COMMENTARY

BELOW THE RADAR: PARADOXES IN PHILIPPINE STEM HUMAN RESOURCE DEVELOPMENT[1]

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1. AHEAD OF THE CURVE

The development of scientific manpower in different countries often follows a template patterned after what have been implemented in more advanced countries. For a developing country, however, blindly applying a borrowed template carries with it pitfalls often unnoticed and unrecognized by planners who then keep on wondering why things are not working the way they should. Failure to recognize and pinpoint seemingly unimportant characteristics and behavioral features of a culture could undermine any well laid long-range plan. Using a wrong template to achieve targets is like an ill-fitting dress with the wearer urging the body to bulk up or slim down quickly, and refusing to realize it is much more efficient to simply change the dress and move on from there.

Successful nations looked within themselves and, though aided by rigorous analysis of foreign models, were not shackled by them. This independence of mind has been amply demonstrated by countries like China. The economic rise of China is said to have broken known economic rules at that time. China created its own template which suited its own people and culture and thus lifted more than 800 million Chinese out of poverty[2]. In scientific manpower development, by 2016, China had the world's largest number of graduates in Science, Technology, Engineering, and Mathematics (STEM) with 4.7 million, followed by India's 2.6 million, and USA's 568,000 STEM graduates[3].

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The problem with imitation is that one is always two or three steps behind. The *East Asian Miracle* featured four Asian tigers (Taiwan, Singapore, South Korea, and Hong Kong) which experienced a rapid economic rise of more than 7% a year between the 1960's and 1990's[4]. Possessing a small market, the Asian tigers revved up their export policies in their own unique ways. Among other observations, academics at that time were wont to conclude that for a rapid high growth, a nation should be small enough – a characteristic shared by the four Asian tigers. However, the economic rise of China with 1.39 billion people changed the parameters of the game. China exhibited the fastest sustained growth with an annual real GDP averaging 9.6% starting in 1979 when they implemented free-market reforms up to 2016[5]. The apparent disadvantage of having a large population was turned into an advantage, validating the philosophical view that human resource is the most fundamental, the most precious, and the most important of all resources. From "*small is beautiful*" of the Asian tigers to the "*big is might*" of China, the model road to progress keeps on evolving. We can

[1] Parts prepared for an invited lecture at the *22nd Samahang Pisika ng Visayas at Mindanao (SPVM) National Physics Conference:* ***ConVIRTUALisation, October 2020.***

[2] World Bank, "China Overview", (2017); available at http://www.worldbank.org/en/country/china/overview

[3] N. McCarthy, "The Countries with the most STEM Graduates," https://www.industryweek.com/talent/article/21998889/the-countries-with-the-most-stem-graduates.

[4] https://en.wikipedia.org/wiki/Four_Asian_Tigers

[5] W. M. Morisson, "China's Economic Rise: History, Trends, Challenges, and Implications for the United States," CRS Report RL33534 (2019).

indeed learn from others, but if the Philippines really wants to be ahead of the curve, we should look deep within ourselves and chart our own destiny. Reliance on inner strength is also exemplified, for example, by the Vietnamese who looked and drew resilience from within thus defeating two superpowers in a couple of long drawn-out wars: with France (1946 – 1954) and the USA (1961 – 1975). Charting our own destiny becomes imperative when it comes to building up our nation's scientific manpower. Recognizing our strengths, weaknesses, and idiosyncrasies especially at the battlefront and the trenches will make us cognizant of the mismatches a borrowed Western template has with our colonial culture.

2. OBVIOUS ANSWERS THAT MORPH INTO A PARADOX

Templates that provide seemingly obvious answers to familiar situations could morph into paradoxes. Let us discuss five examples at different stages of a scientific manpower development program. The chain from high school to graduate school all the way up to a young scientist's career is replete with potential weak links and bottlenecks undermining any well-intentioned and well-written development plan.

PARADOX 1: Support for Philippine Science is Small, and yet the Department of Science and Technology Returns Money to the National Government

The Philippine Research and Development (R&D) expenditure for science hovers around 0.16% of the country's Gross Domestic Product (GDP)[6]. This is small compared to other countries such as the 0.53% of Vietnam, 1.94% of Singapore, and 4.81% of South Korea (see, Table 1 for selected countries).

Table 1: Funds spent to create new knowledge and its applications for selected countries.

COUNTRY	R & D Expenditure (% of GDP)[5]	Most Recent Year
ISRAEL	4.95	2018
SOUTH KOREA	4.81	2018
JAPAN	3.26	2018
GERMANY	3.09	2018
DENMARK	3.06	2018
USA	2.84	2018
CHINA	2.19	2018
SINGAPORE	1.94	2017
AUSTRALIA	1.87	2017
MALAYSIA	1.44	2016
THAILAND	1.00	2017
VIETNAM	0.53	2017
INDONESIA	0.23	2018
PHILIPPINES	0.16	2015

The Philippine science community has been clamoring for larger budget allocations based, for instance, on Table 1. Despite the small budget for R & D, however, it is not uncommon for the Department of Science and Technology (DOST) to return unused funds to the national government at the end of the year. This could be systemic in nature going beyond the administration term. Why are funds not fully utilized? There are several cited factors such as the schedule of yearly approval and release of government budget but this, perhaps, holds true for other Departments of the government. Does the science community lack the absorptive capacity for available funds? There appears, however, to be a lot of unfunded research projects submitted by Philippine researchers where the funds could have been committed. The claim is that many projects do not meet the criteria for scientific research funding.

HOBBLING THE ARMY

There are two temptations that plague research fund givers: (a) the first is structural in nature, and (b) the other is more personal. Giving in to these temptations often results in, for example, the DOST returning unused funds to the national government while, on the other side of the wall, scientists rally for more research funds. Let us look at possible causes of the apparent lack of fund-absorption capacity of the science community.

(a) STRUCTURAL: Right Template at The Wrong Time. It should be noted that Philippine science is still at its infancy. Applying the right template at the wrong time could be disastrous. Applying the procedures, techniques, and methods of a Formula 1 driver to a batch of student drivers is tantamount to hobbling an army. Research fund givers in the Philippines often fall into this trap forgetting that the bigger goal is to slowly elevate the research capability of Philippine researchers by giving them funding. Withholding funding because project proposals do not meet the standards of the US National Science Foundation (NSF) is applying a good template at the wrong time. This leads to more serious problems such as frustrated young idealistic science researchers who are starting to build their own laboratories. Oftentimes, they may have no track record because they may be building the first lab of its kind in the Philippines and they are building it from scratch. Also, Ph.D.'s who venture into research areas at the border of two disciplines may not also have a track record outside of their original discipline. Sadly, we have personally encountered well published researchers whose project proposals for government funding were either rejected or delayed for a year or even more. For us, at this stage of national development, we would rather immediately pour money into these research proposals as long as these are headed by a Ph.D. holder, and then fully assess them three years later provided a yearly, or biannual, financial report is given. Publications, patents, and research output have a long gestation period. Discovering the laws of nature or innovating a new technology are not done overnight.

Funding research in non-mature fields and technologies, funding big or small scientific meetings, are better in the long run than returning money to the national government. This, we believe, is a better template at this stage of development. Currently, one of the strongest internationally published institutes in the Philippines – the National Institute of Physics (NIP) in the University of the Philippines[7] – had humble beginnings as a small physics department with only four Ph.D.'s. Established in 1984, and with no Ph.D. in experimental physics in sight, one of the vibrant research groups of NIP during its first two years was essentially manned by masteral students. They were young, full of spirit, and succeeded in fabricating from scratch the first laser made in the Philippines. It was historical, but these M.S. students' project would not have received funding based on NSF level criteria since lasers were invented in 1960.

We should not forget that in the US, there are more researchers than available research funds, but the opposite is true in the Philippines where returning science funds to the national

[6] https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS.

[7] C. P. David and M. C. M. Geronia, "Insights on the Scientific Publications of the Faculty of the College of Science, UP Diliman: 1998-2017," *Science Diliman* **31** (2019) 68-81.

government is still a rather frequent affair. We need a template that allows us to fund our current developmental stage and not abort budding research endeavors. Definitely, Philippine researchers with excellent research track records should have a first crack at the budget and should be supported since we need them to hold the fort, move forward, and maintain the desired trajectory. We need, however, a flexible template that would engender attainment of a critical mass of R & D researchers in our country, and not dissipate the enthusiasm of those who are still starting to climb. In the end, our nation's ascent would depend on how much we are willing to lift others. How about excellence and quality assurance? Once maturity and a critical mass are attained outstripping available funds, the islands of excellence would naturally multiply in a world of journal impact factors and H-indices. By that time, the template would then have evolved.

(b) PERSONAL: Science in the Philippines is 99% Politics. Fresh from a successful stint as a scientist working with a Nobel laureate abroad, a friend of ours returned to the Philippines for good inspired by the EDSA revolution and change of administration. His first impression was embodied in this comment: "*Science in the Philippines is 99% politics*." It is a power play. This figurative assessment may no longer be *that true* after a few decades, but the vestiges still linger and always threaten to re-emerge with a vengeance. *The refereeing system and selection of referees for project proposals could be a weak link*. At this stage of development, we would rather that referees err on the generous side and take care of our small scientific community. Inevitably, our small scientific community would grow and mature to play a precious role. We believe in insulating our young researchers from too much politics and administrative work in searching for research funds. If a generous funding scheme could be institutionalized into a template, it would prevent a slide back to a science dominated by politics.

PARADOX 2: Decades of Extremely Costly Teacher Training and we still Lack STEM Teachers in Basic Education.

In 1998, the Philippine government implemented the project: Rescue Initiatives in Science Education (RISE). At that time, studies showed "*that 90% of secondary physics teachers are not physics majors and 80% of chemistry teachers are not chemistry majors. Only 1.5% are mathematics and science majors among the prospective teachers enrolled in Bachelor of Science in Education (BSE)*[8]." The exodus of Philippine teachers together with other skilled professionals to other countries, however, negated whatever training the Philippine government implemented (see, Figure 1). *The Philippines has literally been spending money to train teachers to solve the problems of other countries*.

An educational program that implements the traditional teacher-induced learning can only be as good as the teachers one employs. Hence, there has been a perennial mad rush to train teachers to handle millions of Philippine students in thousands of schools all over the country. The template employed for decades is to raise or borrow more money (in the order of hundreds of millions of dollars) to train more STEM teachers – our standard knee-jerk reaction. However, despite the huge amount of money, government loans, time, and effort on training teachers, especially in STEM, our apparent never-ending problem is still the lack of qualified teachers. The obvious answer may have morphed into a paradox. We keep on pushing the same button (see, Figure 1) hoping that a different result would come out.

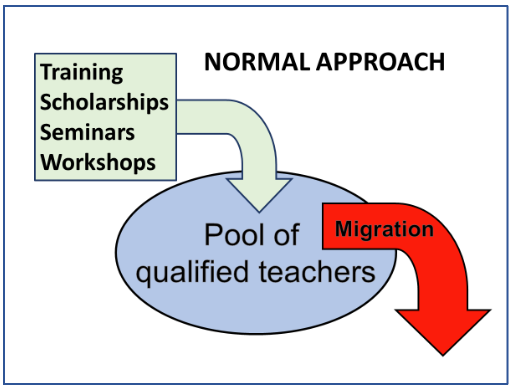

Figure 2: Decades of spending by the Philippines end up solving the problem of other countries: trained Philippine teachers in Basic Education migrate to other countries where there is also a dearth of qualified teachers.

A better strategy, therefore, is an educational program that is immune to teacher migration. This is what motivated us to design an educational program that could bypass the lack of qualified teachers in basic education. The CVIF Dynamic Learning Program (DLP) introduced in 2002 is a data-driven, evidence-based, systems approach to process-induced learning in contrast to teacher-induced learning[9]. It may be worth mentioning that in 2011, the CVIF-DLP was implemented in the DepEd Divisions of Bohol and Basilan in Mindanao. National Achievement Test as performance indicators are shown in Figures 2 and 3 for Bohol and Basilan, respectively. Figure 4 shows the Failure Rate recorded in the DepEd Division of Bohol for the same period.

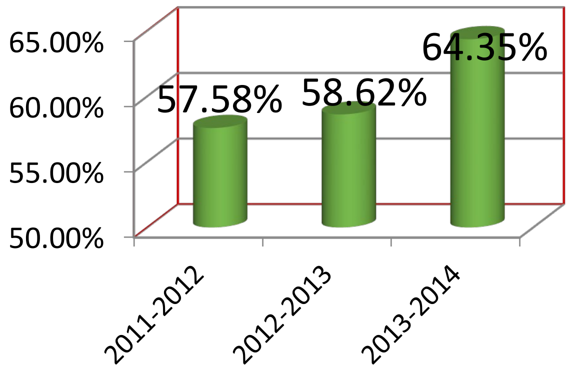

Figure 1: National Achievement Test results of 162 public high schools in the DepEd Division of Bohol after implementation of the CVIF-DLP in 2011.

[8] http://legacy.senate.gov.ph/lisdata/79787214!.pdf

[9] M. V. Carpio-Bernido and C. C. Bernido, "Science Culture and Education for Change, Part I: Innovative Strategies for Secondary Education in the Philippines," *Transactions of the National Academy of Science and Technology, Philippines* **26** (2004); "CVIF Dynamic Learning Program: A Systems Approach to Process-Induced Learning," in *Proc. of the epiSTEME 4* (2011, Mumbai:HBCSE), http://episteme4.hbcse.tifr.res.in/proceedings/strand-iii-curriculum-and-pedagogical-studies-in-stme/bernido-bernido.

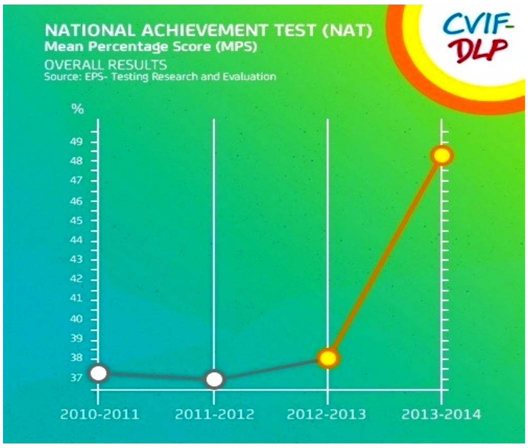

Figure 3: National Achievement Test results for 19 public high schools of the DepEd Division of Basilan, Mindanao, after implementation of the CVIF-DLP in 2011.

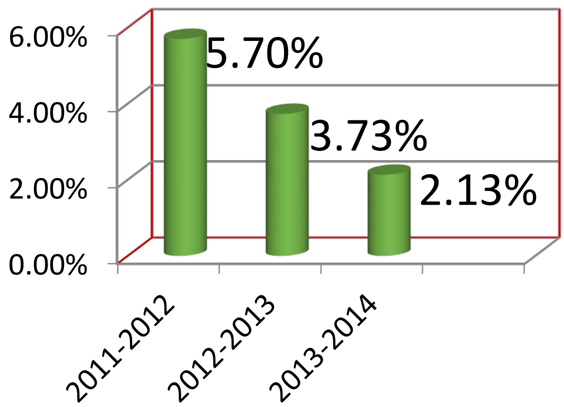

Figure 4: Failure rate of students decreased in the DepEd Division of Bohol after implementation of the CVIF-DLP in 2011.

The CVIF-DLP is also proving to be viable during pandemic situations where face-to-face interaction between students and teachers is prohibited to avoid the spread of infection. The program could also bypass the lack of Internet connectivity during a pandemic so that no learner is left behind[10].

PARADOX 3: Science High Schools – A Case of Big Input and Small Output?

With Philippine performance indicators showing that only 1% to 2% enter college to take science and engineering courses, exposing the younger generation to the world of science through exhibits, contests, multi-media is well and good. Moreover, many seem to agree that the High School stage is critical in developing scientific manpower. Elementary may be too early, and college is too late. It has been observed, however, that students attracted to and take up science courses in college soon shift out. Inspired to take up science or engineering, discouragement slowly filters in when they are unable to handle college math and science subjects. Their high school has not equipped them to tackle math and science subjects. This is among the reasons why science high schools are instituted. But has this obvious answer to the situation given us the desired result?

Consider the Philippine Science High School (PSHS) System which is the epitome of science high schools in the country. Established in 1964, there are now 16 PSHS campuses all over the country. The cost of high school education at PSHS is around PhP 250,000 per student per year (annual PSHS budget / number of students) which is much more than the cost of college education per year at Ateneo de Manila University or De La Salle University. The government budget for PSHS for 2020 is PhP 2.6 billion[11]. Although the Filipino people through the government spends for each PSHS student, a good number of them end up taking law, and other non-science subjects. Casual conversations point to the fact that it was the parents who decided that their child should go to PSHS, but the student had other interests outside of science. Entering PSHS at 12 or 13 years old, may be too early to pin down a child's interest and what the student plans to do with the rest of his or her life.

Of the PSHS graduates who did go to science and engineering, many end up pursuing their careers abroad. In determining where all the PSHS graduates have gone after more than half a century of government spending, the answers seem to be incomplete or vague. Perhaps, as a first approximation, we could learn from a quick survey of the College of Science and College of Engineering faculty of the University of the Philippines on whether they graduated from PSHS or not. A similar quick survey of the National Academy of Science and Technology (NAST) may also give an approximate assessment. If contributions by PSHS to the faculty of the top Philippine university, or the members of NAST, is comparable to any other private or public high school at far lesser cost to the Filipino people, maybe it is time to go back to the drawing board. This brings us to the question: is the PSHS system the right template to efficiently reach our targets given our minimal resources?

PARADOX 4: Bright M.S. students 'overstay' in graduate school.

In our drive to accelerate scientific manpower development, there may be serious bottlenecks that are below the radar screen. These are day-to-day issues that we may take for granted or have been desensitized to, but still needs to be addressed, no matter how painful for us.

GRADUATE SCHOOL ADVISING

For scholars of DOST, the prescribed period for masteral studies is two years. This is a rather typical time frame to get an M.S. degree, plus or minus one year. However, there have been cases of bright masteral students in the Philippines taking 5 to 7 years for their masteral studies[12]. This is alarming! These masteral students already have publications in international journals and yet they are somehow staying longer than the expected two years. This, of course, can be a student-owned problem, but it could also be an advisor-owned option. Some advisors' mindset is that graduate students are there to help the professor's career and implement their projects. Mentoring to enable graduate students to quickly build their own scientific career without further delay becomes secondary. There is always the temptation to keep longer under the advisor's wings the good, bright, and hardworking graduate students who can be relied on, and to forget that the student's graduation could be one of the best contributions of an advisor to the world of science and society at large. After a prolonged stay for masteral studies, students

[10] https://www.youtube.com/watch?v=jm_VAoWwDLU&feature=emb_title.

[11] https://www.pna.gov.ph/articles/1081129#:~:text=The%20DOST%20scholarship%20programs%20are,6%20billion

[12] See, also, C. P. David, "What does it take to finish your graduate degree?: Issues, Challenges and Recommendations to the UP College of Science Graduate Program," *Science Diliman* **23** (2011) 1-7.

may experience burnout and may no longer wish to pursue a Ph.D.. This would be a loss to Philippine science at a time when every Ph.D. counts.

The problem of prolonged stays of M.S. students may go beyond an advisor-owned option, and could be a template problem. Two tracks toward an M.S. degree could be institutionalized: (a) the Thesis option, or (b) a Non-thesis option. The Non-thesis option normally involves course work and passing a comprehensive examination which could be oral or written or both. Passing the examination automatically gives an M.S. degree. Publications at the M.S. level should be optional since this is a formula for unnecessarily delaying students. At the Ph.D. level, publications in international journals, however, should be a requirement to gauge the research capability of a student.

Another template to avoid burnout at the masteral level is a straight Ph.D. program. This is practiced by universities here and abroad. This means that selected B.S. graduates could enroll directly into a Ph.D. program where they could dive into course work, comprehensive exams, and do research for their publication and Ph.D. thesis. Picking up an M.S. diploma along the way would just be an option.

PARADOX 5: A Series of Education Reforms and We are still at the Bottom

Philippine basic education has undergone a series of reforms for the past four decades. From the 1973 Revised Secondary Education Program, there was the Education Act of 1982, then the 1989 Secondary Education Development Program (SEDP), followed by the 2002 Basic Education Curriculum (BEC), and a year later the Revised BEC, then the Enhanced Basic Education Act of 2013. Despite the reforms with billions of pesos in budget and loans for their implementation, the Philippines has been a cellar dweller in international standardized tests and examinations (see Table 1). In the 1996 Trends in International Math and Science Studies (TIMSS), the Philippines ranked 39 out of 42 nations. After more than two decades, in the 2018 Programme for International Student Assessment (PISA), the Philippines ranked 78 in Math and Science and number 79 in Reading out of 79 participating countries. For decades, the usual solutions of more textbooks, more teacher training, more lab equipment, more homework and advanced topics for students using the conventional type of teaching have generated a paradox. Once again, we kept on pushing the same button expecting a different result without a deep analysis of how learning is going on at the battlefront and trenches at the level of Philippine classrooms.

Table 2: Conventional teaching methods yield a consistent low performance for the Philippines in international student assessments.

YEAR	INTERNATIONAL ASSESSMENT	RANK OF PHILIPPINES	NUMBER OF PARTICIPANTS
1996	**TIMSS** (*Trends in International Math and Science Studies*)	39	42 Nations
2000	TIMSS	36	38 Nations
2003	TIMSS	42	45 Nations
2018	**PISA** (*Programme for International Student Assessment*)	**78:** *Math and Science* **79:** *Reading*	79 Nations

Is lack of funding the problem? Money is always a standard excuse for any project that falls short of expectations. Let us look, therefore, at the highly selective Philippine Science High School which attracts the *crème de la crème* of students in the Philippines. The PSHS, one might say, is not short of funds allotted for each student (refer to Paradox 3). In the 2003 TIMSS, however, the performance of PSHS students in Science was *below* the international mean. In Math, the PSHS students scored a little above the international average, but still below the average performance of top-performing countries like Singapore. The country did not join the 2007 TIMSS, but in 2008, there was a TIMSS Advanced Math where the Philippines was represented by PSHS students. Here, we ranked last, placing 10th out of 10 participating countries (see, Table 3). The score of the Philippines compared with the 9th placer also tells a story. The essential problem of PSHS is not funding, but structural in nature which deserves a separate serious discussion.

Table 3: Ranking of the 10 participating countries in the 2008 TIMSS Advanced Math where the Philippines was represented by PSHS students.

ADVANCED MATHEMATICS ACHIEVEMENT Average Scale Score	
RUSSIAN FEDERATION	561
NETHERLANDS	552
LEBANON	545
TIMSS Advanced Scale Average	500
IRAN, ISLAMIC REP. OF	497
SLOVENIA	457
ITALY	449
NORWAY	439
ARMENIA	433
SWEDEN	412
PHILIPPINES	355

Although several graduates of the PSHS moved on to Princeton University, Harvard University, the Massachusetts Institute of Technology, and other top universities in the world, nation building has a different prerequisite. We should not lose sight of the fact that "*the problem of basic education is not really about developing an elite that can be showcased: it is about improving the lives of many who, for better or worse, are relegated to the public school system*" [13]. The Philippines draws the next generation of scientists from a large pool of roughly 27 million students in basic education[14] – a number five times the total population of Singapore. As Tables 2 and 3 reveal, however, we apparently could not get our act together. For instance, we have gone from a spiral curriculum a few decades ago, and then went disciplinal or linear due to poor outcomes, but back again to a spiral curriculum for the new K-12 curriculum, with legislation encoding the spiral progression in Republic Act 10533. There is, indeed, a crying need for solutions to clear and present problems. But this can only be done by identifying paradoxes borne out of standard templates that do not match our culture and temperament, and worse, not based on data analytics.

3. DISCRETIZING A COMPLEX PROCESS

A complex process can be divided into many smaller and simpler steps. In solving multifold problems, one can then opt to focus on component problems that pop up in any of the smaller steps. Macrodiscretization of the STEM human resource development is composed of several stages which may be viewed as shown in Figure 5. Macrodiscretization would then be at the level of gross graining of the education and training ladder. Microdiscretization, on the other hand, is at the level of the curriculum down to the daily learning activities at all grade/year levels in all subjects (e.g., in the CVIF-DLP way). It is then

[13] Philippine Human Development Report (2000).

[14] Based on data of the Philippine Statistics Authority.

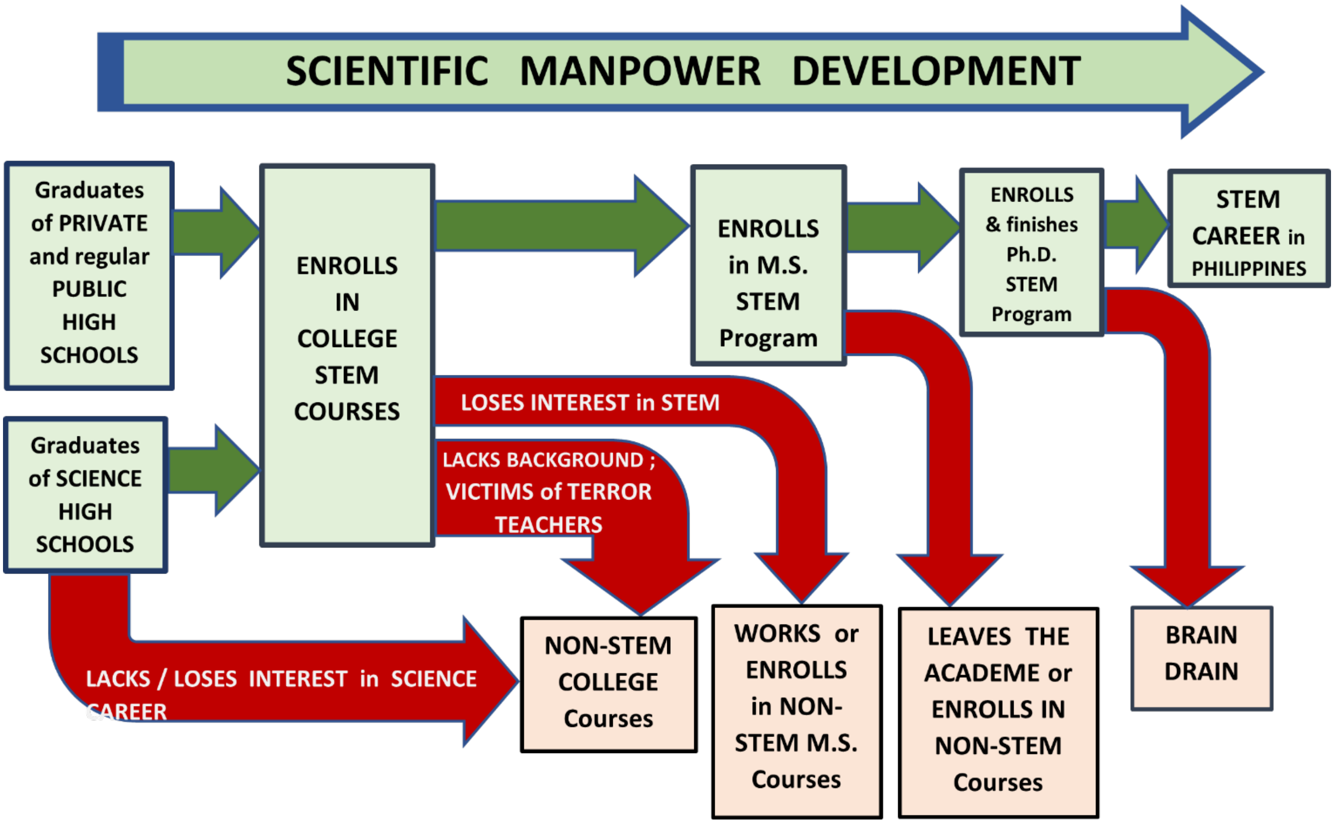

Figure 5: In accelerating scientific manpower development, the green arrows should be enhanced, and the red arrows minimized.

easier to check if an obvious answer has morphed into a paradox since a discretized unit always has an expected outcome.

In Figure 5, the target is for the green arrows to be enhanced and the red arrows minimized by implementable projects and programs with measurable outcomes. For example, the last red arrow on the right is partially remedied by the *Balik-Scientist* Program of DOST where Philippine scientists can interact with foreign based scientists[15]. Aside from international publications catalyzed by the *Balik-Scientist* program, an offshoot such as the collaborative *Versatile Instrumentation System for Science Education and Research Laboratory* (VISSER Lab) [16] has benefited the Philippine educational system. Moreover, the program has also facilitated the resettling of some scientists back in their motherland.

To reverse brain drain, a commendable template at the university level is exemplified by the *Balik Ph.D.* Recruitment Program of the University of the Philippines (UP)[17]. Under the Program, UP hires foreign-trained Ph.D.'s or postdoctoral fellows as faculty members together with a start-up research grant of PhP 2.5 million, and a relocation package of PhP 500,000. Moreover, the new Ph.D. recruit receives an additional start-up foreign research collaboration grant of PhP 1.0 million which "*will be used primarily to support a foreign postdoctoral fellow from the foreign collaborator's laboratory to spend 4 to 6 months in the Balik-PhD's laboratory to help establish the Balik-PhD in his/her various research activities*"[15]. Under the collaboration grant, counterpart funding by the foreign collaborator is to be indicated for the joint project. We may note that UP has also risen in the world-wide university rankings the past few years.

4. A HUB IN THE SOUTH

The College of Science and Mathematics (CSM) of Mindanao State University-Iligan Institute of Technology (MSU-IIT) is an active science hub in southern Philippines. We are most familiar with its Physics Department whose experience is worth noting. In the 1990's, there were only 2 Ph.D.'s in the department, both graduates from US universities. By now, there are 15 Ph.D.'s in the Physics Department, 12 of whom obtained their doctoral degrees from abroad as follows: Japan (5), France (4), New Zealand (1), Taiwan (1), and USA (1). This exponential growth will soon be augmented by several others who are still on study leave abroad.

AN EMERGING TEMPLATE

The MSU-IIT learned early from its mistake when an internationally multi-awarded young physics Ph.D. who did postdoctoral work on nanophotonics at the prestigious Cavendish Laboratory, Cambridge University, returned to Iligan. The returning Ph.D. got stuck in the Instructor position because of an outdated faculty ranking policy of MSU-IIT. The salary may be low but failing to give value to one's academic background was the last straw and MSU-IIT lost this young faculty. The faculty ranking policy of MSU-IIT has now been amended, with special emphasis on international publications, which may be responsible for the recent climb in the number of Ph.D.'s at the physics department.

For returning Ph.D.'s, the infrastructure to support one's research also serves as a magnet. In December 2016, MSU-IIT inaugurated its *Premier Research Institute of Science and Mathematics* (PRISM) which is mandated to "*facilitate and strengthen interdisciplinary collaboration among researchers in*

[15] https://bspms.dost.gov.ph/home3/awardees2?yr=0&selexp=25&selname=undefined

[16] https://upd.edu.ph/science-kit-for-stem-students-developed/

[17] https://ovpaa.up.edu.ph/balik-phd-recruitment-program/

various fields of Sciences, Mathematics, and allied fields"[18]. With support from the Commission on Higher Education (CHED), the new five-story building of PRISM was designed to house all the research laboratories of CSM to encourage collaboration between existing research groups from different disciplines. Of course, buildings are not enough, but they have also started to publish in reputable international journals. Aside from the usual government partners such as DOST, the Department of Health, and CHED, the PRISM has also partnered with UNILAB which is one of the leading private pharmaceutical companies in the Philippines. External funding for PRISM projects has also been received from Japan and UNESCO.

In 2017, the MSU-IIT also established the Knowledge and Technology Transfer Office (KTTO) which is "*dedicated to the professional management of the movement of technology generated inside the Institute through its research and innovation activities to its partners in the industry*"[19]. The Director of KTTO obtained his Ph.D. from Japan and has also been the head of the Materials Science Laboratory of the Department of Physics. In October 2019, the KTTO inaugurated its new three-story building.

The importance of the Physics Department at MSU-IIT as an emerging template acquires further significance in view of its location far from the traditionally dominant universities in Metro-Manila. Products of the Physics graduate program of MSU-IIT are now providing much needed faculty to other Mindanao universities such as the Western Mindanao State University in Zamboanga, Ateneo de Davao, and some universities in the Visayas.

It may be difficult to have a one-size-fits-all template as one goes from one locality to another. A template, however, possesses coarse-grained as well as finer features. Applicability of a template at the coarse-grained level may be possible and adjustments to suit the peculiarities of another system may have to be made. For instance, there are intangible factors involved in the case of the Physics Department of MSU-IIT such as their nurturing atmosphere. Whether this budding template at MSU-IIT could be sustained and strengthened is in the hands of the next generation.

5. SAIL INTO THE OPEN SEA

There is always a risk that when we dig deep into a problem, we might not like what we see. It then becomes difficult to go out of our comfort zone and we would rather resort to standard answers to familiar situations even if these failed for decades to give the desired results. It would be good to remember, however, that assessing the functional cost of a program should always be in the context of whether the expected output is attained or not. For us, a peso saved from an efficient endeavor could always benefit other important sectors such as Health since many public hospital beds are still being shared by two or even four patients, and in Social Welfare for the homeless, those with disabilities, and the millions who live in squalor and conditions of abject poverty in urban and rural areas. The stakes are high for our country and there lurk behind the shadows other unmentioned paradoxes. "*It is important not only to be moving, but to be moving in the right direction; not only to be doing something well, but to be doing something worthwhile*"[20]. Stepping back, looking within no matter how painful, and unraveling the paradoxes might require us to have a new mindset and take the road less travelled. New insights should translate into new templates and paradigms, even as we draw insights from the old. It takes courage and sacrifice to sail into the open sea of independent thinking and not hug the coastline of conventional approaches. Indeed, this is what other successful advanced countries have done to get ahead of the curve.

EPILOGUE AND ACKNOWLEDGEMENTS

This manuscript consolidates an evolving thought geared toward data-driven analysis and assessment of Philippine STEM HRD conditions [21,21]. Our target, shared with other groups in collaborative effort, is to come up with a viable, workable plan of action – promising positive measurable outcomes initially catching up with our ASEAN neighbors within 5 to 7 years in education, research, development, and industrial capabilities. We are contributing our personal perspectives and experiences in the educational frontline and trenches – basic education, college, and graduate school physics thesis advising – the endeavors we are currently involved in. We are happy to join efforts of colleagues in STEM, do the work and go the distance until the good numbers rise and bad numbers fall.

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