Briefing Document: New Framework of Technology and Engineering Education for Creating a Next Generation Learning

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Purpose: This document outlines a new framework for technology and engineering education in Japan, developed by the Japan Society of Technology Education. It addresses the need to adapt technology education to the rapidly changing societal and technological landscape, including the rise of Society 5.0 and the increasing importance of STEM/STEAM education.

Key Themes and Ideas:

1. **The Evolving Role of Technology in Society:** The document emphasizes that modern society is built upon advanced technology, and technological innovation (innovation) drives progress. However, it also acknowledges challenges like economic competitiveness and the need for sustainable development, highlighting the direct link between technology and goals like those outlined in the SDGs (Sustainable Development Goals). The document states: "Currently, the society we live in is supported by advanced technology, and new value has been created and continues to develop through technological innovation (innovation)." It also notes that "the relationship between technology and society faces numerous serious challenges in terms of building a sustainable society."
2. **The Crucial Role of Technology and Engineering Education:** Given the pervasive nature of technology and the challenges facing society, the document argues that technology and engineering education plays a crucial role in cultivating the qualities and abilities necessary for all citizens to make democratic decisions with a view towards the future and to proactively lead and guide the advancement of technology.
3. **Addressing Societal Changes and Technological Advancements:** The framework is a revision of previous JSTE publications on technology education, recognizing the significant changes since 1999, particularly the Fourth Industrial Revolution, Society 5.0, and Connected Industries, characterized by the advanced integration of new technologies like AI, IoT, robots, and big data.
4. **Integration of Design Science and STEM/STEAM Education:** The document aligns with the Science Council of Japan's reevaluation of academic systems, which proposes "the inquiry into what exists" (Recognition Science) and "the inquiry into what should exist" (Design Science) as a new framework integrating humanities and sciences.

Technology education, especially in the context of Design Science, is seen as interdisciplinary, dealing with all types of artifacts and their systems. The document also acknowledges the rise of STEM education and the growing importance of STEAM (adding Art/humanities). It notes that "STEM education (Science, Technology, Engineering, Mathematics) focusing on science and engineering education has emerged in various countries," and the importance of the "liberal arts-science integrated STEAM education" (adding Art, a wide range of humanities and arts education) is being pointed out.

5. **Defining Key Terms:** The document provides clear definitions for crucial terms within the framework:

- **Technology:** Problem-solving strategies and their results created consciously applying natural laws, mathematical logic, and empirical rules under societal, cultural, and natural constraints to realize human desires, while controlling various conditions for optimal artificial outcomes (production, development, invention).
- **Engineering:** Scientific problem-solving strategies for creating optimal artificial outcomes (production, development, invention) to realize human desires, and the body of knowledge related to the realization of these strategies.
- **Technology and Engineering Education:** Education aimed at fostering the qualities and abilities related to technology, with content knowledge and procedural knowledge structured according to the system of technology, and a learning process including problem discovery and solving based on the developmental stages of learners.

1. **Scope of Technology Education:** Technology education is positioned in relation to other fields such as mathematics, science, art, and society. It encompasses traditional technology, industrial technology, and science-oriented technology that utilizes the achievements of science (both natural science and engineering science). The framework emphasizes that technology has both a unique domain and a broad base shared with other fields. Therefore, the proposed technology education centers on content and procedural knowledge related to technology (including industrial technology, traditional technology, and science-oriented technology) and engineering science, as well as problem discovery and solving activities including engineering design processes and "making things." It also deals with the interrelationships between these and other subjects/areas, including natural science, applied mathematics, and societal aspects like civic life and policy, through collaboration.
2. **Types and Roles of Technology Education:** The framework categorizes technology education into two types:

- **Technology Literacy Education:** Aims to foster basic technological qualities and abilities (technological literacy) in all citizens. This includes general education from kindergarten to high school and liberal arts education in higher education. The goal is to enable individuals to understand the relationship between technology and related fields, skillfully and creatively use technology to discover and solve problems, evaluate the role of technology in society, and control it appropriately as citizens.
- **Technology Expert Education:** Aims to train professionals and experts in technology. This includes specialized high school subjects (industrial, agricultural), technical colleges, university faculties (engineering, science and technology, agriculture, fisheries), vocational schools, and training centers. Technology literacy education is seen as crucial for inspiring students' interest in technology-related careers and academic fields, guiding them towards technology expert education.

1. **Concept of Technological Literacy:** Technological literacy is defined as the basic qualities and abilities necessary for all citizens living in a technology-supported society to enrich their lives and contribute to building a better society for the future. It includes:

- Understanding engineering science and the relationship between technology and society, environment, and economy.
- The ability to proactively discover and solve problems in daily life and society through technology.
- The ability to participate in technological innovation and technological governance for building a sustainable society.
- Ethical values related to technology, dexterity, perseverance, diligence, and a creative attitude towards generating new value.

1. **Goals of Technological Literacy Education:** Based on the concept of technological literacy and considering developmental stages, the goals are set as:

- Scientific understanding of technology.
- Understanding the relationship between technology and society, environment, and economy.
- Fostering the qualities and abilities for technological problem discovery and solving.
- Fostering the qualities and abilities to participate in technological governance.
- Fostering the qualities and abilities to participate in technological innovation.

1. **Expected Learner Outcomes:** Achieving these goals aims to cultivate individuals who are:

- "Technologically literate citizens" with a general understanding of technology supporting society.

- "Responsible users" who can appropriately evaluate, select, utilize, and manage existing products and systems.
- "Creative individuals" who can discover and solve technical problems in daily life according to their purpose.
- "Lifelong learners of technology" who continue to learn about technology as needed.
- "Fair decision-makers" regarding societal issues related to technology.
- "Engineering trainees" aiming for careers related to technological innovation (optional).
- "Culture creators" who can support technological innovation creation in society as a whole.

1. **Generic Qualities and Abilities Fostered:** Technology literacy education is expected to foster both specific technological literacy components and generic qualities and abilities, including:

- Integrated cognitive and application abilities (scientific and social understanding, intellectual curiosity, inquiry skills).
- Problem-solving skills (tool usage, design thinking, logical thinking, critical thinking, computational thinking, information literacy).
- Dexterity, perseverance, diligence.
- Evaluation, judgment, and decision-making skills.
- Fairness and integrity based on empathy for common human values (sustainable development).
- Creativity (idea generation, proposal skills, creative attitude).
- Communication, collaboration, responsibility, leadership, followership, democratic and constructive dialogue.
- Career awareness, work ethic, project management skills, social safety awareness, ethics, social value creation. These abilities are linked to the concept of "Agency" in the OECD Learning Compass, aimed at achieving individual and societal well-being.

1. **Structure of Technology Literacy Education:**

- **Educational Content (Scope):** Emphasizes a systemic perspective due to the integration of advanced technologies in Society 5.0. The content is structured around four frameworks: (1) Overview of Technology (Common Aspects), (2) Understanding Different Fields of Technology (Specifics), (3) Ability to Connect Technologies (Systems Thinking and Methods), and (4) Ability to Connect Technology with Other Fields (Life and Society). Specific fields include Materials and Processing, Biological Cultivation, Energy Conversion, and Information Technology. "Systems" is a key component for addressing the integration of various technologies

and interdisciplinary connections. Technological Innovation and Technological Governance are positioned at the highest level.

- **Content and Procedural Knowledge:** While following the general understanding of content and procedural knowledge, technology education includes "principles of methods" as content knowledge and "procedures for executing methods" as procedural knowledge to facilitate learning "methodology" in a broad sense.
- **Technological Problem Discovery and Solving Process (Triple Loop Model):** A model is proposed that reflects the engineering design process in society. It consists of three loops: (1) Needs Exploration Loop (clarifying human desires, problems, requirements, constraints), (2) Seeds Exploration Loop (researching and developing the core technology), and (3) Creation Loop (realizing the artifact through activities like planning, design, manufacturing, evaluation, and improvement). This model integrates Recognition Science and Design Science.
- **Developmental Stages of Problem Discovery and Solving:** The Triple Loop Model is adapted for different developmental stages (kindergarten to high school), starting with simple tinkering and exploration of ideas, progressing to project-based learning focused on making things and then engineering design processes, and finally engaging in R&D type engineering design processes for addressing societal issues and participating in technological innovation and governance.

1. **Technology Literacy Education and STEM/STEAM Education:** Technology literacy education is positioned as a crucial component within the broader STEM/STEAM education curriculum. The "T" and "E" in STEM are explicitly stated as being within the domain of technology education. Collaboration with science (natural science education) and mathematics education is encouraged in primary and secondary education. In STEAM education, technology inherently plays a key role in connecting Science, Art, and Mathematics through the design process and value-creating problem-solving activities. The document provides a model where technological problem discovery and solving is at the core of Project-Based Learning (PjBL), integrated with learning from humanities, social sciences, natural sciences, mathematics, and arts, to foster participation in technological innovation and governance and contribute to sustainable development.
2. **Future Research Issues:** The document acknowledges that this framework is a work in progress and requires further refinement. Future research should focus on:

- Empirical research on implementing the framework in schools and evaluating its educational effects.

- Learning science research to validate the framework's alignment with students' cognitive processes and development.
- Developing curriculum standards based on the framework.
- Research on the professional development needed for teachers to effectively implement the framework.
- Comparative studies with technology education trends in other countries.
- Examining the consistency of the framework with research in other STEM/STEAM fields.
- Collaborating with various research organizations to obtain external evaluations and improve the framework.

Overall Significance: The document presents a comprehensive and forward-looking framework for technology and engineering education in Japan. It emphasizes the importance of technological literacy for all citizens in an increasingly complex and technology-driven world, advocates for a systemic and interdisciplinary approach, and positions technology education as a vital element within the broader STEM/STEAM movement. The framework's focus on problem discovery and solving, technological innovation, and technological governance reflects a strong commitment to preparing students to be active and responsible participants in shaping the future.

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