Preparing math students for careers in industry: A perspective from a career changer

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About Me

- PhD Mathematics, Washington University

- Arithmetic Combinatorics, Number Theory, Harmonic Analysis

- 2007 – 2014: Teaching positions at Indiana University, St. Louis University, University Kentucky

- 2014 – Present: Data Scientist at Allstate
What is Data Science?

- Extract knowledge and insights from vast amounts of data
- Interdisciplinary field combining techniques from statistics, software development, mathematics, machine learning, etc
How do I spend my time?

- 25% of time in data acquisition
- 50% of time in "data cleaning"
- 10% of time building and validating models
- 5% of time interpreting results
- 5% of time discussing specifications or results with business partners
Who are my fellow data scientists

- Almost all have PhDs or MSs. Those without graduate degree have many years experience in business analytics

- Backgrounds include mathematics, physics, statistics, computer science, material science, econometrics, actuarial science, public policy
Challenges in adapting to industry

- You work on what your client deems as valuable
- What your client deems as valuable can change mid-project
- Your client can change mid-project
- Project assignments can change mid-project
Challenges for mathematicians

- Real world problems never have solutions
- Real world questions are always vague and ill-posed
- Real world data is always messy
- Computational run time is always an issue
- Real world work is experimental, not deductive
  - You can never prove your result
Preparing Students for Jobs in Industry
Communication Skills

- Ability to determine the appropriate level of detail
- Ability to effectively communicate at that appropriate level
- Ability to communicate effectively to different audiences
In applied work
- Questions are always ill-posed
- Assumptions are always vague
- Problems can be valuable or solvable, but never both!!

Progress requires working iteratively:
- Reformulate until problem is solvable, but no longer valuable
- Reformulate until the problem is valuable, but no longer solvable
Defend Assumptions

In applied work

- Questions are **always** ill-posed
- Assumptions are **always** vague
- Problems can be **valuable** or **solvable**, but never both!!

Progress is made by **reformulating** problems. There is never a "right way" to reformulate a problem. So you must always be prepared to answer "why did you reformulate it in this way?"
Written Communication Skills

- Majority of written work in industry job will be writing executable code or writing documentation for code
- There are lots of similarities between writing code and writing a proof
- So training students to write better proofs will also help them write better code
Lessons Learned from Software Development Community

- **Clean Code Principles**
  - Variables, methods, and classes should be descriptively named
  - Methods should do one and only one thing
  - One level of abstraction per method
  - Avoid repetition — encapsulate into methods instead

- **Refactoring Code**
  - Improving the internal structure of code without altering its external behavior

- **Standards for documenting code and assumptions**
Adapting Software Development Principles to Proof Writing

- Use descriptive names
  - No more “We say a function has property A if ...”
- Lemmas should encapsulate one and only one significant logical idea
- A proof should operate at a single level of abstraction
  - Multiple levels of detail is a sign that parts of the proof should be encapsulated into a lemma
- When the same argument is repeated multiple times, encapsulate that argument into a lemma
Adapting Software Development Principles to Proof Writing

- Refactoring in the context of proof writing?
  - Decomposing long complex proof into a simpler series of lemmas
  - Makes proof much easier to follow
  - Isolates where different hypotheses of the theorem are used
  - Makes it easier to modify proof to yield new theorems
Conclusion

- Improving soft skills will help students succeed in industry jobs
- This can be done directly in math courses
- This can be done in a way that strengthens the current curriculum
Thank You

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