Tips for Undergraduate Research Project Design

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This worksheet provides suggestions on issues to consider when designing an undergraduate research project. It presents a series of questions to answer and steps to complete as you think about designing an undergraduate research experience. As with all plans, the plan you initially create will likely need to be adjusted as the research experience proceeds, but the process of thinking through these questions before the research experience begins will help lead to a more positive and productive experience for your student. When you need to modify your project plan in response to research realities, working collaboratively with the undergraduate researcher on those adjustments would be a value learning opportunity for the student.

Brainstorming a meaningful, non critical[2] research question/project

One way to think about this is to think about the project creating a supporting or explanatory figure that would be nice to include in a paper or thesis, but is not essential to the success of the paper or thesis. Another possibility is to think of a project that would do some exploratory work that extends an existing idea into a new realm. Some possible questions to consider:

- Do you have some existing research results that are not fully explained and you would like to better understand by collecting and analyzing more data on an already existing system?
- Do you have some existing research results that have made you curious about how your tool or approach would apply or work in a different setting or for different inputs?
- Do you have existing collected data that you have not found time to analyze or visualize for specific characteristics, where the results could lead to deeper understanding of your approach or point to new problems to explore?
- Is there a small, relatively straightforward artifact (e.g, survey, software feature) that you need implemented and evaluated that builds on an already existing system or process?

Delineating the goals and steps of a research project

1. What is the precise research question you want this research project to answer?
    - How is the answer to this question meaningful/helpful to your research?
    - List the sub questions associated with the larger research question. Identify which sub questions are complicated enough to be their own small research projects.
2. For a given research question or sub question, what is the set of small, measurable deliverables that must be achieved to answer it? (You may choose to structure this set of deliverables using an if/then organization if the work that needs to be done at a stage is dependent on the outcome

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[2] The project should be non-critical for a first time student researcher because the student will initially be slow to produce results as they will be learning about research (including making lots of mistakes).

of an earlier deliverable.) Completion of these individual deliverables should advance the project regardless of whether all of them are completed in the given time frame.

3. For each of these small, measurable deliverables, answer the following questions:
    1. What technical skills / knowledge are needed to complete each deliverable?
    2. What technical skills / knowledge will an undergraduate student have been required to learn in their coursework, given their current progress in the major?
    3. What is the difference between 1 and 2? These are the new skills the student will need to acquire to complete this deliverable.
    4. Of these new skills/knowledge that must be learned to complete the deliverable, which ones can be learned by an undergraduate sufficiently within a few days or up to a week? Which ones would take longer to acquire? For skills/knowledge that take longer to acquire, can you or a more experienced student complete the tasks requiring those more advanced skills/knowledge instead?
    5. Are there resources that provide an example solution to a similar problem that the student can learn from?
    6. Have you identified tools/techniques/papers/documentation that enable the student to acquire those technical skills / knowledge, and is there someone who can answer questions on those materials?
    7. Are any of these deliverables decomposable into repetitive subparts that can be tackled independently?

Creating a project timeline

1. Create a dependency graph where each item is either
    a. a small, measurable deliverable as defined above
    b. a technical skill or knowledge that must be acquired
2. For each item in the dependency graph, determine a **realistic** amount of time it will take for an undergraduate student to complete. For deliverables with decomposable parts, determine a time estimate for each independent part. (Be slightly pessimistic in your time estimates)
3. Map the tasks from 1 onto a Gantt chart using the information from 1 and 2.
4. **If the resulting timeline is too long** for the research experience's duration, consider places you can cut tasks or parts of tasks in order to revise the Gantt chart. For example,
    a. Can repetitive tasks be reduced to fewer repeats?
    b. Can a team of students work in parallel on repetitive tasks?
    c. Can one of the defined deliverables become the new final goal, with the expectation that the remaining deliverables will be completed by the same or another student in the future?
5. Keep in mind that this initial timeline should be viewed as a *draft* plan that will likely need to be adapted during the student's actual research experience based on the progress being made and the challenges encountered. As the research experience proceeds, keep in mind ways to expand or shrink the set of tasks as required.

Stitching Multiple Research Projects Together to Answer the Original Research Question

- Have you established a shared space for each deliverable and its supporting data, artifacts, analyses, documentation, experimental notes?
- Have you established the organization and protocol the student must use to share each deliverable? This includes when items should be shared.
- Have you established a protocol for reviewing the student's deliverables and providing feedback for revision? This includes how quickly feedback should be given.
- Have you ensured that you will retain access to these documents when the student leaves the group and/or graduates?
- Have you shared these expectations with the student and provided any necessary documentation for performing these steps?