Detecting Understanding Gaps

“It ain’t what you don’t know that gets you into trouble. It’s what you know for sure that just ain’t so” Charles F. Kettering - wiki (a frequently misattributed quote)

“A problem thoroughly understood is always fairly simple” Charles F. Kettering wikiquote

“Everything should be made as simple as possible, but not simpler” unknown Quote Investigator

Detecting weaknesses and shallowness in your understanding and logic is a difficult but essential part of grant writing. Although several cognitive biases act to cause the problem, just being aware of these doesn’t prevent the problem. Instead, you have to employ processes shown to reduce the problem. That is the purpose of this exercise.

This problem is called IOED (illusion of explanatory depth). Compared to linear processes, self-judging our understanding of complex systems and processes is deceptively difficult. Our self-judgement of our understanding of a linear process, such as the unfolding of a story or movie plot, is usually correct. But when the correctness of our understanding of a complex process is evaluated, it is often found wanting. “A Private Universe” (YouTube fragment), filmed at a Harvard graduation and elsewhere, famously demonstrated this problem and led to curricular delivery changes.

An animal is a complex, adapting, self-correcting biological system. Identifying the weaknesses in our understanding of the relationships within even a small part of such complex biological systems is difficult for several reasons. We perform many things technically with successful outcomes that don’t require the deeper understanding needed for successful research. Experience with a system breeds familiarity, leading to an increasing sense of understanding even though our underlying understanding actually doesn’t improve. Our working memory is too limited to simultaneously comprehend the many interactions and relationships between the components involved in a complex system. Instead, we often hold a reductionist understanding based on holding other factors artificially constant. System dynamics focuses on understanding the behavior of complex systems over time, using computer simulations to evaluate this understanding. The discrepancies between model behavior and actual system behavior are often surprisingly large, suggesting that our understanding of the cause-and-effect relationships between system components often have serious weaknesses. We often reinforce our belief in learned but erroneous dogma by committing a Type III error, which occurs when we interpret seeing an outcome we expect as supporting the erroneous but unexamined dogma.

Causal knowledge is organized around explanations of specific why questions. Because causal knowledge about complex systems is nested from general to specific, sequential why questions either lead to a deeper explanations or illuminate a gap in understanding. For science, most why question chains should end at a primary refereed scientific paper, preferably several. The deeper one’s causal knowledge, the deeper questions one can ask and the more complex problems one can solve. Root cause analysis, sometimes called the 5 whys, is one process for pursuing deeper explanations.

The first principle is that if you can’t explain it, you don’t know it. If you can’t explain it, you are likely making assumption(s), which in turn may be erroneous. How do you know it? If you don’t know how you know it, you are likely using dogma rather than scientific knowledge.

Principle - Docendo discimus - “by teaching, we learn” - Seneca the Younger

To successfully describe something to someone else, you have to have formed a complete and understandable explanation yourself.
Process:
In groups of three, each person takes up to 10 minutes to explain the natural process at the core of their research project, what is not known about that process, and how they will determine that answer to their two peers. The two peers listen, constructing questions and then spend five minutes asking their questions. After 15 minutes, switch roles, the idea being to balance time for everyone. Be careful of getting hung up on a point.

Explainer:
With attention from your non-expert peers, diagram the cause-and-effect relationships (causal map) of your problem in pencil on a sheet of paper. Include the environmental factors that would impact external validity in the clinical environment as well as the confounding and nuisance factors that impact internal validity of your study. Get the clear pieces down before addressing the fuzzy or unknown pieces. The more specific than abstract you can be, the better. Make the causal connections between all the components, indicating what influences what, the direction of this influence, positive or negative, and how time is involved, such as immediate or lagged. Explain these relationships to your peers as you diagram them. What is the structure? What ties ideas together? What are the important details? When you detect a gap in your understanding, note it as a gap. When their question uncovers a gap in your understanding, note it as well. Note the words you use for which the meaning is not completely clear to you. Although you may construct a diagram ahead of time for practice, to avoid overloading your questioners' working memory (comprehension of unfamiliar material occurs at about the speed of drawing) you must draw a new one during your explanation.

Two Questioners:
Your role is to construct at least several well-founded, focused, effective questions about what is assumed, what is missing, what might be extended, and what is vague or unclear while listening to the explainer. Pay attention to the explainer's chain of reasoning sufficient that you could re-create their causal diagram. Consider making your own cause-and-effect diagram so you that you can attach your questions to specific points on it.

To avoid disrupting the explainer's thoughts, consider asking your questions after the explainer has completed their explanation. What is the real question the explainer is addressing? The right questions clarify understanding, expose issues, and focus attention on features that matter. If you don't understand a concept or a relationship, ask a question for an explanation. Do not assume that the explainer knows the full explanation that led to their conclusion. If an alternative occurs to you, ask a "What if . . . ?" question. Don't play gottcha and don't pretend to know more than you do but don't gloss over ambiguity. Construct genuine, probing questions. If discussion gets hung up on a question without progress, table it and move on, returning to the question if time remains after all the other questions have been addressed.

For discussion and feedback in the final 5 minutes - How did this go? What worked well? What didn't work so well? What might work better next time?

A similar approach is "the Feynman Technique"; Googling the phrase yields hundreds of hits explaining how to do it. - Scott Young’s version - pdf YouTube
Another approach is the ADEPT Method - Learn Difficult Concepts with the ADEPT Method - Better Explained

references:
● Chap 4: Understanding how things work, pgs. 89-119 in: Smart Thinking: Three essential keys to solve problems, innovate, and get things done, 2012 - A Markman (KC2MM) - Amazon
● The Five Elements of Effective Thinking, 2012 - EB Burger, M Starbird - Amazon