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New Directions of STEM Research and Learning in the World Ranking Movement

A Comparative Perspective

Edited by

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Preface: The Impact of STEM Research in a Knowledge-Based Society and the Need of Integrated Study of STEM and Other Disciplines

The impact on the knowledge economy in a globalized world has become larger and larger in recent years and there is a growing expectation and demand for innovation in higher education. It is generally expected that Sciences, Technology, Engineering, and Mathematics fields of study will take a leadership position in innovation. The word STEM coins the widely recognized concept of integration between science, technology, engineering, and mathematics. Many countries, such as the United States, United Kingdom, Australia, Singapore, China, Japan, and others put more emphasis on Science and Technology policies than other fields of study. Eventually, STEM education reform from K-12 to higher education has become increasingly important. Many countries devise policies to increase the number of university students as well as graduate students in STEM fields and to connect university research with industry to create a foundation for future job markets. At the K-12 level, the issue of upgrading the quality of STEM teachers is also being discussed.

Research in STEM fields has many commonalties in content, innovative aspects, and direction. Therefore, researchers worldwide submit their papers to distinguished international journals published in English. Acceptance, as well as citation rate, becomes an important indicator in the world ranking of universities. Thus, government STEM-oriented policies are closely related to the world ranking competition. Many universities in the world are therefore forced to become conscious of world ranking regimes, to secure more research funding, more foreign

students, increase their world reputation, and to get national funding. Thus, STEM disciplines have received a disproportionate amount of attention largely due to the link with global ranking systems.

On the other hand, in 2015, the issue of restructuring the social sciences and humanities (SS/HUM) in the context of the STEM emphasis at the university level became a national issue in Japan. Nobody contests STEM fields' important role in research and development, with respect to future jobs and the improvement of global ranking scores. The abundance of STEM-oriented policies obscures the importance of other disciplines such as humanities and social sciences. At the same time, there has been a call for interdisciplinary collaboration based on STEM and other disciplines. There is a growing concern that students in STEM disciplines need to acquire specialized knowledge based on other disciplines to acquire global competences, such as communication skills, intercultural knowledge and skills, and interdisciplinary contextualization and innovation. This raises the question about the future direction of STEM education in higher education. Is it important to integrate STEM fields with other fields, such as humanities, arts, and social sciences? Should STEM students be exposed to international education and exchange programs as other students do in the humanities and social sciences.

This project intends to analyze the dominance of STEM fields in various university rankings and the reason why and how many governments in the world disproportionately give value to STEM fields. STEM is an up and coming hot theme. However, most of this attention focuses on research which leads to national productivity, innovation, and world competitiveness. There is little research to discuss the relationship of recent world science and technology policies, STEM disciplines and the world university ranking movement. The world university ranking movement is also a new trend and it influences higher education policy globally. Thus, research on STEM receives large amounts of research funding, influences the mobility of foreign students, and develops industry and university collaboration.

Second, although there is a general agreement that STEM fields are important, we also examine the role of interdisciplinary and multidisciplinary approaches for a revised STEM education. What should be the direction of STEM higher education in the future? Both purposes are analyzed comparatively in examples from the United States, Canada, Japan, China, Korea, and Taiwan. The study is a comparative analysis

that will clarify the commonalities and differences between countries. There is a hypothesis that many countries covered in this study have commonalities of science- and technology-oriented policy in the knowledge-economy society, however, there are some differences of approach for STEM higher education and STEM higher education reform. We will examine what makes commonalities and differences between countries and how we might propose new directions for STEM higher education in the twenty-first century. The chapters of this book illustrate some new directions of STEM higher education from the perspective of twenty-first century types of learning outcomes and thus focuses on the need of developing an interdisciplinary approach for STEM higher education reform.

The Introductory Remarks written by John N. Hawkins illustrates the existence of a dilemma of STEM integration in the Arts, Humanities, and Social Sciences and argues that this dilemma has had profound implications for the current debate on the value and action implications of various ranking regimes.

In Chapter 1, Reiko Yamada analyzes how globalization and knowledge-based economy have impacted the promotion of STEM human resource-oriented policies worldwide in comparative perspective and then, examine the necessity of global competences for STEM college students from the interdisciplinary aspect.

In Chapter 2, William R. Stevenson III shows the relationship of university ranking and field of STEM, examined from the historical perspective. It becomes clear that for over a century, universities have been assessed and ranked according to both outcome-based approaches and student-oriented input-based criteria.

It is recognized that science and innovation will increase the productivity and bring the well-paid jobs and enhance competitiveness and result in the economic growth. Chief Scientist (2014) states that the advancement of science technology and growing occupations require technology and skills in STEM fields. Also, STEM research is recognized to contribute to increasing world university rankings. However, emphasis on STEM fields may increase inequality issues in higher education. In Chapter 3, Tristan Ivory examines inequality issues arising from emphasis on STEM fields at three general levels—the individual, institutional, and national.

Chapter 4 written by Jason Cheng-Cheng Yang demonstrates how the impact of ranking also can be found on faculty behaviors at top

universities in Asia and university's internal allocation of funds on different subjects. He chose Taiwan as a case to study the relationship between world higher education ranking and STEM research.

Chapter 5 by Grant Jun Otsuki discusses cases in which people have worked at and across this boundary in ways that defy easy categorization as "STEM" or "H&SS." These interactions, it is suggested, are as important to the work of scientists as they are under-recognized. This will lead us to a discussion at the end of some of the consequences of the persistence of this boundary despite its porousness.

In Chapter 6, Aki Yamada shows the direction of interdisciplinary collaboration in US higher education and then analyzes similar developments in Japanese higher education, such as the Empowerment Informatics Ph.D. Program (EMP Program) at the University of Tsukuba. These institutions merge STEM majors with of artists, humanists, and social scientists in collaborative classwork, research and development, and field work.

Although there are limitations to the measurement of global poverty, it is a large enough indicator to draw the interest of global and regional development banks, bilateral and unilateral aid from governments, and research initiatives from companies, think tanks, and universities. Concerning global poverty research, there are eight development labs (at seven universities) funded by USAID. In Chapter 7, Christopher S. Collins focuses on the role of interdisciplinary work at university development labs.

In Chapter 8, Byung Shik Rhee aims to fill that gap by examining the humanities competencies of STEM students enrolled in two Korean research universities, one comprehensive university and one science and technology university by asking the following questions: (1) What are the current humanities-competency levels of STEM undergraduate students at two research universities in Korea? (2) Do the humanities competencies of STEM students change by year during college?, and (3) How are the humanities competencies of STEM students related to faculty mentoring, student engagement, institutional climate, and liberal arts courses taken?

From the 1950s, strengthening science and technology became the core policy of Chinese education and thus, China is now matching and surpassing most of the western countries. But this overemphasis on science has led to a neglect of studying the arts and there exists a tendency

to generally undervalue the arts and regard them as unimportant. Chapter 9 by Yi Yang analyzes Chinese arts education policies in a new era in relation to the perspective of "From STEM to STEAM."

In Chapter 10, Masaaki Ogasawara demonstrates that consistent Japanese special higher education policy on STEM field after Meiji Era had contributed to produce many graduates with technical and scientific abilities to lead our industrial society. However, at present, Japanese STEM disciplines are suffering from the decline in the number of students who have interests in STEM fields. He argues that the existing traditions and customs in the Japanese system has caused the present STEM issue.

Chapters in this book illustrate some new directions of STEM higher education from the perspective of twenty-first century types of learning outcomes and thus focuses on the need of developing an interdisciplinary approach for STEM higher education reform.

Kyoto, Japan Reiko Yamada

Contents

Notes on Contributors

Christopher S. Collins is an Associate Professor of Higher Education at Azusa Pacific University and serves as an Associate Director for the Asia Pacific Higher Education Research Partnership (APHERP). He is interested in research on the role of higher education related to poverty reduction, knowledge extension, public good, and social rates of return. Past publications include *Higher Education and Global Poverty: University Partnerships and the World Bank in Developing Countries* (Cambria Press, 2011) and *Education Strategy in the Developing World: Revising the World Bank's Education Policy* (Emerald Group Publishing Limited, 2012). In addition, he has published articles in *The Review of Higher Education*, *Higher Education*, and the *Journal of Higher Education*. He earned a Ph.D. in education from the University of California, Los Angeles.

John N. Hawkins is a Professor Emeritus at the University of California, Los Angeles and former Co-Director of APHERP, East-West Center. Hawkins is a specialist on higher education reform in the United States and Asia and the author of several books and research articles on education and development in Asia. Recent books include *Changing Education: Leadership, Innovation, and Development in a Globalizing Asia Pacific* (with Peter D. Hershock and Mark Mason, Springer, 2007) and *Policy Debates in Comparative, International, and Development Education* (with W. James Jacob, Palgrave Macmillan, 2011). He has served as President of the Comparative International Education Society and Editor of the *Comparative Education Review*.

Tristan Ivory is an Assistant Professor with appointments in the Department of Sociology and Black Studies Program at the University of Missouri. He received his Ph.D. in 2015 from the Department of Sociology at Stanford University and completed a Postdoctoral Fellowship at the Center for Research on Race and Ethnicity in Society at Indiana University. Tristan's areas of specialization include international migration, race and ethnicity, inequality, and transnationalism. His dissertation uses ethnographic observation, interviews, contemporary news accounts, and archival data to examine the resources and strategies Sub-Saharan African migrants use to try to maximize social and economic outcomes in the Tokyo Metropolitan Region. Tristan is currently revising articles from his dissertation research as well as writing the first chapters of his dissertation book project, tentatively titled "Greener Pastures: Sub-Saharan Africans and the Pursuit of Social Mobility in Japan."

W. James Jacob is a Professor of Higher Education Leadership in the Department of Leadership at the University of Memphis. He also serves as Co-Director of the Center for the Study of Higher Education and as a member of the Leadership Memphis Executive Program. Prior to joining the University of Memphis, he served for 10 years at the University of Pittsburgh as Director of the Institute for International Studies in Education. He is the Co-Editor of two book series related to the development of comparative, international, and development education scholarship: *International and Development Education* (Palgrave Macmillan) and *Pittsburgh Studies in Comparative and International Education* (Sense Publishers). His most recent books include *Strategic Transformation of Higher Education: Challenges and Solutions in a Global Economy* (with Stewart E. Sutin, Rowman & Littlefield, 2016); *Trends in Chinese Education* (with Hongjie Chen, Routledge, 2016); *Indigenous Education: Language, Culture, and Identity* (with Sheng Yao Cheng and Maureen Porter, Springer, 2015); *Community Engagement in Higher Education: Policy Reforms and Practice* (with Stewart E. Sutin, John C. Weidman, and John L. Yeager, Sense Publishers, 2015); and *Policy Debates in Comparative, International, and Development Education* (with John N. Hawkins, Palgrave Macmillan, 2011). He has written extensively on comparative, international, and development education topics with an emphasis on higher education.

Masaaki Ogasawara Doctor of Engineering, is a Professor Emeritus of Hokkaido University and the fomer President of the Japan Association

for College and University Education. He worked as a Professor in the Faculty of Engineering for a long time and he worked for the developing "integrated science." As the Director of the Research Division for Higher Education, he contributed to the educational reform of general education in Hokkaido University. His recent edited work includes a book entitled *Liberal Arts Education of Hokkaido University* (published in 2016).

Grant Jun Otsuki (http://www.gjotsuki.net/) is a Lecturer in the School of Social and Cultural Studies at Victoria University of Wellington, New Zealand. From 2015 to 2017, he was an Assistant Professor of Anthropology at the University of Tsukuba, Japan. His research focuses on the anthropology of history of science and technology, the anthropology of contemporary Japan, and science and technology studies. His field research has investigated the practices of wearable technology and robotics researchers in Japan, the transhumanist movement in North America, and the use of technology in Japanese popular culture.

Byung Shik Rhee is a Professor of Higher Education and Director of Center for Global Higher Education at Yonsei University. He previously served as a visiting scholar within the Higher Education Research Institute at the University of California, Los Angeles. He has served as an Associate Dean of the University College at Yonsei University, as an advisory member of the Presidential Committee on Education Innovation, as well as in the President's Office of Education, Science and Technology, and Culture. He holds a Ph.D. in Higher Education (Organizational Behavior and Management) from the University of Michigan. His current research interests are impact of college on students, institutional performance, and management and leadership in higher education institutions.

William R. Stevenson III is an Associate Professor and the current Chair of the Department of Education and Culture at Doshisha University. He received a Ph.D. in Japanese History from the University of Hawaii at Mānoa. He teaches and publishes primarily in the field of education history, and spends his free time exploring the hills surrounding Kyoto with his wife and three young boys.

Aki Yamada received her Master of Arts in American Studies from Doshisha University, Kyoto, Japan, studying at Stanford University for one year as a Freeman Spogli Institute Visiting Researcher. In 2015 she

completed her Ph.D. in Education at UCLA, writing her dissertation on new Japanese migrants and immigrants living in the United States. Her research interests include globalization, contemporary Asian immigration, transnational identity, and internationalization of higher education. Aki is now working as an Assistant Professor in the Empowerment Informatics program at University of Tsukuba. Her recent work includes "Changing Dynamics of Asia Pacific Higher Education Globalization, Higher Education Massification, and the Direction of STEM Fields for East Asian Education and Individuals" in *Redefining Asia Pacific Higher Education in Contexts of Globalization Private Markets and the Public Good* (Palgrave Macmillan, 2015).

Reiko Yamada is Dean and Professor of the Faculty of Social Studies and Director of the Center for Higher Education and Student Research at Doshisha University, Kyoto, Japan. She was the inaugural President of the Japanese Association of the First-year Experience. She received a Ph.D. from UCLA. She is the author of *For the Quality Assurance of Undergraduate Education* (Toshindo, 2012), and editor of *Quality of Higher Education and Its Evaluation: Japan and the World,* (Toshindo, 2016). Her recent publications include *Measuring Quality of Undergraduate Education in Japan* (Springer, 2014), "Comparison of Student Experiences in the Era of Massification: Analysis of Student Data from Japan, Korea and the USA" in *Managing International Connectivity, Diversity of Learning and Changing Labour Markets: East Asian Perspectives* (Springer, 2016).

Jason Cheng-Cheng Yang is an Associate Professor in the Graduate Institute of Educational Administration and Policy Development at National Chiayi University (NCYU), Taiwan. He completed his Ph.D. degree in International Comparative Education at University of California, Los Angeles in 2010. His research interests include higher education administration, higher education policy, and comparative education. His research articles cover topics ranging from management in university to higher education policy issues in Taiwan and other Asian countries. His current research projects focus on exploring organizational justice in higher education and the hybridizing process of Western forces and local academic culture in the Taiwanese higher education system.

Yi Yang received her M.A. and Ph.D. in Education from Kyoto University. Her research areas include educational thought, history of

education, aesthetic education, arts education, and comparative education. She is an Associate Professor of the College of Contemporary Education at Chubu University. Her recent publications include an article in *Social Science Review* titled "A Study on the Development of the Aesthetic Education Movement A: Cai Yuan-pei's Practice from the 1910s to the 1920s."

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