



Singapore's Higher Education Systems in the Era of the Fourth Industrial Revolution: Preparing Lifelong Learners

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INTRODUCTION

Global society is changing because of the shifts in technological capacity. Higher education must change with it. Singapore is, once again, at the forefront of innovation in higher education. This chapter reports on research that details the large-scale government initiatives launched to develop an education system that is future ready. Singapore serves as a model to nations around the world wanting to prepare their workforce with ways of thinking and working that are in demand in the fourth industrial revolution (4IR).

Singapore's economic prosperity is closely linked to its successful education system. With a population of approximately five million people, outstanding development, good public health, and robust economic growth, the employment prospects for most of its citizens have been strong to date. However, McKinsey Global Institute data recently claimed

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that 44% of jobs in Singapore are automatable.¹ That represents a third of the workforce that will need to be upskilled and retrained in the near future. Singapore's education system has a reputation for preparing excellent STEM learners, where students learn to the test. This was useful in creating a workforce that crunches and manages numbers efficiently. Creative and critical thinking did not come from this sort of preparation, however. Now plans are under way to develop more holistic education systems that teach students *how* to learn, rather than *what* to learn in order to adjust and continue to have an education system that delivers what the economy needs.

Singapore has always been adaptive, and this is reflected in its approach to education. This chapter explains the current revisions of higher education in Singapore, which are designed to instill lifelong learning tendencies in the Singaporean population. Through the implementation of three ambitious government-led efforts, Singapore is altering the way it educates people. The three specific higher education developments reported upon here are the Smart Nation Singapore, SkillsFuture Singapore, and the establishment of several new higher education institutions. Through these initiatives Singapore is preparing for the future economy with remarkable ingenuity.

IMPACTS OF 4IR ON GLOBAL SOCIETY

Many current jobs are automatable; time will tell just how many and in what areas. Automation is the result of technological developments facilitated by advances in big data, cloud computing, and machine learning. Indeed, the processes under way are changing what it means to be human. How we work and live is changing because we now have access to massive amounts of data which can tell us new things and can enable machines to do new things. Some new jobs will come, but it is also true that we face a future in which there may be economic growth without job growth.

The so-called fourth industrial revolution involves cyber-physical systems (CPSs) taking over much of the work currently being done around the world. The mechanisms of that change are complex but acting swiftly. CPSs are at the heart of the changes many in the world are already experiencing.

¹Lin Diaan-Yi, "What executives need to know about automation," February 2017, <https://www.mckinsey.com/~media/McKinsey/Locations/Asia/Singapore/Our%20insights/Automation%20DY/Automation%20DY.ashx>.

CPSs are computer-based algorithms that work with physical processes in which embedded computers and networks monitor and control the physical processes of machines and artificial intelligence (AI) in a feedback loop whereby one informs the other. Today the technology is new but advancing very fast. Driving trucks, cars, or lawn mowers is no longer a human job. This has significant implications for economies all over the world. In the past, production has relied on machines to make core human labor more productive. We face a future in which humans may no longer be needed for production at all. Humans remain integral to 4IR; their creativity and ideas are driving the change. It is not as simple as machines taking over all routine and predictable tasks. Humans will work alongside robots, some claim as “cobots”, and together they will amplify what is possible.

WHAT 4IR MEANS FOR HIGHER EDUCATION

Traditional undergraduate education through information transfer is no longer a viable form of education to ensure employment and a career. In this context we must ask how do we prepare employable and responsible citizens in our tertiary education systems? Michael Peters has argued that education by itself will be insufficient to address problems of technological unemployment.² Others have emphasized the importance of liberal arts education as the ideal solution for creating future-ready graduates.³

Education through traditional institutions of higher education is still important, but their collaboration with industry and governments needs to be much more intense. Of course, universities still need freedom in their research, and many do not want their research agendas and curriculum dictated to them, but more communication is always a good thing. Financing from industry and government to upskill existing populations is also essential.

Currently, we understand that algorithms and CPS are doing routine and pattern-based work. This includes everything from making pizzas, to designing buildings, to reading radiology charts. The message from AI experts is that it is that which makes us human, our emotional intelligence and creativity, that will be in demand when this transition to automation is complete. Adaptive, flexible minds will be the most employable in the future, as they will have the cognitive agility to keep up with the fast-paced

² Peters, “Technological Unemployment: Educating for the Fourth Industrial Revolution,” *Journal of Self-Governance and Management Economics* 5, no. 1 (2017): 28.

³ Pericles Lewis and Katherine Rupp, “Liberal Education in Asia: Trends, Challenges, and Opportunities,” *New Global Studies* 2015; 9(3): 245–266.

shifts in work place projects. *Accenture*, in a recent report, explains that a major trend of 4IR is the so-called liquid workforce, which turns away from older siloed models of work that were aligned to specific business functions.⁴ Future work, instead, will be based on adaptive workforces organized around projects, supported by embedded training.⁵ This new kind of employee needs a different kind of education in preparation.

Erik Brynjolfsson and Andrew McAfee argue that in order for people to remain “valuable knowledge workers,” they must “work to improve the skills of ideation, large-frame pattern recognition, and complex communication.”⁶ Not everyone in the world can be a skilled worker in this context. The creative destruction of jobs will be disruptive, but new jobs will come in their place. As Joseph Aoun noted in his book *Robot-Proof: Higher Education in the Age of Artificial Intelligence*, thinking of creative ways to work is essential and universities are “ideal entrepreneurial ecosystems.”⁷

Much research has been committed to understanding how people learn and what the best approaches are for teaching them to think creatively.⁸ Students in different cultures and of different ages learn differently.⁹ Furthermore, how educators themselves understand the concepts¹⁰ of problem solving, critical thinking, and creativity is discipline specific and subjectively realized.¹¹ Evidence has shown that students learn more and recollection is greater when problem-based learning with an authentic

⁴ Accenture, “Liquid Workforce: Building the workforce for today’s digital demands” https://www.accenture.com/fr-fr/_acnmedia/PDF-2/Accenture-Liquid-Workforce-Technology-Vision-2016-france.pdf. Accessed March 12, 2017.

⁵ Accenture, “People First.”

⁶ Brynjolfsson and McAfee, *The Second Machine Age* (New York: W. W. Norton, 2014), 12.

⁷ Aoun, *Robot-Proof: Higher Education in the Age of Artificial Intelligence* (Cambridge: MIT Press, 2017), 69.

⁸ Ambrose, Susan A., et al. *How Learning Works: 7 Research-based Principles for Smart Teaching*, (San Francisco, John Wiley & Sons, 2010).

⁹ Siew Chee Choy, Daljeet Singh Sedhu, Yow Lin Liew, Mun Yee Lee, Audrey Malenee, and Norkhadirah Anuar, “Influence of Culture on Students’ Awareness of How and Why They Learn,” *Malaysian Journal of Learning and Instruction* 12, (2015): 49–67.

¹⁰ UNESCO, *Preparing and Supporting Teachers in the Asia-Pacific to Meet the Challenges of Twenty-first Century Learning* (Paris: UNESCO, 2016). <http://unesdoc.unesco.org/images/0024/002468/246852E.pdf>.

¹¹ Siew Chee Choy and Phaik Kin Cheah, “Teacher Perceptions of Critical Thinking Among Students and Its Influence on Higher Education,” *International Journal of Teaching and Learning in Higher Education*. 20, no. (2) (2008): 198–206.

outcome is the mode of education. Problem-based learning is student centered. A key characteristic is that students work in groups to solve open-ended challenges.¹² In particular, project-based learning has demonstrated itself to make students more motivated¹³ and to encourage more effective engagement with discipline content.¹⁴

Building on the work of Carol Dewick's growth mindset,¹⁵ psychologists Paul O'Keefe, E. Horberg, and Isabelle Plante have recently found that when students are interested, their attention narrows, yielding focused engagement.¹⁶ Even better for work in the automation economy, this interest increases attention, eliciting exploratory engagement around the focused area.¹⁷ This is the engagement that educators should be striving to elicit in their student learners. A large lecture theater with a single professor, in which information is transferred from the instructor to the 200–500 students seated in the room, is an outmoded approach to student learning. This pedagogy does not deliver the skills necessary for the automation economy as rote memorizing is not a skill needed in the era of 4IR: the machines will do that bit of the job for us. Such knowledge is not without value, but the content it is designed to deliver is only part of the puzzle of efficient and good work. Students need to learn new ways to manipulate content, over and over again. Problem-based learning and experiential learning are essential components to higher education pedagogy in the era

¹²Terry Barrett and Sarah Moore, eds, *New Approaches to Problem Based Learning* (New York: Routledge, 2010).

¹³Kay N. Drake and Deborah Long, "Rebecca's in the Dark: A Comparative Study of Problem-Based Learning and Direct Instruction/Experiential Learning in Two 4th-Grade Classrooms," *Journal of Elementary Science Education* 21, no. 1 (2009): 1–19; Mary Maloney, "Professional identity in early childhood care and education: perspectives of pre-school and infant teachers," *Irish Educational Studies* 29, no. 2 (2010): 167–187.

¹⁴Michael M. Grant, "Getting a Grip on Project Based Learning: Theory, Cases, and Recommendations," *Meridian* 5, no.1 (2010): 1–17, retrieved from <https://projects.ncsu.edu/project/meridian/win2002/514/project-based.pdf>; John Larmer and John R. Mergendoller, "Seven Essentials for Project-Based Learning," *Giving Students Meaningful Work* 68, no. 1 (2010): 34–37; Robert J. Marzano, *The art and science of teaching: A comprehension framework for effective instruction* (Alexandria: Association for Supervision and Curriculum Development, 2007).

¹⁵Dweck, *Mindset* (New York: Random House, 2006).

¹⁶O'Keefe, Horberg, and Plante, "The Multifaceted Role of Interest in Motivation and Engagement," in *The Science of Interest*, eds. Paul A. O'Keefe and Judith M. Harackiewicz (Cham: Springer, 2017), 49–67.

¹⁷O'Keefe, Horberg, and Plante, "The Multifaceted Role of Interest in Motivation and Engagement."

of 4IR.¹⁸ Brynjolfsson and McAfee highlight the value of these self-organizing learning environments as well suited for what they call the second machine age, and understood more broadly to be the 4IR, and its employment demands.¹⁹ Students need the habits of mind that such pedagogical approaches deliver in order to harness the benefits of 4IR.

HIGHER EDUCATION AND 4IR COALESCE IN SINGAPORE

Singapore is embracing the automation economy, known as the “Future Economy” in the city-state. Since independence just 50 years ago, the nation has pulled itself out of poverty and forged an economic powerhouse out of an island just 720 square kilometers in size. Singapore is recognized as one of the four Asian Tigers, with economic growth as high as 7% between the 1960s and 1990s. Under the leadership of Mr. Lee Kuan Yew, education was prioritized under the Constitution’s “Fundamental Liberties Article 16, Rights in respect to education.”²⁰ This article proclaims that no discrimination against any citizen may be allowed on the grounds of religion, race, descent, or place of birth in order to withhold financial aid or pertaining to the payment of fees. Education is highly valued in Singapore, with students testing best in the world. In 2000, Singapore passed the Compulsory Education Act 2000, making national primary school a requirement for all Singaporean citizens born after 1996.²¹ This again reflects Singapore’s emphasis on advancement through educational merit. The Organization for Economic Co-operation and Development (OECD) provides a world-wide study through the Programme for International Assessment (PISA) which measures scholastic performance of 15-year-olds in mathematics, science, and reading. The OECD Report on PISA 2015 global results found that in science and reading Singapore has performed better than the OECD average and improved since 2006.²² And that for mathematics, it is also

¹⁸ Raja R. Hussain, Wan Hasmah Mamat, Norani Salleh, Rohaida Mohd Saat, and Tony Harland, “Problem-based learning in Asian universities,” *Studies in Higher Education* 32, no. 6 (2007): 761–772.

¹⁹ Brynjolfsson and McAfee, *The Second Machine Age*.

²⁰ “Rights in respect of education,” Government of Singapore, accessed December 28, 2017, <https://sso.agc.gov.sg/Act/CONSI963?ProvIds=pr16-#pr16->.

²¹ “Compulsory Education,” Ministry of Education Singapore, last updated November 17, 2017, <https://www.moe.gov.sg/education/education-system/compulsory-education>.

²² OECD, “PISA 2015 key findings for Singapore,” accessed December 27, 2017, <http://www.oecd.org/countries/singapore/pisa-2015-singapore.htm>.

better than the OECD average and has been stable in its ranking since 2006. In all three subject areas, Singapore has the maximum share of high performers.²³ For the PISA test, this means:

Top-performing students in science can use abstract scientific ideas or concepts to explain unfamiliar and more complex phenomena and events. In mathematics, they are capable of advanced mathematical thinking and reasoning. In reading, top performers can retrieve information that requires the student to locate and organize several pieces of deeply embedded information from a text or graph.²⁴

The OECD summary report also finds that the gap between boys and girls is very low in all three subjects (though it has increased since 2016 among boys and girls in science).²⁵ Yet there are challenges and controversies associated with the system and the testing results. Rote memorization does not yield the necessary critical thinking skills when the students reach the job market. Furthermore, the population is now aging, which means innovations in higher education are only reaching those currently enrolled in tertiary education. But nonetheless, the test results demonstrate a significant commitment to education in Singapore, both structurally and socially.

There are deep cultural and economic motivations behind these strong testing results, and those conditions make Singapore primed to prepare a 4IR-ready population. Pak Tee Ng contributes important insights into the cultural and historical context within which Singapore seeks to win in the global talent wars.²⁶ Indeed, Singapore has sought to be an education hub as part of the global talent wars,²⁷ but also as an effort to address labor demands in the global economy. Research is demonstrating that Singapore has been winning the talent war with the incentives it creates for citizens and foreigners alike.²⁸ The challenge remains developing citizens with an

²³ OECD, "PISA 2015 key findings for Singapore."

²⁴ OECD, "PISA 2015 key findings for Singapore."

²⁵ OECD, "PISA 2015 key findings for Singapore."

²⁶ Ng, "Singapore's response to the global war for talent: Politics and education," *International Journal of Educational Development* 31, no. 3 (2011): 262–268.

²⁷ Ka Ho Mok, "Singapore's global education hub ambitions: University governance change and transnational higher education," *International Journal of Educational Management* 22, no. 6 (2008): 527–546.

²⁸ Balbir B. Bhasin and Kim Cheng Low, "The Fight for Global Talent: New Directions, New Competitors – a Case Study on Singapore," *Career Development International* 7, no. 2 (2002): 109–114.

entrepreneurial spirit able to reconcile the cultural adherence to reverence toward authority with the need for risk-taking creativity.²⁹

Aside from cultural and political factors, the demographic evolution of Singapore is an important piece of the 4IR and higher education puzzle. The nation maintains a complex balance between citizens, residents, and non-residents that has implications for what types of education are needed in the future economy. Singapore was a nation of 5.61 million people in 2017. Of this 3.44 million are Singaporean citizens, 0.53 million are permanent residents (making 3.96 million residents), and 1.65 million non-residents which excludes tourists and short-term visitors.³⁰ The non-resident population employment passes can be used to support industries where talent is currently lacking in Singapore, be this in construction or in high-end computing.

Singapore's unemployment rate remains low in 2018 at around 3%. In terms of labor force, Singapore has another unique demographic circumstance.³¹ One-third of Singapore's population comprises non-resident employment pass holders. This means that a large portion of the population is there on a special work permit basis that is justified by their skill set. The numbers of long-term residents can be tweaked based on the skills the government and industry need relative to what is already available among the Singaporean local population. In this way, the government has a lever it can pull to allow more jobs for newly skilled local Singaporeans. And while the tap cannot be turned off for highly skilled labor, the type of labor Singapore needs can be ascertained by turning the dial on what types of employment passes and for what skills these visas are issued.

The small nation also faces the challenge of an aging population. According to the Department of Statistics, Ministry of Trade & Industry, Singapore residents over the age of 65 made up 13% of the resident population in 2017, coupled with the median age of the resident population of 40.5 years. Both these numbers have been on the rise for over a decade

²⁹ Søren Christensen, "Higher Education and Entrepreneurial Citizenship in Singapore," *Learning and Teaching* 5, no. 3 (2012): 39–55.

³⁰ "Population Trends 2017," Department of Statistics Singapore, accessed December 18, 2017, http://www.singstat.gov.sg/docs/default-source/default-document-library/publications/publications_and_papers/population_and_population_structure/population2017.pdf.

³¹ "Report of the Committee on the Future Economy," Ministry of Communications and Information Singapore, accessed December 28, 2017. https://www.gov.sg/-/media/cfe/downloads/mtis_full%20report.pdf.

now and are anticipated to continue upward.³² This means that Singapore must invest in the education of its adult learners as well as prepare for a shrinking in its overall enrollments for institutes of higher education. In fact, Singapore's Ministry of Education (MOE) has announced that 14 primary schools and 6 secondary schools will merge in 2019 to adjust to the changing demographics.³³ Institutes of higher education are also experiencing lower enrolments as the demographic shifts reach them. These demographic trends mean that policies and higher education institutions need to support all ages, not just those in the 18–25-year-old range, in order to ensure enough of the right kinds of labor and jobs, and a continuing tax income for the government.

SINGAPORE'S 4IR PREPARATION

The *Report of the Committee on the Future Economy* came out in February 2017 outlining Singapore's economic strategies for 4IR preparation. This effort was a follow-up to the 2010 Economic Strategies Committee's work intended to take into consideration challenges of the automation economy.³⁴ The goal of the 2017 strategy is to ensure that Singapore experiences economic growth at 2–3% per year on average, stronger performance than most advanced economies to which Singapore compares itself. The report recognizes that Singaporeans must constantly retrain and upgrade their skills to stay relevant. The report lays out an innovative 7 Strategy Plan to alter society in preparation for the technological changes pending. Those that explicitly mention higher education and adult learning are:

1. Deepen and diversify our international connections
2. Acquire and utilize deep skills
3. Build strong digital capabilities³⁵

Through these three efforts, Singapore is internationalizing its education and creating more experiential learning opportunities.

³² Department of Statistics Singapore, "Population Trends 2017."

³³ Lianne Chia, "14 primary schools, 6 secondary schools to merge in 2019," Channel Newsasia, April 20, 2017, <https://www.channelnewsasia.com/news/singapore/14-primary-schools-6-secondary-schools-to-merge-in-2019-8741660>.

³⁴ "Report of the Economic Strategies Committee," Economic Strategies Committee, February 2010, <http://www.mof.gov.sg/Portals/0/MOF%20For/Businesses/ESC%20Recommendations/ESC%20Full%20Report.pdf>.

³⁵ Ministry of Communications and Information Singapore, "Report of the Committee on the Future Economy."

The first education strategy, “Deepening and Diversifying International Connections,”³⁶ is pursued in education through the Global Innovation Alliance (GIA) initiative intended to build new networks through which youth can facilitate innovation. The alliances are formed between Singapore’s institutes of higher learning and major innovation hubs around the world to collaborate with overseas partners. An example of this already in place is the National University of Singapore’s (NUS) Overseas Colleges, which has year-long or semester-long entrepreneurial start-up internship programs in Beijing, Israel, Lausanne, Munich, New York, Shanghai, Silicon Valley, Singapore, and Stockholm. A similar program, SkillsFuture Leadership Development Initiative (LDI), works to identify future corporate leaders and expose them to high-quality opportunities to acquire knowledge of regional markets.

The second education strategy relative to higher education and 4IR is to “Acquire and Utilize Deep Skills.”³⁷ Deep skills include analytical and evaluative capacities combined with complex problem solving and effective team collaboration capabilities. This government policy calls for two significant shifts in social understandings of education. First, the report calls for a new approach which no longer expects students to seek the highest possible academic attainment as young as possible, but rather to learn and acquire new skills throughout their lives. Second, the report calls on Singaporeans to acquire deeper skills that create value. To survive these shifts and successfully transition to a digital economy, modularized programs are supported. This strategy is designed to help Singaporeans easily adapt to new labor demands and meet the needs of a transforming economic base, either in new jobs or to stay relevant in their current industries. According to this report, Nanyang Technical University (NTU), Singapore University of Social Sciences (SUSS),³⁸ and several of Singapore’s polytechnic tertiary schools have launched more than 500 skills-based modular courses between 2015 and 2017.

There is an important cautionary note here. The ability and resilience to jump into many different skills-based training opportunities requires cognitive flexibility that does not come from this sort of vocational education.

³⁶ Ministry of Communications and Information Singapore, “Report of the Committee on the Future Economy.”

³⁷ Ministry of Communications and Information Singapore, “Report of the Committee on the Future Economy.”

³⁸ SUSS was formerly Singapore Institute of Management, and then UniSim. It changed its name to Singapore University of Social Sciences in December 2017. It is the sixth and final autonomous university in Singapore as of 2018.

Indeed, the skill-based modular approach could very well reinforce old models of education that do not develop the necessary skills for lifelong learning. It will be very important that these programs and, for future generations, the primary and secondary school education system, emphasize how to learn and not what to learn through pedagogy strategies noted earlier.

The third relevant strategy is to “Build Strong Digital Capabilities.”³⁹ In response to the new industries emerging from digitization and the resulting big data production, this effort involves creating strong human capacity in data analytics and cybersecurity. Singapore intends to build joint laboratories between industry stakeholders and the government to train data scientists. Again, there will need to be creativity and interdisciplinary content woven into such efforts for them to be useful in the longer term. Interestingly, in March 2018, President Tan of the National University of Singapore (NUS) announced that computational thinking—namely statistics and programming—will be required of all NUS students regardless of their major.

THREE EDUCATION-FOCUSED INITIATIVES TO PREPARE FOR 4IR IN SINGAPORE

Singapore’s higher education profile has shifted to reflect these realities in the past ten years. Attainment among Singaporeans of some form of higher education is up significantly. In 2016 over 52% of the resident population aged 25 and above has at least post-secondary qualifications, which is an increase from 36.7% in 2006.⁴⁰ The proportion of university graduates increased by 9.5% between 2006 and 2016, rising from 19.6% to 29.1%.⁴¹ The proportion of residents receiving diplomas and professional qualifications increased by 3.9% over the same ten-year period.⁴² Noting a change in demographic emphasis, data show that younger people are now more inclined to complete university education, with 54.3% of 25–34-year-olds graduating from university in 2016.⁴³ In the slightly older age bracket over the ten years between 2006 and 2016, 21.7% of those aged 35–44 years completed a diploma or professional

³⁹ Ministry of Communications and Information Singapore, “Report of the Committee on the Future Economy.”

⁴⁰ Department of Statistics Singapore, “Population Trends 2017.”

⁴¹ Department of Statistics Singapore, “Population Trends 2017.”

⁴² Department of Statistics Singapore, “Population Trends 2017.”

⁴³ Department of Statistics Singapore, “Population Trends 2017.”

qualification⁴⁴ reflecting an investment in lifelong learning by the older learners. Part of the reasons these numbers have been able to rise is because MOE has established new and specialized institutes of higher education to create more options for Singaporeans and international students alike, this includes recently created of Singapore University of Technology and Design, the reconfiguration and autonomy of Singapore University of Social Sciences, Duke-NUS Medical School, and Yale-NUS College. Table 7.1 illustrates the intensive growth in this higher education sector in Singapore. As part of an effort to instill more diversity and autonomy in the local university system, many new institutions of higher education have been built in Singapore.⁴⁵

One such initiative, within which Singapore's MOE has invested substantial financial resources, is Yale-NUS College. A collaboration that began in 2011 between Yale University and NUS resulted in the first liberal arts college in Singapore and one of the first in Asia. Yale faculty, together with experts from around the world, designed a unique curriculum linked with a distinctive pedagogical approach. The first cohort of students began studying at Yale-NUS College in August 2013.

The unique features of the College include an interdisciplinary international common curriculum, team-based teaching in the common curriculum, small class sizes which are capped at 18 students, extremely diverse student body, and a required four-year residential experience. The residential experience allows the learning to take place outside the classroom, which is important to the development of lifelong learning skills and is practiced elsewhere in Singapore to varying degrees.⁴⁶ These efforts are combined with experiential learning opportunities for all students and a robust study-abroad program. As noted above these are the sorts of self-organizing learning environments that foster the needed knowledge workers for the 4IR.

Yale-NUS students hail from over 50 countries, and ~50% of the student body is comprised of Singaporeans from diverse backgrounds themselves. The curriculum and faculty therefore must be culturally attuned, and training in this area is a consistent effort of the administration. The College's 14 majors and 5 double-degree programs are taught through blended disciplines and organized across three divisions of sciences, social sciences, and

⁴⁴ Department of Statistics Singapore, "Population Trends 2017."

⁴⁵ Søren Christensen, "Higher Education and Entrepreneurial Citizenship in Singapore," 42.

⁴⁶ Karen. K. Inkela, "Good practices of living-learning programmes," *Asian Journal of the Scholarship Learning* 6, no. 1 (2016): 64–76.

Table 7.1 Singapore's growing higher education sector

<i>Year established</i>	<i>Institution of higher education</i>	<i>Academic focus</i>
August 1980	National University of Singapore (NUS) formally established by combining several pre-existing institutions with nearly 80 years of operational history on the island	16 different faculties covering engineering, social sciences, business, law, and many others. Undergraduate and graduate programs
July 1991	Nanyang Technological University (NTU) opened	Engineering, sciences, business, liberal arts, and medicine. Undergraduate and graduate
July 2000	Singapore Management University (SMU) established	Broad-based education with emphasis on business and management
September 2009	Duke-NUS Graduate Medical School	Medical school. Graduate-level only
May 2009	New LaSalle College of the Arts campus is officially opened	Contemporary arts and design
2009	Singapore Institute of Technology (SIT)	Applied degree programs in engineering, chemical engineering, Infocomm technology, health, and social sciences
May 2012	Singapore University of Technology and Design inaugurated	"Technology-intensive design education and research"
August 2014	Yale-NUS College	Undergraduate Liberal Arts and Sciences
August 2014	[Singapore Institute of Management/UniSim] renamed Singapore University of Social Sciences (SUSS) in 2017	Practice oriented for working professionals and adult learners in accounting, marketing, finance, HR management

Ho Yuen-Ping, Annette Singh and Poh-Kam Wong, "National University of Singapore," in *The Development of University-Based Entrepreneurship Ecosystems*, eds. Michael L. Fetters, Patricia G. Greene, Mark P. Rice, and John S. Butler (Cheltenham: Edward Elgar Publishing, 2010); "Our History," Nanyang Technological University, accessed December 28, 2017, <http://www.ntu.edu.sg/AboutNTU/CorporateInfo/Pages/OurHistory.aspx>; "History," Singapore Management University, accessed December 28, 2017, <https://www.smu.edu.sg/about/history>; "The Duke-NUS Story," Duke-NUS Medical School, accessed December 29, 2017, <https://www.duke-nus.edu.sg/about/duke-nus-story>; "History & Milestones," Lasalle, accessed December 28, 2017, <http://www.lasalle.edu.sg/about/history-milestones/>; "Local Diplomas," Singapore Institute of Technology, accessed December 28, 2017, <https://www.singaporetech.edu.sg/local-diplomas>; "President Tony Tan officiates at celebrations at the Inauguration Ceremony of SUTD," Singapore University of Technology and Design, May 7, 2012, <https://sutd.edu.sg/About-Us/News-and-Events/Press-Releases/2012/5/President-Tony-Tan-officiates-at-celebrations-at-t>; "Milestones," Yale-NUS College, accessed December 28, 2017, <https://www.yale-nus.edu.sg/about/milestones/>; "SIM University to start Full-time Programmes in 2014 and to set up Third Law School in Singapore," Singapore University of Social Sciences, October 16, 2013, http://www.unisim.edu.sg/Happenings/Latest-Highlights/Pages/H2013_16Oct.aspx

humanities. Admission to the school is needs blind, holistic, and extremely competitive. All 105 full-time tenure-track faculty members at the College are expected to maintain both research and teaching excellence, publish in top-tier journals, and present at impactful conferences. The goal of all these efforts is to prepare the best minds to live a positively impactful life. Singapore has enabled the development of this liberal arts school as one of several strategic initiatives to develop 4IR-ready graduates for the economy.

The distinctive pedagogy involves close interactions between faculty and students both inside and outside the classroom. This is something that is relatively new to Singapore's higher education landscape. Teaching at Yale-NUS is learner centered and problem based⁴⁷ with very few lectures. Seminars last 1.5–3 hours in order to elicit deep discussion. Experiential learning and international experience are integral to the learning experience, which is consistent with Singapore's desire to internationalize its citizens. Through the College's Centre for International and Professional Experience (CIPE), experiential learning opportunities are mandatory for the entire first-year class. For example, one group of 18 students traveled to South Africa with a psychology professor and an international relations professor to study the psychology of racism with a close review of apartheid. Faculty-designed and faculty-led experiential learning trips—known as Learning Across Boundaries (LABs)—are interdisciplinary and are designed to get students into the field to apply the concepts, theories, and questions developed in the College's common curriculum.

The majors also provide depth in a given field but typically with an interdisciplinary focus. For example, the Mathematics and Computational Science (MCS) major offers students a unique opportunity to go beyond frontiers of traditional mathematics education. As the major's website explains, "We encourage students to participate actively in these flourishing developments. Displaying keen interest in this discipline, our students have embarked on projects to design robots, launch software start-ups, analyse big data networks, develop data visualisation tools, and philosophise on randomness and chaos."⁴⁸ Students have access to research attachments in cryptography, hypercube coloring, modeling, and simulation. These experiences are necessary for developing skills in ideation whereby students learn to ask questions about what they see and how concepts are applied. The courses students can take range from number

⁴⁷Hussain, Mamat, Salleh, Saat, and Harland, "Problem-based learning in Asian universities."

⁴⁸"Why MCS?," Yale-NUS College, accessed December 28, 2017, <https://mcs.yale-nus.edu.sg/programme/why-mcs/>.

theory to theoretical computer science, to operating systems, to statistical inference, and to statistical computing. Students in this program forge their own pathways. There is no single ascribed understanding of MCS. The flexibility and ingenuity of this major, coupled with the exceptional faculty and student capacity, make this a unique spot within Singapore's higher education landscape ideal for the 4IR context. Graduates of this programme will have the necessary cognitive flexibility and interdisciplinary understanding to tackle complex global challenges.

The Yale-NUS College example is very different from the goals of developing deep skills through focused, performance-based learning. The development of this college, as well as the others noted in Table 7.1, demonstrates the efforts to which Singapore's MOE has gone to create the best global learning environments for both Singaporean citizens and global talent. There is a broad range of types of education available, for different types of learners. This will keep Singapore's labor force diverse and agile. Adult learners are also returning to the classrooms of these universities and colleges, to upskill the older population as well.

The example of the creation of Yale-NUS College is just one petri dish in Singapore's higher education laboratory. These institutions are the front line of preparation for 4IR, but they are only one piece of a grandeur effort to assist Singaporeans and the economy in the era of 4IR. Two large initiatives, SkillsFuture and Smart Nation, are working with and alongside Singapore's institutions of higher education to prepare the population for living and working in a fully digital era.

SKILLSFUTURE

SkillsFuture is a national movement to provide Singaporeans with the opportunities to develop their fullest potential throughout life, regardless of their starting points. Through this movement, the skills, passion and contributions of every individual will drive Singapore's next phase of development towards an advanced economy and inclusive society. ... Skills mastery is more than having the right paper qualifications and being good at what you do currently; it is a mindset of continually striving towards greater excellence through knowledge, application and experience.⁴⁹

SkillsFuture is a government-led initiative to help Singaporeans adjust their mindsets and their capacities for the automation economy. This is

⁴⁹ "SkillsFuture," Government of Singapore, accessed December 28, 2017, <http://www.skillsfuture.sg/AboutSkillsFuture>.

important, as many nations are focused on taxing robots and preparing for universal basic income (UBI). Some, including Bill Gates,⁵⁰ have suggested that a tax on robots could be used to distribute the economic gains from automation efficiencies that will not be reaching the unemployed. This is not Singapore's approach. The cultural belief in the value and necessity of work is strong, and citizens have a deep-rooted commitment to working for a living. The initiative of SkillsFuture is culturally responsive in that way.

The SkillsFuture initiative is based on four key thrusts. First, it is intended to help individuals make decisions about their education, training, and how this might align with their career. Formerly called the Individual Learning Portfolio (ILP), MySkillsFuture is a one-stop education, training, and career guidance website. The website is intended to align the acquisition and the utilization of skills for Singaporean citizens and is integrated into the nation's job bank.

Second, SkillsFuture runs an integrated high-quality system of education and teaching that responds to the shifts in 4IR technology and corresponding industry jobs. Third, the initiative representatives work with industry to ensure there is employer recognition for upskilling certificates and the corresponding promotion/compensation for mastery of skills. Fourth, SkillsFuture works to foster a culture that supports and celebrates lifelong learning across Singapore. Public messaging through posters, advertisements, and the like is common around the city-state.

SkillsFuture is organized into five levels of support: student, junior level, middle management, senior management, and career switcher. There are multiple opportunities across Singapore for adult learners in particular. Research is expanding into better understanding how to engage adult learners as well.⁵¹ For many, re-education and upskilling is expensive. Singapore has three different funding mechanisms in place for this. There are SkillsFuture credits for all Singaporean citizens so that they do not have to have the financial means to afford this upskilling. There are also SkillsFuture qualification awards and student awards and an Earn and Learn program. SkillsFuture works with institutions of higher education but also maintains the Institute of Lifelong Learning, where Singaporeans

⁵⁰ Kevin Delaney, "The robot that takes your job should pay taxes, says Bill Gates," *Quartz*, February 17, 2017, <https://qz.com/911968/bill-gates-the-robot-that-takes-your-job-should-pay-taxes/>.

⁵¹ Grace McCarthy, "Motivating and enabling adult learners to develop research skills," *Australian Journal of Adult Learning*, vol. 55, no. 2 (2015): 309–330.

at all levels can take targeted courses to gain new skills. The intention is that labor disruption will be less socially alarming and economically challenging as a result. Furthermore, Singaporeans will be better prepared for the automation economy, benefiting themselves and the nation's economy.

SMART NATION SINGAPORE

Smart Nation Singapore is separate government initiative developed to help citizens ease into the social and economic changes that are already emerging with the automation economy. Singapore launched its Smart Nation effort in December 2014. The approach expands from the idea of a Smart City, which emerged in the 1980s, and today involves the application of technology to sustainable and inclusive ICT connectivity. The technology supporting Smart Cities involves the Internet of Things (IoT) and a Wi-Fi-enabled network of sensors and devices all talking to each other to enhance life for city residents. But the ability of a city community to take advantage of such technologies requires a digitally literate population. Ezra Ho argues that Singapore was already a Smart City by 2014, but that the Smart Nation initiative “is about coordinating and intensifying the effort to develop the institutions, regulations, and talent for a hyper-connected, datafied urbanity.”⁵² In order for Singaporeans to take advantage of the higher education and SkillsFuture opportunities, they must have digital literacy. Digital literacy is demonstrated as technical and cognitive competence in a variety of areas. It is the “ideas and mindsets, within which particular skills and competencies operate, and about information and information resources, in whatever format”⁵³; the most accurate definition of digital literacy is drawn from Allan Martin's work:

Digital Literacy is the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyse and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of

⁵² Ho, “Smart Subjects for a Smart Nation? Governing (Smart)Mentalities in Singapore,” 3107.

⁵³ David Bawden, “Origins and Concepts of Digital Literacy,” in *Digital Literacies: Concepts, Policies and Practices*, eds. Colin Lankshear and Michele Knobel (New York: Peter Lang Publishing, 2008), 19.

specific life situations, in order to enable constructive social action; and to reflect upon this process.⁵⁴

Having these skills is essential in order for a society to benefit from Smart Nation efforts and 4IR more broadly.

As detailed by Hoe Siu Loon, Singapore's digital literacy journey began in the 1980s with the National Computerization Plan.⁵⁵ Since then there has been a succession of government-led initiatives to upgrade the physical digital capacity as well as the human capacity of the nation including the National IT Plan of 1986, the IT2000 plan of 1992, the Infocom 21 plan of 2000, the Connected Singapore plan of 2003, the Intelligent Nation 2015 plan, and more recently in the Infocomm Media 2025 plan.⁵⁶ Smart Nation Singapore identifies five key domains in which digital technology can enhance the lives of citizens. These include transport, home and environment, business productivity, health and enabled aging, and public-sector services.⁵⁷

The networks and structures put in place to implement Smart Nation Singapore are important to understand for those seeking to integrate such a program into their own higher education and lifelong learning national programs. In January 2016, Dr. Janil Puthuchery was appointed as the Minister of State, Ministry of Communications and Information and MOE, and placed in charge of the Smart Nation initiative. This was an important leadership position and is strategically placed across both ministries. In March 2016 the Smart Nation Fellowship program was launched to recruit and create a network of computer scientists and technology experts to collaborate with the government on how best to create projects for the public in line with adapting the population to a new way of living and working.⁵⁸ Then, in May 2016, the "Lee Hsien Loong Interactive

⁵⁴Allan Martin, "DigEuLit - a European Framework for Digital Literacy: a Progress Report," *Journal of eLiteracy* 2, no. 2 (2005): 135–136.

⁵⁵Hoe Siu Loon, "Defining a Smart Nation: The Case of Singapore," *Journal of Information, Communication and Ethics in Society* 14, no. 4 (2016): 323–333.

⁵⁶Hoe, "Defining a Smart Nation: The Case of Singapore."

⁵⁷"About Smart Nation," Smart Nation and Digital Government Office, last updated November 9, 2017, <https://www.smartnation.sg/about-smart-nation>.

⁵⁸"IDA Launches Smart Nation Fellowship Programme to Foster a Network of Top Data Science and Tech Talents for Singapore," GovTech Singapore, March 7, 2016, <https://www.tech.gov.sg/media-room/media-releases/2016/03/ida-launches-smart-nation-fellowship-programme-to-foster-a-network-of-top-data-science>.

Digital Media (IDM) Smart Nation Award” was established to help make visible the good efforts of full-time polytechnic students working on interactive digital media projects that contributed to the Smart Nation efforts.⁵⁹ All of this effort on a national scale inevitably resulted in the need for more administration oversight. In May 2017, the Smart Nation and Digital Government Office (SNDGO) was formed under the Prime Minister’s Office to prioritize and help deliver digital solutions for citizen and business needs.⁶⁰ Collaboration with primary, secondary, and tertiary education has been consistent throughout the development of Smart Nation Singapore and will likely become more important as the digitization process intensifies.

The government has also recognized the security risks associated with the new reality of life being online, plugged in, and always connected. For this reason cybersecurity is paramount.⁶¹ Safeguarding the relevant systems and networks of Smart Nation for all citizens and compliance with the nation’s privacy of data laws is a priority. A key element of Smart Nation is building computational capabilities in cybersecurity and data analytics. Here efforts are five pronged. For the youth of Singapore, IMDA Playmaker program is deployed to expose young children to technology while gaining educational experiences. Also, Code@SG is a movement that introduced coding and computational thinking to students in schools, again working to enhance digital literacy in preparation for 4IR jobs. Starting in 2018 Singapore will add Coding to 19 different schools’ “O” Level subject testing in order to measure capacity better in this area. Smart Nation is also working with SkillsFuture to upgrade programming in the area of ICT. Lastly, Smart Nation will continue to invite Smart Nation Fellows to work on short stints to build robust cybersecurity systems.

⁵⁹ “Launch of Lee Hsien Loong Interactive Digital Media Smart Nation Award,” Prime Minister’s Office Singapore, May 6, 2016, <http://www.pmo.gov.sg/newsroom/launch-lee-hsien-loong-interactive-digital-media-smart-nation-award>.

⁶⁰ “Milestones,” Smart Nation and Digital Government Office, last updated January 5, 2018, <https://www.smartnation.sg/about-smart-nation/milestones>.

⁶¹ Smart Nation and Digital Government Office, “About Smart Nation.”

CONCLUSION

The purpose of Singapore's approach is that Smart Nation, SkillsFuture, and the efforts of Singapore's institutes of higher education will combine to upskill and educate a workforce and citizenship that is uniquely educated for 4IR. This is how Singapore is planning to shift its populations' skill sets. Singaporeans will have opportunities throughout their lifetime to learn new skills. The efforts are characterized by three main thrusts. They are working to make a more digitally literate and technologically competent population through the Smart Nation and SkillsFuture initiatives. They are creating cohorts of ideation experts through unique higher education opportunities like Yale-NUS College, Singapore University of Technology and Design, and Duke-NUS Medical School. Finally, Singapore is internationalizing its population and creating a more globally savvy and connected citizenry.

What Singapore is doing is expensive. But pieces can be adapted. Benchmarking a nation's digital literacy is a good first step. From here government, NGO, and MNC training programs for a variety of skills should be rolled out. Internationalization of education is important, and higher education institutions can reach out to peer institutions around the world to establish tighter connections with student and faculty exchanges.

The impacts of 4IR are still emerging in Singapore. How will they know if Singapore is succeeding in these efforts? The goal has been set to maintain 2–3% economic growth per year. Three key indicators to monitor in this area will be GDP growth, unemployment, and foreign work permit allocations. It will be telling to follow the number of employment passes and permanent resident visas issued by the Singaporean government. If these numbers continue to drop substantially, one anticipated correlation will be an increase in 4IR-relevant jobs filled by Singaporeans.

The policies and programs being erected to address technological unemployment and to prepare for 4IR are not without their detractors. The ever-present connectivity that automation brings clashes with some notions of privacy. This analysis of Singapore's approach does not address the viability of the effort as a whole in Singapore to apply elsewhere. Rather, the efforts in Singapore are presented as an example of the multi-pronged approach being taken so as to suggest how other nations might adapt such a combination of efforts as is appropriate to their cultural and legislative context.

Singapore has invested heavily in higher education as a government tool for economic development for its citizens to exploit. It boasts two of

the world's best universities and several others who are delivering quality education. Lifelong learning has been identified as the essential element for success in the era of 4IR. We do not know what is coming next, so we must prepare minds that are agile, flexible, and cooperative. SkillsFuture and Smart Nation are programs which address the labor disruption pending from automation. Combined with new and innovative high-quality institutions of higher education such as Yale-NUS College, Singapore is well poised to capture the potential benefits of 4IR.

All countries should examine the Singaporean education system as they develop digital literacy programs so that their citizens are able to harness the benefits of 4IR. What is replicable and scalable from the case of Singapore is difficult to tell. Singapore has the financial means to put large sums of money and human capital into the retooling of its entire education system. The overall lesson is that nations need to be preparing for change. The status quo will likely result in significant unemployment in most countries, thus adapting some of Singapore's innovative policies will help offset this. For those nations in which quality higher education is only attained by a select few, there are exciting opportunities to leapfrog more advanced economies that will be locked into brick and mortar solutions and tied down by bureaucratic legacies. In preparation of 4IR, Singapore is deploying a multi-faceted strategy that merits rigorous appraisal by other countries and institutions of higher education.

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