Dimensions of Excellence in a Dissertation

CSE 5800

Empirical Research Methods

Spring 2002 – Cem Kaner

Please Treat These Notes as First Draft

- The notes that follow reflect my personal opinions and are not the positions of Florida Tech or the Computer Sciences Department at Florida Tech.

- I've spent a fair bit of time thinking about this topic, but I haven't read enough or connected to enough other faculty to have confidence that this is "the right" set of ideas. Please treat this as a working document, send me criticism, mine it for ideas, but don't rely on it as authoritative.

Overview, and the Dimensions as I See Them

- The objectives of the research

- Originality

- Development by the student

- Connection to existing work

- Problem difficulty

- Impact

- Exposition

- Proof of skill

Objectives of the Research -- 1

- A Ph.D. program prepares students to become the peers of the faculty.
  - When we graduate someone with a Ph.D., we are making a statement to the world that this student is fit (in terms of skills and intelligence and knowledge) to work at a university.
- Ph.D. programs that do not attempt to produce peers do their students a disservice.

Objectives of the Research – 2 (from Phil Pfeiffer)

- Even the meaning of the word "research" changes, depending on the context in which the term is used:

- **"undergraduate" research:**
  This phrase, as used by organizations like Council on Undergraduate Research, typically refers to activities that are far closer to "project work" than basic research: for example, the redoing of classic under slightly different experimental conditions, in ways that usually yield unsurprising results.

- **"master's level" research:**
  This phrase, when used in the computer sciences, typically refers to a project that recapitulates known work, and advances the state of the art by a relatively small amount.

- **"Ph.D.-level" research --**
  This phrase, when used in the computer sciences, typically refers to an endeavor that involves a substantial element of original work, including a convincing demonstration that the work is original. This demonstration ideally involves a careful review of known literature on the problem under attack.

- **"commercial" research --**
  This phrase typically refers to an endeavor that yields a concrete, incremental improvement in a well-established product or process—one with significant potential for payback.

Originality

- Concepts
- Models
- Proofs
- Methods (research methodology)
- Applications
- Implementation
- Synthesis

- Any of these *could* be the original contribution. Implementation is *rarely* the primary original contribution in a Ph.D. and *infrequently* the primary original contribution in a Master's thesis.
- A synthesis of ideas, with literature review, may be sufficient for a Master's thesis but for Ph.D., it must be accompanied with more (e.g. experiments that tie the ideas together in useful and theoretically interesting ways)

Originality: How Much is Enough?

- Originality is one factor among many factors. Some degree of originality is essential.

- A project *might* involve relatively little originality but be acceptable if (for example) it tackled a difficult problem, demonstrates theoretical, research, and/or implementation skill, and is likely to have high impact.

- A project is not original if it merely reproduces results that are known (e.g. in industry) but not yet published.

- The ultimate criterion is this: the reader must agree that the project adds new knowledge that is worth having.

Development by the student

- The student must be able to design her own research program

  - Students often go through emotional rollercoasters choosing their thesis topic—*better now, while you are a student, than later, when you are expected to know what you are doing.*

  - Part of the job of a graduate faculty member is the discipline to resist the temptation to take the student out of her difficulties in choosing or defining the topic. The advisor should listen carefully, ask questions, provide references, and *sometimes* point out errors, but leave the definition and refinement of the topic to the student.

  - Large labs with established programs often graduate students who cannot start a research program from scratch. These students may have high publication records and still be considered unemployable as professors.

Development by the student

- The doctoral project is a small-size, long-duration project.
    - Completing it is proof that you can design, manage, and finish a significant project. *For some companies, this is the main reason that they prefer Ph.D.'s to Master's or Bachelor's graduates.*
    - There is great long-term as well as thesis-term value in applying project management techniques to the project that is probably the largest one you've done to date.

Connection to existing work

- This is your entry into the community of scholars
  - *Scholarship* is essential
    - Connect to the work in your field
    - If your project has applied aspects, don't expect to find the application-related material in academic (theoretical) journals. Find the practitioner's literature that cover's your topic area.
    - If your project connects to another discipline (e.g. business, math, psychology, etc.), find that discipline's literature that relates to your topic area.
  - Plagiarism (intentional or unintentional) is flatly unacceptable. *You are a big kid now. You are expected to know and understand the standards without needing a babysitter.* If you are not familiar with U.S. customs and expectations regarding intellectual integrity, find out.
- Another issue I see raised when we interview new Ph.D.'s for jobs as faculty (and evaluate the resumes of other applicants) is whether they understand how their work fits in the broader realm of Computer Science

Problem difficulty

- The problem might be unusually challenging because of (for example):
    - Difficult mathematical (or other) models
    - Weak foundation in the theoretical literature that you start with, or requires significant theoretical advance
    - Need for high sophistication in a research method
    - Unusually difficult to implement (design and code)
    - Need to translate original source materials of relevant literature
- If getting over the difficulty requires you to develop and use skills that we would consider important for a professor of Computer Science, you get "credit" for difficulty.
- If getting over the difficulty requires you to do primarily time-consuming (e.g. administrative work, legal disputes, straightforward but excessive coding), you will get sympathy, but no "credit."

Problem Difficulty / Scope

- What is the contribution that justifies your work?
    - Theoretical advance
    - Formal model
    - Experimental results
    - Code
    - Literature review and synthesis
- Most theoretical advances and experimental advances are relatively narrow.

Impact

- Theoretical advance that theorists will use
- Methodology advance that researchers will use
- Implementation techniques or algorithms that people will use
- Solves a practical problem in a way that practitioners will use

Exposition

- If you can't communicate in the language of the University where you study (here, English), your work will rarely be acceptable, even if it is brilliant.
  - This is your problem, not the Department's.
  - Build time in your schedule to practice your language skills (if you need the practice)—otherwise, your project schedule is at high risk.
  - Faculty/student and committee/student agreements are much less certain if your language skills are weak—too many opportunities for confusion
  - Faculty guidance is a challenge if you find it hard to communicate with the faculty member

Proof of Skill

- Mathematical

- Modeling

- Empirical research

- Fundraising

- Software engineering process

- Coding

- Proof that you know how to do a wide range of tasks that a professor should know will be well received.