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Development and Improvement of Human Resource Development in Nuclear Engineering for National College Students in Japan

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Abstract

Human resource development program in nuclear engineering has been developed and carried out for national college students in Japan. It consists of (a) remote lectures and e-Learning contents on radiation and nuclear related subjects, and (b) on-site workshops and visits at nuclear related facilities or Nagaoka University of Technology. In approximately 10 years since it was started, more than 10 thousand of students participated in the program, which, we believe, was effective to enhance their understanding in these fields. However, as an educational system, it seems possible to be improved through utilization of ICTs etc. From our understanding that the problem is the lack of bidirectional feature in our program. In the future, we are planning to provide substantial amounts of exercises base on Active-learning with ICTs to deepen the understanding of the subjects carried out in the workshops or facility visits.

Keywords: Human resource development; Nuclear engineering; National Colleges in Japan; E-Learning; Active learning

1. Introduction

National Colleges in Japan were established in the 1960s to meet the requirement from the industries which were under rapid development after the world war II. They were consolidated into one institute, namely National Institute

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of Technology (NIT), in 2004 and have been carrying out education utilizing the scale merit of 51 colleges. Since their establishments, education on practical engineering has been carried out for the students to develop practical engineer who can take important role in the industries [1]. A lot of curriculums or programs have been developed and carried out in various educational fields which are expecting synergistic effect between education and practice [2]-[5]. For the reason, most graduated national college persons have been practical-minded, who are responsive to the social needs, and receive high commendation from many companies. One of the good examples is the field of power generation. A lot of students got jobs in the fields of power generation related to nuclear engineering. They are highly evaluated as practical engineers in those industries.

As there has been no department or course in the colleges of NIT, education on nuclear engineering has been carried out mainly in the lectures on Physics, Electronics, and Chemistry etc. To increase the interests of the students, NIT started the feasibility study of human resource development on nuclear engineering on 2010 with the support of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). However, on March 11 of 2011, the great earthquake occurred in the Tohoku area of Japan, and, due to the large Tsunami caused by it, the severe accident at Fukushima Daiichi Nuclear Power Plant occurred. After the accident, the general minds in Japan and in the world became anti-nuclear [6]-[9] and the regulatory standard on the safety of nuclear powerplant in Japan has been made stricter. Besides these changes, to keep the already-built nuclear plants to work and keep the safety levels, the needs for practical engineers in this field remained after the accident, where the near-future plans to decommission the nuclear plants also increase the necessity of the program. So, NIT has been continuing the human resource development up to now as (a) "Human resources of practical and fundamental engineers in nuclear fields based on education for disaster prevention and safety" (2011-2013), (b) "Establishment of educational system for basic nuclear engineering" (2014-2016) and "Improvement of human resource development in nuclear fields for extension of career path" (2017-2019) [10].

In the programs, short-term training programs based on experience-oriented [11] motivation have been developed in the power generation companies and in the nuclear related departments in a University. To realize "synchronous" lecture without geographical factor, we have been carrying out the remote TV lectures on nuclear and radiation engineering. But TV lecture as synchronous remote class has several problems; 1) it was difficult to arrange the schedule to meet the requirements of the attendants, 2) there sometimes were the system errors to make us give up delivering the lecture on that occasion, and so on. To solve these problems, we move to the phase of class design from "synchronous" class to "asynchronous", such as e-Learning. In this paper, we will introduce the education contents developed in the 10 years and will also discuss the possibility of deepening the education on Active-learning procedure.

2. Outline of the program

The program was firstly adopted by MEXT in 2010 as a feasibility study for one year. We have developed the short-term training at Japan Atomic Energy Agency, Nagaoka University of Technology and some national colleges. The period in Japan was called "nuclear renaissance" where some plans were proposed to increase the power generation by nuclear power plants because of their high economic efficiency and low emission of greenhouse gasses. Our program was to meet the requirements to educate the students as engineers in those fields.

After the change of the regularity standard, it became difficult to restart the nuclear power plants in Japan. Some of them were decided to be decommissioned because the economic efficiency of power generation became worse as additional safety system and facilities were required. However, as power generation by nuclear fission reactors has still been recognized as important base load source, it has still been recognized as important as before to develop human resources in the fields. So, MEXT has been maintaining the subsidiary for such a purpose.

Our program is composed with (a) lectures and development of teaching materials, (b) practical workshops at each college and (c) group training at nuclear related facilities and university. The details of each program are explained as follows.

2.1. Lectures and development of teaching materials

At the national colleges in Japan, there are very few academic faculties who specialize in nuclear or radiation engineering. So, the students had been difficult to have the occasions to study nuclear engineering at their own colleges. To overcome the difficulty, we have been offering TV lectures on this technical field, which the students can watch and study through the TV lecture system connecting all the colleges. The numbers of the TV lectures provided were 7 (FY2016), 7 (FY2017) and 4 (FY2018), and the cumulative total number of students who attended TV lectures reached 2123 in the three fiscal years.

However, as they are composed with unilateral lectures, just presentation by teacher only, it was difficult to deepen the understandings of the students by themselves. To solve the problem, we have been developing e-learning materials composed with lecture video and exercises. They have been developed on the ILIAS [12] system in Nagaoka University of Technology, which is an open source learning management system developed by the University of Cologne and initiated and organized by Wolfgang Leidhold. The subjects of the developed e-Learning materials are shown in Table 1. We have prepared the materials concerning the fundamentals of energy demand/supply, radiation physics, nuclear plant system, safety strategy, backend technologies and medical application of radiation. The cumulative total number of students reached 214 for the fiscal year of 2018.

From the questionnaire surveys after the lectures for both style, TV lecture and e-Learning, it was clearly seen that more than 75 % of the students could understand these provided lectures well (Fig. 1). Comparing with the TV lecture, more than 90% students answered that they understood the lecture. These results indicate that 1) understanding of the students depend on the subjects explained in each lecture, 2) the way of speaking style and the presentation materials had little influence on the results, 3) the depth of understanding may depend on whether the students could check the contents at his/her own pace. At present, as it was the first trial for our group to use this kind of system for education on nuclear engineering, it seems the instructions to some students were not adequate, which let some students to start solving the exercises before watching the lecture videos and the attendance time became shorter (Fig. 2). This should be improved by instructing the teachers themselves how to motivate the students to study deeply with the system. The other students attending more than two hours watched more than one lectures before solving the exercises, where the average time for one content seems one to two hours. The responses of the students showed that the TV lectures were valuable as they could study the subjects from lectures of famous professors and researches which were usually difficult for them to attend.

Table 1. Subjects of the developed e-learning materials.

	Subjects ((J) denotes the subject in Japanese and (E) denotes that in English.)
1	Energy policy of Japan and development of nuclear technology (J)
2	Recent global trends and perspective of nuclear power generation (J)
3	Fundamentals of radiation and its measurements (J)
4	Fundamentals of nuclear reactor physics (J)
5	Principle of nuclear power plant and mechanical engineering (J)
6	Introduction to materials engineering for nuclear plant (J)
7	Chemical engineering and nuclear fuel cycle in nuclear field (J)
8	Geological disposal of high-level radioactive wastes (J)
9	Fundamental philosophy of nuclear safety (1) (J)
10	Fundamental philosophy of nuclear safety (2) (J)
11	Risk communication (J)
12	Fundamentals of accelerators (J)
13	Medical application of radiation - Nuclear medicine - (J)
14	Medical application of radiation - Physics for nuclear medicine (J)
15	Power generation by nuclear fusion (J)
16	Fundamentals of Reactor Physics (E)

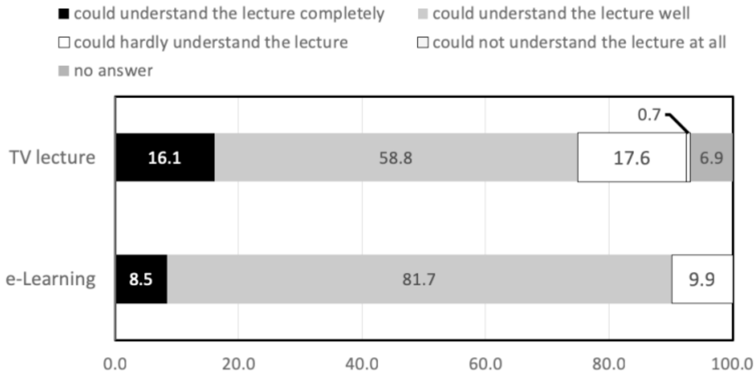


Fig. 1. Answers to the questionnaire, where the question was "Could you understand the lecture?".

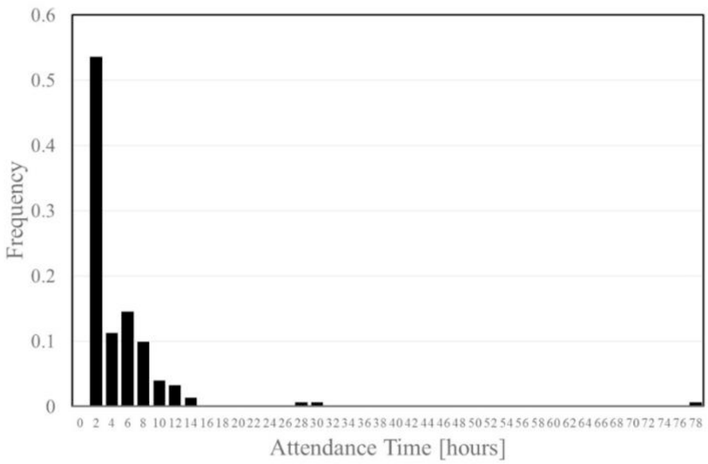


Fig. 2. Distribution of the attendance time for the e-Learning contents.

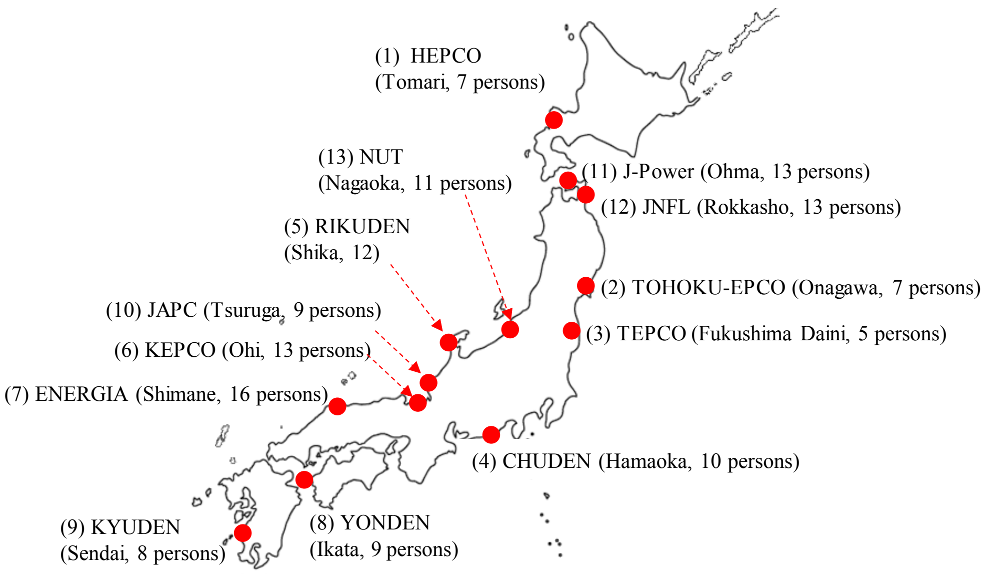
2.2. Practical workshops at each college

As the practical workshops at each college, we have carried out the measurements with the pocket dosimeters and a NaI (Tl) scintillation survey meter. The workshop with the pocket dosimeters is mainly for young students less than 18 years old, where a dosimeter is rent to each student of one class and continuous measurements are carried out for one week. We believe it will enable the students to understand the existence of background radiation.

The NaI (Tl) survey meters are used to measure the spatial dose rate at each college. The measurements have been continued for 7 years, which shows the change of the dose rates after the Fukushima Daiichi Nuclear Power Plant. From the results, it can be observed that, soon after the accident, the dose rate at Fukushima college was very high, however, after eight years, the dose rate in Fukushima college has become lower than that at Toyama college. The results are open for all the students, which let them understand the decay of the radioactive materials emitted by the accident.

2.3. Workshops at nuclear related facilities and university

To cover the lack of nuclear and radiation related experiences, group training workshops have been developed in the program. Especially in the program since 2017, wide variety of workshops has been developed at the companies on power generation and spent fuel reprocessing. Also, at Nagaoka University of Technology, the workshop has been developed for the students who will enter universities after graduating from the colleges. Fig. 3 shows positions the plants where the workshops were carried out, where the number of the students who attended each workshop is also shown. In Fig. 4, the results of the questionnaires asking “interests”, “depth of understanding” and “significance of workshop” about the workshops are shown Combined with the educational effects by the lectures, 90 % of the students answered the deepening of their understandings. It can also be seen from the large number of the students who chose “Very useful” for the question about the significance of the workshops, besides the score for “could understand the lecture completely” reached less than 20 % in Fig. 1. It means the effectiveness of workshop is enormous in the sense of "experience-oriented" program.



Abbreviations:
(1) HEPS: Hokkaido Electric Power Company, (2) TOHOKU: Tohoku Electric Power Company,
(3) TEPCO: Tokyo Electric Power Company, (4) CHUDEN: Chubu Electric Power Company,
(5) RIKUDEN (Hokuriku Electric Power Company) , (6) KEPCO: Kansai Electric Power Company,
(7) ENEGIA: Chugoku Electric Power Company, (8) YONDEN: Shikoku Electric Power Company,
(9) KYUDEN: Kyushu Electric Power Company, (10) JAPC: Japan Atomic Power Company,
(11) J-Power: Electric Power Development, (12) JNFL: Japan Nuclear Fuel Limited,
(13) NUT: Nagaoka University of Technology

Fig. 3. Positions the plants where the workshops were carried out, where the number of the students who attended each workshop is also shown.

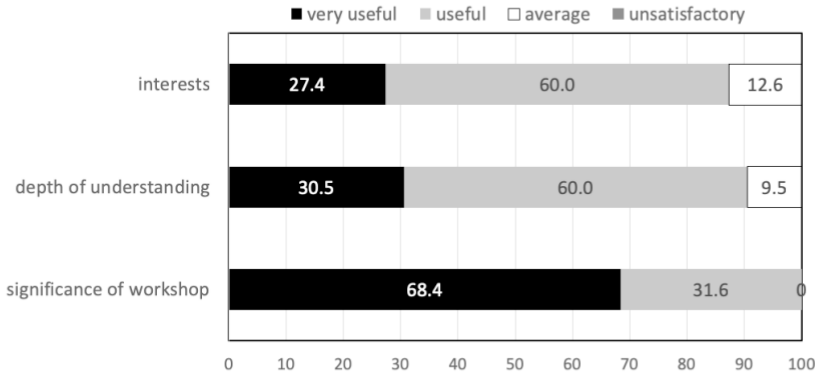


Fig. 4. Answers to the questionnaires on "interests", "depth of understanding" and "significance of workshop" about the workshops.

3. Problems and desirable improvements on the present project

Based on these practices, we discuss the problems and desirable improvements on the present project. At the beginning of the discussion, we redefine the position of the project, and extract the points to improve on this project.

3.1. Position and aims of the project

The position and the aims of the projects are summarized in Fig. 5. As the fundamental needs for the projects, there is the certification system of Professional Engineers in Japan. The system has been developed to certificate practical engineers in 21 Technical Disciplines as Mechanical Engineering, Marine & Ocean, Aerospace etc. Nuclear & Radiation is also included in the Technical Disciplines with the optional subjects of Nuclear Reactor System Design & Construction, Nuclear Reactor System Operation & Maintenance, Nuclear Fuel Cycle, Radiation Application and Radiation Protectionto be tested at the examination. The present project is ultimately aiming to develop the professional engineers in the Nuclear & Radiation areas, besides, because of the young ages of the college students, the education level should have been fundamental compared with the goals in the system of Professional Engineers.

Also, because the demands have been larger and larger to develop the human resources with global sense of minds, following abilities are required to be developed in education programs: (a) language ability for communication, message delivery and contribution to standardization, (b) initiative, activeness, challenging mind, cooperability, flexibility, a sense of responsibility and mission and (c) understanding ability of cross culture and identity as Japanese. Our human resource development projects have been carried out to meet these requirements [13].

As a human resource development program which takes the system of Professional Engineers in Japan into consideration, the contents can be divided as shown in Table 2 for "lectures" and "workshops". They had been designed that the lectures are specialized on the fundamental contents, although the workshops include the practical subjects to deepen the understanding. As the present program has been mainly focused on the workshop side, besides the development of e-learning and Active learning contents are still under development. In Fig. 4, the contents shown in blue boxes are mainly for storing knowledges, however, to deepen the understanding, the contents of exercises which are shown as the red allow in Fig. 4 is important. For example, the fundamentals on radiation physics and nuclear plans system have been included in the TV lectures and e-learning contents in addition to the lectures carried out in the workshops at nuclear facilities or universities. However, they have not yet been discussed about what the effective educational procedure and techniques. Even in the e-learning contents, the lectures are carried out one-sidedly while they have small number of exercises, therefore, we need to develop new exercise system based on ICT to enable the process of deepening knowledges before moving to the workshop stage. We have that fact in mind as an important issue to be improved in the future program.

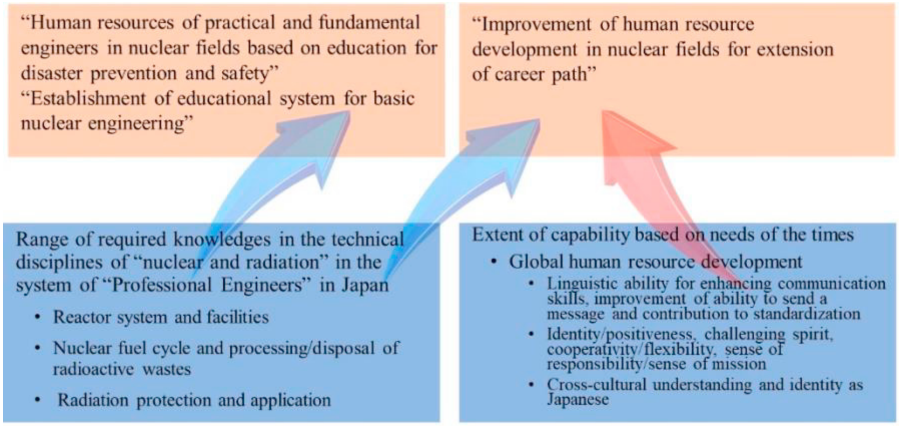


Fig. 5. Position and aims of the project.

Table 2. Summary of the contents which are desired to meet the requirements from the system of Professional Engineers in Japan.

Subjects	Contents in the lectures	Contents in the workshops
Nuclear reactor system and facilities	Fundamentals of nuclear plant	Training on reactor control system
	Nuclear engineering	Visits to safety system and facilities, including those utilizing site conditions
	Safety principle and system	Study on countermeasures to meet emerging standards and regulatory Issues
Nuclear fuel cycle/ Reprocessing and disposal of radioactive wastes	Enrichment and fabrication of nuclear fuel material	Visits to fuel reprocessing plants
	Methods of processing radioactive wastes	Workshops on chemical treatments adopted in reprocessing spent fuels
	Technologies for disposal of radioactive wastes	Understanding of the systems adopted in intermediate storage facility
Radiation protection and application	Fundamentals of radiations and their interactions with matters	Workshops on radiation measurements to understand how to select and use the detectors, and data processing techniques
	Radiation measurement	Understanding of physical phenomena through measurement workshops
	Application of radiation to medical field and nuclear fusion etc.	Visits to the radiation related advanced facilities
Operating and maintenance jobs in nuclear related facilities		Introduction of the practical jobs by young researchers and engineers

3.2. Present status and perspectives of the human resource development in nuclear engineering for students of national colleges

For developing human resources in nuclear engineering, one of the important contents is the enhancement of the technical skills, for which knowledges and technologies or skills should be learned through memorization of those. For that purpose, our program has been developing the TV lectures and e-Learning contents on fundamentals of radiation and nuclear engineering, safety engineering, backend technologies and radiation applications.

The other important contents are the visits to the related facilities or experience-based learning at those facilities, which should be based on the cross-cultural understanding abilities for unknown fields. The experiences should enhance the understandings on those areas.

From these contents, we believe we have been educating the colleges students in this technical field, however, we recognize the lack of bidirectional feature in our program. It may have made the understandings of the students to be shallower than we had expected. In the future, we are planning to provide substantial amounts of exercises base on ICTs to reduce the time necessary for classroom learning, which should result in the enough time which can be used for practical workshops or facility visits. For that purpose, we will cooperate with the universities which have know-hows and advanced facilities for e-Learning like the ILIAS system in Nagaoka University of Technology. The developed programs will be provided to the national colleges which have already joined the e-Learning Higher Education Linkage Project (eHELP) [14] where the contents will be shared for improving their qualities. In the future, the environment for collaborative learning will be implemented in the LMS which will make it possible to share the measured results with pocket dosimeters and scintillation survey meters among the students along with the geographic information provided the Google map system. Also, we can find advanced examples of Active learning about nuclear safely using virtual environment, which can be a candidate to deepen students understanding on the social aspects of nuclear energy production [15]-[17]. We believe these new trials will enhance the effectiveness of the human resource development project.

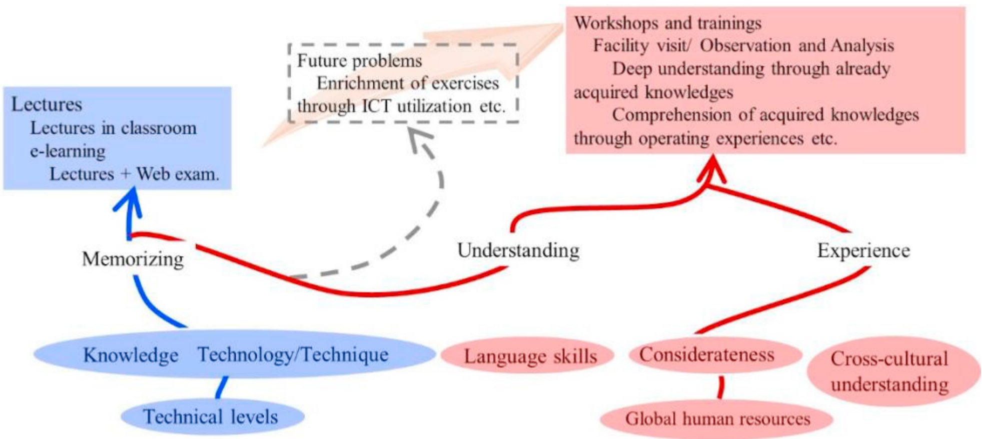


Fig. 6. Perspective of improved human resource development in nuclear engineering.

4. Conclusions

We have been developing and carrying out the human resource development program for national college students in Japan. It consists of (a) remote lectures and e-Learning contents on radiation and nuclear related subjects, and (b) on-site workshops and visits at nuclear related facilities or Nagaoka University of Technology. More than 10 thousand of students participated in the program, which, we believe, was effective to enhance their understanding in these fields. However, as an educational system, it seems to be able to be improved through utilization of ICTs etc. Further attempts will be continuously done through discussions among our group.

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