

ON GRADUATE SCIENCE PROGRAMS IN THE PHILIPPINES AND THEIR IMPACT ON NATIONAL AND ECONOMIC SECURITY

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ABSTRACT

Building up the scientific manpower of a country has become even more critical with the advent of the 4th Industrial Revolution and the unprecedented global conditions imposed by the Covid-19 pandemic. At the core of scientific manpower development are the graduate science programs in universities. In this paper, we discuss how university policies can have repercussions on the national and economic security of the Philippines.

Keywords: *Graduate science programs; scientific manpower; economic security*

THE MID-21ST CENTURY LANDSCAPE

As the mid-21st century looms on the horizon, countries which are weak in science and technology could be dominated, not only militarily but also economically, by nations which have a strong science and technology workforce. History tells us that a technologically superior country breeds superior ambitions that may not respect national boundaries. The final phase of World War 2 was cinched by the Manhattan Project led by brilliant scientists to create a weapon impactful enough to turn the tides of war. Nowadays, conflicts are not anymore decided on who can build better drones, but also on who could attack and defend better in cyberspace. Moreover, discoveries in science and technology drive a knowledge-based global economy and knowledge-based advanced societies. Better products are manufactured and services efficiently rendered when anchored on and adapted to rapidly evolving advanced technology. Even business decisions are presently more heavily based on data analytics and the latest biotechnological innovations. Food production to feed millions will rely on genetic engineering, mathematics, biochemistry, and bioinformatics, among others. Advanced countries know this too well noting that in the USA, for example, “it is estimated that the \$ 3.8 billion spent by the federal government over 10 years on the Human Genome Project resulted

in \$ 796 billion in economic gain” (Purugganan, 2013). Countries which value and nurture the best minds can better defend themselves in an economic war without borders. In the race for a cure for COVID-19, only countries with the required bio-scientific expertise can compete while the rest of the world are left as spectators on the sidelines begging for lower prices or dole-outs. No wonder that there is now a global competition in the training and recruitment of the best scientific minds in the world, since countries with excellent scientists and engineers can dominate those countries without the required scientific manpower. It is, therefore, imperative for each country to develop the required scientific manpower to meet the challenges of the times. And this burden, this mission, falls on the shoulders not only of national agencies, but also of universities and colleges which are the breeding ground for the next generation of scientists and engineers. For example,

the Chinese government successively launched ‘Project 211’ in 1995 and ‘Project 985’ in 1998 by focusing its financing resources on developing top Chinese universities. ‘Project 211’ is the Chinese government’s endeavour initiated in the 1993 Outline with an aim to strengthen about 100 higher education institutions and a number of key disciplinary areas in terms of teaching, research and administration as national priorities for the 21st century. The figures of 21 and 1 within “211” are from the abbreviation of the 21st century and approximately 100 universities respectively. The project has been implemented since 1995. In addition, these institutions are expected to become the basis for training high-level professionals and solving major problems confronting the country’s economic and social development. Many of these institutions are also expected to play a key and exemplary role in adapting to regional and sectional development needs (Chinese Ministry of Education). (Cai, 2013).

BIRD’S EYE VIEW OF PHILIPPINE SCIENCE

In 2008, the semiconductor company Intel Corporation with around 3,000 employees shut down its test and assembly plant in the Philippines and moved to Vietnam. Intel started in 1974 and by the time they closed shop, it had already poured in some US\$1.5 billion worth on investment in the Philippines (Calimag, 2008). Vietnam’s “*work force was a key factor in Intel’s decision*” (Mason, 2006). In conversations with Intel personnel, one statement struck us: “*If we have a job opening for a Ph.D., it’s very difficult to find an applicant in the Philippines. In Vietnam, if we have a vacancy, there would be 20 applicants all with a Ph.D.*” The numbers may be exaggerated, but a reality check depicted in Figure 1 and Table 1 is disturbing. A few years before Intel shuttered its test and assembly plant, its Research and Development (R & D) activities in the Philippines transferred to Shanghai, China, since with “*a growing number of highly trained researchers and technologists, China is creating the kind of dynamic environment that is an impetus to great R&D*” (Intel, 2005). The numbers tell the story. The scientific power of Southeast Asian countries compared with China, USA, Germany, Japan, and S. Korea is shown in Table 1.

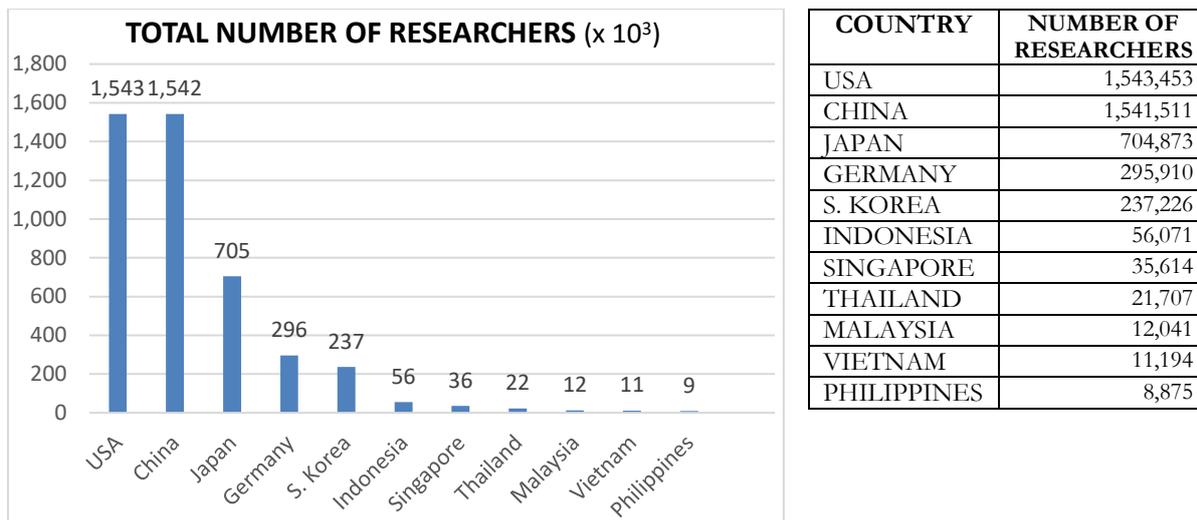


Figure 1. The total number of researchers is obtained from the number of researchers per million inhabitants (latest available year) multiplied by the country’s population. Sources: <http://chartsbin.com/view/1124>; <https://www.worldometers.info/world-population/population-by-country> (downloaded: 24/08/2020).

Table 1. (a) Scientific productivity as measured by the number of published papers. (b) Research influence as measured by the number of citations. Sources: https://en.wikipedia.org/wiki/List_of_countries_by_number_of_scientific_and_technical_journal_articles; <https://www.scimagojr.com/countryrank.php> (downloaded: 24/08/2020)

COUNTRY	NUMBER OF PAPERS (2016)	COUNTRY	NUMBER OF CITATIONS (1996-2019)
China	426,165	USA	339,229,687
USA	408,985	Germany	70,371,678
Germany	103,122	China	61,658,138
Japan	96,536	Japan	48,232,916
S. Korea	63,063	S. Korea	17,047,690
Malaysia	20,332	Singapore	6,839,745
Singapore	11,254	Malaysia	2,737,551
Thailand	9,582	Thailand	2,452,571
Indonesia	7,729	Indonesia	793,905
Vietnam	2,961	Vietnam	671,649
Philippines	1,569	Philippines	571,112
Brunei	217	Cambodia	82,660
Cambodia	117	Brunei	48,497
Myanmar	111	Laos	47,899
Laos	85	Myanmar	45,036

NORMALIZING THE PYRAMID – THE PHILIPPINE CASE

With a young population, the Philippine drop-out rate in basic education is significant. Typically, for every 100 children who enter grade 1, only around half would finish high school (ADB, 2018). Of the high school graduates who enter college only around 1% to 2% would enroll in a science or engineering program, and fewer still will end up pursuing a graduate degree (Carpio-Bernido, 2016). Compare this with the 10% tertiary enrollment in Science, Math and Computing in the US in 2014. Tremendous effort has been spent on enticing Philippine students to go into science and engineering (See e.g., programs of the Science Education Institute of the Department of Science

and Technology, <http://www.sei.dost.gov.ph/>). However, the problem of producing more research-level scientists and engineers is further compounded by the lack of good universities offering science graduate programs. Indeed, the development of a strong scientific manpower is a gargantuan problem and universities in the Philippines have a crucial role to play since the M.S. and Ph.D. programs are where students are trained to create new knowledge. We pictorially depict the situation by a pyramid in Figure 2.

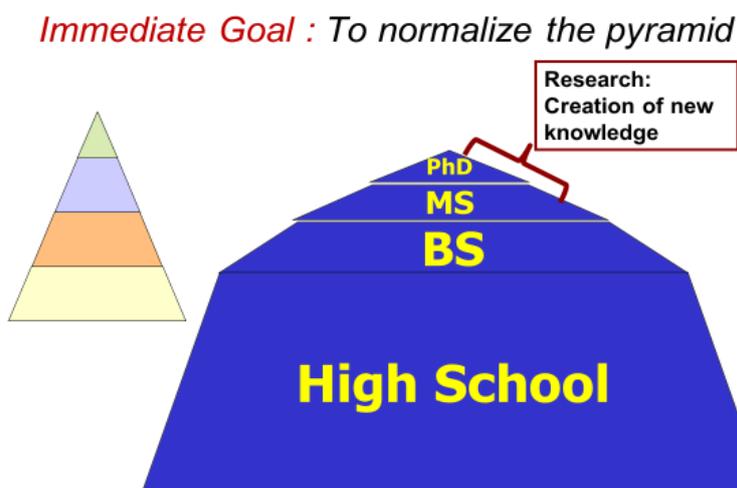


Figure 2. A fertile source for the creation of new scientific knowledge are the M. S. and Ph.D. programs of universities. But very few students enter these programs. The short-term target is to achieve the shape of the triangle at the upper left.

THE CORNERSTONE THAT THE BUILDERS REJECT

Running a university with a tight budget, especially private universities, is always a challenging task. To save money, university officials tend to retain only those programs with large enough enrollments. This attitude, however, directly threatens science programs, most especially the M. S. and Ph.D. programs in the basic sciences since normally not many take up these courses because of their inherent difficulty. If one applies a policy where only those classes with at least 20 students should be retained, many universities worldwide would have to close down their graduate programs in the sciences. This policy would eliminate outright many of the few science graduate programs that we have – our country’s cornerstone for national development.

THE GOOSE THAT LAYS THE GOLDEN EGGS

To concretize our discussion, let us consider as an illustrative example the discipline of Physics which has served as a fountainhead of revolutionary ideas contributing even to the other basic sciences. This is exemplified by the physicist Wolfgang Pauli who contributed to chemistry through the “Pauli’s Exclusion Principle”. Remove Pauli’s principle and you cannot form the Periodic Table of Elements and, consequently, no chemistry. Likewise, the English physicist Francis Crick, together with James Watson, produced a landmark-work in Biology with their Nobel Prize winning paper on the double-helix structure of DNA. In mathematics, we of course have Isaac Newton who invented calculus. Many principles and formulas from physics are continually being used in engineering, nanotechnology, geology, meteorology, and many others. The world-wide-web (www) was created in one of the biggest physics laboratories, CERN, in Geneva. Given its importance, how are the Philippine universities when it comes to producing Ph.D.’s in Physics?

For a country of 109 million people, the Philippines has only a total of five universities offering a Ph.D. (Physics) program, two of them are state supported: the National Institute of Physics (NIP) at the University of the Philippines (UP) in Diliman in the National Capital Region (NCR) and the Mindanao State University (MSU) - Iligan Institute of Technology (IIT) in Iligan City in Mindanao. The private universities offering a Ph.D. (Physics) program are De La Salle University (DLSU) and Ateneo de Manila University (AdMU), both in the NCR. The newest Ph.D. (Physics) program was established 8 years ago by the Physics Department of the University of San Carlos (USC) in Cebu which is, uniquely, the only one outside of Metro-Manila offered by a private university. Despite being new, the Ph.D. (Physics) program of USC has graduated 4 Ph.D.'s all of them with publications in internationally reputable scientific journals. A few more Ph.D. students and publications are in the pipeline for this school year. The USC Physics Department has, in fact, the sought-after stamp of “*Center of Excellence*” given by the Commission on Higher Education which brings prestige to USC, on top of the added funding and state-of-the-art research equipment it receives from government research grants. However, with only five (5) Ph.D. (Physics) programs offered nationwide, the task of producing the required number of physicists for our country to be competitive will be an arduous climb for the coming decades. Nevertheless, the climb is not impossible. Sustained government support and inter-university cooperation are essential and effective as shown by the experience of the NIP at UP. From only two (2) Ph.D.'s in the early 1980's and negligible internationally published research, at present, the NIP has 24 Ph.D.'s in its senior faculty with more positions to be opened up, and publications output that is world-class (<http://nip.upd.edu.ph>). The NIP has also been producing Ph.D.'s who have now dispersed to universities in different parts of the country and presently contributing to the building up of their departments and institutes.

The problem of Ph.D. (Physics) programs in the country is not only on how to increase the number, but also how to maintain existing ones, including the program at USC. Being a private university, USC naturally tends to favor academic programs which in its view are financially sustainable. The idea of retaining only those academic programs which have, for example, 20 students in each class has been floated for several years now. Physics, being one of the most difficult disciplines could have less than 15 students to a class. However, closing the Ph.D. (Physics) program at USC, or its feeder, the B.S. (Physics) and M.S. (Physics) programs, would not only be myopic, but is akin to killing the goose which lays the golden eggs. In the Times Higher Education (THE) criteria for worldwide university rankings, Research (volume, income, reputation) weighs 30%, and Citations (research influence) another 30% out of a total of 100%. This implies that publications and patents (citations depend on these) are responsible for around 60% of the THE criteria. Internationally cited publications, however, can only be realistically achieved by a university if it houses active Ph.D. programs in the sciences. In fact, at USC as well as in the highest ranked university in the Philippines, the science departments have been churning out the most number of research publications in reputable international journals. Given the international standards, therefore, closing or “freezing” science programs which have less than 15 students per section is a recipe for downgrading a university to the status of a small college. After all, the existence of active Ph.D. programs is a *requirement* to be rightly called a university. Instead of giving up on “non-cost-effective programs,” creative ways of funding graduate programs should, therefore, be explored such as Professorial Chairs from endowments of generous individuals, alumni, or corporations who directly benefit from a supply of graduates from strong undergraduate and graduate science programs. Creating a university science foundation dedicated to support graduate research may also attract fund-givers from outside. This was done by the College of Science of the University of the Philippines at Diliman in the 1980's when there was a dearth of Ph.D.'s and lack of funding support. Beyond these private initiatives, significant support could be obtained from government entities with the mandate for supporting scientific research and development such as the Department of Science and Technology, the National Academy of

Science and Technology, and the National Research Council of the Philippines. This was done in the 1980's to fund a consortium of UP, DLSU and ADMU to establish the first Ph.D. (Physics) Program and in other disciplines in the country. This move was not without criticism, with critics harping on the quality and sustainability of such a program. However, bullishness of the consortium has eventually proved the pessimists wrong with bright performance indices that also reveal much potential for more achievements.

GO INTO THE DEEP

Universities offering science programs geographically distributed in different islands of our country should be our target. The logic is simple. Who knows that maybe the next Einstein may be in Marawi City. After all, the Physics Nobel laureate, Carl E. Wiemann, attended a rural primary school with only three classrooms, and his home was miles away over unpaved roads to the nearest store (<https://www.nobelprize.org/prizes/physics/2001/wieman/biographical/>). If the Philippines must leapfrog as a country into 21st century science, it is important to look for natural talents by going deep into the countryside. There is wisdom, therefore, in Japan's decision in the late 1800's to have seven prestigious Imperial universities scattered from north to south of the country to catch the local talents. Likewise, in Germany, more than 80 world-renowned Max Planck research institutes are spread out all over the country. This idea of scattered centers of excellence was our inspiration in 1992 for establishing a Research Center for Theoretical Physics (RCTP) in the island province of Bohol. The RCTP is small, with no regular budget, but we felt somebody must start something important enough to be done. By now, the RCTP has organized nine (9) international workshops with Proceedings published by the American Institute of Physics (USA) and World Scientific (Singapore) (CVIF, 2020). Two of our workshop speakers later won the Nobel Prize in physics. The goal for each workshop was to give young Filipino graduate students the opportunity to interact with noted foreign scientists and mathematicians. The transfer of new research ideas was paramount. Spread-out centers of excellence was also our motivation for helping the Physics Department of MSU-IIT in 2007, then USC starting in 2014, to build a Ph.D. (Physics) program. For us, this entailed regularly crossing the sea separating the islands of Bohol and Mindanao, then Bohol and Cebu, to help our colleagues in their heroic effort to provide a chance for a mustard seed to grow into a big tree.

OF WHAT GOOD IS A NEWBORN BABY?

Let us look at analogies. There are several national newspapers which are losing money but are still maintained through the years. They are maintained, not because they may be profitable later, but because they serve a bigger purpose. The media, like national dailies, shape the minds of people and affect their decisions and, hence, form an excellent instrument in realpolitik. Science programs, especially in private Philippine universities, may be costly but should be maintained and strengthened. They should be strengthened, not because they may be profitable later, but because they have an impact on our over-all national interest and long-term economic security. The graduate science programs, no matter how small, underpin our country's scientific manpower development.

Why do parents feed, change diapers, spend sleepless nights for a newborn baby? Why do parents suffer to earn money just to send their children to school? The baby or child does not provide income and causes a continuous drain of financial resources, aside from sometimes being a source of consternation. Parents sacrifice because they know their children may be their source of security when they are old and weak. Or parents sacrifice because they simply love their children and no rationale for their actions is needed. After Michael Faraday demonstrated his discovery of electromagnetic induction in 1831, he was asked, "Of what good is it?" Faraday's answer: "Of what good is a newborn baby?" (See e.g., <https://dfg2020.de/en/of-what-use-is-a-newborn->

baby/) Today, much of information and digital communications and the 4th industrial revolution are an offshoot of Faraday's discovery. It is the same with maintaining apparently financially draining science programs in a university. Producing scientists and engineers is our security against other countries that could easily dominate us economically and intellectually. This is realpolitik in the 21st century. An across-the-board university rule, or a one-size-fits-all policy on maintaining only "cost effective programs", could do irreversible damage. Redemption of a country presupposes sacrifice (Rizal, 1891). The sacrifice involved in supporting fledgling science programs should be viewed in the larger context of our country performing respectably in the 21st century. Now is the time to discern the essentials from the peripherals and make a stand to exhaust everything within our means to support the vision of creating a strong science and technology base for our country. This requires faith and commitment to such a noble cause, as this might mean walking on water. Future generations, however, would look kindly on those universities that did not turn their backs to the Filipino people, and showed willingness and courage to achieve a great vision for the dignity and welfare of our long-suffering nation.

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