Research Skills
(for career and life)

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Slides at
http://people.engr.ncsu.edu/txie/advice/researchskills.pdf
Motivation for This Talk

• Many students lack important (research) skills to succeed in academic or professional career
  – Many students don’t realize that
  – Not to say that they know how to improve

• This talk intends to increase awareness of
  – Important research skills
  – (high-level) ways of improving these skills

• This talk is based on my own experience and observation while working with students

• Many skills described here applicable not only to research, but also to career and life
Important Research Skills

• Self-directed and motivated
• Problem solving skills
• Engineering skills
• Innovation skills
• Communication skills
• Learning skills
• ...

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Self-directed and Motivated

• If you need someone to push you to do your research, it often doesn’t work well
• Research driven by passion:
  – Community/upper/peer recognition
  – Intellectual curiosity
  – Make impact (on the research field, practice, world)
  – Learning new things
  – Better understanding (of things)
  – ...
  – Better career path
• Work hard and strategically
  – “strategically” related to engineering skills
  – effectively and efficiently
Research Ethics

• Absolutely follow (research) ethics
  – Responsible and responsive
  – Absolutely no fabrication or fraud of data
  – Absolutely avoid plagiarism
    • Plagiarism ex: copy a sentence from another source (even wiki) to your paper without citing the source
    • Plagiarism ex: copy a sentence from another source (even wiki) to your paper without rephrasing even when citing the source
      – http://www.acm.org/publications/policies/plagiarism_policy
      – ...

http://www.chass.ncsu.edu/ethics/
Avoid Duplicate Submissions

http://www.acm.org/publications/policies/sim_submissions/
http://www.ieee.org/web/publications/rights/Multi_Sub_Guidelines_Intro.html
http://www.icse-conferences.org/sc/guidelines/duplicateSubmissions.html

“if there is substantial overlap in the technical content of the conference submission and any other work that is:

– under review at another publication,
– has been accepted by another publication, or
– has appeared in another publication, at any time before the conference review process is complete.”

“publication”: any peer-reviewed scientific archive such as a conference, journal, or technical book.

Also avoid LPU: Least Publishable Unit

http://en.wikipedia.org/wiki/Least_publishable_unit
Research Paper Lifecycle

**W**: Workshop position paper (4-7 pages)

[Note that some workshop accepts full research paper, which shall be viewed as conference full paper]

→ **C**: Conference full paper (10-11 pages)

→ **J**: Journal paper (15-20 pages)

[At least 30% new content over C]

C/J can treat W/C as a previous version of C/J, and claim contributions of W/C as C/J’s contributions (need to explicitly state so and explain the main differences of two versions, e.g., in footnote)

But some PC members may evaluate C based on only the diffs of C and W → then publishing W is discouraged
Self-directed and Motivated cont.

• Try to improve external factors
  – Your assigned project idea may not be always promising
    • Try your best to improve the idea
    • Try your best to change to another idea
    • Ex. my past summer internship experience

• Try to do/try your best with the external factors
  – Sometimes you cannot change these factors
    • Ex. My past master thesis research

• Seemingly negative factors can turn out to be positive one (if you treat them right)
  – Ex. hands-off vs. hands-on advising style
Problem Solving Skills

• Examples of lacking debugging skills
  – A student came to me informing me that the Java code doesn’t compile, giving some error messages; I found out that the student didn’t set classpath correctly for the required jar files
  – A student complained to a third-party tool’s developers that the new release of the tool didn’t work with an example input; I found out that the example input didn’t even work with the old release
  – A student presented me a Java file telling me that the file cannot be processed by a tool whereas the tool can deal with other files; I had to narrow down the cause to specific constructs for the student.
Problem Solving Skills cont.

• Debugging skills
  – Having a passing case and a failing case → the failure-inducing input portion(s)
  – Having a passing old version and a failing new version → the failure-inducing change(s)
  – Delta debugging http://www.st.cs.uni-sb.de/dd/
  – Where to seek help?
    • Google the error message
    • Contact relevant people (tool authors, etc.) with “minimal” or “reduced” failure-causing inputs (cc. your advisor)
    • Seek upper/peer support
    • Tradeoff between “try hard yourself vs. ask others for help”
Problem Solving Skills cont.

• Improving debugging skills

http://www.whyprogramsfail.com/
Problem Solving Skills cont.

- Tool-development skills
  - Programming skills
  - Program understanding skills
  - Software reuse skills (sometimes you can reuse without requiring to understanding everything)
  - Think about alternative easier way of implementation

- Searching skills ("Google" skills)
  - Which keywords to pick
  - How to find out what you want in query result sets
  - How to refine keywords based on query result sets
  - Options: "filetype:ppt", ...
  - Ex: searching available NSF proposals on the web
Engineering Skills

• Cost-benefit analysis
  – Example cost:
    • How much development effort?
    • How much evaluation effort?
    • Any existing infrastructures to exploit or reuse?
  – Example benefit:
    • How much novelty of the work?
    • How much research/practical value of the work?
    • How much you accumulate infrastructures for next idea?
    • How much you get yourself skills to get into an area if you want? (real option value)

• Always think about alternative (easier) ways of implementation (especially in feasibility study)
• Help decide do it (or not) or do it now (or later)
Engineering Skills cont.

- Automate (or not) in experiment: I wrote my paper’s LaTeX source files so that when I update my experimental data by redoing my experiment, my LaTeX source files are automatically updated
  - Cost: constructing macros (if you haven’t done it, learning curve cost)
  - Benefit: when rerunning experiments, you don’t need to do extra work
  - Analysis: benefit > cost?

- Remember your ultimate goal
  - Often you need to convince readers that you research idea works with prototype/evaluation
  - Indeed, sometimes evaluation or your research goal calls for a highly usable tool in practice
Engineering Skills cont.

• Risk-reduction skills (spiral model)
  – Research full of risk (just like software development)
    • Initial ideas/whole direction may not work
    • Choosing the wrong existing infrastructure
    • You misinterpret your advisor’s ideas/mind
  – Counter-measures
    • (Heavy) manual feasibility study phase, e.g., mining code for bugs
    • At least you need to find out one convincing, motivating example before you go ahead
    • Prototype features iteratively and try subjects to get feedback
    • Formal writing of abstract, intro, example, approach sections sent to advisor before doing full tool development; experiment design section before doing full experiment
Engineering Skills cont.

• Deadline-making skills
  – Some people are last-minute persons and some are not
  – But many students are not good last-minute persons and finish work (or not) to the last minute before the deadline
    • Late submission to your advisor → no or insufficient help from your advisor to improve your submission
  – Many students don’t have good sense of
    • Task selection/prioritization: which tasks to focus first given the limited time (acceptance chance/time spent)
  – Many students tend to postpone their writing to the last minute (they don’t like writing; few does)
  – Goal: anytime you are stopped, you shall have a good-shape draft (incremental style towards the deadline)
Innovation Skills

• Critical thinking/questioning skills/assessment skills
  – Not every idea of your advisor or authority in your area is correct or the best
  – Questioning almost anything (not just questioning others and also yourself)
    • Ex. A student questions almost every idea that I gave him (not enough, need constructive solving skills)
  – Capability of judging research is not easy (Ex. reviewing papers)
    • Requiring the knowledge breadth and depth of the subarea, insights, ...
    • Always think about whether and how the paper convinces the readers that the work is indeed useful.
Innovation Skills cont.

• Constructive invention skills (Not easy at all!)
  – Require months/years of accumulation, learning, training, thinking, exercising ...
  – Need to force yourself to think
    • I got many new ideas when I stared at the blank research task portion in my proposal being written
    • New ideas generated while joggling, attending talks, even in dreams, ...
  – Need to know about background and related work
    • WebMon: http://www.markwell.btinternet.co.uk/webmon/
  – Need to have the habits of (creative) thinking
    • Can I apply this idea from field A to my field B?
    • Can I address this solution for problem A to my problem B?
    • ...

My Advice on Getting a Start into Research
http://people.engr.ncsu.edu/txie/adviceonresearch.html
Choose Research Problem/Idea

• Novelty: is the problem novel? Or is the solution novel?
• Utility: can the research produce practical impact? E.g., with help of industrial collaborators
• Risk: how likely the research could fail? Reduced with significant feasibility studies and risk management in the research development process
• Cost: how high effort investment would be needed? sometimes being able to be reduced with using tools and infrastructures available to us.
Choose Research Problem/Idea cont.

• Competitive advantages:
  – what is it that your group has that places you at an advantage with respect to others -- a particular tool, a particular technique, some colleagues, an insight, etc.
  – “secret weapon”

• Underlying assumptions and principles
  – core values that drive your research agenda in some broad way
  – “how do you choose what to pursue?”
  – can be problem-driven or solution-driven

Contributed by David Notkin
Communication Skills

• Technical writing
  – Avoid lacking of logical thinking, ex.
    • Use before define, define without explanation
    • No strong causal/transition relationships between sentences
  – Countering careless mistakes
    • Use spell check (or style check in MS Word)
    • Customize style-check with historical issue patterns
    • Ask for peer review before submitting to your advisor
  – Learn from patterns and anti-patterns

Advice on Writing Research Papers:
http://people.engr.ncsu.edu/txie/publications/writepapers.pdf
Common Technical Writing Issues:
http://people.engr.ncsu.edu/txie/publications/writeissues.pdf
Tools and Tips for Writing Papers:
http://people.engr.ncsu.edu/txie/publications/writingtools.html
Communication Skills cont.

• Oral communication
  – Presentation skills
  – Effective meeting with advisor (be prepared)
    • Bring in an agenda (discussion items listed)
    • Prepare backup discussion items in case you still have time in your allocated time
    • Use written materials to help oral communication
  – 5-mins elevator talk
    • Most students would start with low-level details of their research, forgetting about the motivation, problem domain
    • Lose the big picture due to being too familiar or excited about the solutions
    • Don’t address “why do I care?” “how can you convince me that your work is useful?”
Learning Skills

• Traditional learning skills

• Be mindful and learn from your successful and failing experience
  – After you finish doing something, you shall be able to abstract and summarize your lessons learned and convey to others your tips
  • Studying for a course, preparing for your GRE, applying for grad schools, contacting professors during application, getting started in a new research area, working with your advisor, writing high-quality papers, preparing for job interviews and applying for jobs, negotiating your hiring packages, writing funding proposals, increasing visibility in community, ...
  – Opportunities are visible to only people who keep their eyes wide open and think proactively
Summary

• Self-directed and motivated
• Problem solving skills
• Engineering skills
• Innovation skills
• Communication skills
• Learning skills
• …

Welcome additional skills that you feel important but are not described here!
Let me know!
What next?

• Now you know what skills are important
• Next you need to think about improving these skills in your professional and personal development
  – Not an easy task but you shall try and try hard
• Browse my advice collections at:
  – http://people.engr.ncsu.edu/txie/advice/

My research group/research web at:
https://sites.google.com/site/aserggrp/

We always look for motivated students/researchers to collaborate with