PLuS Alliance Nuclear Engineering Online Course Exchange Program

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INTRODUCTION

The PLuS (Phoenix-London-Sydney) Alliance is a tri-university partnership between Arizona State University (ASU) Phoenix, King's College London (KCL), and the University of New South Wales (UNSW) Sydney. While KCL is involved in nuclear nonproliferation research and nuclear security education, we report here about the exchange between ASU and UNSW of nuclear engineering courses developed for distance learning on two different continents.

THE UNIVERSITY NUCLEAR PROGRAMS

UNSW is currently the only provider in Australia of a nuclear engineering degree program, in particular an MSc in nuclear engineering delivered by the Faculty of Engineering, and the option for undergraduate students to enroll in an introductory course on nuclear engineering. The nuclear engineering program at UNSW was established in 2014 and was primed by a philanthropic donation from The Tyree Foundation and from ANSTO (Australia's Nuclear Science and Technology Organisation). While Australian legislation currently makes electrical power generation illegal if derived from nuclear fission reactors, there is still the need for a domestic pool of nuclear-conversant engineers. These engineers are essential for domestic national laboratories (ANSTO) and the nuclear regulatory bodies: the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and the Australian Safeguards and Non-Proliferation Office (ASNO). There is also an international need for nuclear engineers, and a number of UNSW graduates in nuclear engineering now work overseas in nuclear construction, regulation and R&D. Australia is a large continent and has a population particularly in rural and remote communities that are keen to study remotely.

ASU delivers a 15-semester-hour graduate-level certificate program in nuclear power generation (NPG). The NPG program has a multidisciplinary nature with a goal being to prepare students and professionals from a variety of engineering and scientific disciplines to work effectively in the nuclear power industry. A more detailed description of the ASU NPG program is given in Ref. [1].

The ASU and UNSW graduate nuclear programs are complementary in several respects. Both are multi-disciplinary in nature, and neither assumes that students hold a baccalaureate degree in nuclear engineering. Interestingly, both the ASU and UNSW nuclear programs were established by electrical engineering academic units.

ONLINE COURSE EXCHANGE PROGRAM

Both universities offer a traditional introductory nuclear engineering course as well as a reactor theory/physics class. At a first glance, this overlap might appear inconsequential, but a closer consideration reveals that this can provide students with an alternative timeframe (flexibility) in which to complete a fundamental (prerequisite) course so as to stay on-track with their degree plan.

As shown in Table I, there are also unique courses guided by each university's individual faculty strengths, program goals, and research activities. For instance, the U.S. Nuclear Regulatory Commission (NRC) provided a monetary grant to help create a course on interdisciplinary nuclear power operations [2], which was developed in cooperation with the nearby Palo Verde Nuclear Generating Station, which is presently the largest nuclear power plant in the U.S. At UNSW, a grant from ANSTO enabled the nuclear program to include adequate nuclear safety, security and safeguards materials and, as a consequence, leverage practical expertise of ANSTO staff, who subsequently authored and assisted in the design and development of the online materials. This is a strong motivator for students in Australia to enroll as they are accessing not only academic expertise, but also the experience of professionals dealing with the day-day issues at a working nuclear site (e.g., OPAL reactor) as well as wider-scale international developments. By leveraging these types of resources, the two universities are able to offer students with a greater breath of knowledge such that they can better advance their education and career goals.

Clearly the sharing of courses permits a strategic utilization of mutual and diverse resources between UNSW and ASU. For instance, this partnership would allow ASU to gravitate from the 15-hr graduate certificate to offering a 30-hr master's degree. The structure of the respective course streams is shown in Fig. 1.

TABLE I. Courses Unique to the Universities

ASU Courses	UNSW Courses
463 Electrical Power Plants	9743 Fuel Cycle, Waste and Life Cycle Management
498 Health Physics	9744 Nuclear Safety, Security and Safeguards
564 Interdisciplinary Nuclear Power Operations	8930 Uranium Mining Fundamentals

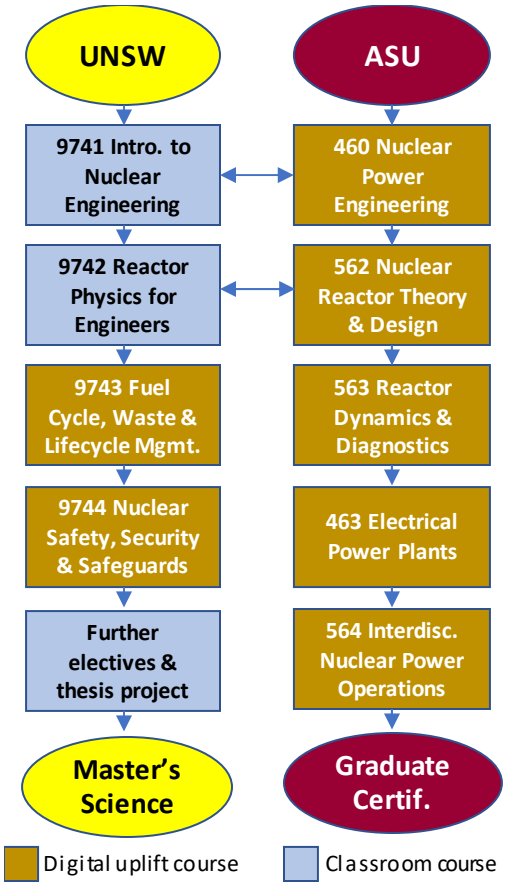

Fig. 1. Structure of the program streams at UNSW and ASU. Horizontal arrowed lines indicate inter-university equivalencies; vertical lines denote program progression.

On Digital Uplift

Our experience in digital education has shown that a given education technology—for example the many options available for teleconferencing, forum discussion, online lectures, quizzes and even animation [3]—may be effective in specific cases, but if deployed exhaustively across an entire course its attractive potential may lessen. Therefore, all of our online courses use a variety of different teaching strategies. While all 100% online, each individual course has acquired a quite different 'feel' depending on the approach of the convener.

In a local context, digital uplift (DU) obviously offers efficiencies of scale and better utilization of campus resources. One challenge is that the investment of effort to make an engaging digital course is not notably less than a classroom taught course, and this effort is only repaid by an ability to scale if enrollments increase significantly. Another perspective is to see DU as an enabler of distance learning, and a way to geographically extend the beneficial educational experience of learning in a relatively small class, which is often an attractive characteristic of nuclear engineering programs.

The digital uplift of UNSW PLuS Alliance course 'Nuclear Safety Security and Safeguards' took place 2018-2019. Concerned primarily with regulatory and safety challenges of nuclear technology, a significant requirement of this course was to access higher level learning outcomes, such as the Synthesis and Evaluation levels of Bloom's taxonomy. A safety case is effectively a Synthesis of learning and can only be assessed using a capability to Evaluate. To become effective nuclear engineers, students need to be able to present justification for a safety case, to advocate and not just to report their technical solutions, and to constructively critique the work of their peers.

To provide the context for this to occur, we made quite high use of teleconferencing tutorials in the course. Video conferencing in a small group allows digital, synchronous discussion. It provides a venue for traditional teaching, for students to meet and discuss, and present work. We use this to present, and to critically appraise, student safety cases for changes to a test reactor, and to hold the tutorials in which students practice negotiation between different stakeholders for the development of a design basis threat as part of their nuclear security coursework. One advantage of video conferencing is that continual advances in internet connection speeds and device processor power mean that quality of the experience always improves year after year.

Overall, digital uplift does not have to imply the loss of a personalized and social learning experience and is suited to delivering the higher level learning outcomes that equip students with the essential elements of a nuclear safety culture.

Online Course Delivery

At ASU, the fully online courses are filmed in a recording studio using a green screen background with only the instructor and producer present. The green screen permits overlaying the instructor to the side of the PowerPoint slides being used; see Fig. 2. The lectures include closed captioning and are accessed anytime via the Internet-based Canvas learning management system (LMS), which provides a discussion board and a portal for homework submission and grading. On-campus students can enroll in a hybrid version of the course which simply means that the examinations are administered at a preset time in an on-campus classroom setting to that cohort, whereas distance learning students take the exams online using a university-funded remote proctoring service that monitors the students via their computer web camera.

At UNSW, the online courses also make extensive use of green screen recording, combined with additional asynchronous online resources such as podcasts and voice-over presentations and regular synchronous teleconference sessions, which serve as a discussion board and tutorial to integrate and deepen the understanding of the content provided in the online lectures. Student learning is largely based on asynchronous online activities, both individual and

team-based. These include recording and posting online-presentations, commenting and discussing each other's presentations, and participation in a self-moderated forum.

The inaugural course exchange occurred at the start of 2018 when one UNSW student began the introductory nuclear engineering course at ASU. This was followed in August 2018 with eight UNSW students enrolling in ASU's semester-long reactor theory and design course. The most recent exchange (in 2019) was an ASU student completing UNSW's fuel cycle, waste and life cycle management class. The first (and most recent) delivery of the UNSW fuel cycle course received a satisfaction rating 8.3% above the engineering faculty average. It is expected that future iteration will improve thanks to the lessons learned in the first round.

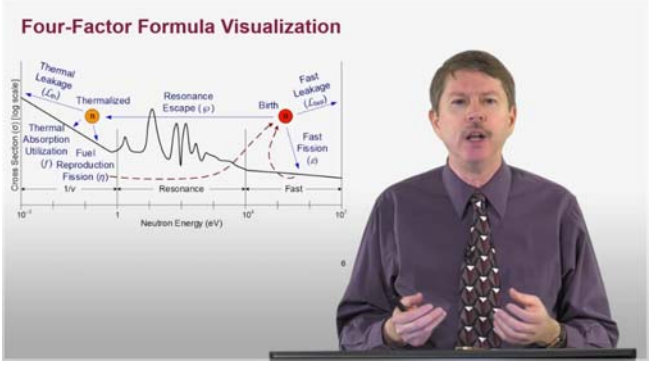

Fig. 2. Screen snapshot of an online nuclear class lecture.

Challenges and Lessons Learned

The development and deployment of an online course exchange program of this type has encountered challenges. Fortunately, dedicated staff members are in place at each university to address administrative details, thus avoiding significant additional overhead being placed on the course instructors.

There are logistical challenges besides the obvious time zone difference between the universities. Minor nuisances include differences in the grading scales and number of credits for a class, dealing with the U.S. Family Educational Rights and Privacy Act (FERPA). A greater challenge can be the difference in the academic terms as compared in Table II in which we strive to avoid using the colloquial references to the seasons (e.g., 'spring' and 'fall') due to the universities being sited in opposite hemispheres. As a case in point, some of the key UNSW courses are offered in the second term (June–August) which is summer in the U.S. when students are traditionally on break—this has resulted in a smaller cohort of ASU students enrolling in the UNSW classes.

Although Sydney is 18 hours ahead of Phoenix, there is a window in the UNSW morning (9 to 11 a.m.) and the ASU afternoon (3 to 5 p.m.) when working hours overlap, thus providing an opportunity for instructors to host online office hours when students in both countries are likely awake.

A paper-based examination across different countries and time zones also incurs additional administrative loads. These include liaising with multiple approved examination venues and/or proctoring authorities (typically third parties), and the need to put in place additional measures to prevent the dissemination of exam material between students across different time zones. Owing to these complications, in the second iteration of some courses it was decided to move all assessment away from paper-based examination, favoring instead online quizzes, essays, assignments, and asynchronous online activities such as recorded presentations and self-moderated fora.

The self-moderated forum is an exemplar case of a successful activity that is only rendered possible because of the online nature of the group. In this task, one team is given a contentious topic that they must introduce to the class, and everyone must participate in a discussion. The topics are chosen such that there is no clear-cut correct answer, and no marks are associated with the student's responses (to promote open debate), but only with the level of engagement and ability to moderate often contentious topics. This type of activity has helped create a sense of community within the online course, which is often a challenge.

TABLE II. Comparison of Teaching Terms

ASU Terms	UNSW Terms
January–April	February–May
May–July	June–August
August–December	September–December

RESULTS

This online course exchange program benefits students at both ASU and UNSW with more course offerings while allowing the two universities to leverage resources. In addition, the online courses provide an additional networking conduit (i.e., international contacts in the same field of training) for both students and faculty.

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