking this course/participating in this learning community and what they would like to get out of the course. Have them jot down some notes or write a one pager on this topic and bring it to the meeting.

The facilitator should introduce themselves and then lead the group in a round of introductions. Then ask for volunteers to introduce themselves share their motivations for participating and what they hope to learn. Depending on the size of the group you could do this as a think-pair-share to allow for more in depth discussion with larger groups or as a whole group discussion with smaller groups. Once the sharing dies down, ask all those who did not share to introduce themselves so everyone gets a chance for an introduction.

The facilitator should try to pick out common themes in what participants share and verbally affirm those to the group, or if there aren’t really common themes then they can note that as well and mention how interesting it is that there is a large range of motivations.

Activity #2 Developing a Scientific Question (~20-25 minutes):

Activity Learning Goals:

By the end of this activity participants should be able to:

- Apply/adapt Dr. Depace’s strategy for picking a scientific question to their own research situation/environment.
- Discuss which strategies for picking a scientific question they think are a good idea, which have been successful for them in the past, which have worked for their peers in the past.

Before the meeting, the facilitator should print out and make enough copies of the infographic regarding Angela DePace’s strategy for picking a scientific question to give to each participant. The getting involved with the course and deciding to facilitate the learning community.

Activity #2 Developing a Scientific Question:

If the facilitator is confident that the group has completed module 1 and therefore watched the “A Process to Develop a Research Project” video you can skip watching that video or skip to specific sections of the video that are especially salient to the points they are emphasizing.

It is possible that some participants may convey that they had very little choice in the question that they are currently working on because the lab or the PI had a question that needed answering and they were put on that project without a ton of discussion. In this case, the facilitator may want to acknowledge that this is the case for a good number of trainees and that we will talk more about mentor relations in modules 5 and 6. For this activity, you can ask these participants to pick out which portions of the process that Dr. DePace proposed they think would have been most/least useful if they had been able to take advantage of this or a similar process.
facilitator should also be ready to play the “A Process to Develop a Research Project” video from module 1 for the group. Both of these items can be found in the table at the end of this document.

Watch the “A Process to Develop a Research Project” video with the group. After the video, ask how many of the participants have chosen or are currently working on a defined scientific question through a show of hands.

Start handing out the printed infographics to the participants and ask those that have not chosen a question to identify and mark on the infographic where they are in that process of picking a question and if they are using a much different process than is outlined by Dr. DePace to note that on the sheet. Then ask them to brainstorm and note on the sheet how they might accomplish the remainder of the process in the context of their own interests. For example:

- What papers they might want to read.
- Who they might want to talk to.
- How they might decide between competing questions of interest.
- What they think they might need to put into their proposal for their PI.

For those who have already chosen a scientific question, ask them to compare and contrast the process developed by Dr. Depace to the process that they used when picking a scientific question and make notes of the similarities and differences between their process and Dr. Depace’s. In addition, ask them to note what practices they thought were helpful when picking a question and which were not as helpful.

Come back together as a group and first ask the group who has not picked a question to share where they are in the process and what they think they need to do moving forward. Then ask the group who has picked a question to share some of the similarities and differences between their process and Dr. DePace’s as well strategies they
<table>
<thead>
<tr>
<th>Meeting #:</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Content Discussed:</td>
<td>Week 2</td>
</tr>
<tr>
<td>Length:</td>
<td>60-90 minutes</td>
</tr>
<tr>
<td>Location:</td>
<td>Provide a location for in-person meeting or link for joining virtual meeting.</td>
</tr>
<tr>
<td>Participant pre-meeting work:</td>
<td>View all content and complete all assessments in week 2 of the course.</td>
</tr>
<tr>
<td>Facilitator responsibilities:</td>
<td>Review all content and assessments in week 2 of the course. They may also want to complete the assessments to be able to use them as examples for other participants.</td>
</tr>
<tr>
<td></td>
<td>Outline discussion questions/activities that they would like participants to engage with during the meeting.</td>
</tr>
<tr>
<td></td>
<td>Distribute any additional pre-work they would like participants to complete at least a week before the meeting.</td>
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<table>
<thead>
<tr>
<th>Activity #1- What Makes a Scientific Question Good? (~15-20 minutes):</th>
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<tbody>
<tr>
<td><strong>Activity Learning Goals:</strong></td>
</tr>
<tr>
<td>By the end of this activity participants should be able to:</td>
</tr>
<tr>
<td>● Discuss the characteristics of what makes a scientific question good.</td>
</tr>
<tr>
<td>● Align these characteristics with their current scientific question.</td>
</tr>
<tr>
<td>● Refine their scientific question using feedback from peers.</td>
</tr>
<tr>
<td>Ask the group “From what you learned in module 2, what are the three main characteristics that define a good scientific question?” (a scientific question should be specific, testable and have a clear impact).</td>
</tr>
<tr>
<td>Once the group has answered with these three characteristics, ask them to think about and jot some notes on how well their current or potential scientific questions fit these characteristics and if they don’t, how might they be able to make adjustments so that they align better with what you have discussed so far.</td>
</tr>
<tr>
<td>Then ask participants to form groups of 2-3 and discuss what they discovered in their reflection. Each participant should take 2-3 minutes explaining their question and their alignment with the above characteristics and then another 2-3 minutes receiving feedback from their peers.</td>
</tr>
<tr>
<td>Come back together as a group and ask for volunteers to share what how their question aligned and if/what adjustments they could make to fit with these characteristics better.</td>
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<table>
<thead>
<tr>
<th>Activity #2- The Difference Between a Question and a Hypothesis (~25-30 minutes):</th>
</tr>
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<tbody>
<tr>
<td><strong>Activity Learning Goals:</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Activity #1: What Makes a Scientific Question Good? (~15-20 minutes):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depending on the timeframe, the question and answer section about the three main characteristics could become a longer group discussion because there could be some really good points that may not have been covered in the course but are still important.</td>
</tr>
<tr>
<td>If participants have not yet picked a question to research, ask them to think about a question they might be interested in as a potential research question and use that question for their discussion.</td>
</tr>
<tr>
<td><strong>Activity #2 The Difference Between a Question and a Hypothesis:</strong></td>
</tr>
<tr>
<td>If the facilitator has already done activity #1 they can use the definitions and characteristics that the group decided on during that activity for a scientific question and ask the new groups to focus on defining a hypothesis and then compare the crowd sourced definitions of a hypothesis to what they decided on for a scientific question in activity #1.</td>
</tr>
<tr>
<td>If the groups were able to...</td>
</tr>
</tbody>
</table>
By the end of this activity participants should be able to:

- Define both a scientific question and hypothesis.
- Describe the similarities and differences between these two concepts.
- Generate a refined hypothesis for their scientific question.

Divide participants into two groups.

Ask the first group to take 5-10 minutes and collectively come up with their definition of a "scientific question" as well as what makes a good scientific question and write both the definition as well as the characteristics of a good scientific question down (either on a board or on paper).

Ask the second group to come up with their definition of a "hypothesis" as well as what makes a hypothesis good and write both the definition as well as the characteristics of a good hypothesis down (either on a board or on paper).

When each group is finished, take 5-10 minutes and ask a representative (or several) from each group to explain to everyone the definition and characteristics of their assigned topic.

Use these definitions and characteristics to start a discussion comparing and contrasting a scientific question vs. a hypothesis with emphasis on how they are different and how you might turn a scientific question into a hypothesis.

For the final 5-10 minutes of this activity ask each participant to try and generate a hypothesis that fits all of the group's good characteristics from the scientific question that they are working with. Then ask them to turn to their neighbor, share their hypothesis (along with the scientific question from which it was generated) with each other and provide feedback on each.

write their definitions and characteristics on a board the facilitator can use that for the large group discussion but if not they should take write the definitions and characteristics on the board as they are described to the whole group.

The think, pair, share activity at the end can be organized with groups larger than two if the group has more time, just remember that the larger the groups that are giving feedback, the longer it will take for all of them to give and receive feedback.
<table>
<thead>
<tr>
<th>Meeting #: 3</th>
<th>Activity #1: Developing an experimental approach (20-25 minutes):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Content Discussed: Week 3</td>
<td>Activity Learning Goals:</td>
</tr>
<tr>
<td>Length: 60-90 minutes</td>
<td>By the end of this activity participants should be able to:</td>
</tr>
<tr>
<td>Location: Provide a location for in-person meeting or link for joining a virtual meeting.</td>
<td></td>
</tr>
<tr>
<td>Participant pre-meeting work: View all content and complete all assessments in week 3 of the course.</td>
<td>Make sure all of the participants complete assessments 16-21 (Q16-Q21) before the meeting and bring their answers to the meeting.</td>
</tr>
<tr>
<td>Facilitator responsibilities: Review all content and assessments in week 3 of the course. They may also want to complete the assessments to be able to use them as examples for other participants.</td>
<td>Ask participants to take ~10 minutes and use their answers to Q16-Q21 to draft a coherent experimental plan that they believe will address their scientific question. This plan should include what experiments they will do (in order of importance and chronologically) as well as how each experiment connects to their scientific question.</td>
</tr>
<tr>
<td>Outline discussion questions/activities that they would like participants to engage with during the meeting.</td>
<td>Once the participants are finished drafting their experimental plans, ask them to divide themselves into groups of 2-3 and share their plans with the others in the group to get feedback on their plan and how their plan aligns with their scientific question.</td>
</tr>
<tr>
<td>Distribute any additional pre-work they would like participants to complete at least a week before the meeting.</td>
<td>Bring all the groups back together and ask for a few volunteers to share their plan as well as any good feedback they received from the group and how that feedback changed their plan.</td>
</tr>
</tbody>
</table>

Activity #2: Evaluating Skills, Interest and Temperament (~20-25 minutes):

Activity Learning Goals:

By the end of this activity participants should be able to:

Many participants may not have easy access to a printer so the facilitator can ask them to either print their assessments themselves or email them to you 24 hours prior to the meeting and then the facilitator can print them out and bring them to the meeting for the participants.

If the facilitator completes activity #1 before starting activity #2 they can use the experimental plan they drafted in activity #1 for their considerations and discussions in activity #2.

If activity #1 is not done before activity #2 you may want to allow for a little more time for participants to remember/jot down some of the experiments they are planning since they may not have a fully formed experimental plan in front of them.
- List their current and aspirational experimental skills set
- Articulate their scientific interests and research preferences (as they are affected by the participants temperament)
- Determine how their skill sets, interests and temperament align with their current or proposed experimental plan.

Watch the video “Skills, Interest, and Temperament” with the group. Then ask the group to take 5-10 minutes and write down:

1. Their current skill sets in the lab
2. Consider the experiments they are planning and whether those experiments will require them to learn a new skill and if so what those skills are.
3. What are their top 3 main scientific interests
4. How much risk, complexity and tolerance for experiments that may only produce results in the long term.

Briefly come back together with the whole group and ask if there was anything that was surprising to them as they considered their skills, interests and temperament.

Finally ask them to turn to their neighbor, and discuss how their skill set, interests and temperament align with their current (or proposed) project/experimental plan.

Briefly come back together with the whole group and ask if there are any changes that any of the participants will make to their experimental plans as a result of this discussion activity.

<table>
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<tr>
<th>Meeting #: 4</th>
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<tbody>
<tr>
<td>Course Content Discussed: Week 4</td>
</tr>
<tr>
<td>Length: 60-90 minutes</td>
</tr>
</tbody>
</table>
| Activity #1- IDP Discussion/Outline (~10-15 minutes):
  Activity Learning Goals:
  By the end of this activity participants should be able to: |
| Activity #1: IDP discussion/outline:
  If the facilitators institution has a specific IDP tool that they use and most of their participants are from that |
**Location:** Provide a location for in-person meeting or link for joining virtual meeting.

**Participant pre-meeting work:** View all content and complete all assessments in week 4 of the course.

**Facilitator responsibilities:** Review all content and assessments in week 4 of the course. They may also want to complete the assessments to be able to use them as examples for other participants.

Outline discussion questions/activities that they would like participants to engage with during the meeting.

Distribute any additional pre-work they would like participants to complete at least a week before the meeting.

- Become familiar with IDPs as well their individual institutions requirements/formats for IDPs.
- Articulate the value of IDPs
- Create an outline for their IDP or evaluate a previous IDPs alignment with their research activities.

For this activity the facilitator should research the IDP requirements as well as the format the IDP takes at the institution before the meeting. If the group has participants from multiple institutions, ask each participant to conduct this research for their own institutions before the meeting. In this case the facilitator should also gather some of the more general IDP resources that are presented in the course to provide to participants.

If all participants are from the same institution, spend the first five minutes going over the IDP requirements and format at that institution. If not all participants are from the same institution, ask for a few volunteers to talk about the requirements/format that their institutions and then start a discussion about the similarities and differences between IDPs.

Then ask the group what they think the value of IDPs are. As they come up with specific points make sure to note them on the board.

Finally, ask the students to take the last five minutes of their time in this activity to create a plan for completing their IDP if they have not done so. If they have already completed an IDP for the designated time period, ask them to compare how their IDP has aligned with their activities over this time period.

**Activity #2- Goals Peer Review (~25-30 minutes):**

**Activity Learning Goals:**

By the end of this activity participants should be able to:

institutions, make sure that the facilitator is familiar with this tool and can explain it to the group.

**Activity #2: Goals Peer Review Activity:**

At the end of the activity when they are discussing their reviews with one another make sure that each clearly explains their reasoning behind all of the numerical ratings they gave so that those being reviewed have a clear concept of what they might do to address any issues the reviewer perceived.
● Articulate 3-5 fully formed short term and 3-5 long term goals for their research project.
● Use a specific rubric to provide constructive feedback on their peer’s goals.
● Use peer feedback to refine, change or reformat their short term and long term goals.

Ask participants to bring the 3-5 short term goals and the 3-5 long term goals they created in assessments Q25 and Q26 to the meeting with them as well as the experimental plan they created earlier in the course, a copy of their scientific question and their hypothesis.

Explain that they will be exchanging their responses to Q25 and Q26, experimental plans, scientific questions, and hypotheses with another in the group for peer review. For the peer-review process take ~15-20 minutes and ask them to rate the goals they are reviewing as follows:

● Will their goals get them closer to answering their scientific question? Score 1-5 (1=Definitely Not, 5= Definitely So)
● How well do their goals align with their ability to address their hypothesis? Score 1-5 (1=Not Well At All, 5= Very Well)
● How well do their goals align with their experimental plan? Score 1-5 (1=Not Well At All, 5= Very Well)

So the maximum score on the review would be 15 meaning their goals will definitely help them answer their scientific question, address their hypothesis and the experiments they have planned are perfect for accomplishing those goals. The minimum score would be a 3 meaning their goals will not help them answer their scientific question at all, will not address their hypothesis and the experiments they have planned will not help them accomplish those goals.

For each rating the reviewer should provide some comments on why they gave the rating they did.
Once the peer review is complete ask those who exchanged their goals to come back together and discuss each other’s goals.

<table>
<thead>
<tr>
<th>Meeting #: 5</th>
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</thead>
<tbody>
<tr>
<td><strong>Course Content Discussed:</strong> Week 5</td>
</tr>
<tr>
<td><strong>Length:</strong> 60-90 minutes</td>
</tr>
<tr>
<td><strong>Location:</strong> Provide a location for in-person meeting or link for joining virtual meeting.</td>
</tr>
</tbody>
</table>

**Participant pre-meeting work:** View all content and complete all assessments in week 5 of the course.

**Facilitator responsibilities:** Review all content and assessments in week 5 of the course. They may also want to complete the assessments to be able to use them as examples for other participants.

Outline discussion questions/activities that they would like participants to engage with during the meeting.

Distribute any additional pre-work they would like participants to

Activity #1: SMART Principle Jigsaw (~20-25 minutes):

**Activity Learning Goals:**

By the end of this activity participants should be able to:

- Define the acronym SMART along with a detailed explanation of each of the terms that comprise the acronym.
- Apply the crowd sourced definitions of the terms encompassed in the SMART acronym to their project goals.

Ask for a volunteer to explain what each of the letters in the SMART acronym means. Once they have listed: specific, measurable, action-oriented, realistic, and time bound, divide the group into 5 subgroups. Assign each one of these subgroups a term that corresponds to a letter in the SMART acronym (specific, measurable, etc.).

Ask each group to come up with a well thought out and coherent explanation of what their assigned term means in 5-10 minutes and be prepared to share it with the group.

Come back together and ask a spokesperson from each subgroup (or the whole subgroup if it is small enough) to teach the rest of the participants what their term means.

Once there is a thorough explanation of each term presented, ask participants to apply the SMART principle as the group has defined it to their goals they developed and workshopped last week. This can be done during the meeting (which would add another ~15 minutes onto the activity) or on their own at home.

Activity #2: Accountability Plan Activity:

While participants are responding to the two questions the facilitator has asked during the large group discussion make sure the facilitator is taking notes on the answers participants give on the board.

The self-reflection on the participants plans can be cut short if it seems as though there are not many changes being made. That section should only last as long as it is useful to participants.

The facilitator should make sure to take notes as each group is presenting on their assigned term so that at the end of the presentations all 5 terms are explained on the board.

**OR**

Ask each group to have a “scribe” who will write the explanation (or the high points from the explanation) on the board during their group’s presentation.
## Meeting #: 6  
**Course Content Discussed:** Week 6

<table>
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<tr>
<th>Activity #1: Failure and What it Means (~25-30 minutes):</th>
<th>Activity #2: Accountability Plan (~20-25 minutes):</th>
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<tr>
<td><strong>Activity Learning Goals:</strong></td>
<td><strong>Activity Learning Goals:</strong></td>
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<tr>
<td>By the end of this activity participants should be able to:</td>
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<tr>
<td>- Articulate what an accountability plan means to them and why they are important.</td>
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<tr>
<td>- Refine their accountability plan to better align with their goals and personal preferences</td>
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<tr>
<td>- Incorporate useful strategies shared by their peers into their own accountability plan.</td>
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</tr>
<tr>
<td>Ask participants to bring their answers to assessment Q33 to the meeting (their accountability plans).</td>
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<tr>
<td>Start the discussion by asking the group: “What does having an accountability plan mean to you?” Once you get several answers to that question follow up with: “Why is having an accountability plan important?”</td>
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</tr>
<tr>
<td>Then ask participants to take ~5 minutes and consider what they have just heard from their peers and revisit their accountability plans to see if the group discussion has inspired them to make any changes to their plans.</td>
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</tr>
<tr>
<td>Finally, ask participants to pick what they feel will be their most successful strategy for keeping themselves accountable, group themselves into small groups of 3-4 and take turns sharing that accountability strategy. Once this is done give the participants 5 minutes or so to update their accountability plans with any of their peers suggestions they thought might be useful to them.</td>
<td>Finally, ask participants to pick what they feel will be their most successful strategy for keeping themselves accountable, group themselves into small groups of 3-4 and take turns sharing that accountability strategy. Once this is done give the participants 5 minutes or so to update their accountability plans with any of their peers suggestions they thought might be useful to them.</td>
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**Activity #1: Failure and What it Means Activity:**

The facilitator should be taking notes on the board.
**Length:** 60-90 minutes

**Location:** Provide a location for in-person meeting or link for joining a virtual meeting.

**Participant pre-meeting work:** View all content and complete all assessments in week 6 of the course.

**Facilitator responsibilities:** Review all content and assessments in week 6 of the course. They may also want to complete the assessments to be able to use them as examples for other participants.

Outline discussion questions/activities that they would like participants to engage with during the meeting.

Distribute any additional pre-work they would like participants to complete at least a week before the meeting.

By the end of this activity participants should be able to:

- Define what failure means to them.
- Articulate any differences between their general definition of failure and their failure in the context of their research.
- Reframe their definition of failure to be a positive tool for improvement rather than a negative experience.

Ask participants to take just a couple minutes and write down what “Failure” means to them. After several minutes ask them to write down what “Failure” in research means to them. Then ask them to compare and contrast the two definitions of failure they have written.

Once they have completed their definitions and comparisons ask them to group themselves into small groups of 2-3 and discuss their definitions/comparisons for 5-10 minutes.

Come back together and ask for several examples of definitions from participants. Then ask if any of the participants’ definitions of failure changed due to their discussions with their peers?

Use several of the definitions shared to demonstrate how failure does not always need to be a negative but can be used constructively to move forward better off than you were before. For example, if someone defines failure as “When an experiment does not have the predicted or intended outcome.” You can highlight how while the experiment may not have worked the way you expected, what did you learn from the results you got? What can you change in your upcoming experiments to account for the lessons you learned in your “failed” experiment? Are there new experimental directions you may be able to take inspired by the unexpected results?

Finally ask participants to take the last ~5 minutes and try to reframe their own definition of failure into something that makes failure a tool for improvement rather than a strictly negative
during the large group discussion at the end.

If time allows the facilitator can link reshaping an individual's perception of failure to having a growth mindset.

**Activity #2: Preparing for a Meeting With Your Mentor**

Activity:

The facilitator should keep in mind that participants may be reluctant to share their concerns/worries/insecurities which is completely fine but the facilitator might want to think of several common insecurities that trainees at their institutions may have so that the group discussion is not just focused on what participants are confident about but also what they might be worried about.

This activity could spark discussions around some very sensitive topics such as worries about research misconduct, sexual harassment, mental health, etc. so the facilitator should be prepared to address some of these issues if they arise. The facilitator should also be ready to diffuse uncomfortable conversations by offering to continue the conversation with the participant after the meeting if they feel the group discussion is no longer productive for everyone. Finally, the
Activity #2: Preparing for a Meeting With Your Mentor (~15-20 minutes):

Activity Learning Goals:

By the end of this activity participants should be able to:

- Articulate their points of confidence as well as points of concern regarding a meeting with their mentor about their research plan.
- Internalize and critically consider other participants' points of confidence and concern.

Ask participants to take several minutes and think about and jot down what they feel most confident about with regard to their upcoming (or yet to be scheduled) meeting with their mentor as well as what they are most concerned/worried about.

Then ask them to turn to their neighbor and share either their point of confidence or their worry. Once they have discussed for 3-5 minutes ask them to turn to their other neighbor and do it again to get multiple perspectives on their points of confidence or worry. Make sure to note that if the participants' partner shares a concern that they may not be looking for a resolution to that concern but might just want an ear to listen so the participant should only offer advice if it is asked for.

Come together as a whole group and ask for several volunteers to share either their points of confidence or their insecurities with the whole group.

facilitator can develop a list of resources (at their institution and beyond) that they can direct participants to if the facilitator does not feel confident that they can provide useful advice on any of these topics.

Example: Choosing and Evaluating a Scientific Question, using part of the course

Many institutions and educators might not need the full PYSJ course for their training curricula, having fully developed courses already, or wanting, instead, something more customized for their trainees. As such, they
might be interested in using parts of the PYSJ course to bring a variety of formats and contexts into their curriculum or to address a particular concept that hadn’t been integrated into their instruction yet.

Here we present a model of using a small part of the PYSJ course, a criterion to evaluate your scientific question, parts 1&2 lessons, as the basis of a workshop that could be a one-off workshop or integrated into a course or workshop series. The workshop template we provide could be adapted to other topics that we cover in the course.

Workshop Template

In Modules 2 and 3, we present strategies, frameworks and good practices for choosing and refining a scientific question. In addition, towards the end of module 1 we provide a step by step process that one of our experts has used in her lab to help students choose and refine their scientific questions, the basics of this process are:

- **Month 1**
  - Explore different research topics by reading, talking to people, etc.
  - Deliver 3 broad areas of interest to your mentor.

- **Month 2**
  - Dive deeper into your broad areas of interest by reading, talking to people, etc.
  - Pick one idea that is most interesting.
  - Evaluate and refine the idea until it’s a specific, clear, and answerable question.
  - Brainstorm experimental approaches and refine your ideas.
  - Deliver 2-4 experimental aims to your mentor.

- **Month 3**
  - Deliver a written proposal to your mentor.

To use in a classroom situation we suggest you review the relevant sections in lessons 2, 3, and 4 and translate it into an in-person seminar/class with facilitated group discussion. Below is one example of how this section could be translated into a 1-1.5-hour workshop for life science trainees.

**A Workshop on Strategies for Choosing and Evaluating a Scientific Question**

**Class format:** In-person workshop, 60-90 minutes depending on how you structure it.

**Learning Objectives**

In this workshop, participants will learn to:

- Explain why learning to ask a good scientific question is a key outcome of your training and an important transferable skill for your next career stage.
- Articulate the features of “good” scientific questions, so you can develop an interesting and implementable project.
- Describe a scientific question that you are interested in pursuing.
- Explain the potential impact in answering your scientific question.
● Understand the definition of a hypothesis and its role in answering a scientific question.
● Define a hypothesis for your scientific question, if applicable, so you can use it to guide your ideas for an experimental approach.

Workshop Outline

● Before the workshop
  ○ Ask students to brainstorm and list 2-3 of their main scientific interests and to translate those interests into a draft scientific question and an associated hypothesis. If students are in a rotation or have already joined a lab also ask them to think about and jot down some notes on how their draft question could fit into the work that is going on in their lab. If they are not in a rotation or have not joined a lab ask them to research several labs at your institution in which their draft question might fit into the work being done in those labs.

● Introduction (~15-20 min)
  ○ At the start of class, ask the entire group “What is a scientific question to you?” Write some of the student responses on the board, slide (if facilitating electronically) or whatever public notes space you prefer. Then use those responses as well as your definition to come up with a crowdsourced definition of what a scientific question is.
  ○ Small group discussion or think pair share: Ask students to break into groups of 3-4 students. Then ask each group to discuss the question “what are the main characteristics of a good scientific question?” and to document the characteristics that they decided upon with your crowdsourced definition in mind. Then come back together as a whole group and ask for some groups to discuss a few of the characteristics that they came up with. List those in the public space as well.
  ○ Ask them to think about how many of these characteristics apply to their draft scientific question and to take some notes on how they might be able to improve their draft question by incorporating these characteristics.

● Aligning important characteristics of a scientific question with expert scientists (~15 min)
  ○ Watch the video “The Art of Asking “Good” Scientific Questions” available in module 2, lesson 3 of the course and in the “Table of Links and Downloads” below.
  ○ Group discussion: Ask the group to determine how well the characteristics that they outlined align with the characteristics presented by the experts in the video and begin to modify your list of characteristics based upon this discussion.

● A process for choosing a scientific question (~20 min)
  ○ Group discussion: Ask students “With our definition and important characteristics in mind, how would you go about developing a scientific question you would like to answer once you have joined a lab?” As students offer possible processes, briefly note them in the public space.
  ○ Present the students with Dr. Depace’s 3-month strategy for developing a scientific question (outlined above) and possibly provide them with a copy of the infographic associated with that strategy for reference.
  ○ Small group discussion or think pair share: Ask them to break into groups of 3-4 again and discuss how they might apply Dr. Depace’s strategy to their draft scientific question. Come back
together as a large group and ask for a few examples of how they have applied the 3-month strategy to their questions for all to hear.

- Developing an associated hypothesis (~15-20 min)
  - Group discussion: Ask the group “What is the difference between a scientific question and a hypothesis?” and record some of their responses.
  - Watch the video “What’s a Hypothesis Anyway?” available in module 2, lesson 3 of the course and in the “Table of Links and Downloads” below.
  - With your discussion and the information presented in the video in mind come up with a crowdsourced definition of what a Hypothesis is.
  - Minute paper/Individual exercise: As each student to write down what a possible hypothesis for their scientific question could be. Once this is done ask if anyone would like to share their hypothesis (also ask them to share their draft question first so that the group has context for the hypothesis).

- Conclusion: What have you learned and what will you do differently? (3 min)
  - Ask students to “Write down three things you learned in this workshop.” Then, ask them to “Write down what will you implement from this workshop into your research endeavors.”

- Evaluation: Have students hand in a copy of their “What have you learned and what will you do differently” work from the conclusion (could be through electronic means). Examine the responses and assess whether the students overall achieved the learning objectives of the workshop. Also, reflect on the discussion portions of the workshop, did the students grasp the important concepts and seem able to apply them? You can also ask further evaluation of the students in a simple survey they hand in (or do online) in which you can ask about how helpful they found the resources, their satisfaction in the workshop, or pre- and post- knowledge gains around specific learning objectives and competencies.

- This type of workshop structure can be applied to several topics covered in the course such as developing a research plan, mentor relations, setting goals, etc.

Resources for lab notebook/recordkeeping (from Module 4)

- NIH: Guidelines for SCIENTIFIC RECORD KEEPING in the Intramural Research Program at the NIH (PDF)
- NIH: Keeping a Lab Notebook (PDF)
- Enhancing the QUAlity and Transparency Of health Research (EQUATOR) Network: Reporting guidelines for many study types.
- The ARRIVE Guidelines Checklist I Animal Research: Reporting In Vivo Experiments
- The CONSORT guidelines for randomized controlled trials.
- Transparent Reporting for Reproducible Science

Notes for facilitators
● Depending on class size, duration of the workshop, and your own interests, you may want to substitute “think-pair-share” or some other kind of evidence-based teaching strategy for the whole group discussions.

● Tailor the content presented from lessons 1, 2 and 3 of the course presented in this workshop to the needs of your audience. For example, you could concentrate more on developing a hypothesis or the process of developing a scientific question if one of these topics align more with the needs of your students.

Review of “Neil’s Approach to Recordkeeping”

For your reference, here is a detailed outline of Neil’s process for taking notes at the bench and then transcribing them into a digital notebook. This process uses the [lab notebook template](#) for its written structure and is included in the case study video referenced above:

1. Before you even start an experiment, review the protocol that you’re going to follow step by step while you execute it. You should keep this protocol at the bench with you at all times.

2. Then as you are following those steps and collecting data, keep a paper-bound notebook with you to record the data being generated, any notes you might have as well as observations about the protocol or the experiment itself.

3. Once you have completed the experiment, take your paper notebook and transcribe it into digital form following the template outlined in the attachment above. Include any pictures of drawings or tables you made in your paper notebook.

4. The background section of the digital notebook helps document your explicitly stated experimental question, your hypothesis, and your expected results. This will help you and others who might read your notebook in the future see what your underlying thought process was behind why you did things the way you did.

5. Next is the experimental design section which is basically a bulleted list of what you did at the bench from beginning to end including the dates on which you performed each step.

6. Next comes the results and observations section in which you should dump all of the data that you collected from your experiment. This would include all of the observations from your handwritten notes, spreadsheets, explanatory figures, and any pictures you might have drawn or taken.

7. Finally, come the conclusions and future directions section. The conclusions section includes any conclusions you were able to draw from the data, what new information were you able to glean, what meaning were you able to extract from the data? In the future directions section, you should answer the question “Based on what I observed in this experiment, what should I do next?” Does this experiment need to be repeated? Did your results demonstrate any modifications that you need to make to the current experimental protocol? Did this data inspire you to do any new experiments that you had not considered previously?

8. Using this template helps you keep all of your experimental protocols and notes within a common and defined structure so if you are ever going back through your notes you know where everything is.

9. This not only helps you keep a permanent record of what you did but allows you to work through what you did one last time and think about potential changes for the future.
Complete List of References, Recommended Readings, and Resources in Planning Your Scientific Journey

References (by order of appearance in the course):

   http://psycnet.apa.org/psycinfo/1981-27276-001

Recommended Readings:

1. Reflecting on your interests:
   a. Point of View Affects How Science is Done
2. Developing a good research question and hypothesis:
   b. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2912019/
3. How science works:
4. Setting goals for success:
5. Individual development plans:
6. Mentor relations:
   a. Getting the Mentoring You Need
   b. How to Be a Graduate Advisee
   c. Managing Your Advisor
7. Growth mindset and dealing with failure:
   a. The Power of Believing You Can Improve
Recommended External Resources:

These are external resources mentioned in the course as helpful tools.

1. Individual development plans:
   a. myIDP at Science Careers, by the American Association for the Advancement of Science (one of the co-developers of this tool is our course instructor Cynthia Fuhrmann)
   b. ChemiIDP by the American Chemical Society
   c. Graduate Student and Postdoctoral Scientist IDP forms available at Stanford University
   d. The Individual Development Plan form available at the University of Wisconsin-Madison

Table of Links and Downloads

Legend

- Assessment question
- Video
- File
- Discussion Prompt
- Infographic
- Web resource

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## Case Study: Neil's Investigation of Root Growth

### Transcript

- What experiment to do next?
- Flowchart: What Experiment To Do Next?
- Neil's Experimental Setup
- Choosing a Model System
- Case Study: Neil's Model System
- Case Study: Ana's Model System

## Case Study: Ana's Investigation into Mechanisms of Breast Cancer

### Transcript

- What experiment to do next?
- Flowchart: What Experiment To Do Next? (White background)
- Ana's Experimental Setup

## Module 2: Key Elements of Experimental Design

### Transcript

- Keeping Track of All the Variables
- What Are Your Controls?
- Case Study: Neil's Internal Controls
### Module 3: Account for Bias

1. **Be Rigorous and Transparent**
   - View
   - High: Low
   - Transcript

2. **Case Study: Neil’s Initial Bias**
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   - High: Low
   - Transcript

3. **Don’t Be Wed to Your Hypothesis**
   - View
   - High: Low
   - Transcript

4. **Be Aware of Measurement Bias and Blind Yourself**
   - View
   - High: Low
   - Transcript

5. **Think About Your Data and How to Analyze It**
   - View
   - High: Low
   - Transcript

6. **Clarifying the P-Value**
   - View
   - High: Low
   - Transcript

### Assessment questions for Module 3

### Discussion questions for Module 3

### Module 4: Gear Up to Do the Experiment

1. **Familiarize yourself with the protocol**
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   - High: Low
   - Transcript
## Case Study: Neil’s Approach to Recordkeeping

**Neil’s Lab Notebook Template (Google doc)**

**Assessment questions for Module 4**

**Discussion questions for Module 4**

### Module 5: Getting the Experiment to Work

**Pilot Your Experiment**

**Getting an Experiment to Work**

**Troubleshooting Framework (Google doc)**

**Case Study: Neil’s Problem with Gravity**

**Case Study: Ana’s 100 Clones**

**Optimize Your Experiment**

**Signal to Noise Graphic**

**Figure: Dose Response Curve**


**Decreasing Noise**

**Case Study: Ana’s Variability in Tumor Growth**

**Validate Your Results Through Orthogonal Approaches**

**Assessment questions for Module 5**
Discussion questions for Module 5