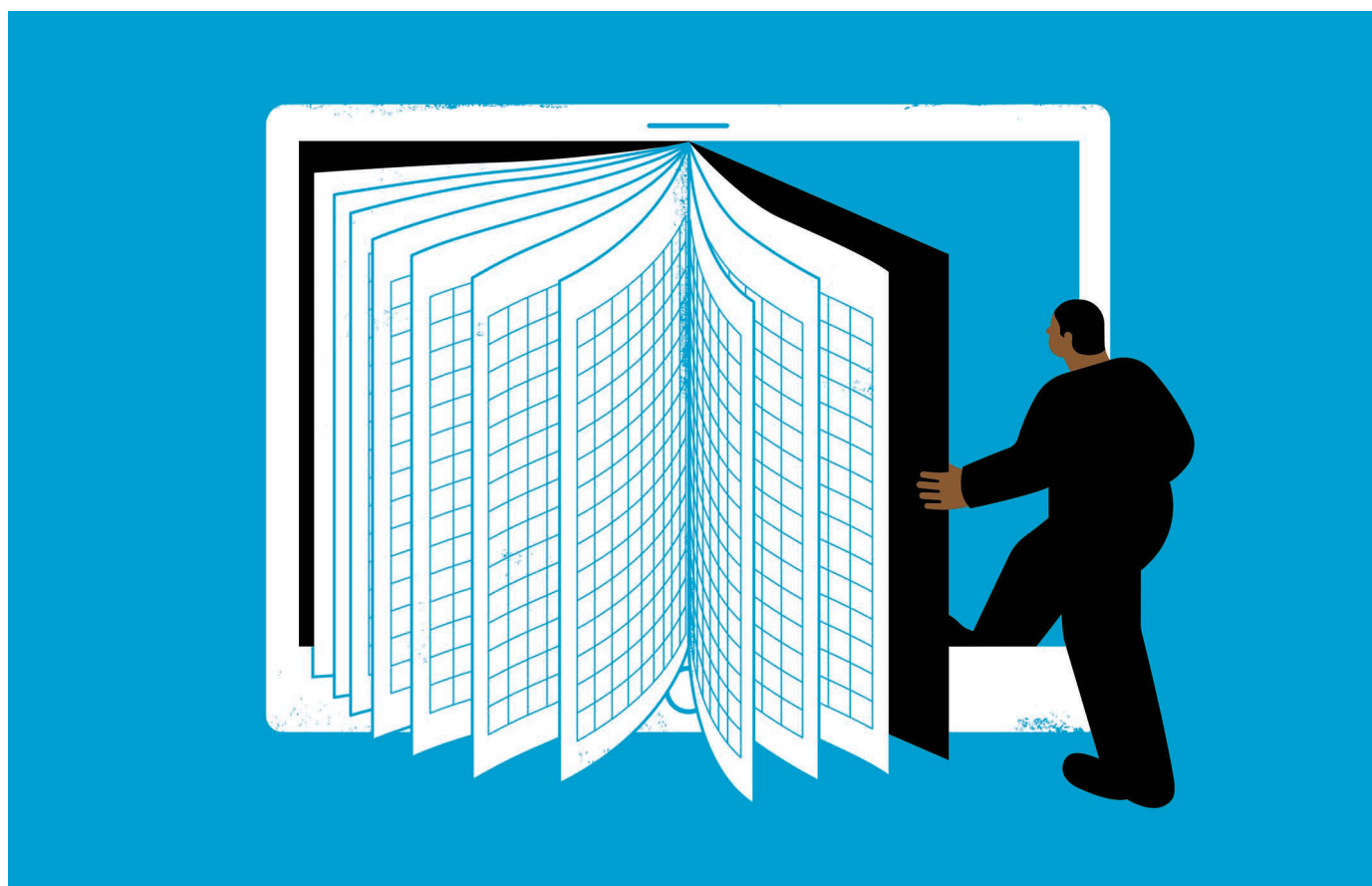


TOOLBOX

LAB NOTEBOOKS GO DIGITAL

A burgeoning array of digital tools is helping researchers to document experiments with ease.

ILLUSTRATION BY THE PROJECT TWINS



BY ROBERTA KWOK

Since at least the 1990s, articles on technology have predicted the imminent, widespread adoption of electronic laboratory notebooks (ELNs) by researchers. It has yet to happen — but more and more scientists are taking the plunge.

One barrier to uptake is the wide range of products available. ELNs comprise software that helps researchers to document experiments, and that often has features such as protocol templates, collaboration tools, support for electronic signatures and the ability to manage the lab inventory. But the ELN market encompasses considerable variety; a study conducted in 2016 by the University of Southampton, UK, identified 72 active products

(S. Kanza *et al.* *J. Cheminformatics* **9**, 31; 2017).

“It’s just insane,” says Sian Jones, a petroleum engineer at the Delft University of Technology in the Netherlands. “It does become very confusing.” And many researchers simply lack the time or motivation to make the move to ELNs.

But today’s early-career researchers, who have grown up with digital technology, tend to expect — and to embrace — electronic solutions. Recent trends in research have also created a demand for such changes: as scientists deal with increasing volumes of data, gluing printed results into a paper notebook becomes more archaic. Concerns over reproducibility, as well as more stringent requirements on data management from funding agencies, have motivated improvements in the documentation of lab work. And the ELN

market has expanded to include more intuitive tools, such as cloud-based products, which are easier to adopt than those requiring information technology (IT) support to install. “I do feel that we’re approaching a tipping point,” says Alastair Downie, head of IT at the Gurdon Institute at the University of Cambridge, UK.

ELN developers say that they have also seen signs of growing interest. Where researchers once questioned the utility of ELNs, now they are quicker to commit, says Simon Bungers, co-founder of labfolder, an ELN company in Berlin. Benchling, an electronic research platform in San Francisco, California, has seen use of its ELN in academia more than double for the past two years, with tens of thousands of researchers now logging in every day, says chief executive Sajith Wickramasekara. ►

► And many universities have started to provide such products to their researchers. For instance, LabArchives in Carlsbad, California, has sold campus-wide site licences for its ELN platform to more than 375 research institutions worldwide. (Last month, LabArchives announced a partnership with Macmillan Learning of New York City, which is part of Holtzbrinck Publishing Group in Stuttgart, Germany; Holtzbrinck is the majority shareholder in *Nature's* publisher, Springer Nature.)

Advocates tout the many advantages of ELNs over their paper counterparts. They are easy to search, copy and archive. And thanks to templates, scientists don't have to rewrite protocols. Researchers can link experiments to specific samples or files, as well as share information easily with other lab members and collaborators, facilitating reproducibility. And supervisors can monitor the activity of their teams remotely.

But there are downsides, too. Although many companies offer free versions of their ELN software, those often come with limits on the number of users, data storage or file size. If the company folds or raises its prices, researchers might find themselves with only a PDF export of their data, which they are then unable to transfer to a competing product. Network interruptions could temporarily restrict access to data. And researchers might still prefer to make some notes or sketches on paper at the bench, which must then be imported into the ELN.

Despite these shortcomings, more and more researchers are going digital. To find a software solution that suits your needs, experienced users suggest taking the following steps.

Get educated. Online resources can give prospective users a sense of the market. Downie's guide to ELNs (go.nature.com/2v7ia9q), hosted on the Gurdon Institute's website, includes information on attributes such as cost tiers, support for computing platforms, and where the data can be stored for 28 products. The Electronic Lab Notebook Matrix (go.nature.com/2n54fma), collated by Harvard Medical School in Boston, Massachusetts, lists the details of more than 50 features for 27 ELNs. And labfolder provides a guide to 16 popular ELNs (go.nature.com/2vco2hz).

Calculate costs. Paid versions of most ELN services used in academia cost US\$10–20 per user per month, Downie says. The restrictions that are associated with free versions of these tools might be malleable, particularly as storage prices fall; Wickramasekara says that the 10-gigabyte limit on Benchling's free academic platform, for instance, can often be raised on request. Open-source options such as the Open Science Framework from the Center for Open Science in Charlottesville, Virginia, also are available.

Understand legal issues. Some funders place restrictions on where data can be stored, so researchers should keep this in mind when

evaluating cloud-based ELNs. Scientists who use personal data that fall within the scope of the European Union's General Data Protection Regulation should consider whether an ELN's data storage complies with those rules. Choosing ELN software that enables completed

“You can't just stick your toe in the water. You've got to dive all the way in.”

pages to be locked and electronically signed could be crucial if the documents are needed to defend researchers against claims of fraud, or must be submitted to the US Food and Drug Administration as part of regulatory processes. Digitally signed and witnessed documents could also be used as evidence in a patent dispute, says Denise Callihan, who manages library services, including patent searching and ELN system, for paints and coatings company PPG in Monroeville, Pennsylvania. PPG uses an ELN software called PatentSafe from Amphora Research Systems in Andover, Massachusetts.

Evaluate stability. Researchers might want to assess the ELN company's chances of survival. Daureen Nesdill, a research-data-management librarian at the University of Utah in Salt Lake City, says she considered this question when evaluating options in 2010. She favoured LabArchives, partly because the company's executives had already launched successful bibliographic-management software. Nesdill advises researchers to choose a company that is at least five years old, has stable funding and states in its terms of service that users will be able to access their data if the firm goes under or is sold.

Think mobile. Some labs prefer ELNs that can run on mobile devices. That was the case for Richard Gates, a chemical engineer at the US National Institute of Standards and Technology in Gaithersburg, Maryland. He and his colleagues wanted to use tablets to record experiments while working in a clean room, because the devices are portable and can be wiped down easily. The researchers, who chose Microsoft's note-taking software OneNote as an ELN, use the tablet's camera to take photographs of instruments and results, and a stylus to annotate images.

Consider software integration. Links to favourite software could tip the scales for some scientists. Organic chemists, for instance, might prefer the PerkinElmer Signals Notebook from PerkinElmer in Waltham, Massachusetts, says Nesdill, because it integrates with the company's chemical-structure-drawing software ChemDraw, enabling structures to be added to the ELN. ResearchSpace in Edinburgh, UK, integrates its ELN with tools such as software-development platform GitHub and reference manager Mendeley, Jones notes.

Go for a test drive. Jones suggests test-driving free versions of a few products, ranging from basic to complex. “Don't look at more than four, otherwise your head explodes,” she says. While evaluating several ELNs last year, Christoph Seiler, who runs a facility for zebrafish experiments at Children's Hospital of Philadelphia in Pennsylvania, asked himself, “Is that an interface I can use every day?” He settled on Benchling, partly because he found its ELN to be attractive and well-organized.

Preferences for minor features come down to personal taste. For instance, Downie likes the way that the ELN from SciNote in Middleton, Wisconsin, provides a flexible, flow-chart-like structure, and Jones enjoyed seeing a feed of other users' activities in Labguru, an ELN from BioData in Cambridge, Massachusetts. (Digital Science in London, which is part of Holtzbrinck, is an investor in BioData.)

Try generic platforms. Some scientists stick with generic note-taking products. Michael Gotthardt, a cardiovascular-disease researcher at the Max Delbrück Center for Molecular Medicine in the Helmholtz Association in Berlin, chose OneNote because he wanted a low-cost product with “essentially no learning curve” that the IT department could install locally with ease. Every month, his team exports pages to PDF files and signs them electronically; the files are then moved to a directory where they cannot be changed. Evernote, from Evernote Corporation in Redwood City, California, is an alternative note-taking option.

Commit to change. In 2017, Downie co-led a trial of four ELNs, in which researchers at the University of Cambridge rated features such as user interface, support for collaboration and file-management capabilities. Although many scientists initially expressed enthusiasm about ELNs, only 37 of the 161 participants completed the exercise. “It shows the level of commitment that's required,” Downie says. “You can't just stick your toe in the water. You've got to dive all the way in.”

That said, some acclimatization might be required. Gotthardt gave his team three months to play with OneNote while continuing to record experiments on paper. Everyone then made the switch — a change that went smoothly, he says. Ulrich Dirnagl, an experimental neurologist at the Berlin Institute of Health, which provides labfolder to employees at one of its institutions, says that he has seen the most uptake when one lab member starts using an ELN and word spreads to colleagues, rather than when the entire group is forced to convert.

“Before, they said, ‘I don't need this, and I just want to scribble down my little notes,’” Dirnagl says. “Three weeks into the ELN, they want to press a button for a cappuccino.” ■

Roberta Kwok is a freelance science writer based in Kirkland, Washington.