

The Research Process

CSCD 555, Research Methods

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What is Research?

- **Excerpts from:**
P. D. Leedy, T. J. Newby, P. A. Ertmer, *Practical Research: Planning and Design*, Prentice-Hall, 1997
- **Research is NOT:**
 - mere information gathering
 - mere transportation of facts from one location to another
 - merely rummaging for information
- **Research IS:**
 - a process through which we attempt to achieve, systematically and with the support of data, the answer to a question, the resolution of a problem, or a greater understanding of a phenomenon
 - research is guided by a specific research problem, question, or hypothesis

Scientific Method

- **Does Scientific/Technological “Research” always conform to the Scientific Method?**
- **Merriam-Webster Dictionary:**
 - A scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses
- **Some notes:**
 - hypotheses are generally tested using statistical methods
 - hypotheses should never be formed from the data used to test them (random correlations WILL exist)
 - beware rejection of the null hypothesis (a subject for another lecture)
- **Much of the progress in Math, Engineering, and Computer Science follows paths that are not data driven**

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3

Examples

- **In order to be considered successful, a research effort should, in some sense, contribute the body of human understanding**
 - discovering something that was not previously known
 - solving a problem that has not been solved before
 - solving a problem in a new way that has advantages over previous approaches
 - reducing some area of knowledge to practice in a novel way (this is more appropriately called development)
 - combining elements of human knowledge in a novel way
 - presenting a novel view of some phenomenon that adds to our understanding of it
- **There is a difference in the level of significance expected of Master’s Level and PhD level work**

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4

Master's vs. PhD

- **Very roughly speaking**
 - Master's level efforts tend to be more towards the green end
 - PhD level efforts tend to be more towards the red end
- **When a research project fails to meet it's objectives**
 - it is often possible to salvage a Master's thesis or project report from the ashes
 - it is usually not possible to salvage a PhD dissertation from the ashes (this is one reason the time to PhD has such a wide range, 3-10 yrs)

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5

Thesis vs. Project

- **Practical Difference**
 - A thesis is bound and published in the library
 - A project report is not
- **Theoretical Difference**
 - A thesis is oriented towards efforts that are more analytical in nature: e.g., presentation of new knowledge, new understandings of phenomenon, derivations, scientific method
 - A project is oriented towards efforts that are primarily reduction to practice: e.g., development of hardware or software that demonstrates a new approach or provides a new tool
- **In either case:**
 - a document should be produced that demonstrates the significance of the work

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6

How to find a project

- **Figure out what you're interested in**
 - what undergraduate courses interested you the most?
 - talk to your employer, if you have one, about possible projects
 - talk to faculty members about their areas of interest and possible projects
 - talk to other grad students
 - read stuff
- **Find one or more advisors and run your ideas past them**
- **Write your ideas down and run it by an advisor again**

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7

Then What?

- **Make a plan**
 - try to plan for some preliminary results if possible
- **Finalize your advisor and committee**
- **Discuss your plan, and completion requirements, with your advisor and committee**
- **Start working, keep working. Work, work, work.**
- **Meet regularly with your advisor and provide progress reports**
- **Seek help when you're stuck**

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8

Definitely Do NOT

- **Put in a lot of work going down a path without guidance of a faculty advisor**
- **Expect to complete a project and then find an advisor, after the fact, who will sign off on your work**
 - it's possible, but extremely risky
- **Stick your head in the sand if you're stuck**
- **Start writing your thesis or project report without discussing an outline with your advisor**
- **Despair if you have no idea what you want to do**

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9

Thesis / Report

- **Start with an outline**
 - a starting point is: Introduction, Methods/Design, Results, Conclusion, References
 - include sufficient detail for others to reproduce your work
 - include implementation details in the body only where they contribute to understanding
 - otherwise implementation details can go into appendices
- **Discuss your outline with your advisor**
- **Share drafts of sections with your advisor**
- **Give credit to information sources**
- **Don't list references that you don't cite**
- **Don't cite sources that you haven't read**

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10

Personal Experience

- **Master's degree**

- upon receiving my BS, I hired into a "New Graduate Training" program that involved rotations through various functional groups
- the program included an expectation that I earn a Master's degree, and offered some financial support
- at the time, TI was introducing their new embedded DSP processors (Harvard architecture, fixed point ALU, hardware multiply-accumulate)
- we were just beginning to discuss possible use of these at work
- simultaneously, some friends of mine were trying to bootstrap a company to produce a hand-held oscilloscope, for which they had a prototype
- they decided to start by doing the data-acquisition in hardware and the rest in software on the IBM PC
- they asked me to design an interface card to the PC, along with an I/O library

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11

Personal Experience

- **Master's degree (cont)**

- I designed the I/O card for a fee
- sometime later they proudly showed me some Spectral Analysis capabilities that they had added by implementing an FFT algorithm on the PC (in MS Basic)
- it was slow
- I suggested that they could add a TI DSP processor and some memory to the I/O card and do those computations on the fly, in near-real-time
- their answer was: "great, why don't you do that for us?"
- so, I approached my Master's advisor with the idea
- he said "great, go for it"
- later he decided to require some additional functionality: using it as a testbed for his digital filter design software (sigh)
- the company purchased the design from me on a royalty basis (dooooonuuuuuuuu)

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12

Personal Experience

- **PhD degree**

- My Master's advisor called to recruit me several times
- I told him I did not intend to pursue one (because a PhD usually reduces employment opportunities in industry)
- besides, the whole idea was scary
- I got married
- I put my wife thru college
- my wife informed me that she wanted to go to Medical School
- my wife informed me that she wanted to practice medicine in a rural area
- I asked, "Honey, I'm an engineer. Exactly what do you expect me to do in a rural area?"
- She replied, "Maybe you can teach"
- I thought, "Maybe I'd better pursue that PhD after all"

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13

Personal Experience

- **PhD degree**

- meanwhile, I had been offered an interesting job by another company (then ATL, now Sonosite)
- I told my boss I was leaving, and he asked, "what can we do to convince you to stay"
- I replied, "help me earn my PhD"
- they offered to give me a partial salary if I would return to work for two years upon completion

- **I was very lucky with financial support**

- as you move through life, make your own luck
- be watching for opportunities, and be ready to take them when they arise

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14

Bottom Line

- **Master's Program**

- can be worked into many lifestyles
- likely to be successful for the good or hard-working student
- enhances employment opportunities

- **PhD Program**

- should definitely consider it
- especially if you want to teach at the college level
- can diminish employment opportunities in some industries
- a huge commitment
- needs to fit your life situation
- there are a lot more ways for it to go sour, even for the good and hard-working student

Final Advice

- **Work Hard**

- **Have some fun**

- **Give something back**