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A new way to equip Africa's science labs: get students to build their own

By Louise Bezuidenhout

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How does one train science students without equipment? As a sociologist of science specialising in African countries, this is a question I get asked with sad regularity.

Water urns become bioreactors with this clever design.

Image credit: Jeffrey Barbee, Alliance

How, African science, technology, engineering and maths educators ask me, can the next generation of globally competitive scientists be trained using teaching laboratories that lack even the most basic equipment?

One of the most basic elements of molecular biology, for example, is to learn about DNA: how genes are expressed and converted into proteins. To do this, students must able to conduct their own experiments – and for that, they need access to a polymerase chain reaction to amplify their DNA samples.

While teaching labs in the global North may have dozens of polymerase chain reaction machines, African departments may have just one per laboratory, if at all. Instead of being able to run their own DNA experiments, students in these labs have to work in groups or watch a demonstration by a tutor.

The critical importance of conducting practical experiments as well as learning theory sets science education apart from many other taught courses. The value of this practical training is two-fold: first, it provides an in-depth understanding of the biological systems that are being studied. Second, the practice of science in industry or academia is essentially a practical undertaking. Any graduate wishing to work as a scientist must have a good grasp of how to conduct experiments and produce data.

While there are increasing amounts of often free educational resources available online: videos, Massive Open Online Courses, papers and tutorials, they can't make up for students getting their hands dirty – so to speak – at the lab bench.

To truly understand their discipline, students need the opportunity to interact with laboratory equipment through practical instruction. Learning how to conduct experiments and deal with both the successes and failures of bench science is an important part of developing as a scientist. The skills that students develop through practical experiments are also fundamental for progressing into successful graduate studies and research careers.

There's been considerable recent support for science and related education in Africa. That includes a rising number of training programmes, graduate scholarships and research support. However, regional universities are still battling to properly equip teaching laboratories. There isn't much money specifically earmarked for this task. Educators often have to rely on equipment bought out of hard-won grants, or rely on the increasingly aged equipment left over from forgotten past projects. New, imported equipment is prohibitively expensive. It's also difficult to maintain.

This is why my colleagues Helena Webb, Jason Nurse, Marina Jirotka and I designed LabHack. It's an event that aims to inspire budding innovators to take matters into their own hands and build the equipment they need to learn. Undergraduate student teams compete to design low-cost versions of basic laboratory equipment using hardware available in a local African context. Our first LabHack was held at the Harare Institute of Technology in Zimbabwe in June 2018. The resulting prototypes were highly inventive and far cheaper than anything that's commercially available.

Innovation in action

During the Zimbabwe LabHack teams of students from four universities, as well as local hobbyists and one high school team, demonstrated their prototypes for low cost laboratory equipment built out of locally-available hardware.

All the teams were interdisciplinary, which was important not only for design issues but also offered a means of building strong links for future collaborations.

The teams were asked to design one of three types of basic but crucial lab equipment: a magnetic stirrer, a polymerase chain reaction machine, and a centrifuge.

There was also an open challenge for students to build other types of equipment that would be used in teaching their specific discipline of science. In this category entries included a digital microscope and a bioprocessor, which is used for culturing cells.

Each team was supplied with an Arduino kit, a single-board microcontroller that allows the equipment to be programmable. Apart from that they were self-funded and used easily available local resources. No team spent more than $100 on their final designs – a clear demonstration of how innovative thinking can produce highly inventive, working prototypes.

The teams also participated in a range of workshops hosted by local tech companies, which exposed students to emerging technologies like 3D printing and 3D scanning. Having these companies present their working models for tech-driven job creation in Zimbabwe also illustrated the possibilities of creating tech start-ups for possible future career choices.

Smart prototypes

The prize for best prototype went to a team that created a programmable centrifuge whose casing was predominantly designed out of plywood and cardboard. It was fully functional and significantly cheaper than any commercially-available models. Another winner created a centrifuge that relied on a motor taken from a toy car.

The winning centrifuge design.

Image credit: Jeffrey Barbee, Alliance Earth

These innovations effectively demonstrated the potential for equipping low-resourced educational laboratories with low-cost alternatives to expensive, imported equipment. We are hoping – with enough funding and sponsorship – that the Zimbabwe event will be the first of many LabHacks on the African continent. These could build a new community of science learners who study science in Africa, on machines designed by Africans for an African context.

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