All About Research

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About Mary Jean

B.S., M.A. math; secondary, college math teacher

UG, M.S., Ph.D. CS, 1988

• U of Pittsburgh, Clemson U, Ohio State U (1988-1999), Georgia Tech (1999-present)
• Software engineering research
  – testing, analysis, verification, maintenance of large, evolving systems
  – tool building, visualization, statistics, machine learning
• CRA-W, National Center for Women and Information Technology, NSF ADVANCE
• TOPLAS, TOSEM boards, ACM Fellow
About Elena

B.S. in Applied Math
M.A. in Applied Math

A few years as a software developer

Back to school!
- Tufts University
- 3rd year MS/PhD

Longing for mathematics.
Intrigued by computer graphics.

"Water drops on surfaces" Wang, Mucha, Turk
What is Research and Why Do It?

What?
- Investigation of a problem in scientific manner
- Discovery of a solution that advances state of knowledge in areas from theory to algorithms to prototypes to experimentation to applications

Why?
- Create, have fun, play
- Invent, be on leading edge of discovery, be a scientist
- Transfer discoveries to benefit society (important applications)
- Work in interesting and rewarding careers (academia and industry)
- Other??
Beginning with the End in Mind

You’re here because you are
– planning to get a Ph.D.
– thinking about getting a Ph.D.

By the time you graduate, you should know how to
– select a difficult and interesting research direction (that matters to someone)
– form hypotheses that can be scientifically evaluated (and how to perform the evaluation)
– conduct research and report on the results (by becoming an effective oral and written communicator)
– obtain funding, run a research group, be an advisor and mentor to your own students, etc. (so you can continue to do research, have an effect on others, etc.)

Plan for a research career not a research project!
Approximate Timeline

Getting started
- Choose a research area
- Choose a research advisor
- Work on a research team
- Secure financial support

Defining your research
- Identify a thesis problem
- Choose a Ph.D. committee

Completing your research
- Develop long term career goals
- Complete your dissertation
- Prepare for your career

Year timeline:
1 2 3 4 5 6
Choosing a Research Area

Many areas could be “right” for you

Criteria
- Exciting and interesting area
- Important problems in area
- Activities suitable to you (theory vs systems)

Ways to identify a research area
- Take courses, attend seminars and colloquia
- Talk to professors, visitors, other students
- Consider both applied and theoretical areas
- Read widely
- Learn about yourself, what you like, etc.
- Solve some research problems
Choosing a Research Advisor

Advisor-advisee relationships are forever!

Criteria

– advisor who will mentor you
  • as a student
    – to complete your dissertation
    – to gain required skills for eventual career (e.g., writing papers, presenting work, preparing proposals)
  • after you graduate, throughout career

– advisor who will promote your career
  • write (strong) letters (e.g., job search, promotion, awards)
  • advocate on your behalf (e.g., committees, awards, leadership positions)
Choosing a Research Advisor

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Ways to find a research advisor

– Talk to other advisees of potential advisors
  • Does advisor have expertise in area of interest?
  • What is the advising style, and does it work for you?
  • Does advisor mentor students in all areas for career?
  • Will advisor advocate on behalf of students?

– Talk to potential advisors
  • What are their upcoming projects?
  • How much time do they spend with new students?
  • How much time do they spend with current students?
  • Do you feel comfortable with advisor?
  • Do they have group meetings?
  • What are their expectations for a Ph.D. student?
  • Do they have research assistantships?
Choosing a Research Advisor

Advisor-advisee relationships are forever

Ways to find a research advisor

– “Try out” a few advisors
  • Take one of their courses
  • Work with them on an independent study
Choosing a Research Area and Research Advisor: Mary Jean’s Experience

While taking UG courses, favorite were systems-types: assembly, operating systems, translators, etc.

M.S. project involved programming a network interface unit; worked with operating systems faculty (had as instructor)

Realized that
1. I wanted to get a Ph.D.
2. I liked systems software not hard-core systems research so needed a new area
3. I needed a new advisor
Choosing a Research Area and Research Advisor: Elena’s Experience

Loved math and art. Always wondering how computer images work (scientific simulations, movie special effects, etc).

Research internship at Mitsubishi Electric. Worked with Adaptively Sampled Distance Fields

Realized that
1. I wanted to get a Ph.D.
2. I liked industrial research and liked the scientists for whom I was an intern
3. My dissertation research is for Mitsubishi
   • Rendering small text in Chinese, Japanese, and Korean on cell phones and PDAs
Working on a Research Team

A research team (group) offers many advantages for your research

Why work on a team (in a group)?
- Research often a collaborative, social process
- Team helps you to learn to communicate ideas
- Team is good place to try new ideas, practice talks, get feedback on papers, learn to advise other students, etc.

How to work on a research team (group)?
- Carve out your problem in the group
- Be generous with giving credit to others, but
- Stand up for your accomplishments
- Your role in the group may change as you progress
- Problems should be brought to team leader sooner rather than later
Securing Financial Support

You’ll probably be responsible for finding financial support at some point

Teaching assistantships (paid by dept)
- Will either teach, or assist in teaching, a class
- If preparing for an academic career, should do this at least one term (build skills, learn styles, etc.)

Research assistantships (paid by faculty)
- Will usually work on grant area initially
- Select assistantships that will produce publishable results
- May provide the opportunity to supervise students or help with grant writing
- Helps you to become an independent researcher

Fellowships (paid by other source)
- Will be able to concentrate on your work
- Look for opportunities for fellowships
Remember

• Many research areas could be “right” for you—so look around and don’t be afraid to change
• Advisor-advisee relationships are forever—so choose carefully
• A research team (group) offers many advantages for your research—so participate and help yourself and others
• You’ll probably be responsible for finding financial support at some point—so start looking early and consider your options
• Choose a research area
• Choose a research advisor
• Work on a research team
• Secure financial support

Getting started

Defining your research

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• Choose a Ph.D. committee

Completing your research

• Develop long term career goals
• Complete your dissertation
• Prepare for your career

Approximate Timeline

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Getting started

Completely your research

1 2 3 4 5 6
year
Identifying a Thesis Problem

Become an expert in the area
- Read papers
  - Start by using papers’ references to get to original papers
  - Keep an annotated bibliography of papers for later reference
    - Main contribution
    - Open questions
    - Your assessment
    - How it relates to your interests, work
- Talk to experts
  - When they visit your university
  - At conferences and workshops
- Attend talks, etc.
  - Carry a notebook to record notes, thoughts, etc.
- Question assumptions made by previous work
- Consider hot topics carefully
Identifying a Thesis Problem

Consider some potential thesis problems

– Thoroughly understand the problem
– Break problem into manageable pieces
– Develop methods that work for you
  • When to work deeply, broadly; when to put aside
  • Plan to have number of activities (2-3) to vary day
  • Set aside blocks of time to focus on research
  • Work consistently on the problem

Remember “luck favors the prepared mind” [Pasteur]
Identifying a Thesis Problem

Develop short-term subgoals
- Plan how to address each subgoal
- Meet with your advisor regularly
  - Arrive prepared
    - Prepare report about your accomplishments
    - Send the report ahead of time
- Describe
  - What you have accomplished
  - What are the hurdles to be addressed
  - How you plan to proceed and why
- Listen to advice and agree on next steps

Remember that drive—not brains—distinguishes the great scientists
Persevere—You Will Find a Topic

“Every morning I would sit down before a blank sheet of paper. Throughout the day, with brief interval for lunch, I would stare at the blank sheet. Often when evening came it was still empty… It seemed quite likely that the whole of the rest of my life might be consumed in looking at that blank sheet of paper…” (Bertrand Russell, autobiography)

Went on to publish (with Whitehead) the 3-volume *Principia Mathematica*
Choosing a Ph.D. Committee

Who should be on your committee?

- Advisor will make suggestions
- Faculty in your dept working in related areas (sometimes will co-advise)
- Faculty outside your dept can provide valuable insights but need to explain work in their terms
- Faculty/researchers outside your university but in your area can provide assessment of the work and act as a reference later

What to do after you’ve selected?

- Talk to each potential member about your research area and thesis topic (provide them with overview of problem, related papers you’ve written—one page)
- Schedule your thesis committee meeting—probably the hardest part!
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Approximate Timeline

1  2  3  4  5  6
year
Developing Long-term Career Goals

Industrial research lab
- Colleagues, few students, few grants (maybe internal), research might be related to company concerns

University
- More multitasking: teaching, research, service, advising, students, proposal writing, etc.
- Need to start planning early so will have required skills, publications in right places, etc.
Completing Your Dissertation

Plan your research, and regularly revisit, reevaluate, and revise these plans
- Map out what needs to be done, the order in which you will pursue each part of your thesis, etc.

Communicate your results along the way
- Identify publishable pieces of your work
- Make appropriate contacts along the way
  • Workshops and conferences
  • Intern or visit with a research group
  • Electronically communicate with researchers doing similar work
- Publish/present your work only with your advisor’s approval
- Understand “rules” for authorship
  • “intellectual” contribution—yes
  • “support” for research—maybe not
  • “main” contributor—first author and presenter at conference
Completing Your Dissertation

Develop good presentation skills (oral and written)
- Get feedback for your presentations
- Practice, practice, practice
  - To your research group
  - To your department
  - At conferences

Take the initiative in your own research
- Usually start out taking advice
  - Advisor and committee set most of goals for your work
- Want to end up being a colleague of your advisor and committee
  - Should know your research area better than anyone else (even your advisor)
  - Should be able to defend your work/decisions
  - Should set directions for next subgoals
Enjoy Your Research Career!