Policy paper on robotics in the philippines

Anton Louise de Ocampo, Alvin Culaba, and Elmer P. Dadios

***Abstract*— Robotics technology has flooded the world market today. Applications of robotics extend from domestic to manufacturing and automation industry. Military and healthcare services also use robots in day to day programs. Economies that had adopted robotics have already flourished and prospered. But, where are we? Why does the Philippines do not benefit from such technology? Why haven't we adopted robotics yet? These are just a few of the questions answered in this paper together with the discussion on the trends in robotics, stimuli, and hindrances for adoption, impacts of robotics, and some recommendations for the utilization of robotics to fire up our economy. The Philippine government may have the power to direct industries to adopt robotics, but the initiative might be needed to come from its people.**

I. INTRODUCTION

For the past two decades, the Internet has constantly changed the business models from the traditional manufacturing-trading scheme into automated productions and on-the-cloud business transactions. Because of this transition, the concept of "Manufacturing + Internet" has opened the new era of industrialization which the Germans coined, "Industry 4.0" or the Fourth Industrial Revolution which first appeared in an article in November 2011. It denotes the fourth stage of industrial revolution after mechanization, electrification, and information (Figure 1) [1] which presents the stages of the industrial revolution as marked by advents of world-changing technologies [2]. Industry 4.0 capitalizes on the use of Cyber-Physical Systems (CPS) in creating intelligent factories that are interconnected, data-driven, and robot-manipulated manufacturing. Physical enterprises are transformed into CPS with the development in the areas of Artificial Intelligence and Machine Learning, Additive/Hybrid Manufacturing, Knowledge Automation, Big Data Analytics, Digital Twin, and Advanced Robotics. According to a study conducted by M. Lynch and sponsored by Bank of America, the robotics revolution will transform the global economy over the next 20 years [3].

But what is robotics and how will it affect the government, the economy, and the social life in the Philippines? How is it being embraced in other countries around the globe? Can the Philippines adopt the technology with its current capabilities? Will it benefit the Filipino people? These are just some of the questions that this paper hopes to answer for us to see where we are and what can we do to capitalize on the benefits of adopting robotics in the Philippines.

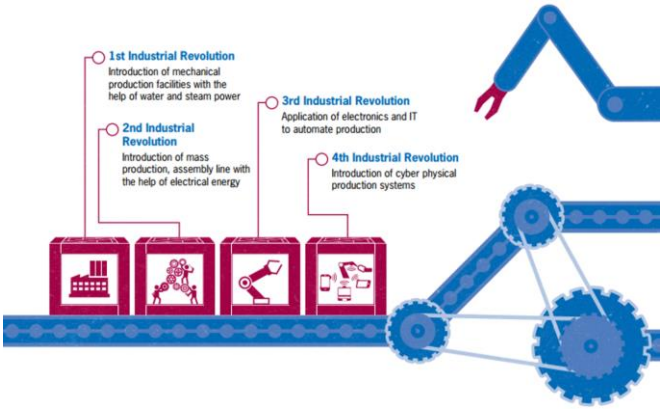

Fig. 1. The four stages of industrial revolution [2]

II. DEFINITION OF ROBOTICS

Merriam-Websters Dictionary defines robotics as "technology dealing with the design, construction, and operation of robots in automation" [4]. So what is a robot? According to IEEE Standards Ontologies for Robotics and Automation, a robot is an agentive device composed of mechanical and electronic parts purposed to act in the physical world to accomplish one or more tasks [5]. The multi-disciplinary coverage of robotics extends to electrical, electronics, mechanical, computer vision, and computing [6]. The field of robotics infuses the discipline of design, building, process, and execution of robots. The intention is to replace humans in vigorous, dangerous, and tedious tasks.

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III. GLOBAL TRENDS IN THE USE OR APPLICATION OF ROBOTICS

The growth rate for global spending on robotics will reach 22.8% for the next 4 years [7]. In some parts of the world, robots are already replacing humans in the workforce. Some think that robots will become an integral part of their day-to-day activities. Globally speaking, robotics is very popular. The following are the global trends in the field of robotics according to their applications. Figure 2 shows the major trends in the use of robotics throughout the globe.

A. Increase in the use of Collaborative Robots

Collaborative robots or Co-bots are robots that can mingle with humans thru the improvements in the use of Artificial Intelligence and sensor systems, making the interaction of robots with humans much better. Robots can now adjust their position to avoid a possible collision with humans, making these robots more suitable in business environments. With such developments on these robots, their use has tremendously increased [7]. People in the academic society think that this one of the important trends in robotics today - Human-Robot Interaction (HRI). For robots to perform tasks synergistically with humans, there should be a seamless HRI that can be provided by the integration of Artificial Intelligence in robots [8].

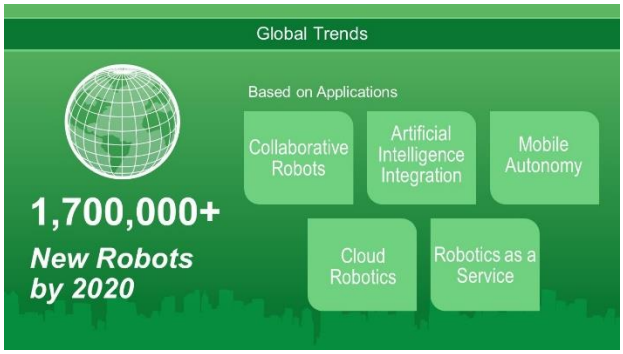

Fig. 2. Five major trends in Robotics around the globe.

B. Artificial Intelligence Integration

Robots are machines that can perform tasks based on the programs embedded in it. So, if Artificial Intelligence is integrated with robotics, robots can be intelligent enough to make some cognitive and inferential thinking based on the data from the sensors due to its environment or from the stream of information from the cloud. Although robots can gain intelligence upon putting Artificial Intelligence to it, still human is the centerpiece in handling complicated tasks. The roles of humans in the workforce will shift [8].

C. Mobile Autonomy

It is expected that the use of autonomous mobile robots will increase rapidly this year. Improvement in sensor systems and localization algorithms allows mobile robots to be self-guided with capabilities of environment perception, path and motion planning, and location awareness. The convergence of the Internet of Things IoT with mobile robots or unmanned aerial/ground vehicles, the robots' ability to navigate in their surrounding will increase. This will be one of the big themes for 2018 [8].

D. Cloud Robotics

Imagine robots accessing the cloud for their inferences and actuation? This is one of the incoming events in robotics. International Data Corporation (IDC) predicts that by 2020, new skills and AI capabilities of 60% of robots worldwide will be dependent on cloud-based software and applications [9]. Traditional robots require powerful computers, complicated pre-programming, and high-density batteries to power them up. If future robots will be cloud-based, they will be lighter, smarter, faster, and cheaper than ever before. Robotics marketplace in the cloud will also allow faster deployment of newly developed programs by various developers.

E. Robotics as a Service

A service robot performs useful tasks for humans but does not have any industrial automation function. Dull, repetitive, or distant tasks are the specialties of service robots. Examples of such tasks include household chores, walking pets, assistant for elderly, and other tasks that are both domestic and commercial. Service robots can be classified as professional or personal service robots. Professional service robots perform commercial tasks while personal service robots do domestic tasks [10]. Experts believe that robots may replace humans in service roles any time soon upon solving the problem of robot sensitivity. Still, humans are far more sensitive thus can give the warmth of service that other humans need. But humans can offload more work to robots more than before because of the recent developments in the concept of Human-Robot Interaction (HRI).

IV. GLOBAL MARKET TRENDS IN ROBOTICS

R&D activities and product development manifest that the robotics marketplace expands wider every day. Investments are rising based on vendor CAPEX and equity funding. The growth of robotics technology in industrial and service sectors drive the developers to intensify research and development in robotics. Even governments worldwide provide programs as an option for funding established vendors and start-ups that are embarking on robotics technologies. It is expected that the global spending market for the robotics industry will grow at 17.29% CAGR during the period 2016-2020 [11]. The estimated annual supply of industrial robots is expected to rise continuously (Figure 3)[12]. There would be around 1.7 million new industrial robots delivered across the globe by 2020.

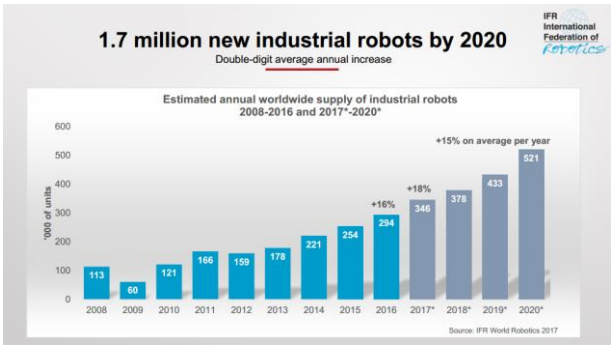

Fig. 3. Estimated annual worldwide supply of industrial robots. 2008-2016 data is based on records while 2017 onward is based on IFR prediction [12].

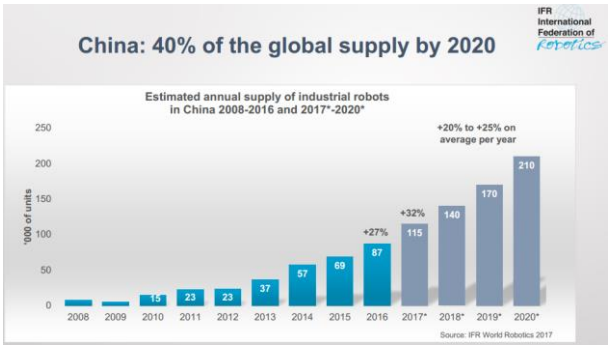

Fig. 5. Estimated annual supply of industrial robots in China. 2008-2016 data is based on records while 2017-2018 data is IFR projections [12]

Some experts pointed out the reasons for this growth: cost, user experience, physical dimensions [13]. While the factors that drive the interest of funding agencies, government, VCs, startups, and established vendors in investing in automation and robotics include a supply for industry, supply by industry, emerging market wage inflation, a broad variety of applications [14]. The major industries have embraced the use of robots from 2014 – 2016 (Figure 4). The main driver or producer of industrial robots is China which by 2020 is expected to supply 40% of the world's total manufactured robots manifested in the projection per annum of China's robot supply (Figure 5)[12].

Of course, the growth of the robotics market is related to human workers. Upon continual use of robotics in automation, then it might be possible that those low-skill human workers will be replaced. An example of this scenario is in San Jose's Orchard Supply Hardware in the U.S. Upon entering the store, robots are available to take a customer's orders. A customer can communicate with the robots which can also show where the exact items are located [15].

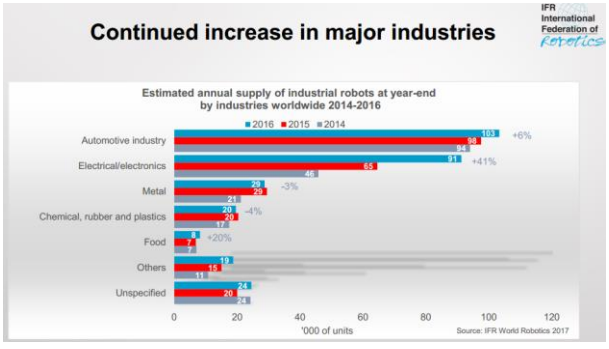

Fig. 4. Estimated annual supply of industrial robots by industries. Automotive industry being the highest usage of robots [12].

V. ROBOTIC TRENDS IN PHILIPPINE SETTING

Multi-national companies doing manufacturing in the Philippine soil adopt industrial robots as mandated by their mother companies based abroad. However, 100% Filipino-owned companies are very slow in adopting robotics due to misunderstanding of the benefits of using industrial robots. Most Filipinos believe that the robot will replace them in the workplace [16]. Hesitant to use industrial robots, Filipino companies moreover do not invest in R&D and manufacturing of robots. Filipinos refer to robotics just as a hobby that is why activities related to robotics only include joining competitions, selling robotics kits, and developing robotics projects in schools and for personal use. An example is a startup founded by engineering students of Mapua Institute of Technology named MachiBox. They are selling robotics kits with their flowchart-based program installed [17].

Examples of competitions enjoined by robotics enthusiasts include the 18th International Robot Olympiad (IRO) held in Beijing, China, and the DepEd-sponsored competition in Cebu City. Philippine Robotics Team composed of delegates from 18 schools comprised of over 70 students were sent to China to compete [18] while a total of 79 schools both elementary and high schools joined the Department of Education (DepEd) Lapu-Lapu Division's 2nd Robotics Cup at the Hoopsdome in Barangay Gun-ob, Lapu-Lapu City [19].

An example of a robotics kit that is considered toys here in the Philippine is the Jimu robot for kids and teens developed by UBTECH Robotics [20]. With just these activities in robotics, some experts say that the Philippines is lagging behind other countries when it comes to robotics. In the recently held Startup project expo at the University of Sto. Tomas last June 3, 2017, an interview with one of the organizers of the event revealed that robotics is not popular in the Philippines [21]. However, some medical facilities in the country have already used robotics in complex procedures in the fields of thoracic, head, oral surgery, colorectal, and urology [22].

VI. APPLICATIONS OF ROBOTICS

Robotics is everywhere. It is used in industries, education, security, military, agriculture, tourism, retail, healthcare, domestic, infrastructure, logistics, manufacturing, and explorations. For example, robots in the service industry can provide internal transport, can work around people, and can provide customer service without the necessity of hardwiring to an infrastructure. Industrial robots are faster, more agile, and now becoming cheaper. Robots used in outer space can be autonomous or controlled by a human from a distant station or earth station. Robotic systems can make residential houses very intelligent working on security and efficient energy consumption. Robots are also used in exploring hazardous places for humans. In the military, robots can serve as support and can be employed to transport fuel, ammunition, and other supplies. In farming, robots are used to harvest crops, milk cows, and even herd sheep. In the car industry, robots are used for manufacturing parts and assembling procedures. They are also used in painting, sanding, and polishing the body of an automobile. In hospitals, robots are used in providing support for doctors doing medical procedures. Rescue robots are also deployed in disaster areas to work on dangerous environments. Aside from this very vast field of application, robots are also used in entertainment and education in which interaction is required.

VII. FACILITATING FACTORS AND BARRIERS TO THE ADOPTION OF ROBOTICS IN THE PHILIPPINES

Adoption of robotics is affected by so many complex combinations of circumstances, beliefs, facts, and events, which may include the political will of our government, opportunities created by waves of other emerging technologies, financial systems which supports the establishment of firms focused on or using robotics, our external affairs with countries already advanced in the field, entertainment and social media, and sometimes by our young generations' curiosity. In this part of this paper, the factors which stimulate and promote robotics as well as the hindrances in the adoption of robotics in the Philippines are discussed.

A. Facilitating Factors

Some educational institutions in the Philippines consider including robotics in their curriculum and research projects of their students. An example is De La Salle University which partnered with Liverpool Hope University in the UK to offer MSc in Robotics Engineering [23]. Together with other HEIs in the Philippines, DLSU collaborates with UK Universities to create Transnational Education (TNE) programs to upgrade the quality of HEIs in the Philippines. The linkages between Philippines and UK universities are made possible with the British Council of the Philippines and the Commission on Higher Education's Joint Development of Niche Programs through Philippines-United Kingdom Linkages. Another example is Our Lady of Lourdes College Foundation which has asked Carnegie Mellon University in Pittsburgh, Pennsylvania to evaluate the capability of the College and High School to include Robotics education in their curriculum [24]. In a similar example, San Beda University partners with FELTA to be the Philippine Robotics Academy which is to offer Ladderized Robotics Programs focused on using LEGO Mindstorms [25]. In addition to the initiatives of HEIs to integrate Robotics in their curricula are the competitions that enthusiasts, associations, and educational institutions are joining. From the past decade, the Philippines has been actively participated in international robotics competitions and has established its local Olympiads to ready the teams playing in the international arena [26]. Aside from competitions, enthusiasts, associations, and SMEs develop or use a robotics kit for educational purposes and fun.

There are also initiatives from DOST and DepEd to provide training to teachers and students which hopes to ignite the interests of the participants in Robotics. Some of these are workshops on LISER Robots, ThinkLab TRC, DOST agreement with FELTA, and DepEd Robotics Training.

Multi-national and international companies having factories in the Philippines are already transitioning to full automation with the use of robots, e.g. Nissan and Epson. Wanting to increase the quality and productivity of their factories make them adopt robotics. Robotics deployed on such factories improve product design, provide stronger cash flow, and provide ease of management and lower production cost.

Universal Robots, a Danish robotics manufacturer, is now expanding its market by partnering with Elixir, a Philippine company focused on material handling, printing, and packaging solutions, for local distribution.

Filipinos are fond of robots based on the multimedia perspective. Robots that appear in movies and tv-shows are quite interesting for Filipinos. Robotics in the entertainment industry seems to capture the interest of Filipinos on robots. For example, the movie iRobot in 2004 has earned $933,318 [27] in the Philippines alone while the movie Pacific Rim in 2013 has earned $3,792,326 [28].

Financing of firms and Venture Capitalists (VC) support startups engaging in the use of robotics or production of robots. Examples of these firms and VCs include QBO, Ideaspace Foundation, DTI, and DOST [29].

B. Barriers and Constraints of Adoption

In this paper, there are eleven (11) barriers identified which hinder the adoption of robotics technology in the Philippines. The first one is from the national government. By looking at the Harmonized National Research Agenda of the Department of Science, one can say that adoption of robotics is not a national priority (1). The term "robotics" appeared only once in that document [30], [31]. From this lack of research programs for the development and use of robots in the Philippines, only a few individuals pursue careers in robotics here in the Philippines. Because there are only a few students who want to study robotics,

there are also few higher educational institutions that opt to offer robotics engineering courses causing insufficient education and training systems for robotics. Robotics subjects only become elective in other schools [32](2). This lack of media for education and specialization training leads to the unavailability of a critical mass for programmers and robot developers [33] (3). The rare number of experts that can design, build and install robots leads to a high compensation rate for hiring these experts which further constrains small and medium enterprises who want to adopt robotics and automation in their businesses. In addition to SMEs' low technical capabilities of SMEs to design, develop, install and operate robotics systems in their factories (4), their low capital for implementing robots in their workplaces hinders them to adopt robotics (5)[34]. These barriers (4 and 5) could be augmented if there is adequate support for SMEs wanting to adopt robotics and automation manufacturing technologies (6) [33]. Aside from these, SMEs are also challenged by the difficulty in integrating robotics with their current work settings which discourages them to use of robots (7). The other four barriers can be summarized by the perspective of Filipinos in the adoption of robotics. Most Filipinos are not aware of the benefits robotics implementation could bring (8)[35]. Although some Filipinos are already working interactively with robots, they may not be necessarily happy with their work environment (9). Also, once robotics has been introduced in the ways of living of every Filipino, it may provoke anxiety (10) [16]. Old habits may need to be broken down to form the new habits in living with robots. Or, face the fact that there are still people who have misconceptions when it comes to robotics (11)[36]. Their idea may still be the definition provided by movies or tv-shows.

VIII. IMPACTS OF ROBOTICS TECHNOLOGY

A. *Economy*

Robotics has impacted so much on the global economy and the Philippines would not be an exception once the technology is adopted. There is a possibility of a much higher GDP due to exports. Suppose that the Philippines adopt robotics in producing our export goods and exploit the benefits of robotics in automation, our factories can produce more products at a higher quality which can boost our exports and decrease our imports. In Figure 6, the top 5 exports of the Philippines are presented [37]. It can be noticed that the type of goods we are exporting is output from factories. These factories can be automated with the integration of robotics into the production process.

B. *Industry and Manufacturing*

Productivity will increase with the integration of robots in the workforce. Robots can work faster and produce accurate results. More can be produced and downtime can be minimized to none, except for preventive maintenance and upgrades. However, implementing robots in the workforce will affect employment. Because robots as employees are untiring, accurate and can always be at full potential, they are generally preferred and they are much easily managed than human resources. Low-skill workers can be easily replaced by robots. But there will be more job opportunities for those high-skilled workers.

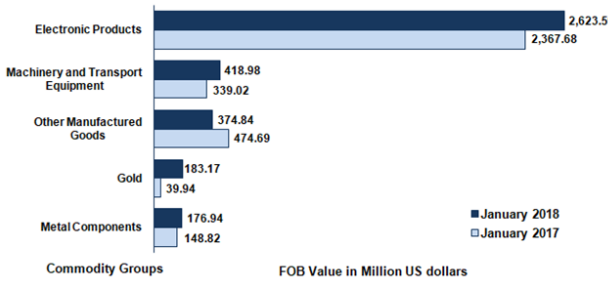

Fig. 6. Philippines' top five exports on the same month of 2017 and 2018

Besides, there will be new alternatives to producing a certain type of goods. Because robots can work with high accuracy, more intricate designs of a certain type of goods can be manufactured which means more options to the consumers.

C. *Society*

The societal impact of robotics is the hardest to measure but much like other technologies, there are the positive and negative effects of robotics in our society. An example is a time that workers can save. Suppose that a farmer owns a herd of milking cows. Manually milking the cows virtually requires that the farmer should be up 24 hours a day. Robotics can automate this job and saves the farmer invaluable time. The creation of new jobs will be prominent when the Philippines society adopts robots. Although some repetitive and low-skilled jobs will be replaced by robots, new jobs will also be generated. Humans can now focus on much more creative tasks and leave the hard, repetitive tasks to robots. Also, new products will be available for human consumption and new entertainment concepts for humans to enjoy. Domestic robots are now available in the market. It will take much time when it floods the marketplace. These robots can serve as pets or companions which can provide new concepts of entertainment. Besides, sports can also be dominated by robots. There will come a time when the boxing ring is filled with robots fighting autonomously or controlled remotely. Of course, the adoption of new technology needs new laws to regulate its use. Otherwise, technology can be used for harmful intents.

IX. CONCLUDING REMARKS

A. *Labor and Employment*

When the demand for robotics systems in the Philippines grew and continually increased, it is expected that the demand for employment will decrease for industries that are directly affected by the adoption of

robotics such as manufacturing, service, IT, and agriculture to name a few. As stated earlier, some jobs will be replaced by the robot system and when this happens, there should be policies that will help absorb the loss of employment.

1. Benefits that can be enjoyed outside the labor

Every Filipino worker should still receive social security benefits even outside formal employment. This is to ensure that the shock of shrinking the workforce due to robot replacement will not cause a catastrophic effect on the ability of the worker to earn a decent living.

2. Ensure receiving minimum salary/income/wage

Every Filipino should be provided with ways other than formal employment to earn minimum income for standard living. Government livelihood programs should be strengthened to absorb the effect of the adoption of robotics in the workforce.

3. Re-training Facilities for New Jobs

New jobs will be created but with a higher skill set requirements. To address this, the establishment of re-training facilities for honing the required new skills for workers must be done.

4. Provision of socially benefiting activities for people outside employment

Social activities such as tree planting, community cleaning, and recycling can be promoted for the usage of the ample time that adopting robotics can save.

B. Human Resource Development / Education

The traditional form of education cannot sustain the requirements of our very fast-changing world. Instead of spending most of an individual's years on generalized education, there should be dynamic curricula that focus on the skills needed by emerging technology. For this paper, let us see some policies that can improve our education system in light of the Philippines adoption of robotics:

1. Segment the workflow of designing, building, defining applications, and testing robots into modules that can be taken by an individual who has or has not finished general education. These modules should be facilitated by a government agency such as TESDA.

2. Provide media for students or learners to expose themselves in the industries that demand their chosen skill (e.g. Designing robots). Learners need ideas, and to generate them, they need exposure. The Academe-Industry linkages should be established and strengthen to produce professionals with the right skills required by the industry.

3. Creation of an educational system that is not laddered or highly sequential. This will allow learners to enroll in relevant courses and learn the necessary skills that are required by the industry and are not dependent on other irrelevant courses.

C. Government Policy / Laws

Looking at the usage of robotics systems, one can say that the Philippines lagged very much. Instead of waiting for technology in other countries to reach our country, the government can start developing laws and policies that will regulate the robotics system in the Philippines. The technology will come! Better to be legislatively ready for it.

D. Research and Development / Innovation

The culture of research and development is quite common to other countries that have already embraced robotics. For the Philippines, establishment and promotion of a similar culture can start with:

1. Initiatives to create communities that will focus on the development and use of robotics. Although there are associations that use robotics for competitions, their presence is not nationwide. Establishment of national robotics organizations that do not just focus on Olympiads but also on different applications of robotics can promote and stimulate the adoption of robotics in the Philippines.

2. Events that could trigger awareness and interests of everyone in the subject of robotics. Holding events such as exhibits, expos, parades, balls, contests, and robot awareness caravans can also help in instilling interest to the young members of the community to be curious about robotics technology.

3. Establishment of publicly accessible robotics systems laboratories nationwide to cater to the needs of researchers, academicians, enthusiasts, and innovators in developing robotic systems. When these people are provided with access to laboratories where they can test their new ideas in robotics, they can establish the research and development culture and expedite the adoption of robotics so that people can exploit the benefits of robotics.

X. RECOMMENDATIONS

The interrelation of the factors which promote a specific technology and the barriers that hinder its adoption is so complex that one cannot directly pinpoint where to begin to stir up the change. Yes, the government indeed has the biggest potential to direct the change but the initiatives may need to come from the people. The author suggests paradigm shift and open-mindedness on the idea and concepts of emerging technologies, for one cannot accept when his cup is full – he must be willing to empty his cup for the new.

ACKNOWLEDGMENT

The authors thank the De La Salle University Gokongwei College of Engineering with Engineering Research and Development for Technology (ERDT) for their support on this research.

REFERENCES

[1] T. Zhou, K., Zhou, L., & Liu, "Industry 4.0: Towards Future Industrial Opportunities and Challenges.," Int. Conf. Fuzzy Syst. Knowl. Discov., pp. 2147–2152, 2015.

[2] A. Chouhan, S., Mehra, P., & Dasot, "India's Readiness for Industry 4.0 : A Focus on Automotive Sector," Grant Thornton, 2017.

[3] M. Loughlin, "Robots and Industry 4.0," 2017. [Online]. Available: http://www.automaticaeinstrumentacion.com/es/downloads2/nelmia-michael-laughlin.compressed.pdf. [Accessed: 26-Feb-2018].

[4] "Robotics," Merriam-Websters Dictionary, 2018. [Online]. Available: https://www.merriam-webster.com/dictionary/robotics. [Accessed: 22-Feb-2018].

[5] IEEE, "IEEE Standard Ontologies for Robotics and Automation," IEEE Robot. Autom. Soc., 2015.

[6] E. P. Dadios et al., "Preparing the Philippines for the Fourth Industrial Revolution: A Scoping Study," PIDS Discuss. Pap. Ser., 2018.

[7] "2018 Trends in Robotics," Tharsus Robotics. .

[8] A. Nicodemo, "In the sky, on the roads, and in the home: Robotics and AI in 2018," News @ Northeastern: Community, Discovery, and Analysis, 2018. [Online]. Available: https://news.northeastern.edu/2018/01/in-the-sky-on-the-roads-and-in-the-home-robotics-and-ai-in-2018. [Accessed: 11-Feb-2018].

[9] J. B. Zhang, "DC FutureScape: Worldwide Robotics 2017 Predictions," in IDC Web Conference, 2016.

[10] "Service Robotics Market Will Grow by 17.8% CAGR to Reach $24.10 Bn by 2022," Zion Market Research. [Online]. Available: https://globenewswire.com/news-release/2018/01/19/1297700/0/en/Service-Robotics-Market-Will-Grow-by-17-8-CAGR-to-Reach-24-10-Bn-by-2022.html. [Accessed: 11-Feb-2018].

[11] N. Trent, "Research and Development Spending in the Robotics Industry Market - Global Industry Analysis, Size, Share, Trends, Growth and Forecast 2018 - 2022," Wiseguyreports.Com, 2018. [Online]. Available: http://www.nbc-2.com/story/37374326/research-and-development-spending-in-the-robotics-industry-market-2018-global-share-trend-segmentation-and... [Accessed: 11-Feb-2018].

[12] International Federation of Robotics, "How robots conquer industry worldwide," 2017

[13] P. Rasmussen, "Trends in Robotics for 2018 and Beyond," East West: Design, Manufacturing, Distribution, 2017. http://news.ewmfg.com/blog/trends-in-robotics-for-2018-and-beyond (accessed Feb. 10, 2018).

[14] R. Powell, "The rise of robotics and automation.," BlockRock, 2017. [Online]. Available: https://www.ishares.com/uk/individual/en/insights/industry-trends/the-rise-of-robotics-and-automation. [Accessed: 10-Feb-2018].

[15] E. Reinecke, "Top digital business trends in 2018," Dimension Data, 2018. [Online]. Available: https://www2.dimensiondata.com/it-trends/digital-business-2018. [Accessed: 11-Feb-2018].

[16] S. Gotfredsen, "The future of robots is now.," Malaya Business Insight, 2017. [Online]. Available: http://www.malaya.com.ph/business-news/special-features/future-robots-now. [Accessed: 11-Feb-2018].

[17] GineersNow, "A Startup By Filipino Engineering Students Create Robotic Kits That Teach Teenagers To Program - GineersNow," GN Feature Story, 2017. [Online]. Available: https://gineersnow.com/students/startup-filipino-engineering-students-create-robotic-kits-teach-teenagers-program. [Accessed: 11-Feb-2018].

[18] "Philippine Robotics Team bags 192 medals in the 18th Int'l Robot Olympiad in China," Malaya Business Insight, 2017. http://malaya.com.ph/business-news/living/philippine-robotics-team-bags-192-medals-18th-int'l-robot-olympiad-china (accessed Feb. 11, 2018).

[19] F. M. Gitgano, "Robotics at work," SunStar. [Online]. Available: http://www.sunstar.com.ph/cebu/feature/2017/09/08/robotics-work-560817.

[20] E. Tortoza, "UBTECH Robotics Launches STEM-Friendly Jimu Robots in PH," Gadget Pilipinas. [Online]. Available: https://gadgetpilipinas.net/2017/09/ubtech-robotics-launches-stem-friendly-jimu-robots-in-ph. [Accessed: 11-Feb-2018].

[21] L. E. de Guzman, "Why we need 'sexy' robots in the Philippines?," Spark Up, 2017. [Online]. Available: http://sparkup.ph/Why-we-need-sexy-robots-in-the-Philippines.

[22] HealthTech, "Robotic Surgery in the Philippines." [Online]. Available: http://www.healthtech.ph/2017/05/robotic-surgery-in-philippines.html. [Accessed: 11-Feb-2018].

[23] I. B. Mia, "DLSU, HEIs to Offer Postgraduate Programs with Partner UK universities," The Lasallian, 2017. [Online]. Available: http://thelasallian.com/2017/07/20/dlsu-heis-to-offer-postgraduate-programs-with-partner-uk-universities/. [Accessed: 10-Mar-2018].

[24] S. J. Elia, S., Hu, S. D., & Liu, "Robotics Curriculum Project." Our Lady of Lourdes College Foundation, Daet, Philippines, 2009.

[25] "Phil Robotics Academy @ San Beda College of Alabang Center for Robotics Excellence," FELTA Multi-Media Inc., 2017. [Online]. Available: http://felta.ph/2017/11/02/phil-robotics-academy-san-beda-college-of-alabang-center-for-robotics-excellence/.

[26] "Pinoy Robot Games Organization," 2018. [Online]. Available: pinoyrobotgames.org: http://www.pinoyrobotgames.org/index.php/prghome.html. [Accessed: 10-Mar-2018].

[27] IMDb, "I, Robot," International Box Office Results - Box Office Mojo. [Online]. Available: http://www.boxofficemojo.com. [Accessed: 11-Mar-2018].

[28] IMDb, "Pacific Rim," International Box Office Results - Box Office Mojo, 2017. [Online]. Available: http://www.boxofficemojo.com. [Accessed: 11-Mar-2018].

[29] PwC, "Off to a great start: The Philippine startup ecosystem," 2017.

[30] DOST(Department of Science and Technology), "Harmonized National Research and Development Agenda," Taguig City, 2017.

[31] "Highlights of the Philippine Export and Import Statistics," Quezon, 2018.

[32] M. T. Montemayor, "Why include robotics in PH school curriculum," Philippine News Agency, 2018. https://www.pna.gov.ph/articles/1040784.

[33] E. Robles, "Robotics to unlock potentials of PH industries," The Manila Times, 2018. https://www.manilatimes.net/2018/03/11/supplements/robotics-to-unlock-potentials-of-ph-industries/385538/.

[34] B. C. Magkilat, "ABB sees robotics opportunities in PH," Manila Bulletin, 2018.

[35] BusinessMirror, "Robots (all steel, don't tire) are coming: Time to be scared?," 2017. https://businessmirror.com.ph/2017/08/02/robots-all-steel-dont-tire-are-coming-time-to-be-scared/

[36] M. Online, "Demystifying 5 Myths About Collaborative Robots," Manila Bulletin, 2020. https://mb.com.ph/2020/07/10/demystifying-5-myths-about-collaborative-robots/.

Philippine Statistics Authority, "Highlights of the Philippine Export and Import Statistics," Quezon, 2018.