

Open-source remote laboratories for accessible, sustainable practical work

Prof Timothy D. Drysdale

School of Engineering,
University of Edinburgh,
Kings Buildings,
Edinburgh EH9 3FG, UK

If you do in-person laboratories as part of your educational activities, then this talk is for you.

These days we are seeing more and more students and the graduate attributes that we want to create are evolving. The kind of experiences we give students need to evolve as well. And in the case of our engineering degree which is fully on campus that direction is more interactive work, more practical work, more exploratory work. Not just putting people in a laboratory to follow some steps, but to really dig into what is going on in that education.

Now if you have a city centre campus in an ancient city like Edinburgh then it is pretty challenging just to whizz up a new building when you want one. It can be done, but it takes time and it takes money. On the other hand, if you have access to remote laboratories, you can short circuit that whole process, and open up a new world of educational opportunities you just can't get in an in-person laboratory. So you win twice when you go this way.

What is a remote laboratory? Let's have a look. This is a remote laboratory that we are using for a third year controls course. The experiments are in these miniature model containers, and that container is to give the sense of the idea of travel. It's hybrid travel. The students connect to the experiment via web browser. Yes there is a streaming energy cost there but it is much much lower than the cost of transporting a student from one part of the country to another or even one part of the city to another.

If we imagine a future world in which every University, every School, has remote laboratories that suit what they do, and shares experiments with other places, then we get all sorts of benefits of this hybrid travel without the footprint that goes with it. Now I am not going to offer any calculations here because it is very difficult to do – what to include, what not to include – but it is pretty clear that we can get some great steps forward in terms of diversity, reliability, robustness and redundancy by all sharing lots of experiments together.

But things are not mainstream yet, and I'll talk a little bit more about that as I go, because the infrastructure we need to do that is growing, we're developing it now, but we've got some steps to take. Looking at the steps we've taken ourselves, in 2021 during the pandemic, one of the few laboratories we ran was the remote laboratory. We had these wooden boxes in one of our classrooms. Moving on to 2022, we turned them into the metal boxes I just showed you.

Now those metal boxes are approved to sit in our foyers and in our public places, and that means that we are able to turn space that otherwise is not as highly valuable as a research laboratory or an office or a teaching space, into something that is really high value to us. So you can imagine seeing science museum-style campuses around which would make it really

interesting for students and visitors, but it is also a great way of getting value out of space you have already got.

It's really important to recognise that we're not trying to replace in-person laboratories. They have characteristics that we just can't translate online. Although those characteristics, the psycho motor skills and sensory appreciation, they are only two of perhaps over slightly more than a dozen different intended learning outcomes that come from labs. So there really are great benefits to doing remote laboratories, but they are complements, not replacements. In fact we can go a step further, and start thinking about the asynchronous nature of them and thinking about whether we are trying to replace teachers with the interfaces but again, we're not. It's a complement. And in fact, we're actually starting to view – if we take a critical post-humanities approach – the technology elements as collaborators in an assemblage, in a process of education, that involves the students, the equipment and the staff, in an asynchronous interaction. There is an awful lot to explore about how those interactions take place between the user interfaces and the students, and how the staff are involved in that. But before we can really get to that amazingly exciting work and all those exciting opportunities, we have to solve the problem of the pragmatic access to the experiments themselves.

And that is where the digital infrastructure comes in. Many remote laboratories to date have been built as part of expensive, externally funded projects, and as a result they focused on producing certain experiments for for certain courses, and it is quite difficult to get access to those experiments as a third party. You typically have to go through a human gatekeeper. That can really slow down development, so there is a great opportunity here to find a different way of doing things that can let us go mainstream with remote laboratories. Of course, we could wait for a commercial supplier to give us something that covers our basic needs. The chances are one size fits no-one, at least not perfectly. And as it is, it is quite a fragmented market, so there isn't a mainstream solution here yet be it commercial or open source. But we do have some really great projects that have started up around the world. The advantage of building something like this ourselves is that it allows us to customise it to suit all of the different cultural variations we see around the world.

If we keep it academic, then we also solve some other problems to do with privacy and surveillance, because we can use the rich data stream but we don't have to monetise it. And that means we can pick and choose only the things that are fair, transparent, and reasonable to pull from that data stream. Surfacing those interactions that are happening in a laboratory is really important too. When we talk about a large in-person laboratory, it's great to interact with students and see what they are up to. It's difficult to get around everybody, and when we go to an asynchronous online system that immediately becomes invisible until we tap into that data stream. But if we tap into that data stream there is a really good chance we can see more than we can see in a conventional in-person laboratory.

Another benefit of remote laboratories is that we can create authentic assessment where students will be interacting with the kinds of things that they will be doing in their graduate professions. So this will take us in a different direction than pen and paper exams, and it is one I am really excited about. And last on my list, but certainly not least, is the great opportunity for student co-creation.

This comes back to needing the right digital infrastructure so there is a really low barrier to entry, but I've learnt so much from the experiments I've put together with other experts in their fields, that I don't know the details of until I start working with the experiments, and then it's a really rich exploratory procedure. So what about students going on that journey? I think that would be really amazing for them. You could almost imagine a world tomorrow where 5th years think about concepts and design experiments to bring them out, 3rd or 4th years might do the implementation, and 1st and 2nd years can enjoy the experiments. And all sorts of variations on that theme. So having the right infrastructure in place allows students to experiment and co-create with us. And that is going to be a really powerful thing for the future.

Of course, all of these benefits sound great, but remote laboratories are not yet mainstream. And in my view that is a two part problem. First of all, the technology isn't there to make it easy to adopt. Because it is not easy to adopt, it's difficult to get personal experience, and unfamiliarity of remote labs, and all the other things we've got going on in our lives, probably adds up for most people to be an insurmountable barrier to get past and we just think "it's unfamiliar, it's not something I really understand, I'm not sure if it is for me, and it would take too much effort to find out."

So I'm on a mission to make it easier to get started, and together with everyone, I'm really looking forward to having a low barrier to entry to remote laboratories and a great worldwide exploration of how we do those interactions, how we design the hardware, how we design the user interfaces, to take advantage of a really great opportunity.

And in fact, given all the pressures we face, it's probably inevitable that we're going to adopt remote laboratories sooner or later, so getting it right, whatever that means, is going to be really important. It's probably not something we can do overnight and as part of getting started, one of the things I would really like to know is from your point of view, what's going to stop you doing this? Whether that is a political or a technical or an educational thought you have, please do get in touch with me and let me know so that I can build it into the things that I am doing to lower the barriers to entry for others beyond those for whom I am already aware of what the ins and outs are. But I would love to know more about what would work for you, and what wouldn't work. So please do contact me via the various means here.

/end