Web-Based Learning as a Tool for Public Education and Outreach – 17503

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ABSTRACT

As internet access grows worldwide, so do online learning opportunities. Academic institutions have provided Web-based courses for many years, more are joining this set each year, and online training is common in the workplace. Web-based learning represents an opportunity for sharing information with members of the public interested in learning more about nuclear energy and approaches for managing associated spent fuel and radioactive wastes. A literature review was conducted to assess current practices and opportunities for Web-based learning relevant to nuclear energy and radioactive waste management, and to identify insights toward enhancing public education and outreach. Results indicate that substantial learning is being achieved online. A review of several online training materials related to nuclear waste management found that while informative, some are text-heavy with few supporting graphics. Many educational materials designed for the workforce could also serve as a foundation for informational materials for the broader public. To address this expanded objective, basic concepts could be illustrated with graphics, the use of video clips could be expanded, a tiered approach could be applied to present increasing levels of detail, and additional practical exercises could be included to reflect field situations. Such enhancements could further strengthen the effectiveness of Web-based learning as a tool for education and outreach, both for the nuclear workforce and for citizens interested in these topics.

INTRODUCTION

Internet access is prevalent in the United States and other industrialized countries, and it continues to increase in emerging economies. At the same time, education and training courses are increasingly available online, as electronic modules, or e-modules, are widely offered by academic institutions for public and private education. These extend from elementary and high school-level courses to college and graduate-level courses, as the Internet has broadened the reach and increased the flexibility of educational access around the world.

Other types of organizations have also engaged in electronic (e-)learning. In the workplace, online modules are commonly used to train employees on topics ranging from safety and security to general information about a particular industry project or policy and standard operating procedures.

Meanwhile, the public has turned to the Internet as a real-time source of information on a wide range of topics. Those with Internet access can open their browser, ask a question, and receive hundreds of thousands of search results within seconds.

With impending retirements affecting much of the nuclear industry, the need for a new generation of technically skilled workers has become more pressing. Meanwhile, the public is keenly interested in how radioactive materials, such as spent fuel from commercial reactors and associated wastes, are to be managed into the long term.

Harnessing the Internet could help address these issues, as a means for introducing students and the broader public to basic concepts underlying nuclear energy and its byproducts, as well as a means for providing more advanced training and simulation experience to a new workforce. Thus, Web-based learning is considered a potential opportunity for expanding educational outreach related to nuclear energy, spent fuel, and radioactive waste management.

DESCRIPTION OF APPROACH

To explore the potential for Web-based learning as an opportunity for educational outreach, a literature search was conducted to understand (a) the existing level of Internet use; (b) the nature of online education and training, with particular emphasis on topics relevant to nuclear energy and radioactive waste management; and (c) the opportunity for further expanding the availability of such materials to a broader interested public. The search was conducted from summer to fall 2016.

Information was sought via traditional literature databases, such as Web of Science, as well as Internet searches. Search terms included: *distance learning*, *e-learning*, *Web-based*, *online, course*, *education*, *training*, in combination with *nuclear energy*, *nuclear reactor*, *nuclear power plant*, *nuclear engineering*, *spent nuclear fuel*, *radioactive waste*, *radioactive waste management*, *storage*, and *disposal.*

RESULTS AND DISCUSSION

The online search produced more than 60 articles and websites with information relevant to education and nuclear energy and associated spent fuel and radioactive waste management. Selected highlights are summarized below to frame insights into possible expanded opportunities for Web-based learning as a tool for public outreach and information sharing.

Internet Use

Recent estimates indicate that about 40% of the world's population use the Internet (more than 3 billion people), including smartphone users [1,2]. This use rate has increased from just 1% in 1995 [2]. Topping the current list are South Korea, Australia, and Canada, at use rates of 94-90%, respectively. Close behind are the United States, United Kingdom, Spain, Israel, and Germany, at rates of 89-85%, respectively. Many large emerging economies are next, with use rates in Russia, Turkey, Malaysia, China, and Brazil ranging from 72-65%, respectively. Internet use

rates are lowest in poorer countries, including parts of sub-Saharan Africa and Asia. For example, rates are 22% in India and 15% in Pakistan [1,2]. Note that most of the countries listed here already have or have plans for commercial nuclear reactors, including India and Pakistan [3].

Academia

Online materials for education and outreach relevant to nuclear energy range from educational resources for science teachers to free college-level courses and full college degree programs, to training materials for workers and fact sheets and videos designed for the public.

In fact, academic institutions have been providing distance learning for more than 120 years. The University of Chicago initiated its distance learning program in 1892 via correspondence; its offerings moved to radio in the 1920s and then to televised broadcasts in the 1960s [4]. In 1985, the National Technological University began transmitting online degree courses via satellite. With the emergence of the Internet, academic courses moved online, and in 1993, Jones International University became the first accredited online university. By 2010, nearly two-thirds of U.S. institutions of higher education identified online education as an essential aspect of their long-term strategy. A year later, massive open online courses (MOOCs) were launched, with more than 160,000 students signing up for a groundbreaking Stanford offering on artificial intelligence [4].

Many college-level degrees can now be earned entirely online in various nuclear science and engineering fields. Bachelor's and Master's degrees are offered from institutions such as Pennsylvania State University [5], North Carolina State University [6], University of Texas at Austin [7], and Excelsior College [8]. Although many academic institutions charge a fee for their courses, MIT is among the universities that offers free online classes in nuclear science and engineering [9].

Other platforms for free online courses include Coursera, with offerings from top universities such as Princeton, Stanford, University of Pennsylvania, and University of Michigan [10]; edX, an MIT and Harvard partnership [11]; Khan Academy, designed for secondary school students, teachers, and parents [12]; and Open Education Database (OEDb), a directory that includes degree programs in engineering and environmental science [13].

Nuclear Industry

In addition to the major role e-learning plays in academia, it is also common in the private sector, including the nuclear industry. Employees take online training as part of onboarding, to learn best safety practices, and to receive advanced training on job-specific topics. Innovative online methods for training and educating employees in the nuclear energy sector include courses offered by Energy Power Lab, which range from the basics of nuclear engineering to economics [14]. Customized training designed to fit the needs of a specific workplace, as well as the needs of specific workforce levels (e.g., new employees) are being used to enhance training efficiency.

For example, the Western Services Corporation (WSC) offers nuclear power plant simulations to train the incoming workforce and prepare them for the work they will perform. WSC explains that their need is not only to educate and recruit but "most importantly (to) attract the next generation of engineers to the nuclear industry" [15].

Agencies

U.S. government agencies such as the National Institute for Environmental Health Sciences (NIEHS) also offer educational materials online, with links to fact sheets and guides related to radioactive waste management. A number of NIEHS resources are specifically geared towards students, educators, and scientists [16]. Similarly, the International Atomic Energy Agency (IAEA) provides an extensive suite of online information resources addressing nuclear facilities and radioactive waste management and has developed training materials designed for member state participants. The IAEA also provides a comprehensive program of fifteen e-modules for countries considering nuclear power; topics range from infrastructure and construction management to emergency preparedness and response [17]. The IAEA is also developing a series of e-learning modules on spent fuel and radioactive waste management, decommissioning, and environmental restoration. These modules are in various stages of development and are available on the IAEA's NUCLEUS portal (https://nucleus.iaea.org/Pages/default.aspx).

The Public

The Internet is widely used by those with access, and that access continues to grow. Smartphone users in the United States are estimated to spend an average of one to three hours a day on their devices, and computer-based Internet access is now slightly below that. Social media is also a popular venue for instruction, and YouTube is an increasingly frequented resource, providing both visual and auditory information. For example, the Khan Academy channel has nearly three million subscribers and almost a billion views, with videos offering a wide variety of topical lectures. Viewers can control the speed of the lecture, and they can pause and rewind to watch and listen again if they do not understand a certain part of the presentation [18].

The evolving field of citizen science provides a similar opportunity for educational outreach. The Citizen Science Academy offers courses on a variety of topics for citizens interested in collecting, analyzing, and sharing data about local environmental conditions. Social media is being used to inform the public about these courses, with registration information provided on Facebook [19]. These examples illustrate Web-based outreach and educational tools that offer opportunities for further engagement by those addressing the shared challenge of managing spent fuel and radioactive waste from commercial electricity generation.

Insights from Educational Materials

A review of several online training materials related to nuclear reactors, spent fuel, and waste management found that while informative, some are text-heavy with few supporting graphics. Many educational materials designed for the workforce could also serve as a foundation for informational materials for the broader public. To address this expanded objective, basic concepts could be illustrated with graphics, the use of video clips could be expanded, a tiered approach could be applied to present increasing levels of detail, and additional practical exercises could be included to reflect field situations. Such enhancements could further strengthen the effectiveness of Web-based learning as a tool for outreach and education, both for the nuclear workforce and for citizens interested in these topics.

Having the access to Web-based learning is only part of the equation; an additional lesson relates to the quality and credibility of online information. It is important for the educational material to be accurate and unbiased, and for the delivery to be in an effective form and format for the intended audience. An example approach for addressing the quality of digital resources is the Learning Objective Review Instrument (LORI). This instrument is widely used to evaluate programs on nine dimensions of quality [20]. Based on ratings and comments from learning resource evaluators, it provides a structure for evaluating the quality of Web-based modules to support e-learning. Many resources examined in this research are from well-respected sources, including IAEA and NIEHS, and MIT and other accredited universities. Their online materials reflect the importance of assuring that learning modules are credible and of very high quality. As online content and courses continue to be developed, the implementation and documentation of quality metrics will continue to be important.

Benefits of e-learning modules include (a) individual accessibility anytime, as convenient to the viewer's schedule and pace; (b) ready availability of materials for repeat viewing once completed, to facilitate refresher learning; (c) practical means for reaching a wide audience independent of collective timing, because e-learning modules obviate the need to coordinate group scheduling of webinars, topical presentations, and other such education and training events; and (d) improved resource management, because while both conventional (in-person instruction) and e-learning modules involve upfront development costs, the burden associated with repeat delivery of the same content is significantly lower for e-learning.

CONCLUSIONS

In the past five years, online training and educational resources have markedly increased, with the striking expansion of free online course offerings. Continued growth is expected, including as Internet access expands worldwide. Online education, training, information sharing, and public outreach continue to be valuable investments for academia, agencies, industry, and the public. Benefits include increased awareness and understanding of science and technology concepts, which could underpin innovations by the next-generation workforce to advance energy security and long-term waste management systems. The evolving field of citizen

science also provides an opportunity for collaborative information sharing and outreach. Online training and educational resources related to nuclear energy, spent nuclear fuel, and radioactive waste management could further strengthen public engagement and transparency efforts. Ready access to scientific and technical information via Web-based learning and outreach tools could help increase mutual understanding, confidence, and trust among agencies and the communities they serve.

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