Japanese Higher Education:

The Need for STEAM in Society 5.0, an Era of Societal and Technological Fusion

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Abstract

In today's information-driven society, the Japanese government envisions the next societal revolution as "Society 5.0," where advanced technologies and service platforms integrate with and empower individuals in a human-based society. While Science, Technology, Engineering, and Mathematics (STEM) education has traditionally focused on technical skills and knowledge in isolation, this paper will look at the potential role and benefits of incorporating liberal arts education into these technical studies. This concept of integrating the liberal arts into STEM education is known as STEAM. The purpose of the study is to create a foundation for clarifying the role of interdisciplinary education in overcoming the vertical division of academic disciplines and restoring the "integrated nature" of scholarship. This study seeks to show how the humanities, social sciences, and arts can be used to enhance STEM education, and, furthermore, how this STEAM approach to education is key to enabling Japan's vision for Society 5.0.

Keywords: global skills, next generation competencies, society 5.0, STEM, STEAM

Introduction

Following the industrial era of machine-made, mass-produced goods, we now find ourselves in an information-based society. Advances in computing, networking, and communications enable the collection and utilization of large amounts of data to create networks of information, virtual goods, and assets. A globalized knowledge-based economy has developed where skills and knowledge are capital that can be transferred across historically limiting geographical boundaries and distances. With the globalization of economies and knowledge, and the pervasive integration of new technologies driving modern economies, lifestyles, and cultures, societies must now confront and adapt to these changes. In order to prepare for increased technological automation and the integration of new technology throughout society, individuals must be trained for fluency in new information technologies and be prepared for the concerns and problems that will consequently arise. Given this prediction, the hope

and responsibility for future innovation has been placed on universities, and especially on their future STEM discipline graduates. In terms of education policy, many countries around the world have announced their intent to enhance and prioritize STEM education in primary, secondary, and higher education. This includes Organisation for Economic Co-operation and Development (OECD) countries such as the United States (PCAST, 2012), Australia (Office of the Chief Scientist, 2014), the United Kingdom (House of Lords, 2012). Similarly, Japan has announced a strategy to cultivate STEM-related human resources in higher education in order to support its competitiveness through innovation (Council for Science, Technology and Innovation, 2016).

Japan has a unique position in relation to this worldwide STEM demand. First, it needs to retain its competitiveness at the global scale but is a relatively small and insular country with diminished immigration and emigration patterns. Compounding this, younger generations possess "inward looking" outlooks on life, lacking internal or external forces to push them into the global economy (Morita, 2013). Second, Japan faces an aging workforce and a declining birthrate, problems which must be solved by attracting international talent and developing and integrating technologies to empower its workforce and society to remain sustainably competitive at the global level. As a result, innovation in science and technology is key to the future sustainability of Japan, and the agenda of the Cabinet Office of Japan is actively seeking to create a "human-centered" smart society made up of people with the skills to be global leaders who can develop and utilize the latest technologies for its benefit. Japan's Fifth Science and Technology Basic Plan outlines the direction of education and a societal vision for the country's future. One of the key points has been termed "Society 5.0," which is envisioned as being the next step in changing societal paradigms, aiming to leverage modern technological advances across society to increase productivity and empower individuals to reach beyond old limitations around the use of technology. This goal is stated as follows:

We aim at creating a society where we can resolve various social challenges by incorporating the innovations of the fourth industrial revolution (e.g., [the Internet of Things (IoT)], big data, artificial intelligence (AI), robots, and the sharing economy) into every industry and social life. By doing so, the society of the future will be one in which new values and services are created continuously, making people's lives more comfortable and sustainable. This is Society 5.0, a super-smart society. Japan will take the lead to realize this ahead of the rest of the world (JapanGov, 2018).

With this vision, Japan's educational institutions face the challenge of preparing future generations to have the knowledge and skills to adapt to these social changes.

The vision for Society 5.0 relies heavily on the continued integration of technology into daily life, necessitating a clear understanding of how technology will be incorporated into society and the significant downstream effects this will produce. The Science, Technology, Engineering, and Math (STEM) fields have become a top priority worldwide for nations to secure and enhance their competitiveness in an increasingly globalized and knowledge-based economy. In turn, the directions of higher education programs have sought to cope with this demand by prioritizing and retrofitting STEM field education, and for Japan, Society 5.0 brings new pedagogical challenges.

Theoretical Background and Methodology

From a research perspective, Japan's Society 5.0 vision is relatively new. There are extensive government policy papers supporting and describing its goals and paths to accomplish them, but still not much examination from a theoretical research perspective, or an analysis of concrete implementation attempts. This paper will provide a close examination of the Japanese government's new vision and policy, and it will describe how an interdisciplinary education involving the arts and humanities can play a significant role in cultivating graduates with the necessary skills to fulfill modern needs. Japanese higher education makes an excellent case study for examining these trends, given the strong government vision and policy, as well as the contrast between the country's educational traditions and the state desired to confront these issues. This research posits that interdisciplinary programs and collaboration between STEM and the humanities, social sciences, and arts are meaningful ways higher education can deliver the "next generation competencies" needed to drive innovation and successfully transition Japan into Society 5.0. These new competencies, achieved by integrating STEM, the humanities, the social sciences, and the arts in university education have been neither clearly defined nor adequately discussed. The incorporation of the arts into STEM programs have been proposed for the development of well-rounded skillsets in both artistic and technical areas, and has led to the coining of the acronym STEAM, which stands for Science, Technology, Engineering, the Arts, and Mathematics (Daniel, 2015). It is widely accepted that the addition of "Arts" in STEAM is a broad categorization of the liberal arts, including humanities, social sciences, physical arts, and music. Many STEAM programs gather participants from both art and technical backgrounds, so students can gain an interdisciplinary and holistic view of learning and problem solving, producing positive results for students regardless of background. Focusing on the contextual challenges and needs raised by the vision for Society 5.0, in which a human-based society and advanced technologies like AI will

coexist, STEAM education can develop the next generation competencies that are needed to elevate STEM education toward resolving complex social issues and societal problems.

This research will examine how a next generation educational model that supports Society 5.0 may manifest through STEAM education, including a grounded case study of one Japanese education program exemplifying this strategy. First, core elements of Society 5.0 will be discussed to provide further context into the necessity of education reform. From this understanding of Society 5.0, this paper will explain the importance of contributions from the humanities, social sciences, and arts towards social innovation. The discussion will then shift to an educational viewpoint, explaining how STEAM and interdisciplinary studies contribute towards the next generation competencies needed to fulfill this vision. The concept of STEM education has long existed in Japanese higher education with the equivalent word "Ri-kei." With rapid globalization, Japanese higher education is seeking to expand and improve upon its STEM field education. Especially in Asia, engineering and non-engineering fields have become largely siloed from one another, and interdisciplinary education is not traditionally embraced. Particularly in East Asia and Japan, there are many unique challenges to importing Western educational models as a result of certain shared traits of Confucian-based education traditions.

To clarify how Japan is adapting to new educational trends, I provide analysis of a graduate program I was involved with: the University of Tsukuba's Empowerment Informatics Program (EMP). During the period of my research this was one of Japan's Leading Graduate Programs, specially funded to represent a significant shift towards the development of interdisciplinary learning and global competencies. While the EMP still enrolls students, it no longer operates under the Leading Graduate Program framework. I will explain how the program was designed to create global knowledge skills and how students were guided through work opportunities, and their goals and outcomes. As an assistant professor, I taught and witnessed firsthand how this program functioned. A qualitative examination of accounts and perspectives from people directly involved with the program is used to support the theoretical importance of STEAM in Society 5.0. Data were gathered from in-person oral interviews conducted between 2016–2018. Participants included six enrolled graduate students, faculty, and staff involved in the EMP. My interviews sought to understand how they perceived STEAM education, including its goals and challenges from a student's perspective. Faculty interviews focused on the design of the program's unique hybrid curriculum and the challenges of teaching students from varied fields. Due to the limited scope of this paper, only a subset of that data is presented as data points for perspective. As the EMP represented the leading edge of Japanese educational reform in STEAM and

globalization, there were many benefits and challenges associated with these changes, and both pros and cons are discussed.

Defining Society 5.0: Challenges and Impact on Society

The next industrial revolution, addressed by the World Economic Forum in 2016, is expected to create an environment that integrates the digital world, the material world, and people through the use of artificial intelligence (AI) to analyze data accumulated by the Internet of Things (IoT, all networked computing devices we use on a daily basis) and the application of this information to all manners of goods and services (Mitsubishi Research Institute, 2017). The Japanese government's Fifth Science and Technology Basic Plan sets forth a policy goal of promoting Society 5.0, defined as a human-centered society that balances economic advancement with the resolution of social problems through systems that seamlessly integrate virtual and physical spaces. Society 5.0 sits atop the categorization of four previous societal orders: Hunting, Agrarian, Industrial, and Information. In Society 4.0, the Information Society, we saw a technological revolution exemplified by the spread of the internet, telecommunications, and information processing capabilities. Japan's Society 5.0 aims to realize what it means to be a super smart society, building on the Information Society to facilitate and provide widespread advanced technological service platforms and societal infrastructure. The Japan Science and Technology Agency (JST) (2016) summarizes the key points of Society 5.0:

1. Society 5.0 aims to increase the quality of human lives, not to increase the power of technology;
2. Smart services aim to increase the quality of human lives, not to increase the power of technology;
3. A service always involves an interaction among humans, and possibly non-humans;
4. We need to understand what human interaction with other humans and non-humans is to understand what smart services are;
5. Interaction is (equivalent to) the 'sharing' of information among participants / agents (p. 12).

As outlined above, Society 5.0 seeks to move forward towards a human-centered society; rather than seeing technology replace humans and jobs, it can be used to augment the capabilities and value of a human workforce.

Gladden (2019) provides a research analysis of Society 5.0 from anthropological and humanistic points of view, considering how it will result in "posthumanism." Gladden defines the "posthumanization" process as "processes or dynamics that are actually at work in a given society that

have the effect of blurring the practical barriers between human and non-human and between the natural and the artificial and that cause the society to become de-anthropocentrized" (p. 8). He argues that, throughout history and the various stages of civilization, society has been shaped and influenced by posthumanization factors ranging from the human to non-human, and from natural to artificial and technological spectrums. In earlier stages of society, hunter-gatherer, agrarian, industrial and technological, non-human entities and beliefs - ranging from spiritual entities, magic, shamanism, and religion - have shaped human civilization in profound ways. Likewise, domesticated animals used as livestock have assisted humans in the production of food and labor, and pets such as dogs and cats have provided companionship. Human interactions with animals, especially those with perceived human traits are cited as important posthumanization factors. These factors have allowed us to transcend or alter our innate limitations and social structures. Given this, Gladden posits that the new trend toward Society 5.0's uplifting of humanity through technological innovation is not entirely new, but a sudden and pronounced shift from non-technical to technological means of posthumanization: AI, androids, robots, body implants and prosthetics, genetic modification, and more. Philosophically, how will we decide which parts of humanity can be replaced and which need to be preserved?

As Society 5.0 centers on a humanistic deployment of new technologies throughout society, social sciences are key to guiding that vision and its grounded implementation. For instance, Gladden's (2019) study on Society 5.0 asks how we can draw analogues from non-technical anthropological studies of the past to figure out how technological posthumanism can be successfully carried out. From an economic perspective, Manyika et al. (2017) estimates that 30% of global work hours can be removed via automation by 2030. Frey & Osborne's (2017) study of occupations in the U.S. predicts that 47% of jobs are at risk of automation through advancing technology. A salient point of their analysis is that many fields involving the arts and humanities are likely to remain in demand as other fields diminish. They predict such fields that require perception and dexterity, creative intelligence, and social intelligence will be the hardest to replace through automation technology. The social science fields provide a humanistic point of view to societies and the people that they encompass, and these fields explain the essence of human psychology and behaviors that will be needed to seamlessly integrate new technologies. For instance, if we consider how AI and future service platforms will communicate with users, there is no doubt that we will expect such technologies to process and respond efficiently to human-based communication norms. Engineers would have to work in close collaboration with social scientists who understand facial expressions, linguistics, and the cultural nuances of communication patterns. For instance, dissatisfaction with current "chat bot" customer service type technologies stem

from a clear lack of perceived humanity and social intelligence, preventing coherent communication (Spohrer in JST, 2016). If we look at the future widespread use of "big data" and information sharing platforms, ethics and law become essential fields for determining how societies will protect user data. Clear lines must be drawn for which data can be shared amongst smart services and individuals, how the user is informed of that, and how much control they have over such personal information. These concerns are already serious issues for existing social network platforms, and they will only continue to grow as societies continue to integrate more pervasive and smarter service platforms in areas such as healthcare and finance. To provide another example of the importance of social sciences, as the development of autonomous driving technologies gets closer to practical applications, there are important philosophical and legal implications of responsibility behind autonomous decisions. If an autonomous vehicle cannot avoid a collision, should it prioritize the safety of the passengers, other vehicles, pedestrians, or even apply a heuristic to assess a value associated with the types and number of individuals impacted? These are just a few of the ways in which the social sciences will be integral to Society 5.0 and greater integration of advanced technologies in our everyday lives.

A core part of Society 5.0 represents the advancement of technology, but rather than focus on efficiency or production alone, it also includes a strong component of "social innovation." The Young Foundation (2012) provides a succinct definition for the wide variety of concerns and processes associated with this term:

> Social innovations are new solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and better use of assets and resources. In other words, social innovations are both good for society and enhance society's capacity to act (p. 18).

According to Nicholls et al. (2015), a trend is developing where governments and institutions are showing increasing interest for collaboration across diverse fields and boundaries to create innovative social change. The need for social innovation partially suggests a failure in the existing market forces and governance, and a need to redirect utilitarian forces toward utopian social outcomes. For Japan, current social innovation activities include healthcare for its aging population demographics, improved disaster relief information and response platforms, and revitalization of regional locales where population, tourism, and economic niches have been lost to urban relocations (Zhao, 2016). As advances in technology result in the integration of AI, advanced robotics, big data, and IoT (Internet of Things), Society 5.0 seeks to shift the use of technology under the framework of social innovation, emphasizing that utilitarian views of technical ability and output alone are not sufficient for achieving its goals. In this

context, new approaches to education and collaboration are required. From a more micro education standpoint, we can prepare for these changes by reintegrating aspects of the humanities in STEM education through holistic interdisciplinary and STEAM education.

Educating for Society 5.0: STEAM and Next Generation Competencies

Certainly, STEM fields are key to the development of the technology and innovation necessary for Society 5.0, but it would be an oversight to ignore potential contributions from the arts and humanities. Former Minister of the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT), Yoshimasa Hayashi, stated:

> In the era of Google, people no longer need to memorize every single fact. Many tasks today are best carried out by computers. Therefore, the emphasis must be on human skills such as communication, leadership and endurance, as well as curiosity, comprehension, and reading skills (Foreign Policy, 2019, para. 7).

As Japan seeks to leverage technology to empower its future society, we can recognize how this creates a paradigm shift in education. If computers can reproduce rote knowledge more quickly and accurately than humans, people can focus on areas where they excel. In such a context, people will be required to obtain skills that differ from many traditional skills. The diverse and skillful use of imagination and creativity to deal with complicated multi-faceted problems becomes increasingly necessary.

In order to understand the importance of STEAM and its distinct role in Japan's future, it is important to cover some fundamental points that illustrate the current state of Japan's higher education. Japan's education system bears many commonalities with other East Asian education systems, like those of China and Korea, and is also very dissimilar to Western education. One of the biggest differences from Western education is that East Asian education places a strong focus on entrance examinations, and teaching methods accommodate this prioritization. One commonly cited theme is that East Asian countries tend to rely on memorization, rather than on open-ended answers that draw on critical thinking. Hawkins (2008) characterizes the Confucian pattern of education as being marked by "Confucian traits of self-denial, frugality, fortitude, patience, self-discipline, rote learning, memorization, and delayed gratification" (p. 53). Problems that students solve tend to be based on formulaic or accumulated knowledge with a single correct answer that must be reproduced. Amassing knowledge and the reproduction of that knowledge is key to measurements of a student's success in many test-driven East Asian educational contexts. To this point, the OECD (2015) noted that, in 2007, up to 53% of Japanese lower-secondary students attended private tutoring schools, also known as "cram"

schools, to prepare for school entrance exams. Thus, Japanese students excel in standardized tests that measure student performance; for instance, they came in second in the OECD's Programme for International Student Assessment (PISA) 2015 science rankings with a mean score of 538 points. However, Japan is far behind in progressive Western teaching methodologies like active learning, problem-based learning, and STEAM education. The oft cited downsides of Japan's strict education model are deficiencies in creativity, critical thinking, abstract problem solving, social and collaborative skills, and an educated view of individual roles in citizenship and global society (OECD, 2015).

Japan has often looked to the West for leadership and scientific innovation, but the hope is that Japan will take a leading role and that a new generation of Japanese innovators might one day create the next Apple, Google, or Facebook. To do this, Japanese education policy is aiming to prepare a workforce that can think and solve problems from different perspectives, exercise flexible skillsets, think "outside the box," and develop synergies with peers from different disciplines. In addition to technological and information literacy, these skills will be essential in the new Society 5.0 era, and education is key to preparing Japanese citizens to adapt to these needs. There are supporting studies that found that multidisciplinary collaboration increased variance in the successfulness of inventions, resulting in more "shots on goal" and potential for breakthrough innovations (Lee, 2007). Okamura (2019) found that, in the research sector, interdisciplinary research resulted in an approximate 20% increase in effectiveness measured by field-normalized citations. The potential value of interdisciplinary education is a widely accepted notion within education, but it is difficult to prove, as while STEM fields are often measured in quantitative metrics of utility, humanities and arts seek utopian outcomes that are not easily quantifiable and compared, or may yield results over longer timeframes or with wider variance (Stewart-Gambino & Rossmann, 2015).

Japan's Challenge of Adapting to Globalization

Globalization has enabled nations to become closer, broken down historical barriers, and helped people to move and operate across the world more easily than before. The increased transmission of goods, people, and ideas has resulted in a globalized workforce and interconnected economies. In the workplace and in society, it is now possible for people from diverse backgrounds to meet and collaborate. In this social and globalized context, STEM education, which has up to this point focused on the acquisition of knowledge and skills in traditional disciplines, faces the need to carry out educational reform. For example, the Association of American Colleges & Universities (AAC&U) promotes 21st century competencies including multicultural understanding and the ability to identify and resolve problems through discussion and cooperation with a variety of people as necessary skills in STEM

education. Downey et al. (2006) notes that global competency in engineering is not just about culture or language, it is also the way the problems themselves are defined, approached, and solved. Studies must be relevant towards post-graduation work, such as producing the global citizenship and leadership needed to succeed in an increasingly globalized economy. Furthermore, international collaboration in engineering education helps students understand and refine the non-technical communication and leadership skills they will need in real workplace scenarios. Prior to Japan's Society 5.0 vision, similar efforts to reform higher education were sought since 2010 under the umbrella MEXT projects to develop "Global Human Resources" (Yonezawa, 2014). These efforts were not as focused on STEM, but more broadly based on the notion that the modern globalized economy and workplaces requires leadership, creativity, and communication skills that were not being prioritized through traditional education. Since then, a wide number of MEXT policy papers, projects, and programs have sought to introduce more holistic learning, such as integrating active learning pedagogy into Japanese higher education (Yamada & Yamada, 2019).

One way that Japan is tackling these challenges is its "Program for Leading Graduate Schools," an umbrella program covering multiple graduate schools that focuses primarily on STEM disciplines while promoting the adoption of interdisciplinary approaches that cut across disciplinary boundaries and incorporate humanistic perspectives. JSPS (2018) describes the goals of the Program for Leading Graduate Schools:

> The Program for Leading Graduate Schools works to advance the establishment of university graduate schools of the highest caliber by supporting the dramatic reform of their education programs in such a way that they will institute degree programs recognized as top quality around the world. To foster excellent students who are both highly creative and internationally attuned and who will play leading roles in the academic, industrial and governmental sectors across the globe, the program brings top-ranking faculty and students together from both in and outside Japan and enlists participation from other sectors in its planning and execution, while creating continuity between master's and doctoral programs and implementing curricula that overarches fields of specialization (p. 2).

> The JSPS further identifies the following as goals of STEM education:

> (1) Ability to collaborate with others while possessing a solid set of values, and to act globally with firm resolve; (2) Ability to identify issues and independently challenge them by developing hypotheses and applying knowledge in testing them; and (3) Ability to ascertain the essence of

matters by applying a wide range of knowledge buoyed by high levels of specialization and an international perspective (p. 3).

For Japan, another benefit of mixing technical and non-technical education is that both education and workplace initiatives seek to maintain Japanese competitiveness at the international level, and at the same time attract international students, researchers, and workers to Japan. Thus, it follows that encouraging international activities and collaboration with international scholars and students can help develop an outward-oriented perspective. Given Japan's dwindling birthrate and aging society, its policy must be inclusive in order to attract foreign talent, as outlined in CSTI (2017). To cite one example, Japan's Program for Leading Graduate schools started down this path, where in 2015, 24% of the enrollees in Leading Graduate universities were made up of foreign students, compared to 17% across all the graduate schools in Japan (JSPS, 2018, p. 7). Keidanren, Japan's business federation, also recognizes the need for a workforce capable of working and leading at the global level through the development of global competencies (See Keidanren, 2016). Japan's higher education is currently facing the challenge of overcoming an educational structure that is vertically compartmentalized by discipline. Responding to a report issued by Japan's Central Council for Education in 2018, a decision was made to undertake partial reform of the standards for establishing a university starting in 2019 with the aim of creating flexible education curricula that cut across multiple fields of study, including engineering. Such a reform will be challenging, but increasing interdisciplinary study and taking a STEAM approach to re-integrating aspects of the arts and sciences can help overcome divisions between academic disciplines and restore the integrated nature of scholarship. By removing rigid boundaries between fields of study, it is believed that new value can be created through interdisciplinary study and the provision of a practical education that is developed in conjunction with businesses to reflect modern needs. This desire to overcome the compartmentalized structure of STEM discipline education reflects a change from the former focus on the acquisition of knowledge and skills in specialty fields to a recognition that next-generation competencies require the acquisition of knowledge and skills in both technical and non-technical fields.

The University of Tsukuba's Empowerment and Informatics Program: A Case Study of STEAM in Japanese Higher Education

While exploring the necessity and emergence of STEAM education for Japanese society, we can examine a concrete case study of a graduate program evidencing the STEAM approach in Japan. The University of Tsukuba's Empowerment and Informatics Program (EMP) was founded in 2014 and selected as one of 62 in the Program for Leading Graduate Schools in Japan. Being a relatively new

program, the EMP represents one of the newest STEAM education style programs in Japan. The EMP is a five-year Ph.D. program, allowing enrollees to receive degrees in human informatics, the study of technological integration with human culture, where topics range from creating wearable devices, to empowering human abilities resulting from disabilities or impairments, to how the arts and technology can be harmonized to extend creative endeavors, and beyond. The EMP is categorized as information studies, concerning as it does the fields of information technology and engineering, but it also views these fields through the lens of the humanities, the social sciences, and the arts, as well as how technology will integrate with people.

Considering the issues of globalization and technological advancement in the vision for Japan's Society 5.0, the EMP recognizes that technical skills are a foundation that must be built upon by soft skills that are traditionally lacking in Japan's STEM higher education. Beyond technical ability, the program takes a three-pronged approach to well-rounded student development, aiming to foster interdisciplinary, frontline skills, and presentation abilities. First, students take courses in interdisciplinary studies in order to be able to approach problems and solutions from multiple perspectives. Human Informatics falls in the intersection between technology and humanity, so the envisioned human-centered Society 5.0 requires an interdisciplinary aptitude. Second, frontline skills concern the desire for a practical education, where academic excellence can be translated to the workplace immediately after graduation. EMP courses seek to prepare students not just with technical ability and knowledge, but also with context so that they can apply what they have learnt to solve real-world problems. Third, training in presentation skills aims to foster what is needed to propose and present research and outcomes. To foster true leadership ability and create strong human resources capable of engaging in a competitive global economy it is important to be able to communicate plans and results with stakeholders from a variety of backgrounds. These goals are manifested structurally throughout the EMP's courses and requirements, using many aspects of the STEAM education model.

Following this model, the program is comprised of students from both engineering and art backgrounds. This is achieved by covering human-centered topics, with a range in interdisciplinary studies that includes psychology, cognitive science, media art, engineering, social science, and medical science. The program actively recruits international students, and many courses are conducted in English and involve domestic Japanese students learning and working side by side with international students. Considering the Japanese need for greater participation in globalization, the program both attracts foreign talent and helps domestic students gain the experience of working in a globalized context. This diverse student body is encouraged to study together and collaborate on projects designed

to develop real-world problem-solving skills and experiences that cross-cut fields of specialization and ethnic and language barriers. The EMP seeks to develop more than strong technical ability alone; it also wishes to nurture soft skills in leadership, teamwork, and interdisciplinary understanding in order to produce students as capable, global, human resources. By choosing the incorporative STEAM approach, students develop interdisciplinary skills through the structural design of the program (Yamada, 2018). Additionally, by creating strong linkages to advisors and partners from industry, students can gain an understanding of industry's practices and learn how to transfer and apply their academic studies to real-world problem solving.

Figure 1

Fields That Are Involved in the EMP Program
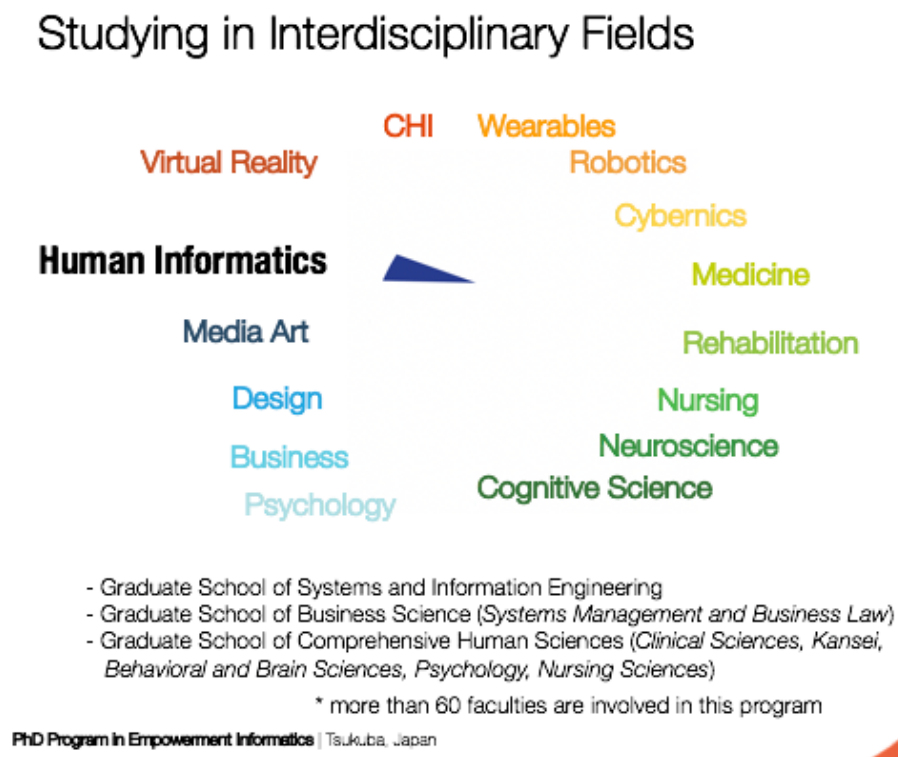
The EMP requires students to take several mandatory courses that are indicative of the diverse and practical student development it seeks:

1. Interdisciplinary coursework: Engineering, methodology courses in psychology and sociology, ethics, medical and neuroscience, and project-based learning in art and design.

2. An advanced tutorial practicum class: Students prepare arguments and engage in active-learning style debates and discussions.

3. A research design practicum class: Provides students with experience in writing proposals, doing elevator style pitch presentations, and presenting research to professional evaluators for real-world problem-solving feedback.

4. An engineering residence practicum: A mandatory internship course where students pursue their research area and are exposed to real corporate/industry working environments and practices beyond academia.

5. Collaboratory practicum: A course for students to work in groups creating a project from proposal to completion.

In the first year of entering the EMP program, students are required to take a project-based research course, where students work in groups composed of different academic backgrounds, such as engineering, art, and design. Together, they work on proposing and producing a project for an actual device that is to be presented in Linz, Austria, at one of the top media arts festivals in the world, Ars Electronica. From an integrated STEAM perspective, the most important aspect of this course is the collaboration with team members who are trained in different methodologies and academic philosophies, use different languages and terminology, learn from each other, and gain an understanding of different values and problem-solving perspectives. Observing and doing qualitative research around the STEAM aspects of EMP, I had the opportunity to interview faculty and students of the program. Many students mentioned the challenging nature of working in teams with others who come from different specializations and cultural and linguistic backgrounds. One graduate student with an art undergraduate background commented:

> After entering this program, it was my first experience in non-art studies, which are important in order to understand the function of art in a device and are related to media art. It was important for me to learn not only the artistic aspects, but also the functional engineering aspects, since it gave me the chance to understand how we can actually develop and run a device. In [the Problem Based Learning] class, I was grouped with an art major and engineer, and our goal was to exhibit the device we made at a media art festival. It was my first experience of us being in a group and pairing with non-art background individuals, and they were not Japanese. In the beginning, it was a challenge for me to speak with them first in English, and then secondly, to communicate using the terminologies of our fields. Despite the challenges that we mostly faced in the first few days, we started to learn and understand different fields' perspectives, values and ways of thinking, and we were able to communicate, and learn from each other, and finally we were able to make a device that we eventually

exhibited in the media arts festival. Looking back, this experience was very rewarding, and it was the first time I've had this type of experience (Transcribed interview, 2018).

Presenting a view from another perspective, an engineering graduate student working in a group with a student specializing in art commented on their media arts exhibition project:

The EMP provided my first experience of thinking how important it is to collaborate and work with art majors, since my point of view was very focused only on the engineering side, and not enough on the artistic side. By having the chance to work and talk with students from other backgrounds I learned many things. It is important to listen to different kinds of people in order to get different ideas and reconsider my own values after hearing their opinions. This was my first experience of this kind and I had never had this moment before entering this graduate program. My process toward creation has changed drastically after working together in pairs with non-engineering students. At first it was a very big challenge, and I wasn't sure it would be beneficial; however, the more time we spent together, the more I learned how to listen to them, and also how to express and share my own thoughts and engineering knowledge (Transcribed interview, 2018).

These two students provide the contrasting views of the STEM and Arts students in the program. Not only do these testimonies evidence just how rare meaningful interdisciplinary work can be in traditional higher education, but they also show how important it is for students from diverse backgrounds to work together and consider how their respective studies are interrelated in practical scenarios. Another international student who studied at EMP elaborated on the differences between the academic backgrounds of Japanese and European students:

On entering the EMP, I've faced many challenges since studying in a different country where English was not spoken outside the campus. First it was very challenging for me to talk about what art and humanities mean to STEM students and for Japanese STEM students who never had any background in my field. Since I had to be in a group paired with a Japanese student, I had to learn about their cultural background, but also, they had to learn how to communicate with me and we both needed to learn about each other and how to share our thoughts in order to make a product. Coming from a European country with different ways of educating and training, through this pairing, I learned what the Japanese way of thinking means, and I believe my partner also had to learn about who I am, and why my values and way of thinking are different (Transcribed interview, 2018).

STEAM's educational approach values the evaluation of problems from multiple perspectives and then defining and solving complex problems. The projects these students prepare and demonstrate at the Ars Electronica media arts festival are a prime example of how the arts and engineering fields can collaborate in practical scenarios. Additionally, by presenting completed projects to diverse audiences beyond academia, students can see firsthand how their work may be evaluated from a variety of opinions and metrics, both functionally and aesthetically.

STEAM education utilizes an approach to learning where collaboration from component fields can enhance student engagement, discussion, and critical thinking by moving the subject matter from abstract field-specific inquiries to real-world scenarios and applications. Working between disciplines like this helps foster holistic and innovative solutions to problems that may not otherwise be considered. Students in the EMP program obtain skills that are applicable for real industry positions and acquire global knowledge and competency skills by studying in the intersection between the humanities and information fields while working with and receiving feedback from industry professionals. The EMP program stands out in Japan for its integration of the arts and social sciences with engineering studies. The introduction of soft skills and new perspectives through interdisciplinary education and the integration of STEAM pedagogy are ways programs like the EMP seek to meet the needs of a modern society characterized by globalization and fast-paced social change and driven by technological advancement.

Critical Points for Introducing STEAM Education

STEAM education has only gained more significant attention in recent years, so there are still many challenges to introducing this interdisciplinary style of education in practice. Not only does STEAM present challenges for students who are used to studies in a singular field of expertise, education programs and faculty must learn how to bring STEAM to the classroom and effectively use it. Similar to earlier efforts to introduce active learning within Japanese higher education, both faculty and students experienced friction due to Japanese education traditions which vary widely from the Western systems they seek to borrow from (Yamada & Yamada, 2019). Thus, effective STEAM education in Japan poses its own additional challenges. One graduate student in EMP explained this situation during their studies:

> STEAM education and collaboration with people from different fields in interdisciplinary studies are very important now, but this is still very new. Not many faculty are even trained for interdisciplinary literacy. Some faculty do understand the importance of STEAM and interdisciplinary studies, however they themselves are not educated and trained in the field of education or other fields, but they have to learn since it is the current trend. I felt the challenge

was not only for students' learning, but also for the faculty trained in one field but having to

learn beyond that for interdisciplinary work and collaboration among different fields

(Transcribed interview, 2017).

This sentiment evidences a critical and challenging aspect of STEAM education that applies not

only to Japan, but to other countries as well. Advocating and utilizing STEAM requires changes for

students, but it is crucially important that involved programs, faculty, and staff contribute toward the

STEAM education model. Interdisciplinary project-based learning has great potential, but requires extra

time and effort from the involved parties for meaningful cross-field collaboration (Stewart-Gambino &

Rossmann, 2015). The aforementioned interviewee was an art student, whereas the majority of EMP

faculty came from engineering backgrounds, so it is likely that such students perceive additional

structural difficulties. Additionally, despite the EMP welcoming and advocating for both art and

engineering, as well as international and domestic Japanese students, it is difficult to overcome

disparities among such divisions. As Japan seeks to globalize and introduce international students into

its education, there are inherent challenges of language and culture for students and faculty.

Additionally, a challenging aspect to successful STEAM outcomes concerns bringing together fields and

educational departments that have traditionally been isolated. Gladden (2019) points out that "[each

domain] possesses its own specialized conceptual frameworks, methodologies, vocabularies, best

practices, and workplace cultures that may be inscrutable even to intelligent and well-trained personnel

in the other spheres" (p. 27). Especially in Japan, STEAM is a new concept, and it is unlikely that the

earlier generations that make up faculty and administrators have prior experience of learning or

teaching within this model. In these regards, there need to be strong incentives for a program to share

and understand the common core educational aspects of STEAM. It is important to recognize the

significant role of faculty and program resources to assist student learning and create a shared

understanding of educational goals and aspirations. If the various components of an educational

program can work with the core parts of STEAM education, in addition to its values, perspective, and a

recognition of the shared and connected aspects of different academic backgrounds, STEAM can

broaden knowledge and provide new ways to evaluate and approach problems.

Conclusion

Today, Japanese society is on the verge of dramatic changes brought about by the development

of - and advances in - technologies such as AI. For example, advanced computing and AI will soon be

capable of replacing fixed tasks and tasks that rely on numerical expression, drastically altering the

structure of industry and eventually leading to a loss of many occupations and a transformation of

existing economic systems. Japan's Society 5.0 presents an overarching challenge of integrating science and technology in a balanced manner for the benefit of a human-based society. Japan continues on a path of increasing globalization, while confronting the challenges of a declining birthrate and aging workforce. Japanese society will need to integrate with advanced technologies and address the need for technological literacy, raising societal concerns over where new technology can and should be used while understanding areas where a human workforce is required. These issues are the driving forces in Japan's Society 5.0, which is a vision for a super smart human-centered society. Higher education is being challenged to prepare individuals who are ready to work in a world where advanced technology is heavily integrated into a human-based society. Society 5.0 will need individuals who can connect technological innovation to social issues, skillfully use technology to solve societal problems, and possess the critical thinking and problem-solving ability to create new value and innovation. In a journal article espousing the need for liberal arts education in technical fields, former Lockheed Martin President and CEO Norman Augustine (2013) wrote:

> So what does business need from our educational system? One answer is that it needs more employees who excel in science and engineering and, more generally, a workforce that is exposed to enough science and mathematics to function in the rapidly evolving, high-tech world. But that is only the beginning; one cannot live by equations alone. The need is increasing for workers with greater foreign-language skills and an expanded knowledge of economics, history, and geography. And who wants a technology-driven economy if those who drive it are not grounded in such fields as ethics?

STEAM programs that utilize the humanities, the social sciences, and the arts constitute one method higher education can use to infuse soft skills and develop next generation competencies into traditional STEM education. These non-technical fields can provide the guidance and perspective needed to holistically integrate technology into a human-based society. As earlier student testimony evidenced, STEAM learning can be highly rewarding, but also very challenging in terms of communication and collaboration when working between divisions of knowledge, expertise, language, and culture. Additional divisions exist at the academic program structure level, while more macro considerations - such as the collaboration between academia, workforce, government, and members of society - will be required by the vision for Society 5.0.

At a high level, there are questions as to whether the Japanese-centric vision and implementation for Society 5.0 can be easily shared at a global scale, as its intercultural translation may not necessarily provide a good fit in other locales (Gladden, 2019). Still, while this paper focuses on the

Japanese view of technology and its integration in future society, these same challenges and educational responses have the potential to apply to other societies and nations seeking to enhance and utilize STEM workforces. As worldwide demand for STEM field graduates grows, we must seek to address areas where traditional STEM education is falling out of sync with modern economic and societal needs. STEAM education fosters greater awareness, allowing students to see how fields are interrelated and can supplement each other to produce effective and innovative results. The Japanese workforce will need people with a broad educational background, including STEM majors who are familiar with the humanities and social sciences, and vice versa (Keidanren, 2016). From an educational perspective, STEAM and interdisciplinary studies will be essential to developing the next generation competencies needed to fulfill the vision for Society 5.0.

Author Note

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