INTERNET REACTOR LAB FOR DISTANCE EDUCATION AND TRAINING IN NUCLEAR FIELD

SEUNGYONG PARK*

Dept. of Materials Science & Engineering, Nelson Mandela African Institute of Science and Technology, P.O. Box 9104, Arusha, Tanzania

CHARY RANGACHARYULU

Dept. of Physics & Engineering Physics, University of Saskatchewan, Saskatoon, Canada

IDDI MKILAHA

Tanzania Atomic Energy Commission, P.O. Box 743, Arusha, Tanzania

BURTON MWAMILA

Nelson Madela African Institute of Science and Technology, P.O. Box 447, Arusa, Tanzania

*Corresponding author: eugene.park@nm-aist.ac.tz

ABSTRACT

For a developing country embarking on a research reactor project, building adequate human resource capacity is one of the biggest challenges. Tanzania has been considering a research reactor for some time. The success of future research reactor project relies heavily on the availability of well educated and highly trained personnel to operate and fully utilize the facility. Around the world, underutilization of research reactors is a chronic issue. It is not only under utilization of valuable resources but also poses potential safety and security concerns. To mitigate such concerns and to promote education and training, Tanzania, with IAEA's support, is working with African and European countries with research reactor. Borrowing from Jordan's success, this paper presents customized curricula to take advantage of distance education and training in nuclear field. The curriculum will have a two-tier approach; the lower level of public outreach programs and the higher level of educating and training of nuclear physics, engineering and power reactor operations.

1. Introduction

For a developing country embarking on a research reactor project, building adequate human capacity is one of the biggest challenges. The United Republic of Tanzania (Tanzania hereinafter) has been considering a research reactor. The success of future reactor project of Tanzania depends on vigorous training and education of necessary personnel to operate and fully utilize the facility.

Tanzania Atomic Energy Commission (TAEC) has been running numerous programs of trainings nuclear technologies since 1956[1]. Recently, increasing population, fast urbanization and changing life styles have brought pressures for the Government of Tanzania to cope with greater demands in energy and technologies resulted due to social, demographic, and economic changes. With increased energy and nuclear technology demands, Tanzania is turning to nuclear power as future energy mix. In the interim, the TAEC has decided to pursue research reactor to build up nuclear engineers and to utilize nuclear technologies for research and development for a wide scope of industry, academia and medical communities.

The TAEC estimates that there are about 1,000 nuclear technologists working in medical, industry, research institutes and higher education sectors in Tanzania. However, Tanzania lacks higher level of nuclear scientists and engineers. Since the available resources for TAEC is limited, it has been realized that the internet reactor lab (IRL) would be a rationale choice to train and develop human capacity in nuclear science and engineering.

In an effort to build human capacity necessary for nuclear science and engineering, the Nelson Mandela African Institute of Science and Technology (NM-AIST), guided by Master Plan for Science Technology and Higher Education of TANZANIA of 1997, has created advanced curricula on the area in the departments of Materials Science & Engineering and Sustainable Energy Science & Engineering. However, lack of access to any research reactor has been the limiting factor in education and attracting better qualified students.

Underutilization is of concern[2,3] at many research reactors around the world. It is not only that resources are left unused but it also poses potential safety and security problems. Tanzania, with the support of IAEA and countries in Europe and Africa, sees a huge potential to engage in IRL towards capacity building in the country which also addresses the issue of underutilization of research reactors. When, in 2010, the IRL at Jordan University of Science and Technology started collaboration with PULSTAR research reactor at North Carolina State University in the USA[4,5], its immediate positive impact on training and education has been well demonstrated. To emulate such an innovative way of utilizing available research reactor, NM-AIST and TAEC are developing the IRL and curricula accordingly.

2. Rationale for Internet Reactor Lab

Thanks to fast telecommunication technologies, distance learning has become more cost effective, reliable, and flexible, in environmentally more acceptable ways of delivering many types of curricula[6,7], if not all. For countries with no nuclear reactors, over the network teaching scheme is an obvious choice. As Fukushima incident in 2011 has brought challenges of public awareness, IRL will not only bring easier public acceptance, but also gives an opportunity to develop outreach programs for better public awareness.

Although IRL cannot replace the real hands-on experience of a research reactor, it still is highly beneficial in understanding nuclear physics and reactor operations. One should not forget that any reactor operation is remote in nature due to highly energetic yet hostile nuclear characteristics. The goal of the IRL project in Tanzania is to train and educate future nuclear scientists, engineers and operators in the following aspects, though not limited to them.

Goals of IRL:

- To develop knowledge and know-how in reactor design and operation
- To train students and other stake holders for advanced nuclear science and reactor physics
- To promote nuclear safety and security
- To apply gained expertise on knowledgeable decisions for future research reactors

Experience and expertise gained from IRL will help better plan and design the functional requirements and ancillary facility of future research reactor in Tanzania.

3. IRL Europe/Africa Project

On September 4-7, 2012, Tanzania was invited to a Consultancy on Establishing an Internet Reactor Lab. The meeting took place at IAEA headquarter in Vienna. The attending countries were, France, Czech Republic, The Netherlands, Lithuania, Tunisia, Montenegro, Algeria and Tanzania. The objective of the consultancy under the umbrella of IRL Europe/Africa project was to give an opportunity to open dialogues on how best to design and integrate the technology into the current nuclear curricula. It was decided that ISIS research reactor in France would serve as the initial host. As demand grows from Africa and Europe, other research reactors may be added in the future.

4. Technical requirements

IRL experiments are created by utilizing the Web server, Hypertext Transfer Protocol (HTTP), Hypertext Markup Language (HTML5), Common Gateway Interface (CGI), and Web cameras. The clients use web browser based software to communicate with ISIS research reactor so that the clients will be able to communicate regardless the operating system they are using. CGI is the essential medium for communication between the HTTP server and the experimental equipment. A web page will be provided to enable the user to send experimental parameters to the CGI program. The server connected to the host side manages the requests from a client and sends back experimental data to the client. Fig. 1 shows the schematic of the interface between a client and a host. The required hardware on the client side is as follows:

- An internet enabled personal computer running any type of operating system;
- A web camera or video conferencing system; and
- Fast internet connection.

Although not required, if the client side is equipped with any nuclear physics experimental apparatus, the client computer may require data acquisition card to handle raw data fed from the host.

The data from ISIS will be two simultaneous streams; one being the data stream and the other being the video stream from the control room, pool top, and reactor hall. Therefore, the internet bandwidth will be crucial. To run the IRL successfully, the IT department at ISIS recommends minimum of 256Kbps, 756Kbps for medium quality, and 1Mbps for better quality video stream. However, with 2Mbps bandwidth, a seamless connection will be achieved.

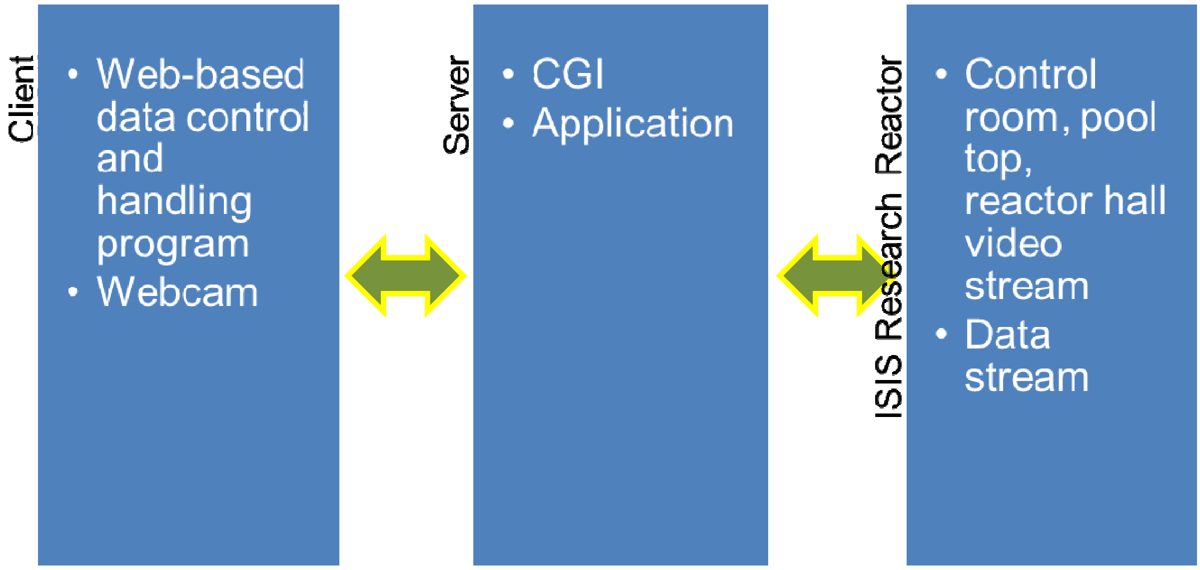

Fig. 1. A schematic diagram of the interface between a client and a host.

5. Curriculum Development

The curriculum will have a double-tier approach; the lower level of public outreach programs and the higher level of educating and training of nuclear physics, engineering and power reactor operation. The public outreach programs are important because raised awareness increases knowledgeable population who may be more supportive of future nuclear power plant. However, the emphasis will be given to educating younger generations and secondary school teachers to plant seeds for future users and customer.

5.1. Pre-recorded Experiments

Some introductory experiments can be pre-recorded to improve efficiency and to reduce cost. Such videos can also serve as good orientational materials for outreach programs. Suggested videos include:

- Nuclear safety
- Radiation Protection
- Production and utilization of radio isotopes
- Controls of NPP versus Research Reactor
- Starting the reactor with a source

- Neutron Beam Applications: scattering techniques, imaging, etc.

IAEA's *e*-learning projects may be of assistance in making recorded versions of the lab experiments listed above.

5.2. Live Experiments

ISIS research reactor currently has about 240 hours of operating time available each year. So one-on-one broadcasts is feasible for ISIS if guests so desire. One-on-one broadcasts are desirable, because it allows the level of experiments to be adjusted to accommodate each client if the client can meet the cost implications.

Operating on the idea of running an experiment every two to three weeks in a 12-week semester, it is possible to run experiments that illustrate applications of a research reactor, in addition to basic physics experiments.

The experiments were grouped into four live experiment sessions and summarized in Table 1. *Lab Session 0* is intended to be an overview and introduction to the reactor for students, and the bulk of that session will be recorded for future introductory class as well as for outreach programs.

Table 1. A list of live IRL experiments.

Lab Session 0	Introduction to ISIS and OSIRIS, entry, safety, fuel loading, control room overview, facility overview, short description of ensuing lab experiments
Lab session 1	Approach to criticality, reactor start-up and changes around criticality (and reactivity effect of devices if possible)
Lab session 2	Calibration curve, rod drop technique, Effect of precursors, and Temperature Effects
Lab session 3	Neutron Detection Systems in a reactor
Lab session 4	Flux Characterization and Measurements, Neutron Activation Analysis

The intention is to run half-day sessions comprising of a few shorter experiments. It is possible that, as the project develops and the level of students is better assessed, the sessions may be broken up into shorter, individual lab experiments.

[1] Mkilaha, I.S.N.,. Nuclear Energy as an Option for the Energy Mix in East Africa, *Technical Working Group Meeting, EAPIC*, Nairobi, 2010.

[2] http://www.trtr.org/Links/TRTR_February.html

[3] http://www.iaea.org/Publications/Reports/ntr2012.pdf

[4] Malkawi, S., et. al., “Exploring the Utilization of Nuclear Research Reactors in Distance Education across International Borders,” *Proceedings of the 1st International Nuclear and Renewable Energy Conference (INREC10)*, Amman, Jordan, March 21-24, 2010.

[5] Malkawi, S.R. and Al-Araidah, O., “EVALUATION OF NUCLEAR REACTOR PHYSICS LABORATORY EDUCATION THROUGH REMOTE UTILIZATION OF RESEARCH REACTORS,” *RRFM 2013 Transactions*, St. Petersburg, Russia, April 21-25, 2013.

[6] Edwards, E., et. al.,”Distance Reactor Laboratory and Virtual Tours,” *Transactions of the ANS 2006 Annual Meeting and Embedded Topical Meeting - Nuclear Fuels and Structural Materials for the Next Generation Nuclear Reactors*, 2006, p 33-35.

[7] Odeh, S. and Ketaneh, E., “A Remote Engineering Lab for Collaborative Experimentation”, *International Journal of Online Engineering*, Vol 9, No 3, 2013, p 10-18.