

# Chapter 1

## Integrating Social-Scientific Literacy in Nuclear Engineering Education

### Approaches Developed in the GoNERI Program

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**Abstract** This introductory chapter explains the historical background, outline, basic concept, and objective of the Program for Advanced Graduate Education system for nuclear science and engineering with Social scientific literacy (PAGES), under which the 2011 summer school was organized and this book was developed. Early efforts and trials in PAGES started in 2008 toward integrating social sciences in nuclear engineering education mainly by organizing summer schools as a test bed. Various important insights on how pedagogically effective integration could and should be achieved were obtained through the summer schools held in 2008–2010. When the Fukushima Daiichi accident occurred in

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March 2011, the organizing committee of the 2011 summer school, which consisted of the authors of this chapter, immediately recognized that this would be a time when PAGES faced a test with regard to its effectiveness, and the previous efforts under PAGES should be fully utilized to understand and address the accident. The organizing committee concluded that while it is still in its infancy, the PAGES approach successfully established an integrated framework for both engineers and social scientists. It changed the perspectives of the participants, both the students and the organizers, and it laid groundwork that the organizers hope that they and others will be able to build upon.

**Keywords** PAGES · GoNERI · Nuclear engineering education · Social scientific literacy for engineers · Integration · Fukushima Daiichi accident

## 1.1 Preamble

Words such as “interdisciplinary,” “collaboration,” and “social aspects” had regularly appeared in various nuclear contexts since long before the Fukushima Daiichi nuclear accident on March 11, 2011. It had already become common understanding that we need to bring together a wider range of knowledge and expertise to deal more appropriately with the place of nuclear technology in society.

This trend had also come to Japan at least about 10 years before the Fukushima Daiichi accident. Responding to that, the Nuclear Engineering Department of the Graduate School of the University of Tokyo was reformed in 2004, to integrate international, social, and even humanistic factors with conventional science and technology research and education. The new English name of the department was “Department of Nuclear Engineering and Management” (UTNEM) and its prospectus [1] describes its purpose as follows: “the Department is involved in international cooperation for education and research with added humanities and social science aspects, including sending its members to international organizations and prominent foreign universities.” The “Nuclear Socio-Engineering Laboratory” was established within UTNEM for exploring “the relation and interaction between technologies and human life” [2] by the strong initiative of Prof. Haruki Madarame,<sup>1</sup> who was well known as one of the most influential advocates of this direction. This laboratory had faculty members who specialized in social scientific fields such as Social Psychology, Communication Studies, Economics, Regulation and Legal System, Risk Studies, Social Studies of Science, and so on, and educated graduate and undergraduate students who worked on research topics closely related to such fields.

However, the “integration” of “humanities and social science aspects” was still only partial, strictly speaking. Even after the reformation described above,

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<sup>1</sup> After retirement from the University of Tokyo in 2010, Prof. Madarame became the Chairman of the Nuclear Safety Commission of Japan.

the group that studied social scientific topics on nuclear technology was somehow “separated” from the rest of department as conventional engineering research labs were the majority. From the point of view of an observant social scientist, the situation after the 2004 reformation at the UTNEM was just an “addition” of the social scientific part, appropriately suggested by the prospectus cited above. This addition model was not a totally meaningless change, of course, but it was not sufficient to cope with contemporary difficult issues centering around nuclear utilization in a so-called post-industrial society.

This process of “integration” seems to require a long-term effort to be accomplished. The Fukushima Daiichi accident clearly exposed the incompleteness of the past efforts at “integration,” as various chapters of this book discuss in detail; even in 2014, three years after the accident, it seems to be still on going.

The abilities required of leading engineers in this post-industrial era are not just to pursue technological development as prescribed (typically by governmental long-term plans or other national programs), but to grasp multi-dimensional needs for technology, to develop technology in collaboration with different stakeholders under a more open societal process, and to fulfill their social responsibility in compliance with values shared within society.

## 1.2 GoNERI

In 2007, the proposal prepared by UTNEM professors for a brand-new initiative, titled “Nuclear Education and Research Initiative” (GoNERI),<sup>2</sup> for achieving further integration of engineering and social sciences into their education was successfully awarded a grant under the Global Centers-of-Excellence (COE) program by the Japan Society for the Promotion of Science (JSPS), funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. The GoNERI program included various tasks for the purpose of developing an advanced nuclear engineering curriculum. Among them, the task of “integration” was given the highest priority. An official statement of the GoNERI program framed this attempt as “the first systematic education on nuclear energy in the world ... incorporating the social, liberal arts and technical subjects as they relate to nuclear utilization.” [3] The UTNEM professors were aware that the faculty and students of UTNEM in many cases did not yet have sufficient command of the fundamentals of the social sciences (their domain, concepts, terminology, methodology, etc.), and that this separated them from social scientific activities even at the time when GoNERI started in 2007 and limited them in collaborating with social scientists and citizens. Consequently, three researchers with different social scientific backgrounds (history of science, risk communication studies, and sociology

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<sup>2</sup> “Go” is short for Global COE program.

of science and technology) were invited into GoNERI to pursue this concept, and they began their work to develop an advanced graduate educational program with social scientific literacy.

### 1.3 PAGES

To this end, in partnership with the Nuclear Engineering Department of the University of California, Berkeley (UCBNE), UTNEM engaged in various efforts. Those included a series of bi-weekly seminars and field work at the Waste Isolation Pilot Plant (WIPP), at Carlsbad, New Mexico in January 2009, as well as the Japanese sites of Toyo-Cho and Rokkasho-Mura in July 2008. Of particular importance was a one-day workshop held in Santa Fe, New Mexico, embedded in the field trip to WIPP. Intensive discussions were conducted to clarify the challenges and to explore approaches and solutions toward better integration [4]. Through these discussions, we came to share the basic understanding that engineers can gain from, and indeed be expected to have, basic literacy in the social sciences as part of their essential competence, not as an “additional” or “optional” skill that might sometimes be admired.<sup>3</sup> In particular, opening up the decision-making process on socio-technical issues (e.g., introducing participatory methods) calls for more insightful, communicative, and open-minded engineers who can interact with other stakeholders, naturally including ordinary citizens. Engineers should be able to more fully understand various subtle, but critically important, societal contexts regarding technology, explain available technical options to stakeholders and society, and proactively take part in public discussion. In this context, rather than inventing “the best solution” for problems on behalf of society, engineers are considered to be experts who can offer their formulation of problems, multiple options available to society, and, if possible, proposals of solutions.

Sharing the thoughts listed above, it was decided to organize summer schools for topics that were considered inseparably related to social aspects, such as radioactive waste management, as a test bed for developing an advanced educational program to cultivate leading engineers who have this capacity. This collaborative program was given the name PAGES, Program for Advanced Graduate Education system for nuclear science and engineering with Social scientific literacy. Under PAGES, three summer schools were conducted.

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<sup>3</sup> Conversely, social scientists need a better grasp of engineers and engineering practices, of course.

## 1.4 PAGES 2009 and 2010 Summer Schools

Before the Fukushima Daiichi accident, PAGES conducted the 2009 Advanced Summer School of Radioactive Waste Disposal with Social Scientific Literacy in Berkeley, California, and the 2010 Advanced Summer School of Nuclear Engineering and Management with Social-Scientific Literacy in Honolulu, Hawaii, with the participation of Tokai University, Japan. Table 1.1 summarizes the outlines of the PAGES 2009 and 2010 summer schools.

The first 2009 PAGES summer school was realized by the strong initiative of Joonhong Ahn, one of the editors of this book. None of the GoNERI members had been involved in such an ambitious project before. But Ahn and other members recognized that radioactive waste disposal was the one of the most urgent issues that should be tackled as an interdisciplinary challenge. Under this understanding, the 2009 PAGES summer school invited guest speakers who could provide “social aspects” education for engineers from the following fields: sociology, social psychology, economics, risk studies, science and technology studies (STS),

**Table 1.1** Outlines of PAGES 2009 and 2010 summer school

PAGES 2009	PAGES 2010
<i>List of organizing committee members</i>	
Joonhong Ahn (UC Berkeley)—Chair Satoru Tanaka (U Tokyo)—Co-chair Mick Apted (Monitor Scientific) Cathryn Carson (UC Berkeley) Gary Cerefice (UNLV) James Conca (NMSU) Tom Isaacs (Stanford University) Shinya Nagasaki (U Tokyo) Jooho Whang (Kyung Hee University)	Shinya Nagasaki (U Tokyo)—Chair Tatsuhiko Kamisato (U Tokyo)—Co-chair Joonhong Ahn (UCB)—Co-chair Satoru Tanaka (U Tokyo)
<i>Venue</i>	
University of California, Berkeley	Hawaii Tokai International College, Honolulu
<i>Program</i>	
Registration and reception: Aug. 2 (Sun) Lectures: Aug. 3 (Mon)–Aug. 5 (Wed) Symposium: Aug. 6 (Thu)–Aug. 7 (Fri) Field Trips: Geo tour in Bay Area: Aug. 8 (Sat) Waste Isolation Pilot Plant, Carlsbad, New Mexico: Aug. 10 (Mon)	Registration and keynote lecture: Jul. 25 (Sun) Lectures: Jul. 26 (Mon)–28 (Wed) Special Lecture and Workshop: Jul. 29 (Thu) Workshop: Jul. 30 (Fri) and Aug. 2 (Mon)
<i>Number of participants (students)</i>	
30 (from 5 countries)	15 (from 7 countries)
<i>Number of participants (lecturers)</i>	
28 (from 4 countries)	25 (from 4 countries)
<i>URL</i>	
<a href="http://goneri.nuc.berkeley.edu/pages2009/index.html">http://goneri.nuc.berkeley.edu/pages2009/index.html</a>	<a href="http://goneri.nuc.berkeley.edu/pages2010/index.html">http://goneri.nuc.berkeley.edu/pages2010/index.html</a>

and consensus building practices. Also, we held a symposium by those lecturers, PAGES members, and student participants on the final day of the program.

After this first trial case, on the one hand, we heard many complaints from student participants that there was not enough time for discussion with lecturers and other participants, even though 60 or 90 min were allocated for each lecture. On the other hand, academic interactions among invited lecturers from different backgrounds were strongly stimulated, extended, and deepened. Both the importance of the concept of PAGES and the actual experiences there were highly appreciated by almost all the expert participants. Such reactions had not been expected beforehand. This reaction reflects the reality that the number of opportunities for such intensive discussion among experts in different fields had been limited, although such efforts had been encouraged for a long time. This situation is no doubt common outside the nuclear field as well.

This experience strengthened our confidence in the PAGES project. In March 2010, about half a year after the first PAGES summer school, a closed workshop “What is social literacy for nuclear engineers? From problem-solving engineering to program-formulation engineering” was held at the University of Tokyo with 9 outside experts. The direction of “social literacy” education including the design of the PAGES summer school program, and more generally the future of engineering education, were intensively discussed. This workshop resulted in two important findings: (1) Engineering students prefer that a more object-oriented educational program be available not only for social-literacy education, but also for general engineering education, rather than the traditional lecture-style program; (2) Social literacy education must be embedded not only in nuclear engineering education, but in other fields of engineering education as well, in light of recent rapid social changes around engineering and technology.

Inspired and driven by these understandings, the second summer school was held in Honolulu, HI, in August 2010, in collaboration with Tokai University, Japan. Honolulu was selected as the venue for the school because it was the “midpoint” between the U.S. and Japan and an “away” place for both Japanese students and continental U.S. students. In the 2009 summer school, which was held in Berkeley, UC Berkeley students and professors (the majority of the participants) went home after each day’s program, and interaction between them and the Japanese students was not as deep as the organizers expected. PAGES project members realized that this “home and away” gap should be and could be reduced by the venue selection.

Also, the content of the program was modified in response to the March 2010 workshop’s conclusion, feedback from the 2009 PAGES participants, and other discussion among PAGES project members. Tatsuhiro Kamisato, a core member of the PAGES project and a historian of science, took the initiative for this second PAGES summer school in collaboration with Shinya Nagasaki, the chair of the organizing committee and a nuclear engineering professor at the University of Tokyo. In this year, two major improvements were made from the 2009 school.

The first point was the relativization of nuclear engineering as a field in the scholarship. Participants were encouraged to free themselves of stereotypical

thinking such as “nuclear engineering as the given (fixed) field + social aspects.” The program was designed to help open their minds more and realize that nuclear technology has been invented, developed, and deployed through interdisciplinary collaboration among various different fields of scholarship. Lectures from engineering fields other than nuclear engineering (i.e., electric engineering, civil engineering, and so on) and social and human sciences (i.e., political science, history, social psychology, and so on) were included in the program, and guest lecturers were invited from various countries and regions including Europe, the U.S. and Japan. The concept of “engineering in society,” including issues centering on technology governance, risk, and ethical considerations, were broadly addressed in lectures and interactively discussed.

Another brand-new idea was the introduction of so-called project-based learning (PBL) for object-oriented education. In the later half of the summer school program, students were divided into small groups and given research topics. They conducted intensive surveys, discussions, and reports during a short period of time and made final presentations at the end of the program. The following four topics were chosen and studied by student groups: “Safety of High Level Waste Radioactive Disposal,” “Introduction of Technology for Society and its Process,” “The Necessity of a HLW Geological Repository,” and “Nuclear Power Generation Systems for the Non-Nuclear Armed Countries.”

## **1.5 Concept, Aim, and Design of PAGES 2011 Summer School**

### ***1.5.1 Planning for PAGES 2011 Summer School***

After these two summer schools in 2009 and 2010 as trial cases of the educational program, in January 2011 we started preparing for the third summer school, for which the issue of high-level radioactive waste (HLW) disposal technology and society was selected. It was to be held in Sweden, in collaboration with the Swedish Radiation Safety Authority (SSM). We had a meeting in Stockholm in January 2011 and agreed upon an outline for the approximately 10-day program, which included a series of site visits to so-called back-end nuclear facilities in Sweden and Finland. This program was planned to function as an applied curriculum mainly for alumni of our past summer schools. The site visits were intended to deepen students’ understanding of the societal aspects of nuclear utilization through the site observation tours, conversations with site officials and local people, and discussion with lecturers and fellow students.

However, we found our plans unsettled by one of the most serious nuclear disasters in world history: the Fukushima Daiichi nuclear accident, which was triggered by the Great East Japan Earthquake and its subsequent tsunami on March 11, 2011. From the discussions accumulated in the previous PAGES activities, we

immediately thought of the accident as a joint socio-technical failure.<sup>4</sup> This accident raised many fundamental and controverted questions regarding the traditional approaches of nuclear engineering and its utilization in society. We believed that engineers and other experts involved in nuclear utilization needed to take those questions very seriously and be responsive to criticism and concern expressed by citizens.

Consequently, the organizing committee decided to make the third summer school a venue for preliminary, yet multi-dimensional learning from the accident by focusing on reflections on that shocking event (although we still hold that the importance of HLW disposal remains unchanged, or perhaps becomes even more urgent in the disaster's aftermath). This decision led to a change of venue, as well as the introduction of an amended topic for the school. While we first considered the possibility of having the school at the University of Tokyo campus or any other place in Japan, this option was rejected due to (among other reasons) the serious burden of a projected shortage of electricity in the summer season. We also wanted to make this summer school a place that enabled the participants to critically address the situation and issues involved in this accident, and to exchange their views candidly.

Based on such considerations, the 2011 Advanced Summer School of Nuclear Engineering and Management with Social-Scientific Literacy: Reflections on the Fukushima Nuclear Accident (PAGES 2011) was held in Berkeley, California, in the first week of August (July 31–August 5), organized around 12 lectures and a series of facilitated discussions. It attracted 18 students from various fields and countries, principally nuclear engineering students in graduate programs in Japan and the United States, but including some social science students as well as students from other nations studying in these countries. In the rest of this introductory chapter, we will explain the concept, aim, and design of our educational program; offer a brief assessment of its effectiveness; introduce a couple of intriguing discussions held by participants; and discuss the program's implications for the post-Fukushima nuclear context.

### ***1.5.2 Aim and Design of PAGES 2011 Program***

The PAGES 2011 summer school was a 5-day program that focused on the issues raised by the Fukushima Daiichi accident, in the larger context of interactions and relations between nuclear technology and society. This program was not intended to reach a single agreed-upon conclusion about the accident. Rather, we designed the program to encourage participants to develop their own philosophies, stances, and/or principles that they believed to be appropriate and responsible in the post-Fukushima nuclear context. These were to be based on the collected and confirmed technical facts on the accident, on social-scientific methods and approaches

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<sup>4</sup> To understand more about this perspective, see Chap. 10 by M. Matsumoto of this volume.



that enable us to think about the event more deeply and analytically, and on intensive dialogue among participants. The word “reflections” in the title of the PAGES 2011 school and the title of this book indicates our intention; it means that as participants we should not make comments or criticisms as outsiders, but instead should critically examine our past practices and thinking and subsequently change our assumptions, approaches, methods, and stances, from a position of open-mindedness.

We understood that this approach would be different from standard nuclear engineering curricula. In particular, we wanted to give an important role to the students themselves. We decided that the best way to implement this intention would be a combination of lectures and intensive facilitated discussions, leading to student presentations and individual written essays (see Part IV).

To realize this concept, we brought together 12 lecturers and 3 discussants from various fields centering on the interface of nuclear technology and society: i.e., the chemistry of radioactive nuclides in the environment, reactor physics, radiation protection, reactor design, engineering ethics, technology governance, sociology of science and technology, history of nuclear technology, and long-term energy portfolios and nuclear policy. Table 1.2 is the list of lectures and lecturers. This book includes the chapters by most of the lecturers listed in the table, though their contents are updated and reflect the discussion during the school.

Each of the first four days included two or three lectures (45 min each). On the first day (August 1), three lectures on a technical analysis of the Fukushima Daiichi accident were provided. Those sessions were intended to provide a common grounding in technical facts for all participants, as the basis for social-scientific discussions in following days.

On the second through fourth days (August 2–4), lecturers with deep knowledge and expertise in various social science disciplines and problem areas demonstrated social-scientific approaches that could be helpful in thinking about this complex and tragic socio-technical failure.

Stemming from these lectures, students were encouraged to join in discussion with their fellow students and lecturers. Morning discussions spanned 30 min, and afternoon classes included a 90 min “reflection and discussion” slot. In these latter sessions, discussants (three postdoctoral researchers took this role) encouraged interaction among participants by proposing points to be explored and steering discussion as needed.

Students formed small groups (about 4–6 people) during the group discussion/work sessions. This grouping was undertaken by the students themselves and was based on shared interests. Students repeatedly held discussions within the groups and formulated tentative answers to some of the questions posed by lecturers, as well as other questions they found important in the larger group discussions.

To accelerate interactions among student participants, “student session” slots were scheduled for the evenings of August 2 and 3. In these sessions, the students gave oral presentations that introduced their own, often quite intensive activities after the Fukushima accident, described their thoughts regarding the event, and sought feedback from other students and lecturers.

**Table 1.2** List of lecture(r)s at PAGES 2011 summer school and questions provided by lecturers

8/1 Mon.	<p>Scientific Analysis of Radiation Contamination at the Area around the Fukushima-Daiichi Nuclear Power Station, Prof. Satoru Tanaka (Univ. of Tokyo)</p> <ol style="list-style-type: none"> <li>1. How can we improve the transmission of information?</li> <li>2. How can we accelerate decontamination outside of the reactors site and people's returning home?</li> </ol>
	<p>Physics of Fukushima Damaged Reactors and its Preliminary Lessons, Prof. Naoyuki Takaki (Tokai Univ., Japan)</p> <ol style="list-style-type: none"> <li>1. How serious is the consequence of Fukushima accident? Consider from various views, such as the number of deaths; health risk for current and future generations; fears and inconvenience imposed on the public; impact on economy, etc. Is it unacceptable even if benefit (energy) derived from it is considered?</li> <li>2. If society allows continuous use of nuclear, what attributes should a nuclear system in the new era have? Give a concrete image/concept of such a new nuclear system (e.g., reactor plant and its fuel cycle)</li> </ol>
	<p>Radiation Safety Regulation under Emergency Condition, Prof. Toshiho Kosako (Univ. of Tokyo)</p> <ol style="list-style-type: none"> <li>1. What do we think about the emergency workers dose limit? (Cf. Japanese regulation: 100 mSv, changed to 250 mSv during this period) What happened to the remediators' working conditions when dose limits are exceeded while working on emergency tasks?</li> <li>2. What do you think about evacuation for general public under a nuclear emergency situation? (Cf. Japanese regulation: 10 km as a typical evacuation zone) What kind of arrangement is possible after using SPEEDI code? The arranged area should be circle or fan-shape?</li> <li>3. What is the main reason for administration of iodine pills to children? (Japanese regulation: about 40 mg for children)</li> <li>4. What kind of arrangement is effective for making surface contamination maps? Use only radiation monitoring?</li> <li>5. What do you think about the radiation level for school playgrounds? What is your idea for a dose rate guideline?</li> <li>6. Is it possible to remove contaminated soil by slicing off 5 cm for the decontamination of radionuclide in all areas of Fukushima prefecture?</li> <li>7. What method exists for the control of foodstuffs after the accident? Please explain your idea</li> </ol>
8/2 Tue.	<p>Impact of Fukushima for Reactor Design Practice, Prof. Per Peterson (UC Berkeley)</p> <ol style="list-style-type: none"> <li>1. Discuss "backfitting" policy (10CFR50.109 in the U.S.) which establishes the types of changes that a national regulatory authority can require to existing nuclear facilities. Consider analogies to policies for when existing buildings must be upgraded to meet new building code requirements, and requirements for when automobiles and consumer products must be recalled for repair or replacement. Discuss the societal tradeoffs in requiring backfitting (balance of the cost of backfitting against the benefit of improved safety). Discuss how backfitting policy might affect decisions to introduce improvements in new reactor designs</li> <li>2. Considering the vertical axis of the Farmers chart for the frequency of internal initiating events, discuss the commercial risks associated with introducing different fuels and materials in new reactor designs, and how such risks can be reduced</li> </ol>

(continued)

**Table 1.2** (continued)

	<p>Ethics, Risk and Uncertainty: Reflections on Fukushima and Beyond, Prof. William E. Kastenber (UC Berkeley)</p> <ol style="list-style-type: none"> <li>1. Are risk analysis methodologies robust enough to assess and manage the risk of core-melt accidents, such as at Fukushima, i.e., could the accident have been predicted or mitigated?</li> <li>2. Was emergency planning and emergency response adequate enough to protect public health and safety both before and after the Fukushima accident?</li> <li>3. Was there an adequate “safety culture” in place prior to and following the accident?</li> <li>4. What would it take to improve the quality of risk analysis and emergency planning so that the loss of public confidence could have been avoided?</li> </ol>
<p>8/3 Wed.</p>	<p>“Failure” of Regulation and Issues in Public Policy Studies, Prof. Hideaki Shiroyama (Univ. of Tokyo)</p> <ol style="list-style-type: none"> <li>1. Who and what mechanism should play roles for searching and integrating diverse knowledge that is necessary for managing a complex system?</li> <li>2. What is the way for strengthening regulatory capacity? Or how to keep civilian nuclear regulatory power without military use (which provides fund and personnel)? Or is it possible to restructure voluntary safety capability?</li> <li>3. Is it possible and effective to organize and implement nuclear safety research separated from nuclear research and development in general?</li> </ol>
	<p>The Structural Failure of the Science-Technology-Society Interface: A Hidden Accident Long Before Fukushima, Prof. Miwao Matsumoto (Univ. of Tokyo)</p> <ol style="list-style-type: none"> <li>1. How was the mutual relationship between success and failure in the little known but serious accident that happened during wartime mobilization?</li> <li>2. What do you think is the mutual relationship between success and failure in the Fukushima accident?</li> <li>3. What are the similarity and the difference between the accident during wartime mobilization and the Fukushima accident in terms of the mutual relationship between success and failure in the science-technology-society interface?</li> <li>4. What do you think about possibility of detecting the cause of structural failure in advance and incorporate structural remedies, if there are any, in your design practice?</li> </ol>
	<p>Three Mile Island and Fukushima: Some Reflections on the History of Nuclear Power, Dr. J. Samuel Walker (Former USNRC Historian)</p> <ol style="list-style-type: none"> <li>1. What are the most important lessons of Three Mile Island?</li> <li>2. To what extent would a good understanding of the lessons of Three Mile Island have been helpful in the response to Fukushima? Would they have been useful in reacting promptly and as effectively as possible to the technical failures caused by the earthquake and tsunami? Would they have been helpful in responding to media questions and public fears about the effects, real and potential, of the accident?</li> <li>3. Is it ever appropriate to intentionally provide information to the public about a nuclear accident that is incomplete, overly optimistic, or misleading? If so, under what conditions?</li> <li>4. How do authorities deal with the problem of providing accurate and up-to-date information when their own knowledge of the situation after a nuclear plant accident is fragmentary?</li> <li>5. Are the benefits of nuclear power worth the risks?</li> </ol>

(continued)

**Table 1.2** (continued)

8/4 Thu.	<p>Engineers in Organization, in Industry and in Society: Ethical Considerations, Prof. Jun Fudano (Kanazawa Institute of Tech., Japan)</p> <ol style="list-style-type: none"> <li>1. Compare and contrast the Code of Ethics of the American Nuclear Society (<a href="http://www.new.ans.org/about/coe/">http://www.new.ans.org/about/coe/</a>) and its counterpart in Japan, namely, the Code of Ethics of the Atomic Energy Society of Japan (<a href="http://www.aesj-ethics.org/02_02_03_/">http://www.aesj-ethics.org/02_02_03_/</a>). Also make a list of values, in order of priority, which are stipulated in each code</li> <li>2. Which ethical principles have been violated in the case of the Fukushima Nuclear Accident?</li> <li>3. Reflecting on the Fukushima Accident and referring to the above codes and any appropriate ones, write your own code of ethics (cite all codes you used)</li> <li>4. Explain, to laypeople, why engineers, especially, nuclear engineers, have special responsibility</li> </ol>
	<p>Long-Term Energy and Environmental Strategy, Prof. Yasumasa Fujii (Univ. of Tokyo)</p> <ol style="list-style-type: none"> <li>1. When should we use uranium resource in the long-term perspective of human civilization?</li> <li>2. To what extent can we depend on intermittent renewable energy?</li> </ol>
	<p>[After-dinner Talk] from Fukushima to the World: How to learn from the experience in Japan, Dr. Tatsujiro Suzuki (Atomic Energy Commission of Japan)</p>

Note Affiliations are as of August 2011

In addition to lectures by academic researchers, we were fortunate to have Dr. Tatsujiro Suzuki, then vice chairperson of the Atomic Energy Commission of Japan, as the after-dinner speaker on the evening of August 4. His talk was intended to deepen students' appreciation of the connection between academic research and the policy-making process (see Chap. 16 of this volume for the text of his speech).

The four days of lectures and discussions then culminated in student presentations on Friday, August 5. The self-organized student groups made presentations about their questions and answers and received feedback from lecturers and other participants.<sup>5</sup> The summer school closed with a session on reflections by the lecturers and organizers and a general discussion with the student participants.

### *1.5.3 Specific Arrangements for Educational Effectiveness*

To make this educational program more focused and effective, we made several concrete arrangements before, during, and after the term of the program as listed below:

<sup>5</sup> We created a "No Power Point" rule for these student presentations. Students were required to make oral presentations without projected computer slides. Although many students found this uncomfortable, we applied the rule in order to encourage them to speak concretely and, ideally, to present their ideas through dialogue with each other.

- Student applicants for this school were required to write a short essay on the root cause of the Fukushima accident<sup>6</sup> and to articulate what they wanted to gain from the summer school.
- The organizing committee asked lecturers to prepare five-page (at most) summaries of their lectures before the school was held. They were also asked to provide questions regarding their topics that encouraged students to think about the accident more deeply (see Table 1.2 for the questions provided). Those materials were circulated to students before the school.
- All students were required after completing the school to submit individual essays that described their own answers to the questions they chose to focus on, based on all of the discussions they participated in, including the concluding sessions. (Some of those essays are collected in Chap. 17 of this volume.)
- Students' reflections on their learning experience, as well as feedback and suggestions, were sought in an open-ended questionnaire on the concluding day of the program.
- The organizing committee asked lecturers to submit their full papers after the completion of the school. Each discussant was also asked to write a paper that summarized the main points covered in the lectures and discussions. The committee collected these papers and used them for publication of this book.

## 1.6 Results and Evaluation

### 1.6.1 Points Discussed During the Program

The PAGES 2011 program brought about very intensive and thought-provoking exchanges among the participants. Across many intriguing discussions, the following points emerged as potentially critical for post-Fukushima nuclear engineering education and societal decision-making:

- Problems centering on the social justification of nuclear utilization. In particular, utilitarian arguments—such as cost-benefit analyses—became a central point of discussion throughout the sessions. Some participants considered these justifications less compelling after the Fukushima Daiichi accident and pointed out the need for deontological considerations to think more fundamentally on this issue, while others argued that cost-benefit evaluation is still reasonable and, ultimately, necessary as a form of science-based assessment.
- In parallel with the issue above, the concept of “rationality” itself was questioned in discussions by lecturers and students. Some participants argued that

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<sup>6</sup> The question was the following: “Outline your current thinking about the Fukushima nuclear accident of March 11, 2011. Describe the issues you see it raising for nuclear engineering professionals and for societies pursuing nuclear power. Discuss what you see as the relevant background and fundamental causes of the accident.”

the role of science (and scientists or engineers) is to provide neutral and logical conclusions based on quantifiable knowledge (and these individuals' expertise), which will render societal decision-making "rational." These participants criticized other social reactions, such as the anti-nuclear movement after the Fukushima Daiichi accident, as "irrational." However, another group of participants voiced the opinion that such social reactions embraced a different kind of "rationality" than that of technical experts. These participants argued that different types of "rationality" should be considered more intensively when society makes decisions regarding science and technology issues. This controversy is associated with the previous point, of course.

- Prof. William Kastenberg raised an issue about "safety culture" in the Japanese nuclear industry (see Chap. 9). He pointed out its weakness in light of the Fukushima Daiichi accident and its consequences, and suggested an explanation of the roots of this weakness based on cultural and historical differences between Western and Asian societies. He illustrated the importance of individualism when considering engineering ethics. This argument triggered much discussion regarding the character of social-scientific explanation and analysis of the root cause of the Fukushima Daiichi accident. Some participants questioned Prof. Kastenberg's theory. This contestation also extended the horizon of participants' perspectives on the mechanism behind the tragedy.
- Many participants also focused on the importance and difficulty of public and inter-expert communication during emergency situations (so-called "crisis communication"). They described some dilemmas: timely information vs. well-confirmed information, simple and understandable explanation vs. detailed and correct explanation, controlled disclosure vs. unlimited disclosure, and so on. Participants realized the possible tough choices for engineers posed by those dilemmas.

As we intended, no particular single conclusion was reached on these complex and difficult issues during this summer school. However, students reported that they conceptualized such dilemmas more sharply than they did before as a result of interactions with people who took different stances, brought different methodological perspectives, and held divergent opinions.

### ***1.6.2 Evaluation of PAGES 2011***

In their post-school feedback, many students strongly emphasized the importance of interaction with people of different backgrounds (for instance, Japanese and American) and different fields (engineering and social science). Many students mentioned a lack of time; specifically, they wanted to have more time for discussion with other students and lecturers. A number also requested more presentations by and discussions with social scientists. Some students regretted the absence of field trips, particularly as these had been included in our 2009 summer school. Students said they wanted to have such occasions both to expand their

understanding and to strengthen relationships with other students, as well as to render their learning more concrete.

As described above, and in accord with our aim, we were able to bring about very intensive and intriguing discussions throughout the program. Every point raised in our discussions on the lessons learned from the Fukushima Daiichi accident offers an important perspective to potentially avoid similar structural failures in future. Not only did students gain knowledge from the lectures, they also broadened and deepened their perspectives on this terrible nuclear accident and nuclear utilization more generally through candid discussion. This summer school stimulated students' consciousness of various socio-technical issues that must be considered by the next generation of leading engineers.

In this sense, we believe we can evaluate the experiment of this school as successful. Our model for the impact of our efforts has been to seed new ways of thinking among rising professionals. We have seen success of this approach among the small cohort of participants in the school. We have also found our own perspectives and strategies changed by the effort, in ways that will continue to shape our own engagement on questions of nuclear technologies and society. We intend that publishing this volume and continuing to work in this area will provide stimulation for others to carry out similar efforts in their own settings and ways.

## 1.7 Concluding Remarks

The Fukushima Daiichi accident is not an event of the past; it is an ongoing and developing story even in 2014, when this book is being finalized. It has reminded us that nuclear technology is an extreme achievement as a man-made artifact in terms of its systematic complexity, its potential risks, and its societal, political, economic, geographic, and historical impacts. However, the PAGES project had already impressed upon us the "extremeness" of nuclear technology, although it had not been well verbalized and conceptualized by project members. All of us project members have become more conscious of the extraordinariness of this technology in the course of this interdisciplinary educational challenge. Of course, the Fukushima Daiichi accident brought definite clarity to this sort of feeling.

For the engineering side, this point might be recognized as a limit of natural-science-based (traditional) engineering scholarship. This should strengthen engineers' motivation to integrate social scientific elements with their own knowledge and skills. If this way of thinking comes to be shared more strongly and deeply by the engineering community than before the Fukushima Daiichi accident, it would mean that PAGES's original concept was a pioneering one. We can commend our own project as a forward-looking effort, though, at the same time, we deeply regret that we were not able to make a contribution to prevent the occurrence of the Fukushima Daiichi accident.

However, we do not think that this is a sufficient evaluation. The trajectory of the PAGES project and the events which have happened after the Great East

Japan Earthquake pose challenges to be addressed not only by the engineering community, but also by the social science community. Social scientists (of course, including people in the PAGES project) should realize that interdisciplinary collaboration for problem formulation and solving is much more difficult and more painful than they may have expected. Engineering places its basis not on critical analysis for its own sake but on the realization of artifacts for the client. In this sense, engineers cannot complete their mission through speeches or writings, fully protected by academic freedom. Although they enjoy the same rights in terms of scholarship, at the same time engineering is also an enterprise in society (and this fact is one of the reasons why engineering ethics is considered an essential part in which social science can/should be involved). Those who collaborate with the people who are dedicated to such an enterprise must make clear their own stance, interests, and position. They must also be required to understand the complex detail of engineering practices deeply, in order to make meaningful contributions in their collaboration.

Social scientists must realize that engineering is a profound and exacting endeavor. This observation does not mean that social scientists should be less critical of engineering or engineers. Rather, researchers should emphasize that it would be neither effective nor convincing if they simply blame engineers when they see the superficial results of engineering practice. If social scientists want to make constructive and critical relationships with engineers and to make technology even more public-interest-oriented, they must open their eyes and listen carefully to the engineers, not isolated in their offices separated from the engineering buildings in their university. PAGES might be considered as the very first step for such sometimes difficult but much more substantial and meaningful collaboration between engineers and social scientists.

Our educational program development is still in its early stages. We educators are still struggling as we take that first step in collaboration. However, we all believe it should be continued so as to supply the new generation of leading engineers with sufficient social-scientific literacy and knowledge, and significantly change the future of engineering and technology.

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