

Student experiences with a remote laboratory and the potential for capacity building in developing countries.

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Loughborough University's Centre for Renewable Energy Systems Technology (CREST) has created an innovative remote photovoltaic lab enabling learners from across the globe to develop experiential knowledge in solar technologies. Students can control real experimental equipment using a visual interface via the Internet wherever there are in the world 24/7.

The increasing deployment of photovoltaic (PV) systems requires large numbers of skilled engineers with a greater understanding of all aspects of PV technology both theoretical and practical. Developing experimental rigs at universities is expensive and limited to students physically attending the university.

Remote labs offer a viable solution and we have seen that our PV remote lab provides a much richer learning environment than its forerunner, solar simulations/virtual lab. Remote lab facilitates students working with authentic equipment and technologies thereby expanding their understanding of its potential for future real-world applications. As a result our students have gained higher marks which have been attributed to the development of deeper understanding through increased engagement with the experiments.

In this paper we outline the systematic approach used in the development of the Photovoltaic Remote Laboratory at Loughborough University, highlighting challenges and successes. We also evaluate the impact the remote lab has on student learning and experience. These were very positive and students, as stakeholders, have made suggestions for improvements. One student commented that "The mere fact of being able to inflict live controlled actions and measure their effects remotely from Egypt all the way in England all while watching it is absolutely brilliant."

As well as being used by distance learners, full time undergraduates have also used the experimental rig to help reinforce learning they gained from the on-campus experiment. The remote photovoltaic experiment demonstrates how e-learning is possible with real hardware. The Lab is a starting platform to ensure that developing countries have access the experiments which would otherwise be inaccessible.

The lab has created considerable interest from Academics in other disciplines across the University who are exploring the possibilities of using remote labs to increase engagement in practical activities. By removing some of the restrictions which exist

with physical labs in terms of time, place and pace students are empowered to take control of their learning. The lab has achieved further recognition and interest by other institutions. It is currently being used for summer schools running in Sweden and demonstrations of its application have been given to the Open University, British University of Egypt, and an Energy Advisory Group from Mexico.

Future activities involve working on capacity building in developing countries such as Kenya, Malawi and India

Interest has also been shown with academics performing the experiment from the British University in Egypt. Further developments will take place to improve the learning experience. The ambition is to develop further remote experiments.