



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
- ...

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.ieee.org/web/publications/rights/ID_Plagiarism.html
 - ...

http://en.wikipedia.org/wiki/Research_misconduct

<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

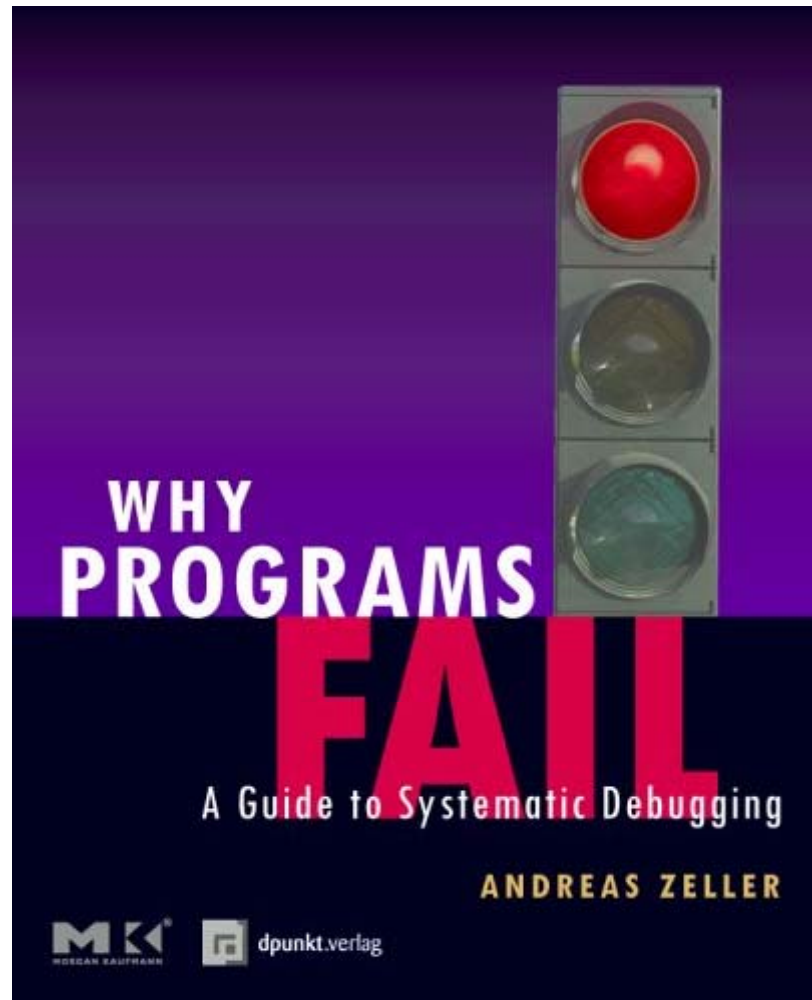
- Examples of lacking debugging skills
 - A student came to me informing me that the Java code doesn't compile, giving some error messages; I found out that the student didn't set classpath correctly for the required jar files
 - A student complained to a third-party tool's developers that the new release 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



¹¹
<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 alterative easier way of implemenation
- 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 your 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

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:

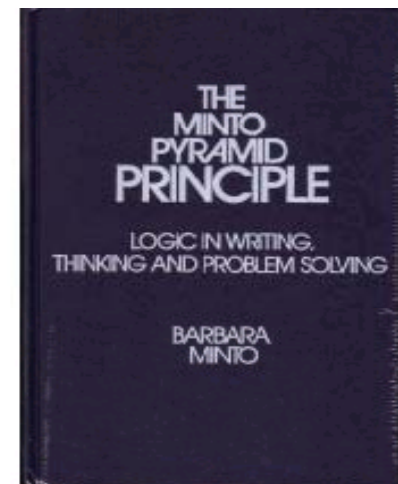
<http://people.engr.ncsu.edu/txie/publications/writepapers.pdf>

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!

