1 Becoming an Expert

1.1 Introduction

As a university student, you are training to become an authority in your area of expertise. This will require hard work, but we are here to support you. In the “real world,” there is no teacher, textbook, or answer guide that can tell you if you’ve solved a problem correctly. The problems you will be solving are more difficult and time-consuming (often taking years to complete a single problem), and the costs of errors are much higher (consider the Space Shuttle Challenger disaster\(^1\), or NASA’s $94 million “metric mixup”\(^2\)).

In this class you are training to become an expert, which will require a shift in your thinking. Here are a few guiding principles to remember. Experts:

1. Reflect on their work. Experts have a deep understanding that is robust and flexible.

2. Persist on working through difficult problems. Just because you can’t do it yet doesn’t mean you can’t learn to do it. Learning comes from struggle; if something feels too easy, you’re probably not learning that much.

3. Support and learn from one another. As a professional, your colleagues will be your most valuable resource, and in this classroom your classmates are your colleagues. Don’t be afraid to ask questions - you don’t have to know everything now, but you have to be willing to learn it.

As a part of your training we will engage in Peer-Assisted Reflection (PAR), a specialized peer activity designed to help you develop deep understanding. Deep understanding of mathematics requires that you don’t just do mathematics (e.g., plug and chug), but that you think about what you are doing, talk about it, and reflect on what it means. You should get in the habit of reflecting upon your work, asking yourself questions such as:

- What was the purpose of...? How does it help?
- How do you know that...? Do things always work this way?
- What does it mean that...? What’s really going on here?

If you really understand something, you should be able to answer these questions.

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\(^1\)The entire vehicle disintegrated after the failure of an O-ring seal in the right solid rocket booster: http://science.ksc.nasa.gov/shuttle/missions/51-l/docs/rogers-commission/Appendix-F.txt

1.2 Classroom Norms

How you engage in class will determine how much you learn. If you just sit passively in class, you will not learn nearly as much as if you are actively engaged. You and your classmates are a learning community. It's your responsibility to help create a positive environment in which you all can learn. Here are some guidelines for learning and helping your fellow classmates learn:

- Ask questions. The class will move at the pace you set. Chances are other students have the same question as you, but are too shy to ask it. The only bad questions are the ones you don't ask.

- Take risks. You’re not supposed to know everything already; the reason you are here is to learn.

- Explain your approach. (Don't just give answers.) The more you explain your ideas the better you will understand them. Other students will learn from you too.

- Talk to the class, not just the instructor. Listen to and learn from your classmates. Your classmates will be your most valuable resource for learning; get to know them and becomes friends and colleagues.

- Respect yourself, your classmates, and your instructor. Encourage your classmates to take risks and help create an environment in which it is okay to do so. In turn, they will do the same.

1.2.1 Working with other students

Throughout the PAR activities and other in-class exercises you will have opportunities to work with other students in the class. Developing the ability to work with others is a lifelong skill that will help you throughout your career. Here are some basic guidelines for working effectively:

- No talking outside your group.

- Everyone stays together. (Everyone in the group has something valuable to offer.)

- You have the responsibility to ask for help and the responsibility to offer it.

- Helping others does not mean giving answers.

- Ask, “why?”

- Call the instructor for group questions only (questions that influence all students in the group, and that you can’t resolve within the group).

- Don’t give up; if you keep trying you will get it.
1.3 Effective Solutions

The purpose of a solution is to communicate understanding. As a professional, you will solve problems that nobody has ever solved before. Others will need to read your solution and be able to learn from it.

Communicating effectively requires consistent practice, and is one of the key goals of peer-assisted reflection (PAR). Communicating in writing is very different from in conversation. Your reader can’t ask you questions, so you need to add extra detail to your writing to avoid any possible ambiguity or confusion. You should always ask yourself whether or not a peer could understand your work without talking to you.

An effective solution should communicate both your approach and some justification that it is correct. It is often hard to be certain that your solution is correct, there are many common pitfalls you can check for obvious ways your solution may be “incorrect.” Here are some questions to ask yourself to make sure your solution is complete.

- Did you answer all questions asked, showing all steps, in the proper order? Is it clear where all numbers and equations used in your work came from?
- Did you explain why (not just what)? In addition to how you solved the problem, is it clear why you solved it that way?
- Did you avoid the use of pronouns (and other ambiguous language)? Is it clear when you’re talking about a property of an object rather than the object itself (e.g., a line is a function, its slope is a number)?
- (If applicable) Did you consult definitions of mathematical vocabulary you used?
- (If applicable) Did you label and explain all graphs, include units, etc.?
- Did you justify your solution (in at least 1 of the following ways):
  - by checking if answers to different parts of the question are consistent?
  - by explaining (in writing) how you know your solution is correct?
  - in some other way? If so, how?