Progression of Technology Education for Atomic Energy Engineering in Tsuyama National College of Technology*


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Abstract
This paper describes the achievements of a program in which technology education is provided to cultivate practical core engineers for low-level radiation. It was made possible by means of (1) an introductory education program starting at an early age and a continuous agenda throughout college days and (2) regional collaboration. First, with regard to the early-age introductory education program and the continuous education agenda, the subjects of study related to atomic energy or nuclear engineering were reorganized as “Subjects related to Atomic Power Education” for all grades in all departments. These subjects were included in the syllabus and the student guide book, emphasizing a continuous and consistent policy throughout seven-year college study, including the five-year system and additional two-year advanced course. Second, to promote practical education, the contents of lectures, experiments, and internships were enriched and realigned in collaboration with the Japan Atomic Energy Agency, Okayama University and The Cyugoku Electric Power Co., Inc. In addition to the expansion and rearrangement of atomic power education, research on atomic power conducted for graduation thesis projects were undertaken to enhance the educational and research activities. In consequence, it has been estimated that there is now a total of fourteen subject areas in atomic energy technology, more than eight-hundred registered students in the department, and thirteen members of the teaching staff related to atomic energy technology. Furthermore, the “Tsuyama model” is still being developed. This program was funded by the Ministry of Education, Culture, Sports, Science and Technology.

Key words: Introductory Education, Syllabus, National College of Technology, Internship, Graduation Thesis

1. Introduction
Tsuyama National College of Technology (Tsuyama NCT) has already been providing outside practice in Ningyo-toge Environmental Engineering Center of the Japan Atomic Energy Agency (JAEA) in the form of internship programs for the fourth-grade students in associate’s degree courses and the first-grade students in advanced engineering courses. Furthermore, since 2008 Tsuyama NCT has been conducting exchange programs with Okayama University and JAEA to allow shared use of nuclear engineering, radiation
management, decontamination, decommissioning, and waste disposal facilities. By utilizing these advantageous resources, the following changes to educational programs for core engineers in atomic energy have been instituted:

(1) an early-age introductory education program and a continuous agenda of the atomic energy education throughout the college,
(2) development and reorganization of the contents of lectures, experiments, and internships, and
(3) enhancement of research works for graduation theses on atomic energy; specifically, remote control and mechatronics technologies, material technologies in view of the use of low-level radiation, decommissioning technologies, and the reuse of waste.

In addition, regarding low-level “radiation” and “safety and security,” educational materials related to safety operation and safety management have been developed and organized in collaboration with The Chugoku Electric Power Co., Inc. In the present study, the program’s contents are reported and discussed.

2. Items conducted

2.1 Establishment of the early-age introductory education program and subjects related to atomic energy

Schematic illustration of the present project is shown in Fig. 1.

2.1.1 Introductory education at an early age

To foster consciousness about atomic energy education starting at an early age, fundamental educational materials have been prepared that can be used for the freshmen in the associate’s course. Display samples of belonging radioactive and availability of gamma ray measurement have been arranged with the help of JAEA.

2.1.2 Continuous education in the associate’s degree courses

The subjects related to atomic energy and nuclear engineering in all grades and all departments have been reorganized, enabling a continuous and consistent education.
2.1.3 Safety education in advanced courses
A special lecture on advanced engineering is given with the keywords “safety and security.” By establishing the collaboration between Okayama University and the foreign research and education partners, practical engineers with international viewpoints are cultivated.

2.1.4 Inspection of atomic energy facilities and Ibaraki National College of Technology (Ibaraki NCT)
Many educational staff members join a mission that observes atomic power facilities where radioactive materials and radiation are practically used in order to enhance their knowledge and understanding of atomic energy and low-level radiation. To establish the educational program effectively, Ibaraki NCT, which has great experience and achievement in atomic energy education (1)-(4), is inspected by some committee members.

2.1.5 Preparation of a self-learning environment
To establish the present educational program, books related to atomic energy and radiation are increased in the preparation of the self-learning environment of students in both the associate’s course and the advanced course.

2.2 Practical education program with internships
2.2.1 Development of experimental materials corresponding to internships
Educational materials used for experiments correspond with internships and are prepared in collaboration with Okayama University, JAEA, and The Chugoku Electric Power Co., Inc.

2.2.2 Arrangement for experiments and their environments required for internships
A rearrangement plan is carried out for student experiments and their environments corresponding to the internship. The details will be shown in 3.6.

2.2.3 Upgradation of the internship
The contents of the internship that have been conducted are upgraded. To achieve this, the preparation environment and pre-learning of atomic energy and radiation is rearranged. The details will be shown in 3.6.

2.3 Practical education program using research works for graduation thesis
Considering the continuation of lectures, experiments, and internships, research projects for the graduation thesis written for the associate’s degree course and the advanced course are launched in collaboration with Okayama University, JAEA and The Chugoku Electric Power Co., Inc.

3. Results and Discussion

3.1 Introductory education at early age
Materials containing low-level radioactive substances, such as heat-resistant bricks, potassium-containing fertilizers, marble stones, and iron slags, were provided by JAEA and have been displayed as shown in Fig.2. An environment where radiation can be measured with a survey meter known as a “hakaru-kun” has been established. In addition, boards explaining atomic energy and radiation have been installed in the physics laboratory as shown in Fig.3.

3.2 Continuous education in associate’s degree courses
The number of subjects related to atomic energy technology in the five-year associate’s degree course has been increased to more than ten. They have been included in the syllabus and the student guide book with an emphasis on a continuous and consistent policy throughout the seven-year college study, consisting of the five-year system and the
additional two-year advanced course. In fiscal year 2009, a lecture on the reaction of the nucleon was given in the subject of "chemistry II". The total number of registered students will be more than 800 in fiscal year 2010 as shown in Fig.4. Almost all graduates study the atomic energy related subjects, but the number of the subjects studied in their school days depends on their belonging department. It is not easy to classify business firms related to this program, however, at least twelve students got their jobs in the related company, in fiscal year 2011. Furthermore, the mined soil for obtaining Uranium ore has been controversial issue in Tsuyama region, therefore the graduates should have correct knowledge on the radiation and the effects of low-level radiation quantitatively in order to have their own opinion as engineer and to lead ordinary people to correct direction. Consequently this program has been expected to be effective for cultivating practical core engineers for low-level radiation.

3.3 Safety education in the advanced course

A foreign researcher named Professor M. Shaliali from Chalmers University in Sweden was invited by Okayama University to give a special lecture on advanced engineering focusing on sustainable development as shown in Fig.5. Students in the advanced course wrote reports on the lecture confirming that many of them realized the importance of sustainability of energy and atomic energy. Additionally, four new subjects related to atomic energy technology have been included in the syllabus and the student guide book of the advanced course in 2009 as shown in Table 1.
Table 1 Subjects related to atomic energy technology included in the syllabus and the student guide book with an emphasis on a continuous and consistent policy throughout the seven-year college study

<table>
<thead>
<tr>
<th>Creative Physical Experiment</th>
<th>2</th>
<th>M,E,S,C-2</th>
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</thead>
<tbody>
<tr>
<td>Applied Physics 2</td>
<td>2</td>
<td>M,E,S-4 (Selective)</td>
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<tr>
<td>Mathematical Physics 1</td>
<td>2</td>
<td>M,E,S,C-4 (Selective)</td>
</tr>
<tr>
<td>Engineering Ethics</td>
<td>2</td>
<td>M,E,S,C-5</td>
</tr>
<tr>
<td>Study of Science</td>
<td>2</td>
<td>M,E,S,C-5 (Selective)</td>
</tr>
<tr>
<td>Environment and Recycling</td>
<td>2</td>
<td>M-5</td>
</tr>
<tr>
<td>Engineering of Electric Power Generation</td>
<td>2</td>
<td>E-5</td>
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<tr>
<td>System Engineering</td>
<td>2</td>
<td>S-5</td>
</tr>
<tr>
<td>Energy Engineering</td>
<td>2</td>
<td>M,E,S,C-5</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>2</td>
<td>MS-1, EC-1</td>
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<td>Engineering Ethics</td>
<td>2</td>
<td>MS-1, EC-1</td>
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<td>Electric Energy Engineering</td>
<td>2</td>
<td>MS-2</td>
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<tr>
<td>Investigative Approach</td>
<td>2</td>
<td>MS-2, EC-2</td>
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</table>

(*) Department  M: Mecanical Engineering, E: Electrical and Electronic Engineering, S: Electronics and Control Engineering, C: Computer and Information Engineering, MS: Advanced Mechanical and Control System Engineering, EC: Advanced Electronic and Information System Engineering course

3.4 Inspection of atomic energy facilities and Ibaraki NCT

The Ningyo-toge Environmental Engineering Center of JAEA, the Shimane Atomic Power Station of The Chugoku Electric Power Co., Inc., and Ibaraki NCT were inspected by the educational staff. The total number of the educational staff members who participated in the inspection was fourteen. The inspection of Ibaraki NCT was conducted by two staff members of the present program, who then reported the activities of Ibaraki NCT to the program’s working group and external assessment committee. The inspection of the Shimane Nuclear Power Plant and Tokai Research and Development Center of JAEA were conducted by twelve members of the teaching staff who were in charge of the atomic energy-related subjects as shown in Fig. 6. Using Microsoft PowerPoint, they documented the information and knowledge they obtained for use as educational materials, which have since been utilized in various atomic energy-related subjects. For the Shimane Nuclear Power Plant, introductory PowerPoint presentations showing the specifications and the
principles of nuclear power generation, and the structures and photographs of the Shimane Nuclear Power Hall were produced. This type of inspections was preferably conducted in many organizations since it is very effective to grade up the capability of educational staff quickly. In addition, it should be noted that there is a specific energy-supplying structure in the Cyugoku area, in which coal combustion thermal power generation produces 35% of the electric power supply and atomic power generation produces 8%, which can be compared with the average overall Japanese statistics of 20% and 18%, respectively. To reduce CO₂ emissions, it is necessary to reduce the proportion of coal combustion thermal power generation to the above mentioned average. To look at these figures, the average emissions of carbon dioxide and the ratio of atomic power to the total electric generation in Cyugoku area were compared with the overall averages and ratios of Japan and other countries were summarized in the PowerPoint presentation. In this lecture, students were interested in the surrounding situation and many questions on the energy issues related to the Cyugoku area including nuclear power station. Further, educational materials corresponding to the "Pul-thermal" plan for plutonium thermal operation, to ethics for industrial engineers, to the relation between nuclear fusion technology and super electric conductivity and to the measurement of natural radiation were produced.

Fig.5 Special lecture on advanced engineering focusing on “Sustainable development” by a foreign professor from Chalmers University in Sweden. Forty five students in the advanced course students wrote reports on the lecture.

Fig.6 Inspection of the Tokai Research and Development Center of JAEA by the teaching staff in charge of the atomic energy-related subjects.

Fig.7 Books related to atomic energy and radiation displayed in research laboratories and experimental rooms supervised by the education staffs that teaches subjects related to atomic energy.

Fig.8 External assessment committee to advise to the present program and discuss the internship and the graduation thesis.
3.5 Preparation of self-learning environment

Thirty-eight different types of books, totaling 182 books, related to atomic energy and radiation were purchased and displayed in research laboratories and experimental rooms supervised by the educational staff that teach subjects related to atomic energy as shown in Fig. 7.

3.6 Practical education program by internship

To upgrade the contents, the internship program, student experiments and the environment in which these are held have been rearranged. Further, the required experiment equipment was installed. These improvements have been applied in a student experiment in a subject of “applied physics II” and a pre-study for “internship” held during summer vacation. Concretely speaking, conventional experiment using portable type detector was replaced by an experiment using survey meter to make students understand the square law of distance. By applying the pre-study for “internship” in environment center of JAEA, they became to start from further study like decommissioning of nuclear facilities and Uranium mine. The number of students participated in the internship at JAEA for 5 days was four, and they could understand the importance of nuclear energy and CO₂ reduction. Further more than two students, including the student conducted an atomic energy related graduation thesis, obtained their jobs in atomic energy related company.

3.7 Practical education program using research works for graduation thesis

Research works for the graduation thesis in the associate’s degree course and the advanced course were planned and prepared using all of the equipment introduced considering the continuation of lectures, experiments, and internships. More than three themes were launched and conducted in collaboration with the related organizations. In fiscal year 2009, the papers “Research on the relation between the distributions of Radon concentration in Tsuyama district,” “Production of a text on the radiation measurement in Applied Physics experiment for the fourth-grade students” and “Fundamental research on the measurement of boron concentration using nuclear reaction analysis” were planned and prepared. In fiscal year 2010, in addition to the progression of the above research works, two other research works, “Research on radiation measurement using an autonomous driving vehicle” and “Production of a text on radiation measurement in electronic and control engineering experiment for the third-grade students” were launched.

4. Assessment of the present program and further works

4.1 Establishment of an early-age introductory education program and a continuous education program

Preparation of a display by JAEA, reorganization of the atomic energy-related curriculum in the associate’s degree course, and a special lecture on advanced engineering by a foreign researcher were carried out as scheduled. It was confirmed, however, that the display samples could not be utilized by many students as a result of the place of installation. The place where the displays were installed was, thus, changed to the research laboratories and the student experiment room for applied physics. For the reorganization of the curriculum, one subject related to atomic energy in the associate’s degree course and one in the advanced course had been planned to be introduced. However, fourteen subjects ended up being reorganized and included in a modified syllabus because of a greater-than-expected effort of the teaching staff. This program had planned to be sustainable even after finishing the support from the external organizer. In addition to the plan, after the end of the two years program, “Atomic energy education working group” has
been launched with annual budget in Tsuyama NCT to continue the activities since fiscal year 2011.

4.2 Practical education program by internship and research works for graduation thesis

The enforcement of the educational program in which internship, research works and student experiments have continuation and consistency has that these approaches are indispensable for enhancing and continuing atomic energy education, in addition to the positive just been instituted and focused. It has been suggested exchange of opinions by related organizations.

4.3 Matters relating to the assessment methods of the present program

It has been suggested that the verification of the educational effect and the assessment method are the remaining themes after confirming the number of registered and participating students. The assessment method was discussed in the external assessment, as shown in Fig.8, and the information on effective methods still needs to be collected from the related organization and other advanced projects.

5. Conclusion

Technology education to cultivate practical core engineers for low-level radiation was conducted in collaboration with the JAEA, Okayama University and The Cyugoku Electric Power Co., Inc. The results are as follows:

(1) An education program starting at an early age and continuous and consistent educational agendas throughout the seven-year college days were established.
(2) The subjects related to atomic energy and nuclear engineering have been reorganized as “Subjects Related to Atomic Energy Education” and have been included in the syllabus and the student guide book.
(3) The information and knowledge obtained from the teaching staff’s technical inspection were documented as educational materials using PowerPoint and they have been utilized for the various atomic energy-related subjects.
(4) Research works for graduation theses in associate’s degree courses and in advanced courses were prepared using all of the equipment introduced considering the continuation of the lecture, experiment and internship.
(5) In consequence, it has been estimated that there are a total of fourteen subject areas, more than eight-hundred registered students and thirteen members of the teaching staff related to atomic energy technology.

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