Reflections on Why and How to Keep a Lab Notebook

The laboratory notebook occupies an iconic, if not always beloved, place within the culture of science education. Students who have taken college-level courses in physics, chemistry, or biology almost certainly have experience with “notebook writing”, although the substance and tenor of such writing probably varies wildly from class to class. In some classes, the writing is almost entirely a set of “answers” to prompts provided by the professor, while in others, the student is given leeway to structure the content and style of the writing.

What science students can lose track of is that, at its best, the notebook is not just another assignment: it’s a powerful scientific tool, used by real scientists in real labs the world over. Bio-informaticist Eric-Wubbo Lameijer notes that “most great scientists had lab journals and/or produced voluminous quantities of writing, and there are even some indications that labjournalling in the right way may not have been a bitter duty to them, but a valuable resource in becoming even more brilliant.” Not only is there ample evidence that ‘thinking with the pen’ provides cognitive benefits to the writer, but the writing itself persists over time, creating an intellectual travelog whose power to bind disparate thoughts and observations sometimes only become apparent once the writer has finished the journey.

There is no single “correct” way to structure a scientific notebook. A naturalist’s notebook might be filled with sketches of plants and animals, a chemist’s might include formulae or diagrams, and a design engineer’s might mix schematics with back-of-the-envelope calculations. Figure 1 shows a snapshot of Thomas Edison’s laboratory notebook. The book is neat and organized, with numbered pages and diagrams interleaved with technical notes. One of Leonardo DaVinci’s notebook is shown in Figure 2. This book is a beautifully configured mixture of text, geometry, and figures, and reflects the authors multifaceted interests in design, art, and mathematics. Figure 3 shows a snapshot of Einstein’s notebook. There is a long chain of equations without page numbers, a few connecting arrows, and just a touch of commentary.

In figuring out how to design your own notebook, it is important to keep in mind is that the purpose of the notebook is to help you marshal your own thoughts. In this sense, the only thing that distinguishes you from an Edison, a DiVinci, or an Einstein is that you happen to be enrolled in a class, and thus need to bring your investigations in line with what the professor thinks is important. (As an independent scientist, you would need to come up with what you thought was an important line of inquiry, and set your own tasks.) But don’t overplay this difference: research is the process of figuring stuff out, regardless of whether you are a world expert or a rank beginner. As an educator, my goal is to help you think and act like a researcher, and the labs that I design and the tasks that I assign are done with this exclusive purpose in mind.

Concretely, then, I propose the following guidelines for filling out your notebooks over the course of this term:

- **Write about you find important and/or interesting.** Different people will take different things away from each laboratory. I give you “Pause for Reflection” assignments in the hope that you will take some small nugget of an idea and run with it, but where and how far you run is up to you. Run with the knowledge that I’m not checking to see whether you got things right or wrong—I’m really only checking to see that you’ve taken ownership of the problem.

- **Observe accurately.** If you run a numerical experiment, record the outcomes in a sensible way. Tables and sketches are good options. Words can be useful to describe features that are difficult to draw or tabulate.
• **Speculate.** Why did you get a certain outcome? Are there further experiments this outcome suggests? Can you conclude anything general about the nature of this sort of problem? What is “this sort of problem”, anyway? Group, classify, synthesize—these activities form the basis of our conceptual understanding of the world.

• **Be playful.** This is your notebook, have fun with it. Include a picture of Kilroy, summarize your results in a haiku, use different colors markers. Writing in a lab notebook will be most fruitful if you do it in such a way that you take creative control of the output.

At the end of the term, you’ll be tasked with writing a paper. In essence, this is a research paper, and has the potential to be of publishable quality, if you pursue it rigorously enough. The more seriously you take your lab book, and the more energy you invest in making it a space for creative thought, the better prepared you’ll be for this process.
Figure 3: Snapshot of Einstein’s notebook.

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\begin{aligned}
\sum_{\alpha\beta} \left[ \eta_{\alpha\beta} \left( \begin{array}{cc}
\frac{\partial y_{\alpha\cdot\xi}}{\partial x_{\xi}} & \frac{\partial x_{\eta}}{\partial x_{\xi}} \\
\frac{\partial x_{\eta}}{\partial x_{\xi}} & \frac{\partial y_{\alpha\cdot\xi}}{\partial x_{\xi}} 
\end{array} \right) - \left[ \begin{array}{cc}
\frac{\partial y_{\alpha\cdot\eta}}{\partial x_{\eta}} & \frac{\partial x_{\xi}}{\partial x_{\eta}} \\
\frac{\partial x_{\xi}}{\partial x_{\eta}} & \frac{\partial y_{\alpha\cdot\eta}}{\partial x_{\eta}} 
\end{array} \right] 
\right] \\
\sum_{c} \left[ \eta_{c\cdotc} \left( \begin{array}{cc}
\frac{\partial y_{c\cdotc}}{\partial x_{c}} & \frac{\partial x_{c}}{\partial x_{c}} \\
\frac{\partial x_{c}}{\partial x_{c}} & \frac{\partial y_{c\cdotc}}{\partial x_{c}} 
\end{array} \right) - \left[ \begin{array}{cc}
\frac{\partial y_{c\cdotc}}{\partial x_{c}} & \frac{\partial x_{c}}{\partial x_{c}} \\
\frac{\partial x_{c}}{\partial x_{c}} & \frac{\partial y_{c\cdotc}}{\partial x_{c}} 
\end{array} \right] 
\right] \\
\sum_{c} \left( \frac{\partial y_{c\cdotc}}{\partial x_{c}} - \frac{\partial x_{c}}{\partial x_{c}} \right) = 0 \\
\end{aligned}
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