Laptops and Diesel Generators: Introducing PhET Simulations to Teachers in Uganda

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This article describes workshops for high school physics teachers in Uganda on inquiry-based teaching and PhET simulations. I hope it increases awareness of the conditions teachers face in developing countries and inspires others to give similar workshops. This work demonstrates what is possible with some concerted, but not extraordinary, effort.

The Physics Education Technology (PhET) Project develops research-based interactive computer simulations (sims) for teaching physics and makes them available free online.\(^1\,^2\) We have sims on a wide variety of topics, including virtual laboratories such as Circuit Construction Kit (Fig. 1) and The Photoelectric Effect (Fig. 2), designed to supplement lab experiments. Research has shown that these sims can also be an effective substitute for lab equipment, sometimes producing greater learning than using real equipment.\(^3\)

PhET sims are used in high school and college physics classes throughout the United States. They could be even more useful in developing countries such as Uganda, where laboratory equipment is scarce but computers are becoming cheaper and more widely available.

While national exams in Uganda contain a major lab component, most schools cannot afford adequate lab equipment. Students who have never seen a real circuit are expected to thoroughly understand circuits for exams. PhET sims can fulfill a vital need by providing virtual labs to explore physical systems that students cannot access otherwise.

PhET sims are ideal for use in developing countries for many reasons: They cover a wide range of physics topics, and thus can substitute for a large number of labs, the equipment for which could cost thousands of dollars. PhET is free and open-source, and can easily be copied and distributed on CDs in areas without Internet access. PhET sims incorporate real-world contexts and applications that can improve people’s lives, an emphasis that is vital for economic development. Finally, the sims are based on research and extensively tested to ensure that they are effective for learning and easy to use, an important feature when both teachers and students have little experience with computers.

In early 2008, I ran two 2-day workshops on PhET sims for high school teachers in Soroti, Uganda (Figs. 3-4).\(^5\) The workshops were organized by Pilgrim,\(^6\) an indigenous non-profit humanitarian organization that runs many development projects in the Teso region of Uganda, including a secondary school for refugee children and a new regional university. Pilgrim has many contacts with educators and is in a good position to oversee the ongoing implementation of sims within its school. The workshops attracted teachers from all over the Teso region, an area approximately the size of Connecticut.

The workshops were modeled on those that PhET runs regularly at AAPT meetings, but with a larger emphasis on inquiry-based teaching, a concept that is less familiar to teachers in Africa. I chose activities that could both serve as models of inquiry-based teaching and also help the teachers learn physics. The types of inquiry-based teaching included interactive lectures with colored cards (a low-tech version of

Fig. 1. Circuit Construction Kit sim.

Fig. 2. The Photoelectric Effect sim.
personal response systems), and conceptual labs, tutorials, and homework. Sample activities included one topic from O-level exams, electric circuits, and one from A-level exams, the photoelectric effect. The schedule was flexible to accommodate laid-back timelines, power outages, and other unexpected events. (See Table I.)

Table I. Workshop Outline.

- Intro to inquiry-based teaching (interactive lecture with colored cards)
- Intro to PhET sims (interactive lecture with colored cards)
- Free exploration of sims (small groups)
- Reviewing sims for use in teaching (small groups)
- Circuits tutorial (small groups) – O level
- Photoelectric effect homework (small groups) – A level

I brought installation CDs to distribute containing the PhET installer and all software needed to run PhET, including Firefox, Java, and Flash, for different versions of Windows, Macintosh, and Linux operating systems. Most computers there did not have Java or Flash, and there was no Internet, so much of the extra software was necessary. Every computer I encountered in Uganda was running Windows, so the software for different operating systems turned out to be unnecessary. Most ran Windows XP, even when the computers were 10 years old.

Although 30 teachers had signed up for each workshop, only 10 came to the first workshop and eight to the second. The organizers speculated that the rest might arrive in the afternoon, since it was a long journey from their distant rural homes. They never showed up, but I rearranged the order of the workshop to start with free exploration of the sims, so that any late-comers would not miss the main presentation. I was thus able to give each of the teachers a lot more personal attention, and starting with free exploration allowed them to discover the properties of the sims for themselves.

Most of the teachers had little or no experience with computers, and I spent much of the first morning showing them how to open files and use a mouse. I was surprised how quickly they picked up the needed computer skills. Within a couple of hours they were exploring and learning from the sims with as much proficiency as our students at the University of Colorado. This was less true in the second workshop, where after the second day many teachers were still struggling with how to double-click a mouse and didn't know when to single-click and when to double-click. The difference seemed to be that most of the teachers in the first workshop were younger than those in the second.

All the teachers saw the value of the sims, and said they were valuable for illustrating important concepts for which their students lacked good visual models, such as electric and magnetic fields. While the teachers were enthusiastic, they were also frustrated, since most in the first workshop did not have access to even a single computer at their schools, and thus would not be able to use these wonderful tools. I had requested that the workshops be limited to teachers who had access to a computer in their school, but this request turned out to be impossible to enforce. The directors of Pilgrim recognized the difficulty of the situation and decided to donate a desktop to the school of each teacher.

Even when the teachers thought they would not be able to use the sims with their students, they still recognized that the workshop was valuable for helping them learn things that they could take back to their students. Several teachers commented, after completing a tutorial on voltage using the Circuit Construction Kit sim, that they had never had a model in their heads of what is happening in a circuit, and now they did, so they would be able to answer their students’ questions more effectively.

Another goal of the workshop was to introduce teachers to the idea of inquiry-based teaching. Locals reported that classes in Uganda universally consist of teachers lecturing and students taking notes. When I described inquiry-based teaching, people responded with enthusiasm but said they had never experienced it in their education. Many of the older teach-
ers nodded in approval and recognition when I discussed the problems with lecture-based teaching. However, it was unclear how well they would be able to use these methods based on a two-day workshop and a very small sample of materials.

I did receive a powerful validation of the impact of the idea of inquiry-based teaching on at least one teacher during a visit from the District Education Officer (DEO). The DEO, the equivalent of a State Board of Education Director, came to observe the workshops to evaluate whether the sims should be used in schools throughout the region. When he asked whether one could demonstrate a concept with a sim during a lecture, I started to explain how to use a projector to put the sim on a screen. However, I was interrupted by a workshop participant who explained that instead of lecturing to students you should help them discover the concepts for themselves, and the sims are ideally suited for this.

The teachers were extremely uncomfortable when I asked them to answer multiple-choice questions with colored cards. It became clear that many did not know the answers to some of the physics questions I asked, and were embarrassed to publicly display their ignorance. Their reactions were more extreme than I have observed from American teachers, probably because the Ugandan culture places a stronger emphasis on teachers as authority figures. I tried to alleviate their embarrassment by asking them to focus on how they could use this kind of activity with their students. In retrospect, however, I should have put more emphasis on the idea of role-playing and answering the questions as their students rather than as themselves.

In the second workshop the teachers asked to practice installing the software from the CDs I provided so that they could do it when they got home. I guided them through the installation process two at a time, with each teacher at his own computer. After spending an hour with each pair, I doubted whether some of them would be able to do it on their own. However, they all had a systems administrator or computer science teacher at their school who was familiar with computers and could install the software.

Power outages are another fact of life in Uganda. The entire country is powered by a single hydroelectric dam built in 1954, which doesn't supply enough power for a rapidly developing country. Power was relatively good during my visit due to recent floods, and there were only two outages during my workshops, one lasting a few minutes and one lasting several hours. We were able to continue working by using the laptop batteries and a diesel generator. While laptops may seem preferable in such an environment because they can run on batteries, locals recommended buying desktops for schools because laptops are likely to be stolen.

In addition to the workshops in Soroti, I also visited King's College, Budo (Fig. 5), one of the most elite secondary schools in Kampala, the capital of Uganda. King's College provides training for teachers from many surrounding schools, so this visit had the potential to introduce PhET sims to a much wider audience. King's College was a sharp contrast to the stories I heard from the teachers in my workshop, who taught in rural schools with no lab equipment and two physics textbooks to share among 70 students. At King's College, a sprawling and well-manicured campus, the teachers' lounge appeared well-stocked with equipment. Teachers were proficient with computers and pulled out their laptops when the 10-year-old desktop failed to work and boasted of a new computer lab with 20 laptops. I demonstrated the sims to the nine physics teachers and met with the headmaster, who was eager to stay in contact and help spread PhET to schools throughout the area.

In the end, what were the outcomes of my visit? I made a strong impression on the teachers who took the workshop, opening their eyes to the possibilities of technology and encouraging them to try it and to press their administrators for more computers. I helped introduce the teachers to both physics and the principles of inquiry-based teaching, aspects of which they may be able to take back to their classrooms. I also made contacts within a relief organization and an elite school, both of which are in a good position to train others to use the sims and are committed to being test sites for the use of the sims.

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