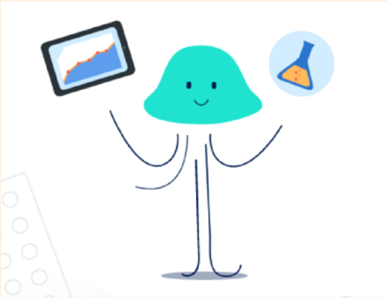

Online Molecular Biology Labs

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Summary

CLOUD-BASED MOLECULAR BIOLOGY SOFTWARE AND DIGITAL NOTEBOOKS are tools I use to encourage students to critically evaluate existing lab protocols, make predictions, or create new experimental designs. These are free to use on any internet-connected device. I use these tools in several ways; for example, sessions can be live with group work; but they also easily support self-directed and self-paced distance learning.

This approach allows students to understand complex laboratory methods before accessing the teaching laboratory, supplementing valuable practical time. Using digital notebooks embeds pre-labs with practicals creating student buy-in for these activities and reviewing "muddiest points" in experimental protocols.

Overview of problem-based learning labs

What are the learning outcomes of a lab-based practical

1) Practical Skills[1]
2) Intellectual skills[2]
3) Transferable skills[3]

[1] Using protocols and equipment, working safely and efficiently in a lab
[2] Higher-order thinking, planning experiments, analysing and intepreting data
[3] Group working and communication, organisation

An overview of a problem-based learning focused lab practical might work as follows:

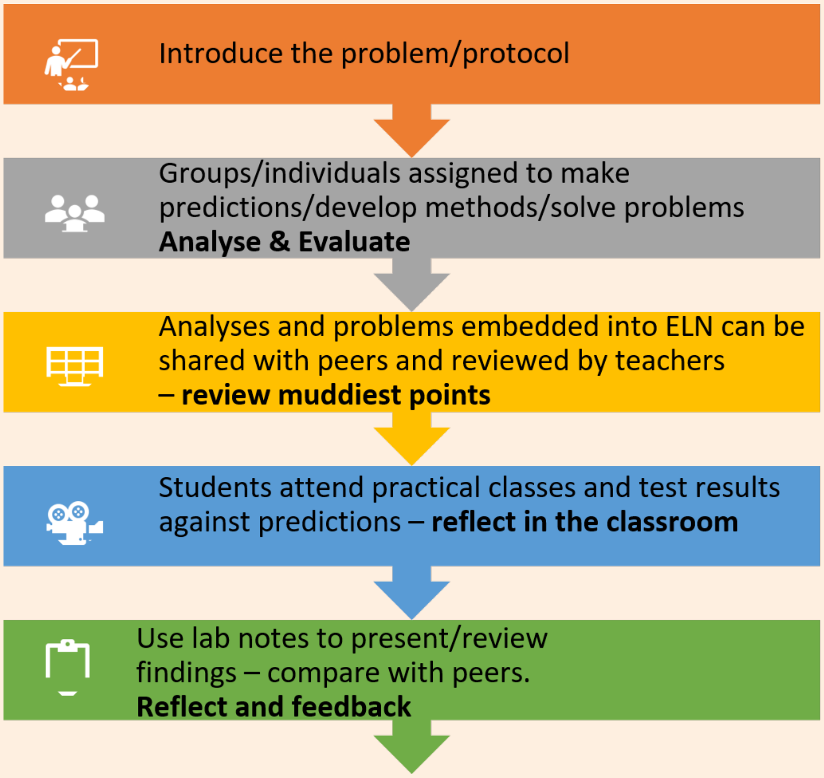

Figure 1: overview of steps

Benchling

Problem-based learning doesn't *have* to use any software or particular platforms, but I use Benchling, a free, cloud-based software platform for academics. Originating as a research tool it incorporates an Electronic Lab Notebook (ELN) and a suite of molecular biology analysis tools. It can be readily adapted to work as a virtual learning tool, helping to emulate a variety of scientific processes without being in the lab. Project level organisation allows instructors to develop protocols and worksheets which can be easily disseminated to students, lab reports and analyses can be easily viewed, shared and exported. Analyses, predictions, sharing and reflection can all occur in one virtual space.

Topics

The Molecular Biology suite has a range of functions and analyses which can be readily adopted for lab teaching[4] and in collaboration with Benchling I have made some very short introductory worksheets that introduce simple problem-based learning approaches to common molecular biology techniques. I would love to get your feedback, so please take a look with the links provided below:

[4] I have written a series of introductory worksheets for students that can help ease them into using Benchling and apply some problem-based learning, In the list here I have made some direct links to different worksheets but you can find the main page here

1. Plasmid cloning
2. Primer design
3. Gel electrophoresis and Restriction Digests
4. CRISPR

All analyses can be attached to Lab Notebooks[5].

[5] Check this link for a short video of me running through a template lab notebook

Accessibility

No installation of software is needed, students have individual accounts that can join instructor administrated classes. Projects can be set up easily to allow for peer-based learning and reflective tasks The whole system is cloud-based and operates most effectively with Google Chrome.

Examples

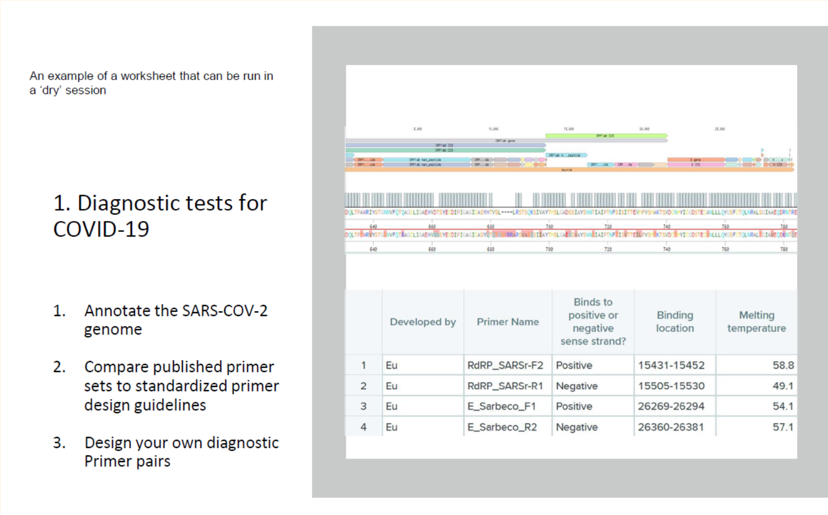

Figure 2: Diagnostic tests for COVID-19: a problem-based learning exercise that can take place outside of the labs. Students first annotate and discuss features of the SARS-COV-2 genome, look at bindings sites of primers and conditions for amplification of diagnostic PCR tests, finally they are asked to design their own primer pairs and discuss

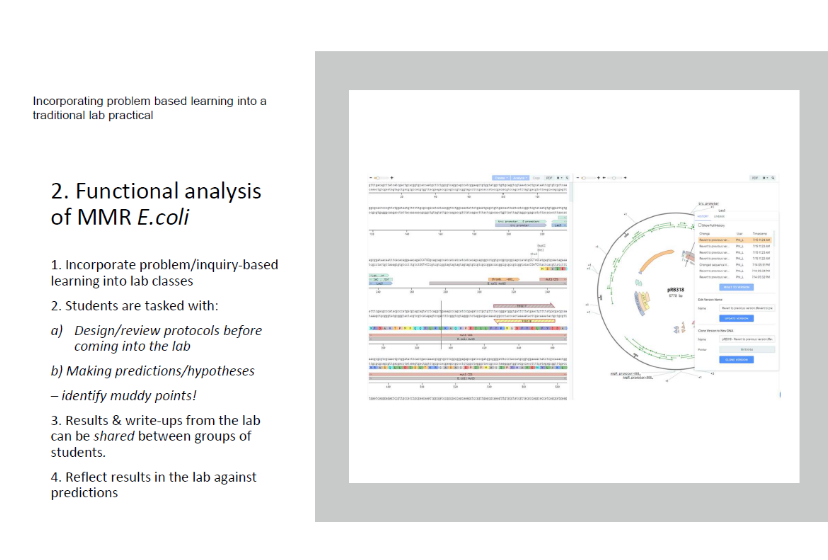

Figure 3: Functional analysis of MMR in E.coli: this lab practical has been modified to include protocol reviews and problem-solving before the students come to their first lab. Students are asked to note down muddy points in the practical, solve small problems and make predictions. Within the lab sessions, students refer back to their predictions as they gather results, and are asked to make reflections. Group working - even under social distancing - is possible through share lab note spaces

Contact

I would love to hear from you - if you want to talk more about problem-based learning in labs, electronic lab notebooks, or geneal feeback then please get in touch with me via e-mail: p.leftwich@uea.ac.uk or Twitter PhilipLeftwich[6]

[6] You can also see what else I get up to, by visiting my website philip-leftwich.github.io