Advisory Opinion

Reference Standard for Comprehensive Synthetic Engineering Fields for Quality Assurance of University Education
～Cultivating human resources in the field of comprehensive synthetic engineering who are dedicated to addressing social issues～

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Science Council of Japan

Committee of comprehensive synthetic engineering
Planning subcommittee of comprehensive synthetic engineering

This Advisory Opinion is issued in accordance with the outcome of the deliberations of Planning subcommittee of comprehensive synthetic engineering, Committee on Comprehensive Synthetic Engineering, Science Council of Japan.

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Executive Summary

1 Background for this Statement

This statement articulates the fundamental concept of the field of "comprehensive synthetic engineering" as a part of the ongoing efforts to establish a "Reference Standard for Quality Assurance of University Education in Specific Fields." This initiative stems from the Science Council of Japan's response to the request for deliberation on quality assurance in university education from the Director of the Higher Education Bureau at the Ministry of Education, Culture, Sports, Science, and Technology in May, 2008[1].

"Comprehensive synthetic engineering" is a new academic field. In the report compiled by the Comprehensive Synthetic Engineering Committee of the Science council of Japan, in 2010,[2] it was defined as “a lateral field in engineering not previously observed in traditional engineering “. It can be defined as ” a field related to artifacts designed and manufactured by mobilizing all engineering systems and knowledge.” Subsequently, in 2017, it was proposed that "Comprehensive synthetic engineering" reaffirms its universal position within the academic system of modern engineering and is a field of study for addressing discovery and resolution of challenges inherent in and confronted by contemporary society[3]. Based on these definitions, discussions have been conducted on essential competencies deemed necessary in comprehensive synthetic engineering for the 24th term of committee, including comprehensive knowledge, civic literacy, art thinking, and data science.

Based on the consideration of fundamental principles regarding the reference standard for the field of comprehensive synthetic engineering, this statement is released in order to be made available for use by universities already establishing or planning to establish undergraduate education programs in comprehensive synthetic engineering, as well as various entities involved in master's programs and other related areas.

2 Current Status and Challenges

In the report titled "Prospects for the Field of Comprehensive Synthetic Engineering" compiled on April 5, 2010[2], it is stated that the academic role of comprehensive

[1]Science council of Japan, Response: “The Approach to Quality Assurance in University Education in Specific Fields”, July 22, 2010 (In Japanese).
[2]Comprehensive synthetic engineering committee, Report: Science council of Japan, “Report: Future prospect of Comprehensive synthetic engineering”, April 5, 2010 (In Japanese).
[3]Comprehensive synthetic engineering committee, Science council of Japan, Recommendation: "Promoting Strengthening of 'Comprehensive synthetic Engineering' to Address Societal Issues", Sept. 6, 2017 (In Japanese).

synthetic engineering, which addresses not only engineering but the entirety of science and technology, is to deepen the involved fields while simultaneously integrating existing disciplines to create innovation, whose goal was to strengthen scientific and technological advancements that create necessary technological capabilities and values demanded by society. However, one year later, an unprecedented earthquake disaster occurred, and based on that experience, the Comprehensive Synthetic Engineering Committee of the Science Council of Japan compiled recommendations in 2017[3], and stated, “The Great East Japan Earthquake and the subsequent Fukushima Daiichi Nuclear Power Plant accident on March 11, 2011, demonstrated that current science alone cannot solve the issues posed by natural disasters and nuclear incidents. In order to not only generate societal and economic value but also to address the resulting societal and economic losses and in order that academia assume comprehensive responsibility for society as a whole, it is necessary to cultivate societal challenges by leveraging all forms of engineering. To this end, it was strongly indicated that there's a necessity for the promotion and reinforcement of comprehensive synthetic engineering, which includes the essential aspect of exercising leadership in the practical application of “Chi no tougou”, the transdisciplinary unification of knowledge."

On May 7, 2014, the National Academy of Sciences (the United States) issued an urgent recommendation emphasizing the need for national-level collaboration to support interdisciplinary research aiming to break through barriers in academia and address cross-cutting challenges. It was recognized that achieving innovation requires a holistic approach that transcends disciplinary boundaries, highlighting the essential role of the "holistic designer" in this pursuit. At that time, the state of "Convergent Research," which integrates fields like life sciences, physical sciences, and engineering, was still facing significant barriers, with a sense of crisis arising from the separate traditional approaches employed within each field. Additionally, Google, a leading global internet service provider, refers to such holistic designers as "smart creative leaders" and considers fostering such leaders as a part of the company's mission[4].

While discussions on the transdisciplinary unification of knowledge in Japan have been ongoing, specific actions have not been sufficiently implemented. To ensure the effective resolution of societal issues, two essential methodologies are necessary: the first one is the "back-casting method," which involves setting future goals for addressing societal issues and designing concrete processes by working backward from those goals; the second one is the "collective impact method," which fosters collaborative innovation by integrating diverse specialized knowledge and expertise at

[4]Eric Schmidt, Jonathan Rosenberg, “How Google Works”, John Murray Publishers Ltd., 2014.

each stage of the process towards achieving those goals[5].

Considering these aspects, individuals engaged in the field of comprehensive synthetic engineering require the following six capabilities[6]:

(1) Imaginative capability (imaginator); the ability to envision a desirable future by adopting a comprehensive perspective towards resolving societal issues;
(2) Planner, designer; the capability to conceptualize and design specific pathways towards resolving issues using the back-casting method
(3) Coordinator; the skill to coordinate projects among experts from various academic disciplines, beyond engineering.
(4) Practitioner; hands-on experience as an active participant in project implementation.
(5) Facilitator; the capability to drive projects forward.
(6) Adaptable talent; a continuous awareness of societal transformations and the ability to adapt to changes in the era.

In order to activate these abilities, it's essential to cultivate six skills: "self-learning capability (active learning)," "communication and collaborative skills," "facilitation skills," "connecting ability," "problem-solving skills," and "creativity." Unfortunately, current university and graduate education programs have nurtured almost no individuals capable of designing processes to address societal challenges by combining various specialties and skills.

3 Contents of the Advisory Opinion

Considering that comprehensive synthetic engineering serves as a discipline aimed at discovering and addressing challenges inherent in or confronted by modern society, this perspective was compiled to outline the cultivation of skills and qualities necessary for individuals to excel in the field of comprehensive synthetic engineering, specifically in confronting societal issues.

The contents of “Reference Standard for Comprehensive Synthetic Engineering Fields for Quality Assurance of Higher Education” are as follows.

(1) Definition of Comprehensive synthetic engineering
(2) Characteristics Specific to Comprehensive synthetic engineering
    ① Perspectives and Roles Specific to Comprehensive synthetic engineering

[5]Mitsubishi Research Institute, Inc., “‘*Kyouryouiki’kara no shin・senryaku innovation wa shakaijissou deketsujitu suru*”, DIAMOND, Inc., 2021 (In Japanese)
[6]Masahiro Okamoto, “Prospects for Issue-based Education as a Basis for Undergraduate Education in the Arts and Sciences: A Case Study of the Faculty of Co-Creation, Kyushu University”, 2022 IDE University Seminar "Considering the Realization of Education Combining Arts and Sciences: From the Perspective of High School-University Connection and University-University Connection", IDE University Association Kinki Headquarters, 2022. (In Japanese)

② Creation of New Academic Fields in Boundary and Fusion Areas

(3) Fundamental Qualities Aimed to Be Acquired by All Students Studying Comprehensive synthetic engineering

① Fundamental "Knowledge and Understanding" Acquired through Field Learning

② "Abilities" Exercised by Utilizing Fundamental Knowledge and Understanding

③ "Generic Skills" Acquired through Field-Specific Intellectual Training

(4) Basic Approaches to Learning Methods and Evaluation of Learning Outcomes

① Learning Methods

② Evaluation Methods for Learning Outcomes

(5) Relationship Between Specialized Education and Liberal Arts Education in Cultivating Citizenship