

# Japanese Higher Education Reform Trends in Response to Globalization and STEM Demand

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## Introduction

Modern globalization is a major factor informing higher education policy and recent educational reform. Globalization encompasses a transnational flow of political, economic, and cultural ideologies and values. It is the “product of the emergence of a global economy [and] expansion of transnational linkages between economic units creating new forms of collective decision making” (Torres 1998, p. 71). Globalization has had a substantial impact in the educational field as new ranks of students increasingly have opportunities and the capability to enter higher education and study abroad. Philip Altbach (2013) explains that mass access to higher education has become a worldwide phenomenon, as evidenced by the United Nations Educational, Scientific and Cultural Organization (UNESCO 2016) statistics that global enrollments in higher education have increased 56 percent from 2004, with most recently available 2014 reporting indicating 207 million enrollments world-wide. Amidst these changes is a rising demand for students to enter into the Science, Technology, Engineering, and Math (STEM) fields, which offer high quality jobs that stimulate economic development and fulfill increasing human capital needs in their respective industries. STEM fields comprise majors ranging from chemistry, physics, software engineering, statistics, and beyond. Given the importance of globalization and STEM development in ongoing global higher education reform, this article will examine these trends and how Japanese higher education seeks to drive innovation and global competitiveness through STEM reform.

Japanese government policy directives and individual university programs are turning toward new approaches in internationalization and development of global competencies that challenge the traditional Confucian methodologies typical of East Asian education. Significantly, Japanese STEM students are increasingly expected to become proficient in foreign languages, international communication, and the development of soft skills previously associated with the social sciences and humanities. These changes reflect the

desire to produce students who possess broadened skillsets that are needed to excel in a modern globalized economy and knowledge based society.

## Globalization and STEM Demand

The nature of globalization has reshaped numerous established institutions, and higher education is no exception. Worldwide, higher education is now facing a major issue of adapting to the changes brought about by modern globalization. Serious competition attributed to globalization drives universities to transform themselves to cope with the rise of a knowledge-based society. Thus, transfer of knowledge and human personnel in a knowledge-based society is regarded as synonymous with internationalization. Increasingly, countries are worrying about their ability to compete within a global economy and their movement towards a global knowledge based society or technology based society. This translates to changing demands in the skills attained at universities, which are particularly apparent in STEM fields. Gisele Ragusa, Cheryl Matherly, and Sarah Phillips (2014) note that globalization, changing socio-demographics, and technological advances are changing the role of engineering in society. The development and integration of new technologies being produced and consumed at the international scale entails both global competition and collaboration. This internationalization of a global stem talent pool is evidenced by a UNESCO (2015) report projecting that graduates from China and India combined will account for 60 percent of the G20 workforce with STEM qualifications by 2030. Thus, beyond technical skills, STEM workers are increasingly being challenged to develop the competencies needed to enter an increasingly global economy.

At the national level, governments and education systems see the STEM fields as key to fueling innovation that drives economic development and international competitiveness in a modern knowledge based society. For example, from an economic standpoint, a U.S. Congress Joint Economic Committee (2012) cites that approximately half the U.S. economic growth in the last 50 years was driven by productivity

gains due to technological innovation. STEM fields are an important aspect of global competitiveness, and many countries have adopted measures to focus on increasing the number and diversity of students pursuing degrees in the STEM fields. Furthermore, market changes are driving a strong demand for a STEM workforce that has been, and is predicted to continue to be, disproportionately higher than those other fields. For instance, from 2000 to 2010, the U.S. STEM field employment growth tripled that of non-STEM field employment. Furthermore, it is predicted that from 2008-2018 STEM field employment will continue to grow at almost double the pace of non-STEM fields (U.S. Department of Commerce 2011). Similarly, the European Centre for the Development of Vocational Training (2014) estimates STEM demand in the European Union countries will grow by 8 percent by 2025, whereas non-STEM fields will only grow by 3 percent. With the challenge to meet this world-wide demand, there are new opportunities for students who possess the appropriate skillsets.

STEM education reform is indispensable to develop students who possess the integrated and flexible knowledge and skills that will solve modern technological and environmental problems. Szu-Chun Fan & John Ritz (2013) surveyed 20 countries and that the two major driving forces behind STEM reform were, “(1) the concern for a qualified STEM workforce that will aid in increasing national competitiveness and (2) the development of STEM literacy within students which might lead to their gaining high-level thinking abilities” (p.10). Massification and globalization have created intense competition for higher education reform targeting internationalization to attract foreign talent, reap economic benefits, and to develop students who have the skills necessary to operate in an increasingly globalized academic and economic context. STEM reform has become a critical high-stakes intersection where the effects of globalization, massification of higher education, and national competition meet. Countries are betting on STEM driven innovation and the global competitive strength of their academia and workforce to elevate their economic standing. Thus, we see that higher education institutions must now adapt and ensure that student learning, assessment, and curricula are updated to reflect significant changes in modern societal demands. Based on the need for global competency, Japanese engineering programs are now introducing aspects of internationalization, the development of collaborative problem-solving skills, and

new courses that challenge students to develop both technical and non-technical skills and knowledge.

### **Japan Policy Direction**

With increasing globalization and fast-paced social change, Japanese higher education must strive to match the changing needs of society and industry in a timely manner. As Japan faces a diminishing and aging population with fewer college entrants and limited natural resources, it is a widely accepted view that Japan must improve its workforce quality, productivity, and increase innovation to remain competitive (e.g., MEXT 2014c, 2015). In 2015, Japan’s Ministry of Internal Affairs and Communications (MIAC 2016) found a record high 26.7 percent of the population was 65 years or older. Thus, the Japanese government policy sees science and technology driven innovation as a key to unlocking productivity gains that can compensate for its diminishing workforce. This direction is not new to Japan, as technological innovation was an essential driving factor in the “economic miracle” that led a WWII devastated Japan to become the second largest economy in the world by the 1960s. Such technologies were used not only in the creation of new products, but also served to boost productivity gains through enhanced manufacturing and development techniques. Importantly, post WWII innovation in machine and chemical industries were heavily aided by the importation of foreign techniques and technologies, underscoring an understanding of the benefits of global ties that extend to Japan’s current situation (Uchino 1969). In order for Japan to create STEM driven innovation and ensure workforce with the skills needed to compete globally, this paper will look at three focal points of Japan’s STEM reform policies: increased internationalization, comprehensive human resource development, and curricula that directly prepares students and researchers to address the actual demands of Japan’s economy and society. At a high level, the 5<sup>th</sup> Basic plan, adopted in 2016 by Japan’s Council for Science, Technology and Innovation (CSTI 2016), recognizes the intertwining issues at the intersection of STEM and globalization, and sets forth policy recommendations aligned with these three points, which will be discussed in turn.

### **Increased Internationalization**

Japanese educational policy has placed new importance on significantly increasing the number of

incoming and outgoing international students and faculty, and developing the competitiveness of universities at the international level. The Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) National Reform Plan, targets include doubling the number of Japanese students studying abroad and the number foreign students studying in Japan by 2020 (2014a). Globally, student mobility has reached new heights, evidencing a segment of the world-wide rising demand for qualified STEM graduates. Per an Organization for Economic Cooperation, Development (OECD, 2013) report, from 2000 to 2011 the number of international students in tertiary education more than doubled, with Asian students making up 53 percent of international students in 2011. As a frame of reference, we can look the United States as the leader in international admissions, where international students in U.S. higher education institutions have nearly doubled to 1,043,839 over the past decade, with 41.5 percent studying in STEM fields (Institute of International Education [IIE] 2016). This “brain gain” is a substantial boon to national competitiveness, as these students provide funding, elevate the programs they belong to, and many seek to remain and work in the United States post-graduation. Likewise, Japan sees an opportunity to become more competitive in utilizing this increasingly large pool of global talent to supplement its diminishing domestic workforce. While international enrollments in Japanese higher education has increased, it is still making up for multiyear decline caused by the Great Japan Earthquake of 2011. New internationalization policy has helped to Japan recover to a new total of 152,062 international student higher education enrollments in 2015, up from 121,012 in 2005 (Japan Student Services Organization [JASSO] 2016). Students majoring in Science and Engineering fields alone accounted for 18 percent of these enrollments. Beyond attracting talented foreign students, higher education institutions with international faculty and researchers are seen as better able to develop international research networks, facilitate joint university initiatives, enhancing the prestige of Japanese schools and companies at the global level.

With the move toward a more globalized and knowledge-based society, a new metric for quality in Japanese education is the production of students with ability to succeed both domestically and have the potential to be global leaders in the international context. Thus, increased internationalization of faculty, students, and program requirements facilitate the development of students with global competencies, such as foreign

language and intercultural communication skills. Yet, a serious challenge to this goal is the trend that young Japanese have become increasingly wary of international ambitions, and are more often content to limit themselves to domestically, both in academics and the workplace. For instance, a 2013 Sanno Institute of Management survey of new graduates found that 58.7 percent of respondents did not wish to work abroad, up significantly from 28.7 percent in 2004 (as cited in Yonezawa 2014). Among those who responded negatively to opportunities to work abroad, 65.2 percent cited lacked confidence in language, and 50.4 percent cited uncertainty about life abroad. Aiming to address such cases of lack of interest and participation internationally, educational policy is placing new emphasis on foreign language ability for Japanese students and faculty. The introduction of foreign language instruction and integration of international students and faculty seeks to boost Japanese confidence in foreign communication and cultural understanding. Programs are increasingly introducing higher expectations for English competency in qualitative assessments, in addition to integrating English courses and curriculum that integrate aspects of internationalization into degree requirements. While these measures are not strictly limited to STEM fields, it is quite significantly, that they are being applied to STEM majors, where curriculum changes supporting internationalization requirements act in opposition to a traditionally technical skillset orientation in student development. As English has been established as the international language for academia and business, proficiency in it has implications in the post-graduation workplace, where employees can then be called upon to facilitate international business, and can be sent to the international branches of Japanese companies. Thus, amidst increasing globalization and student and workforce mobility on a global scale, Japan’s higher education seeks to address deficiencies that would prevent its future STEM workers from reaching their ability to act as global citizens who can succeed in an international knowledge-based society.

There are many concrete policies which are being implemented to increase the numbers of incoming and outgoing international students and faculty, and developing the competitiveness of Japanese universities at the international level. In 2014 the MEXT (2014b), selected 37 universities to spearhead this effort under its “Top Global University Project” (TGUP). Under the project, selected universities have been categorized into two groups, arbitrarily designed “Type A” and “Type

B.” The 13 Type A universities receive funding to support efforts in attaining positions in the top 100 world-class university rankings. 24 Type B universities will focus on driving internationalization of Japanese society through their programs. This is no small shift, in total the 37 universities of the TGUP account for 2.82 million, or 20 percent of all students and faculty staff in Japanese universities (Matsumoto 2015). Universities are expected to integrate comprehensive internationalization and reform by recruiting talented foreign faculty and students, increasing English accessible curriculum and collaborations with international institutions. Participating universities individually design programs carry out these directives using methods of their choosing. The TGUP has also set ambitious program-wide goals for attracting foreign talent, including raising classes conducted in foreign languages to 21.9 percent, raising availability of English translated class syllabi to 69.3 percent, and having 47.1 percent of full-time faculty staff as international or having received degrees at foreign universities (Matsumoto 2015). As an example, TGUP funded program focusing on STEM, it is instructive to look at the Kyoto Institute of Technology’s (KIT 2014) plan calls for raising foreign language criteria such that 50 percent of undergraduate and 80 percent of graduate students meet a Test of English for International Communication (TOEIC) score of 730. The TOEIC English test for non-native speakers is a widely used standard for measuring English proficiency among Japanese universities and during workplace hiring. According to the TOEIC administering Educational Testing Service (ETS), in listening and reading Japan was globally ranked 39 out of 46, with a mean score of 513 in 2015. Substantial foreign language usage and meaningful interactions with foreign students help Japanese students develop skills to operate globally. Kawamura (2016) measured cultural competency using the Intercultural Development Inventory framework and found measurable positive development in intercultural competencies at four highly internationalized Japanese universities, affirming the relevance of efforts to develop global competencies for Japanese students who remain in Japan. Programs like these further seek to increase international leadership skills through joint classes with international students instructed in English, and the addition of overseas internship program requirements. To support such requirements, many university programs are establishing international ties through overseas bases, joint degrees, and collaborative research agreements. The Kyoto Institute of Technology (2014)

describes their program’s ideal human resource product as a “tech leader” combining expertise, leadership abilities, ability to use foreign languages, and a strong Japanese identity. Increasing mobility, internationalization, and global citizenship will only lead to more frequent situations requiring international collaborators to carry out cross-cultural projects in both academic and industry settings. As such, even STEM students who traditionally specialize in a single technical field are now being expected to gain new competencies in foreign language, cultural awareness, and overseas experience.

### **Heightened Human Resource Development**

To cultivate graduates to lead Japanese industry in collaboration, innovation, and entrepreneurship, Japanese higher education policy increasingly favors technical STEM fields to incorporate interdisciplinary knowledge and skills through the introduction of humanities, social sciences, and other fields. While STEM fields have traditionally focused narrowly on providing graduates with the specialized technical knowledge and skills, they are now also seeking to develop soft-skills in global competency, teamwork, leadership, and problem-solving abilities, to supplement their primary field studies (Ragusa, Matherly and Phillips 2014). Interdisciplinary studies are being valued for the development of critical thinking, broader perspective from alternate fields of study, and the ability to translate ways of thought between different fields. Representing the receiving industry perspective on Japanese education reform, the Keidanren Japan Business Federation (2016), has called for, “Science and engineering majors with broad educational background that includes humanities and social sciences; and, humanities and social science majors with broad educational background that includes basic knowledge of advanced technologies and math and science.” Top Global Universities like the Nara Institute of Science and Technology, and the University of Tsukuba with its Empowerment Informatics Program implement such interdisciplinary programs for STEM field students. The 5<sup>th</sup> Basic Plan outlines the opportunity for innovation that is sought by broadening perspectives through interdisciplinary research:

In the midst of rapid expansion and innovation on the frontiers of knowledge, academic research grounded in researchers’ intrinsic motivations is not only creating new interdisciplinary and integrated

cross-disciplinary areas of research, it is also becoming a source of innovation, with the potential for the creation of additional innovation across a wide range of fields. (CSTI 2016, p. 38).

By considering perspectives and knowledge from non-technical perspectives, researchers become more aware of the holistic value of their research to society. Additionally, interdisciplinary studies give students opportunities to prepare for working and presenting their accomplishments to diverse groups of stakeholders, who may not share the same technical perspective.

To create strong leaders, who can communicate and succeed in global environments, it has become advantageous for Japan to introduce aspects of Western education to allow students to work within different cultural and social frameworks. The Japanese education system, along with other Asian education systems, are built upon a strong Confucian basis that is known for its rote memorization and passive learning rather than active student participation, such as in peer learning activities, group debate, or student discussion. Learning in Japan is traditionally teacher-centric, where prepared lesson plans are strictly followed and students learn material in a passive manner, without questioning or debate. The strength of this system is that students tend to excel in math and science subjects, and this is reflected in international evaluation metrics provided by tests such as the Programme for International Student Assessment (PISA), in which East Asian students from China, Singapore, South Korea, and Japan are consistently among the top scoring students in quantitative skills assessments (OECD 2013). Highly developed quantitative skills in science and mathematics can be considered as the greatest strengths of East Asian education. However, the passive Confucian learning model often overlooks the development of the soft skills that are valued in Western education and society, such as critical thinking, problem solving, and spontaneous discussion and debate. To address this deficiency, Japanese higher education institutions are beginning to introduce aspects of Western pedagogy into their curriculum.

To address the need for global competency and the ability to collaborate and lead internationally, Japanese university programs are starting to adopt a new hybrid model that combines aspects of the traditional Confucian educational model and a Western style of active learning. More Western style courses are used to encourage the use of student-centric discussion, debate, and collaboration, preparing Japanese students with soft

skills and communication practice needed to operate in less hierarchical international contexts. Carolina Valiente (2008) found that due to cultural differences in communication and collaboration, East Asian students encountered difficulties when trying to excel in Western environments, resulting in their contributions being overlooked or disregarded in favor of more assertive and outspoken students. Thus, as universities focus on creating globally competent students, the introduction of Western pedagogy helps prepare students to operate and compete in international contexts.

Student-centered learning is cited as an important method to improve learning outcomes and student motivation, self-reflection, and engagement (European Network for Quality Assurance in Higher Education [ENQA] 2015; Yamada 2014). While active learning is conducive to developing the skills required for global citizenship, it is also important for quality assurance purposes, where students and faculty engage in meaningful discourse, and develop relationships associated with higher motivation, satisfaction, and educational outcomes. Previous studies have shown the benefits in engagement, and learning outcomes under a faculty and student partnership in teaching and learning (Cook-Sather, Bovil, and Felten 2014). One favored example of student-centric and active learning is engaging students in problem based learning. While instructors of these classes facilitate coursework and discussion, students are expected to analyze real-life issues, to take steps in response to problems, and to work out strategies to propose and present pragmatic and effective solutions. These cooperative problem-solving skills are viewed as important for global citizenship and international collaboration post-graduation. While it is essential that students be capable as individuals, important values are gained through the ability both to contribute and share knowledge and skills with others and to understand and incorporate ideas into a joint solution with other individuals from different educational and cultural backgrounds. Working in groups provides opportunities to practice expressing ideas and presenting them to others constructively and logically. Numerous studies show the importance of collaborative problem solving in the 21<sup>st</sup> century workforce, which is transitioning from manufacturing to globally distributed teams working in information and knowledge based services (OECD 2015).

## Fulfilling Societal Needs

A third key point of Japanese higher education reform affecting STEM is a shift to prioritize policy and curricula that reflect the needs of society, and setting to human resource development goals to match these needs. Thus, an additional measure of the quality of education is a graduate's development of skills and knowledge that can be transferred to the workplace and meet the demands of Japanese society. In a 2013 interview, the former Minister of Education and Science, Hakubun Shimomura, commented on the critical state of Japan's higher education: "Japanese universities are like isolated ivory towers. Their refrain has long been 'freedom of education and research,' but you suddenly realize they have been unable to cope with today's realities. Few are globally oriented, and few are in sync with the needs of today's society at home" (Tanikawa 2013). Japanese higher education seeks to create national innovation by establishing and strengthening appropriate linkages between industry, academia, and government (MEXT 2015). Because Japanese society follows a concept of long-term employment, crosspollination and transfer of individuals and knowledge to bridge the three sectors have been lacking in the past. Especially in the context of STEM, new policy seeks to drive innovation through continuous relationships, as opposed to separate and segmented ones, such as the divisions between basic research, applied research, and development research (CSTI 2016). Tsukuba Science City and Kansai Science City are cited as locations where this desired continuous feedback and reinforcement of cross-sector ties occurs and results in increased innovation. Another such example is the Nagaoka University of Technology's creation of a "GIGAKU Techno Park" network, where joint industry-academia-government projects are undertaken, both in Japan and abroad. Many programs in the Top Global University Project seek to establish structural ties to industry as part of their curriculum. Furthermore, industry internship assistance and graduation requirements are being used to ensure that students gain hands on experience grounded by societal needs.

## Case Study: University of Tsukuba Empowerment Informatics Program

Driven by government efforts like the MEXT's Top Global Universities Project (TGUP), Japanese universities are adapting to changing expectations and setting new goals in STEM and internationalization. The

University of Tsukuba's was selected as a Type A university under the TGUP, seeking placement in the global top 100 university rankings. Its Empowerment Informatics Ph.D Program (EMP) is cited as an example of a program undertaking higher education reform at the intersection of STEM and globalization discussed above. The EMP seeks to develop internationalization by actively recruiting foreign students and faculty, providing a curriculum that can be fulfilled through English coursework, and offering institutional support for international students. The program encourages meaningful integration of domestic and international students, as some required courses for domestic students are taught in English. Thus, international students can enroll in courses alongside Japanese students and are encouraged to work together in groups for coursework and research projects. The addition of Western style classes encourages active participation and student engagement in group learning environments that favor discussion and debate that are often lacking in Japanese style classrooms. Additionally, the program has formal international ties through partnership with five foreign universities representing the UK, France, Netherlands, and USA, and foreign faculty are invited to assess and provide guidance to projects being worked on by EMP students.

To improve human resource development aspects of its graduates, the EMP targets three aspects of student learning that extend beyond technical expertise:

1. Frontline: The ability to solve problems in the academic, industry, and public spheres.
2. Presentation: The ability to communicate effectively and convey the nature and importance of research achievements.
3. Interdisciplinary: The ability to consider issues from multiple perspectives, to see the "big picture," and to approach issues with creativity and innovation.

As outlined above, problem based learning and interdisciplinary studies are sought to develop critical thinking skills, and introduce team-based problem solving involving multiple perspectives and fields of study. Another unique aspect of the EMP is that it embraces the notion of "STEAM," referring to the incorporation and interaction of the arts within STEM studies. The program mixes students from both engineering and arts backgrounds to work on collaborative projects that have practical outcomes.

As Japanese higher education seeks to better align towards the direct needs of society, the EMP demonstrates a commitment toward this goal. One of

the key aspects of the program is a cycle of exhibition and refinement of student projects through feedback from the general public, as well as academic and industry experts. Student projects are demonstrated at local events such as the Tsukuba Media Art Festival, and globally at special interest international events like the Ars Electronica Festival, and the ACM SIGGRAPH. Additionally, the EMP integrates advisors and partners with major corporations like Panasonic, Nissan Motor Co, Hitachi, NEC, Shiseido. Several practicums are embedded into the EMP curriculum, consisting of advisement from industry professionals, a six-month collaborative project in an industry workplace, and a three-month research period preparing research proposals and working in interdisciplinary laboratories. Through industry involvement students gain insight into bridging their academic work into the workplace and society as a whole. The EMP blend of internationalized, interdisciplinary, and problem based learning projects seeks to develop well-rounded skill sets that are constantly being guided by both academic interests, and real-world application and evaluation.

### Conclusion and Discussion

Growing demand for STEM field workers and heightened attention toward globalization have started to reshape the mission of higher education STEM programs. Higher education reform in response to globalization and STEM demand are often intertwined, as globalization of higher education has affected who is studying STEM and their education and workplace opportunities. Combining the challenges posed by globalization and the demand for high quality STEM graduates, higher education reform needs to prepare STEM students to innovate and solve important problems that stretch beyond geographic, cultural, socio-political, and domain-knowledge boundaries. Japanese higher education reform seeks to develop global human resources who can meet these needs through increased exposure to internationalization. At the same time, Japan is recruiting foreign students, faculty, and researchers help develop its international research networks, and supplement its shrinking domestic workforce. Western pedagogy and active learning techniques that develop soft skills are being utilized to prepare graduates to undertake collaborative work with experts across different academic fields, and to work in teams where team members supplement each other's skills and knowledge. At the individual level, technical research

skills are increasingly being combined with broader knowledge from international and interdisciplinary studies.

Advances in STEM research and development are core to economic growth and the creation and growth of new industries, which manifest themselves in the products and technologies that we use in our daily lives. However, Akiyoski Yonezawa (2014) points out Japanese youths still maintain "inward looking attitudes" and skepticism toward the need and marketability of global skills. Most students will remain within Japan upon employment, and in entry-level positions they are unlikely to realize gains from foreign language ability or cross-cultural training in their daily work. Yet, the educational reform strategies outlined in this paper are driven by a long-term vision where the Japanese workforce needs to be able to compete in an increasingly globalized labor market. Long term policies like the Top Global University Project extend until 2023, so there is still much time to reveal how internationalization and reform efforts will fare. Future studies will be needed to evaluate whether Japan's current policy changes result in an effective workforce that raises its ability to compete at the international level academically and economically.

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