

Getting Started

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Research Project

- At the beginning of a research program, then, you need to establish answers to two key questions.
- First, what is the broad problem to be investigated?
- Second, what are the specific initial activities to undertake and outcomes to pursue?
- Having clear short-term research goals gives shape to a research program. It also gives the student training in the elements of research: planning, reading, programming, testing, analysis, critical thinking, writing, and presentation.

- In choosing a topic and advisor, many students focus on the question of “is this the most interesting topic on offer?”, often to the exclusion of other questions that are equally important.
- One such question is “is this advisor right for me?” Students and advisors form close working relationships that will takes months or years.

- Another important question is, is this project at the right kind of technical level?
- Some brilliant students are neither fast programmers nor systems experts, while others do not have strong mathematical ability.
- It is not wise to select a project for which you do not have the skills or that doesn't make use of your strengths.

Example

- A single research area can offer many different kinds of topic. Consider the following examples of strengths and topics in the area of Web search:
 - *Statistical*. Identify properties of Web pages that are useful in determining whether they are good answers to queries.
 - *Mathematical*. Prove that the efficiency of index construction has reached a lower bound in terms of asymptotic cost.
 - *Analytical*. Quantify bottlenecks in query processing, and relate them to properties of computers and networks.

Example

- *Algorithmic*. Develop and demonstrate the benefit of a new index structure.
- *Representational*. Propose and evaluate a formal language for capturing properties of image, video, or audio to be used in search.
- *Behavioural*. Quantify the effect on searchers of varying the interface.
- *Social*. Link changes in search technology to changes in queries and user demographics.

Project Scale

- Project scale is a related issue. Some students are wildly ambitious, entering research with the hope of achieving something of dramatic significance.
- However, major breakthroughs are by definition rare—otherwise, they wouldn't be major— while, as most researchers discover, even a minor advance can be profoundly rewarding.
- Moreover, an ambitious project creates a high potential for failure, especially in a shorter-term project such as a minor thesis.

Research

- Most research is to some extent incremental: it improves, repairs, extends, varies, or replaces work done by others. The issue is the magnitude of the increment.
- A trivial step that does no more than explore an obvious solution to a simple problem— a change, say, to the fields in a network packet to save a couple of bits—is unlikely to be worth investigating.
- There needs to be challenge and the possibility of unexpected discovery for research to be interesting.

- For a novice researcher, it makes sense to identify outcomes that can clearly be achieved; this is research training, after all, not research olympics.
- A principle is to pursue the smallest question that is interesting. If these outcomes are reached early on, it should be straightforward, in a well-designed project, to move on to more challenging goals.

Research on Product

- Some research is concerned with problems that appear to be solved in commercial or production software. Often, however, research on such problems can be justified.
- In a typical commercial implementation the task is to find a workable solution, while in research the quality of that solution must be measured, and thus work on the same problem that produces similar solutions can nonetheless have different outcomes.

Research Planning

- Students commencing their first research project are accustomed to the patterns of undergraduate study: attending lectures, completing assignments, revising for exams. Activity is determined by a succession of deadlines that impose a great deal of structure
- In contrast, a typical research project has just one deadline: completion. Administrative requirements may impose some additional milestones, such as submission of a project outline or a progress report, but many students (and advisors) do not take these milestones seriously.

Research Planning

- A strong approach to the task of defining a project and setting milestones is to explicitly consider what is needed at the end, then reason backwards.
- The final thing required is the write-up in the form of a thesis, paper, or report; so you need to plan in terms of the steps necessary to produce the write-up.
- As an example, consider research that is expected to have a substantial experimental component; the write-up is likely to involve a background review, explanations of previous and new algorithms, descriptions of experiments, and analysis of outcomes. Completion of each of these elements is a milestone.

Student and Advisors

- Advisors are powerful figures in their students' lives, and every student–advisor relationship is different.
- Some professors at the peak of their careers still have strong views—often outrage or amazement—about their own advisors, despite many years of experience on the other side of the fence.
- Tales include that of the student who saw his advisor twice, once to choose a topic and once to submit; and that of the advisor who casually advised a student to “have another look at some of those famous open problems”. Thankfully these are rare exceptions.

Student and Advisor

- Some advisors, for example, set their students problems such as verifying a proof in a published paper and seeing whether it can be applied to variants of the theorem, thus, in effect, getting the student to explore the limits at which the theorem no longer applies.
- Another example is to attempt to confirm someone else's results, by downloading code or by developing a fresh implementation. The difficulties encountered in such efforts are a fertile source of research questions.
- Other advisors immediately start their students on activities that are expected to lead to a research publication. It is in this last case that the model of advising as apprenticeship is most evident.

Student and Advisor

- Typically, in the early stages the advisor specifies each small step the student should take: running a certain experiment, identifying a suitable source of data, searching the literature to resolve a particular question, or writing one small section of a proposed paper
- As students mature into researchers, they become more independent, often by anticipating what their advisors will ask, while advisors gradually leave more space for their students to assert this independence. Over time, the relationship becomes one of guidance rather than management.

Advisor

- Advisors can be busy people. Prepare for your meetings—bring tables of results or lists of questions, for example.
- Be honest; if you are trying to convince your advisor that you have completed some particular piece of work, then the work should have been done.
- Advisors are not fools. Saying that you have been reading for a week sounds like an excuse; and, if it is true, you probably haven't spent your time effectively.

Check Lists

- Is your proposed topic clearly a research activity? Is it consistent with the aims and purposes of research?
- How is your project different from, say, software development, essay writing, or data analysis?
- In the context of your project, what are the area, topic, and research question? (How are these concepts distinct from each other?)
- Is the project of appropriate scale, with challenges that are a match to your skills and interests? Is the question narrow enough to give you confidence that the project is achievable?
- Is the project distinct from other active projects in your research group? Is it clear that the anticipated outcomes are interesting enough to justify the work?
- Is it clear what skills and contributions you bring to the project, and what will be contributed by your advisor? What skills do you need to develop?

Check Lists

- What resources are required and how will you obtain them?
- What are the likely obstacles to completion, or the greatest difficulties? Do you know how these will be addressed?
- Can you write down a road map, with milestones, that provides a clear path to the anticipated research outcomes?
- Do you and your advisor have an agreed method for working together, with a defined schedule of meetings?