How to Solve a Problem

Insights for Critical Thinking, Problem-Solving, and Success in College

Kelling J. Donald

CRC Press
Taylor & Francis Group

"Donald provides a treasure trove of information applicable to students across the academic spectrum. For example, he presents the rationale for using logic, not rote memorization, to solve problems, and he discusses the importance of getting the most from a textbook. Students will find the information in this book invaluable!"

—*Professor Saundra McGuire, author of* Teach Yourself How to Learn

"Quantitative problem-solving skills are essential for success in introductory science courses. Prof. Donald's text offers a helpful guide for first year undergraduate students on the necessary basic mathematics and general strategies, as well as explaining how students can more effectively study and communicate their scientific results."

—*Professor Joshua Schrier, Fordham University, New York*

How to Solve a Problem

This concise and accessible resource offers new college students, especially those in science degree programs, guidance on engaging successfully with the classroom experience and skillfully tackling technical or scientific questions. The author provides insights on identifying, from the outset, individual markers for what success in college will look like for students, how to think about the engagement with professors as a partnership, and how to function effectively in that partnership toward achieving their pre-defined goals or markers of success. It is an ideal companion for science degree prospects and first-generation students seeking insight into the college experience.

- Offers transferable problem-solving ideas and skills applicable for other disciplines and future careers.
- Provides new students with support and inspiration for their college experience.
- Includes guidance for successful interactions with professors, peers, professionals, and others.
- Encourages thoughtful determination of desired outcomes from the college experience and shaping one's actions toward accomplishing those objectives.

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Dedication

for
My Foreparents

who, in solving problems threatening basic survival,
afford my generation the space, access, and resources
to voluntarily tackle other types of problems

and

My Teachers

Contents

Preface

If a student makes it into a freshman college classroom, the assumption is that the student can succeed academically. As each course gets underway, it falls to the instructor to teach well and to support the student in learning well. It falls to the institution to provide opportunities and resources, and to create a context that encourages and facilitates success, but it falls to those in the arena – the instructor and the student – to make use of those opportunities and resources, in line with our respective roles, to achieve desirable academic outcomes.

For professors in that instructor-student partnership, one of the perennial questions is how to provide students with the relevant support that they need to prosper in a given course or in their work on a particular project. One reason that the question is always under consideration is that there is no single eternal answer, no universal salve that works equally well all the time for every single course. The best approach that an instructor can take, therefore, is to consider each context and identify, based on the pedagogical literature, experience, and insight, relevant and practical strategies to help students succeed.

And what of the student's position in that partnership? Each course and each professor is different, and students work out quite quickly that different approaches are needed in different cases to achieve successful outcomes. Courses may have, for example, different structures, unique stipulations (for types of assignments or modes of completing and submitting them), or even different ways to gain or improve grades (if attendance or participation are mandated or not), and so on. Then there is the

actual work of learning and performing in the course itself. So, students too must consider how best to position themselves to succeed in each course. And, thankfully, students will generally do all of that and more, if they feel and in fact are supported in that effort.

These notes address particular areas of the academic demand on students in the college classroom: problem-solving, critical thinking, and general aspects of generating and reporting scientific results. After over a decade of teaching, advising, and mentoring undergraduates in traditional courses and scientific research, I found that I had accumulated pieces of notes here and there from interactions with students on how to think about and tackle one chemistry question or another. These came sometimes from informal conversations on topics in introductory or physical chemistry, discussions during laboratory sessions, office hour help sessions for problem sets, or reviews of practice exams. Thinking about some of those encounters, a few general themes seemed to emerge, and I thought it would be helpful to assemble those notes and any helpful perspective or strategy that I have considered or shared over the years all in one place where students could encounter and revisit them as needed. In many of those interactions, for example, I noticed that it was often a single missing piece of insight that caused a problem to seem intractable to students, a lack of confidence in pushing a problem to its logical end (yielding sometimes at the penultimate step), or the need for a more orderly and systematic approach to solving problems. Being unprepared in the regular sense – not attending classes, not reading notes or textbooks – was typically not the reason for the problem-solving difficulties mentioned above. This book is a response to those observations and to many mentoring conversations that I have had with students in teaching and research settings.

Students from myriad high school backgrounds converge in our increasingly diverse college classrooms. They are all called on to perform at high levels academically from the outset, and some are inevitably more prepared than others based on the quality of their high school experiences. The hope is that these notes will be useful in supporting students across that spectrum, including students who feel underprepared, to orient themselves to ways of thinking about and encountering, with confidence, the culture and academic demands of the college environment.

Each chapter in the book may be read independently, though some basic ideas do carry over from one chapter to the next. We sometimes develop mental barriers to written technical

questions based on how we perceive them (as too long, or having a lot of jargon or symbols, etc.) before we settle in to read or start to strategize to solve them. In the earliest chapters, the book offers some suggestions for making the most of the information provided directly and indirectly by a problem itself. The reliance on the thread of logic in a question, even in cases where the full path to a solution is not immediately clear, is encouraged, and hints are provided for handling questions that require transparent explanations in prose or 'short answer' form rather than in a stream of equations. Textbooks are severely underutilized if we consult them only when the professor mandates certain chapter or page numbers, and 'Making Textbooks Pay' encourages students to reconsider what textbooks offer – whether they are free electronic versions or costly tomes.

Questions that rely heavily on mathematical skills can be major sources of problem-solving challenges for students in the introductory college science classroom. Memorization and studying to the test, which may have been reliable strategies for some high school classes, are approaches that will rarely work to achieve the highest levels of success in college courses. In such cases, the imperative will be to understand core principles and concepts and to apply them in solving a variety of problems. A relatively long section is dedicated to solving mathematical problems. It weaves problem-solving strategies into a conversation on critical thinking that runs throughout the book, and the chapter integrates an overview of key topics in mathematics that are likely to appear and reappear for science students everywhere. Even for students who take mandatory mathematical courses before launching into biology, chemistry, or physics degree programs, for example, this overview may serve as a handy reference, offering helpful reminders of useful mathematical concepts and insights into other skills and practices that are vital in college. A brief affirmation of the experimental nature of science, the various approaches to sharing the result of scientific investigations, and some additional thoughts on problem-solving are included in later chapters.

This work is intended for students, yet it is not a textbook and definitely not a review of the contemporary literature on academic skills. The focus is on how to think about problems, even as factual scientific and mathematical information is provided along the way. Ideally, it will yield, especially for students near the start of the freshman year, some perspectives and strategies to strengthen their growing problem-solving skills and maturing habits of mind as they move toward their desired academic outcomes.