AN INQUIRY INTO THE IMPORTANCE OF THE LINK BETWEEN PHILIPPINE INDUSTRIAL POLICY AND THE HIGH SCHOOL STEM TRACK

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Abstract

This paper is an initial attempt to emphasize the imperative of the link between the country's industrial policy and the secondary education's Science, Technology, Engineering, Mathematics or STEM track as necessary for Philippine economic development. Such interconnection reveals why there is a job-skills mismatch between STEM track graduates and actual industry needs. This study utilized comparative content analysis of curricula by juxtaposing the country's high school STEM track with those of industrialized and economically developed countries (e.g. South Korea, India, Japan) secondary education curricula. Initial results show that the secondary education curricula in more developed countries embed actual theoretical and practical skills as required per sector (e.g. in South Korea's curriculum, there is a foundational course on Industrial Chemistry and a practical course on Chemical Materials Management, Maintenance and Operation of Chemical Processes, Plastic Products Manufacturing, etc. for those who want to specialize in Chemical Engineering) as compared with the Philippines' high school STEM curriculum which is relatively broad and not sector- or industry-specific. Also, industrialized countries' secondary education curricula are more advanced in terms of topical coverage and competencies (e.g. a stand-alone subject on artificial intelligence in the curriculum of India), making Filipino STEM track graduates below par. This comparative conceptual exploration will provide policy recommendations on how the Philippines' high school STEM curricula can be improved as well as other related policy insights that link education with economic development.

Keywords: jobs-skills mismatch, high school STEM curriculum, applied science, curriculum co-creation, industrialization strategy

Introduction

The K to12 curriculum that was implemented by the Department of Education in 2013 was a major reform in basic education in the Philippines because this included adding years of schooling, extending the years of basic education to Years 11 and 12 - which contains the apprenticeship dimension of the curriculum, hence, making high school graduates employable (Japan International Cooperation Agency (JICA), 2017). Another main thrust of the K to 12 curriculum was primarily on curricular changes, with much focus on the mother tongue-based multi-lingual education delivery during the elementary levels, and with the "spiral" science curriculum in the junior secondary level. This also placed K to 12 graduates at par with their global counterparts, since the global curriculum is also K to 12 (JICA, 2017).

Through the years of the curriculum's implementation, it has been observed, however, that K to 12 graduates are not meeting industry expectations according to the private sector, rendering them unprepared and/or unemployable (Valencia, 2019). It defeats the purpose of the main aim of the 2013 curriculum reform, which is to produce high school graduates who are job-ready. Such feedback recently expedited reforms in the curriculum, with the Department of Education currently pilot-testing a new curriculum that reverted to the K to 10 curriculum structure, among other curriculum changes (Ombay, 2023). It is also interesting to note that the Years 11 and 12 were removed. Thus, the Work Immersion or Apprenticeship component is deleted from the new curriculum being pilot-tested.

This paper will seek to bring back the imperative of the Years 11 and 12, with a focus on the field of STEM as it interrelates with the industrial development plans and policies of the current administration. This research will also bring to the fore, the importance of pursuing a state-supported industrial strategy as the primordial means towards the country's economic development, coupled with manpower forecasting and secondary education STEM curriculum co-creation (school and industry), based on the best practices of industrialized and economically developed countries. In particular, this comparative curricular and conceptual exploration seeks to address the current jobs-skills mismatch in the Philippine K to 12 Curriculum, by creating an eclectic conceptual framework guided by concepts in applied science, economics, and education.

Methods

This study utilized a comparative qualitative content analysis of existing literature on applied science, economics, and education in relation to scrutinizing the Philippines' secondary education STEM curriculum vis-à-vis the high school STEM curriculum of industrialized and economically developed countries. Purposive sampling of online and publicly available documents was undertaken with the following inclusion criteria: 1) high school STEM curriculum from Western and Asian countries that are industrialized and economically developed. Specifically, the secondary education STEM curriculum of the United States, South Korea, Japan and India., 2) high school STEM curriculum of the Philippines, 3) literature on the link between education and economic development, 4) literature on manpower forecasting, 5) literature on the link between industrial development and applied science concepts in high school STEM curricula, and 6) literature on the link between co-located schools and/or universities and industries in relation to regional development. Figure 1 shows the methodological framework or the order through which various literature were compared and analyzed.

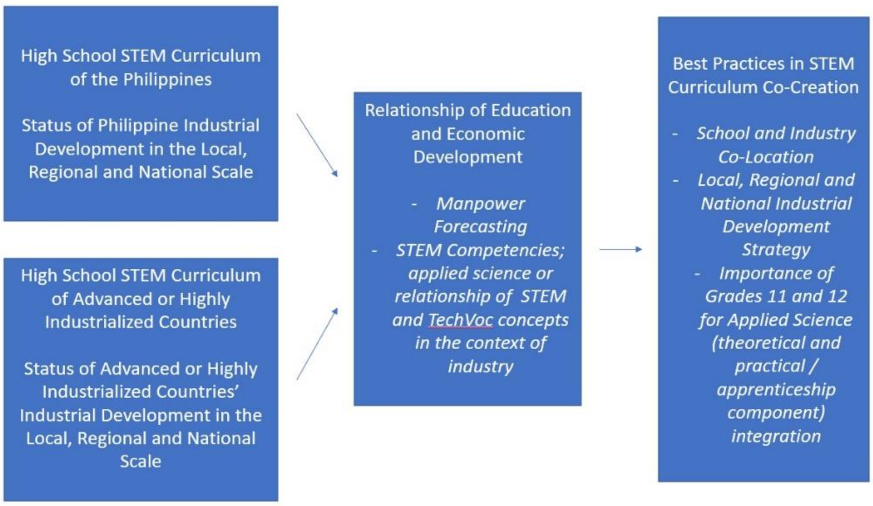

Figure 1. *Methodological Framework*

Results and Discussion

The Relationship of Education and Economic Development

Education helps generate greater productivity and economic growth. Also, education has spillover effects: a more educated workforce fosters innovative ideas which leads to more and better jobs. And most importantly, it results to social mobility (Organization for Economic Cooperation and Development (OECD), 2022). "Given the country's (Philippines) entrenched high levels of inequality, education is the single most important policy tool to redress deep-seated inequities" (Clarete, Esguerra and Hill, 2018, p. 11).

It was in the 20^{th} century that the acquisition of knowledge, skills and education became important in determining a person's per capita income and an entire nation's productive capacity. Aptly called the "Age of Human Capital," economic development called for the successful utilization of the knowledge and skills of its population through education in order to raise quality of life and forward health outcomes (Ozturk, 2001). Such move involved increasing access to secondary and higher education as well as improving the quality of education for all levels. To educate women and girls is a necessary investment in a developing country because it will result to benefits for families such as better family health and nutrition, better birth spacing, lower infant and child deaths, and improved educational outcomes of children (Ozturk, 2001).

Human capital investment can only benefit economic growth if people can utilize their education in competitive and open markets (Ozturk, 2001). Larger and more competitive markets can bring about greater possibilities for using one's skills and education. It was in the 1960s that evidenced-based research showed how investment in human capital, most especially education, contributed to the economic growth of Western countries (Ozturk, 2001).

There are many research inquiries which show that increases in earnings are associated to additional years of education, with the rate of return varying with high level of education (Behrman, 1990, Psacharopoulos, 1994 in Ozturk, 2001). Also, the returns to primary schooling seems to be greater than the returns to secondary and tertiary education (Psacharopoulos, 1994, pp. 1325-45 in Ozturk, 2001). In Thailand, farmers with four or more years of schooling were three times more likely to adopt fertilizer and other modern inputs than less educated farmers (Birdsall, 1993, pp. 75-79 in Ozturk, 2001). Also in Nepal, the completion of at least seven years of schooling increased productivity in wheat by over a quarter, and in rice by 13% (Jamison and Moock, 1994, p. 13 in Ozturk, 2001). Education is also an important contributor to technological capability and technical change in industry. In the case of Sri Lanka, statistical indicators on the clothing and engineering industries showed that the skill and education levels of workers and entrepreneurs were positively related to the rate of technical change of the firm (Deraniyagala, 1995 in Ozturk, 2001).

There are other factors to consider in terms of looking at the effect of education on economic development. For instance, the quantity and quality of investment, domestic and foreign, as well as the policy context in the country and the interplay of market forces can affect economic growth (Ozturk, 2001). Still, human capital investment has an impact on such factors. The quality of the policies that are crafted and the investment priorities are heavily shaped by the education of the policy makers and implementors. Furthermore, the amount of foreign and domestic investment is expected to be larger if the population of available human resources are also large (Ozturk, 2001).

If we are going to utilize a macro-economic perspective, ‘new growth theories’ sought to endogenize technical advancement by incorporating some of these same effects, giving emphasis to education, learning and research and development (R&D). For instance, the higher the level of education of the labor force, the higher the overall capital productivity will be due to the presence of the more educated who are more likely to introduce innovations, which will subsequently have an effect on the productivity of the other members of the labor force (Lucas, 1998 in Ozturk, 2001). Other ‘new growth models’ show that a similar externality is an outcome of the increased education of people which raises not only their own productivity, but also other people that they interact with, so that total productivity rises as the average level of education becomes higher (Perotti, 1993 in Ozturk, 2001). Furthermore, the benefit of education on the nature and trajectory of exports is also another way through which human capital investment results to better macroeconomic outcomes. A developing country’s work force, specifically its education and skills, has an effect on the nature of its factor endowment and consequently its trade composition. Moreso, even ‘unskilled’ factory workers in a modern plant will need the necessary discipline and skills in literacy and numeracy that are a large chunk of the learnings in the primary and lower secondary school levels (Wood, 1994 in Ozturk, 2001).

The Philippines Lacks Industrial Maturity

The country's exposure to globalization revealed the inefficiencies of its industries or its slow industrialization (Miranda, Jr., 1999; Usui, 2011). The Philippines is heavily reliant on Overseas Filipino Worker (OFW) remittances and the service sector. Just recently, the country's economic model led by the services sector and OFW remittances didn't do well during the COVID-19 pandemic. The Philippines' economic growth faltered in 2020 – it entered a negative dimension for the first time since 1999 – and the country suffered from one of the deepest contractions in the Association of Southeast Asian Nations (ASEAN) during that year (Mendoza, 2021). Hence, there is an imperative for the government to find new sources of growth following the economic scarring inflicted by the pandemic, according to the Philippine Institute for Development Studies or PIDS (Jocson, 2023).

The country currently relies heavily from steel imports for most of its infrastructure projects. Also, even its first Philippine-branded mobile phone, Cherry Mobile, relies on manufacturing plants located in China for the production of its parts (Louie, 2016). It is good news that SteelAsia Manufacturing Corp., the country's largest steel manufacturer, exported more than 36,000 metric tons of high-quality steel bars to Canada for use in its infrastructure projects (SteelAsia, 2023), although there are existing steel firms that are still producing low quality steel bars that prompted a recent crackdown on its manufacturers (DTI, 2023; Monzon, 2023).

Macroeconomic Policy of Industrially Advanced and Economically Developed Countries in Relation to Regional Development: Co-Location of Industries and Educational Institutions

"Increase in industrial output is an important indicator to identify the socio-economic development of a nation" (Sankaran, Vadivel and Jamal, 2020, p. 1). Hence, it is important to take a look at how industrially advanced and economically developed countries shaped the macroeconomic policy in relation to regional economic policy. Historically and at the macroeconomic level, the US government has prioritized industrial development and continuous funding for research and development which makes the country a world leader in innovation. At the microeconomic level, this macro policy is evident in the co-location of industries and higher education institutions, with basic education schools also locating nearby. Zeroing in on the Silicon Valley experience, its tradition of entrepreneurship and research is part of the larger picture of the founding and existence of Stanford University and the influx of entrepreneurs who profited from the California Gold Rush during the mid-1800s and the increase in trading with East Asia (Athanasia, 2022). Pique, Berbegal-Mirabent and Etzkowitz (2018) further characterizes the importance of the Sillicon Valley in regional development through the Triple Helix Model (Leydesdorff and Etzkowitz, 1996 in Pique, Berbegal-Mirabent and Etzkowitz, 2018). This model assumes that institutions in a knowledge-based society can be described as becoming increasingly interrelated, specifically the public and private sector, science and technology, and university and industry, which results to a system of overlapping collaborations: "(a) industry operates as the center of production; (b) government acts as the source of contractual relations that guarantee stable interaction and exchange; and (c) universities are the source of new knowledge and technology. Moreover, each sphere, while retaining its primary role and identity; "takes the role of the other," for example, universities take the role of industry in supporting start-up creation in incubator and accelerator projects" (Leydesdorff and Etzkowitz, 1996 in Pique, Berbegal-Mirabent and Etzkowitz, 2018, p. 5).

The overarching frame of Japan's macroeconomic policy was "translative adaptation" – Maegawa Keiji (1998) "argues that the country should take initiative in deciding the scope and speed of integration, making sure that it can retain ownership (national autonomy), social continuity and national identity. The country surely changes, but the change is managed by its government and people and not by foreign firms or international organizations. Foreign ideas and systems are introduced not in the original form but with modifications to fit local needs and context….it is taking advantage of external stimuli to change and grow" (Keiji, 1998 in Ohno, 2018, pp. 6-7). Since the Meiji restoration period, Japan's economic development has been sustainable. During this milieu, the "Zaibatsu," a group of very wealthy entrepreneurs, cooperated with the Meiji government. The Zaibatsus led the industrial development of Japan (Rahardi, Handayni and Sumarjono, 2018). Educational institutions and industries are also co-located in particular areas or prefectures. Moreover, the automobile industry's assemblers and primary suppliers are closely located (Lin, 1994, p. 19). The automobile industry is historically regionally concentrated in the following areas: Tokyo's urban area and the Aichi Prefecture, but recent investments are regionally planned in new locations (Lin, 1994, p. 19).

In the case of South Korea, the government's macroeconomic policy supported large conglomerates or "Chaebols." Chaebols were supported by the SK government through different means, "through providing de facto preferential access to credit, explicit and implicit bailout guarantees, and limiting competition from independent domestic and foreign direct investors" (Chang, 2003 in Aghion, Guriev and Jo, 2020, p. 2). Also, reforms were undertaken - inefficient Chaebols were restructured and hindrances to the entry of non-chaebol firms and foreign investors were removed. This resulted to the opening up of the economy for competition and also helped the economy grow based on innovation. Moreover, the country has overtaken Germany in terms of United States patents applications since 2012 and has 30% more patent applications in 2015 to the United States Patent and Trademark Office than Germany (Aghion, Guriev and Jo, 2020, p. 2). In this connection, the regional policies of the government during the 1960s and 70s sought to create centers of development that promotes industrialization through "intensive regional development" (Lee, 2014 and Korea Research Institute for Human Settlements (KRIHS), 2013 in Kim and Lim, 2016, p. 3). "Industrial complexes in Seoul, Incheon and Ulsan supported increase in industrial production and numerous Social Overhead Capital (SOC) projects came in place to build roads, dams, ports, electricity systems, etc. (Ministry of Land, Infrastructure and Transport (MOLIT), 2014 in Kim and Lim, 2016, p. 3). Such projects also necessitated the establishment of schools and universities in the same regions.

The industrial development of India after independence can be characterized as strategic in terms of economic planning (e.g. Five Year Plans) that includes allocation of scarce resources to priority industries (e.g. investment licensing), protection of new industries from import competition, and price controls, among others (Battacharjea, 2022). In the case of Bengaluru (Bangalore), historically, the progressive elites in the locality focused on the industrialization and the development of quality education in their area. During the nineteenth century, major projects on hydroelectric energy, irrigation and industries such as the Bhadravati Iron Works were established (Kar, 2016).

Manpower Forecasting and STEM Competencies

"The use of modern technology in a more industrialized society is useless if there were no available manpower that possess the required skills to operate them. Moreover, the supply of qualified manpower will not be utilized effectively without the appropriate technology that matches them. Changing technology along with rising capital-intensity that accompanies growth requires adjustment of manpower patterns to maximize production. Thus, the development of technical manpower becomes an important component of manpower planning" (Miranda, Jr.,1994, pp. 164-165). Manpower forecasting necessitates the need for a standard nomenclature for occupational categories and actual industry skills as used in the private and public sector (Miranda, Jr., 1994; Agency for International Development, 1966) so that these can be directly embedded in the high school STEM (and Technical-Vocational Education and Training (TVET); and other strands/tracks as well) curriculum with the matching skillset and job description as juxtaposed with the competency and subject taught. In the United States, STEM competencies are listed in relation to skills and knowledge which are based on a detailed occupational database of current workers called Occupational Information Network or O*NET (Carnevale et al., 2011 in Siekmann and Korbel, 2016, p. 23). Below is Table 1 which contains such list:

Table 1. *Cognitive STEM Competencies*

Knowledge	Skills	Abilities
Production and processing	Mathematics	Problem sensitivity
Computers and electronics	Science	Deductive reasoning
Engineering and technology	Critical thinking	Inductive reasoning
Design	Active learning	Mathematical reasoning
Building construction	Complex problem-solving	Number facility
Mechanical	Operations analysis	Perceptual speed
Mathematics	Technology design	Control precision
Physics	Equipment Selection	
Chemistry	Programming	
Biology	Quality control analysis	
	Operations monitoring	
	Operation and control	
	Equipment maintenance	
	Troubleshooting	
	Repairing	
	Systems analysis	

Source: *Carnevale et al., 2011 in Siekmann and Korbel, 2016, p. 23*

A similar or more detailed database that pertains to the actual and specific operational contexts of knowledge, skills and abilities as juxtaposed with an occupational job description of current job openings in STEM in the Philippines can be created as part of manpower forecasting. It basically resonates the operationalization of applied science.

Job-Skills Mismatch: Zeroing in on the High School STEM curriculum of the Philippines

A highly important JICA (2017) research unearthed the skills gap and skills mismatch among basic education graduates, higher education outcomes, techvoc education and those that are in-demand in industries. The most common reasons that describe the unemployment of new graduates of secondary education, colleges/universities and technical-vocational schools are the following (JICA, 2017, pp. 45-46):

"a) Lack of academic competencies of an average graduate

b) Lack of technical/specialized skills of an average graduate

c) An oversupply of graduates in several fields and/or a shortage of employment opportunities in their field of specialization

d) Lack of information for both job seekers and employers

f) Entry-level position may pay wages lower than what the graduates are expecting

g) Job vacancies are not suitable for the graduate competencies (Some of the domestic industries are not fully developed yet.)

h) High school students (of 10-year basic education) were 16 years old at their graduation, which did not reach to the legal age of an adult in the Philippines, i.e., 18 years old. This 2-year gap was the biggest cause of high unemployment rate among high school graduates who did not go to universities or TVET (JICA, 2017, pp. 45-46)."

One way to solve this mismatch is for industry and school to co-create the high school curriculum that is structured according to a K to 12 structure so that once the student graduates from high school, he/she is already employable.

The Current High School STEM Curriculum of the Philippines and Why Present Initiatives int the Country to Address the Job-Skills Mismatch are Not Sufficient

Much of the research on the Philippine STEM curricula delved on the successes and challenges in STEM learning (Estonanto, 2017; Dacumos, 2021; Rogayan, Rafayan and de Guzman, 2021; Paderna and Monterola, 2022; Locion et al., 2022; Beruin, 2022; Tablatin, Casano and Rodrigo, 2023). It is interesting to highlight a study by Galang (2022), wherein it was found that there was a significant relationship between students' English language proficiency and achievement in STEM strands. There are also inquiries on assessment outcomes of K to 12 students including those in the STEM-track (Almerino, Jr. et al., 2020), as well as the paradigm that will guide the curriculum (Morales, 2017; Pacala, 2023). There are also studies that looked into the factors affecting the pursuance of a STEM career after senior high school (Tondo and Detecio, 2021; Rafanan, de Guzman and Rogayan, 2020; DOST-SEI, 2022). It is interesting to cite a recent tracer study by Domanais, Jr. and Quiapon (2022), wherein they found that most senior high school STEM-track graduates pursue higher education.

On the part of STEM teacher education, most studies focused on proposing a framework or approach for teaching science education (Morales et al., 2022; Aksan, 2021), the integration of technology in higher teacher STEM education and higher education STEM pedagogy (Morales et al., 2019; Morales et al., 2022; Kim and Saldana, 2023) and the importance of professional development of STEM teachers (Morales et al., 2019; Morales et al., 2021). There are also studies exploring what affects STEM teaching in a laboratory context (Arnado et al., 2022) and assessment practices in higher Science, Technology, Engineering, Arts and Mathematics (STEAM) education (Sarmiento et al., 2020; Lampara, 2022). Yet the US National Science Foundation encourages research inquiries on STEM education innovation from pre-K through post-doctoral experiences (NSF, 2020).

The current high school STEM curriculum of the Philippines is too theoretical or there is too much emphasis on the pure/basic sciences. For instance, chemistry is taught, but not its actual application in industry such as industrial chemistry, polymer chemistry, forensic science, etc. Also, physics is taught, but not as contextualized in atmospheric physics, accelerator physics, biophysics, etc.

Moreover, mathematics is taught, but not mathematical programming or integer programming, mathematical applications to logistics, supply-chain optimization, etc. Biology is taught, but not its actual and specific real job/work applications in biometrics, marine biology, biotechnology, etc. If we will also look at the K to 12 STEM curriculum of science high schools (e.g. Philippine Science High School), though there are attempts to simulate a co-created curriculum (school and industry), the initiatives are still lacking because the science specializations are still clustered into broad categories of Engineering, Biology, etc. and are not taught according to its applied sciences and/or actual industry or operational contexts as mentioned above. Similarly, in terms of the practical or work immersion (apprenticeship) side of learning, the Philippine secondary education curriculum has no practical courses or actual job immersion engagement in the context of an applied science as practiced in actual industry or in real job/occupation (e.g. no apprenticeship in industrial chemistry plants, biotechnology laboratories, logistics companies, automotive plants). Hence, the Philippine secondary education STEM curriculum is below par if compared with those of industrialized and economically developed countries' high school curricula.

In terms of present initiatives in the country to address the job-skills mismatch, Dualtech has been engaged in upgrading the skills of 12th grade graduates by partnering with industries, but this is only limited mostly to those who took the TVET track and are to be employed in Dualtech's partner companies (Dualtech, 2022). There are also industrial workers who are sent by their companies for skills upgrading and there are those who are in the supervisory position as well as engineers who need further training and mentoring skills with primary focus on work values (Dualtech, 2022). A study by Tupas and Matsuura (2019) in the context of the Northern Iloilo State Polytechnic College found that the college's bridging program for STEM high school graduates pursuing STEM college courses was a waste of resources (time, effort and money). In terms of curriculum co-creation, UNILAB Philippines is at the forefront of working closely with educators to address job-skills mismatch most especially in STEM (The United Laboratories, Inc. or UNILAB Foundation, n.d.), but efforts are still limited in a micro scale.

Best Practices in the Co-Creation of the Secondary Education STEM Curriculum by Co-Located Schools and Industries in Industrially Advanced and Economically Developed Countries

What is more crucial is the STEM career readiness at the secondary education or high school level, since this is the level that will lay the basics and fundamentals for a STEM career path and/or enable them to find a job right after graduating from high school. For instance in the United States, specifically in North Carolina, the state partnered with an aerospace company for actual hands-on experiences of students in their plant/laboratories (STEM East, n.d.). Also, in Arkansas, a coalition of industry, business institutions and middle schools and other related organizations is also thriving in STEM curriculum integration. For example, Walmart's Arkansas Initiative for Million Women Mentors is engaging 5,000 Arkansas STEM mentors to increase the interest and confidence of girls and women to persist and succeed in STEM programs and careers (Arkansas STEM Coalition, n.d.). Moreover, a Research and Development or RAND research on Ohio, Pennsylvania and West Virginia's co-creation of a middle-skills curriculum shows the usefulness of training for middle skills jobs – requires specialized education beyond high school but not a four-year college degree (Gonzalez, Doss, Kaufman and Bozick, 2019). These three states are known for the Utica and Marcellus shale plays which are the country's largest natural gas reserves. Thus, the RAND study was conducted to find skilled workers who can work, who are knowledgeable, or can be trained on horizontal drilling and hydraulic fracturing which are necessary for the oil and natural gas industry.

In South Korea, the secondary education curriculum is embedded with actual theoretical and practical STEM competencies and skills that are required in existing industries. This resonates a co-created curriculum between schools and industries. For example, there is a foundational course on Industrial Chemistry and a practical course on Chemical Materials Management, Maintenance and Operation of Chemical Processes, Plastic Products Manufacturing, etc. for those who want to specialize in Chemical Engineering. So for instance, those who graduate from high school can already work in the South East Coast and Ulsan, where South Korea's world-leading shipbuilding cluster and other major industries are located. The cluster is home to the chemical industry (such as SK Energy), and manufacturers of steel plates, steel structures and engines, as well as tertiary education institutions specializing in shipbuilding and marine engineering. Ulsan shipyard is currently the largest in the world and has the capacity to build a variety of vessels, including commercial cargo, offshore and naval (IMA, 2018).

A look at the secondary education curriculum of India will show that it includes Artificial Intelligence – their high school graduates can already work in their version of the Silicon Valley located in Bengaluru (Bangalore). It is one of the leading hubs of Information and Communication Technology and Research and Development in India. It hosts most of the country's IT software and hardware companies alongside higher education institutions. The elites with a progressive vision in the locality had a transformative plan for their people - they prioritized education that is aligned with industrial strategies.

In Japan, junior and senior high school students, for instance, participated in a series of accelerator experiment workshops that was organized by Tohoku University, wherein the students were able to interact with an actual cyclotron accelerator which allowed them to apply their learnings on fundamental physics (Tanaka et al., 2022). These STEM workshops are in line with the needs of Tohoku's food and manufacturing, advanced electronics, and automobile industries. Hence, such educational activities facilitate the synchronization of school learnings in relation to industry needs and targets.

These best practices are based on the thesis that schools will create homegrown future employees for the industries that locate in their cities or municipalities. Thus, making high school students employable by the time they graduate and college degrees become optional. This greatly reduces unemployment and poverty since secondary education is already sufficient for living on an everyday basis. High school graduates may immediately help in contributing to the family income, most especially in families that are languishing in poverty.

Emerging Conceptual Framework of the Study

Based on the relevant concepts emerging from the conceptual literature review, this research creates and utilizes an eclectic conceptual framework as analytical frame, that links the interrelationships of the concept of state-supported industrial development, manpower forecasting, and co-creation of curriculum between co-located industries and schools to address the current jobs-skills mismatch in the Philippine K to 12 curriculum, as guided by the disciplines of applied science, economics and education. Figure 2 shows the visual interrelationships.

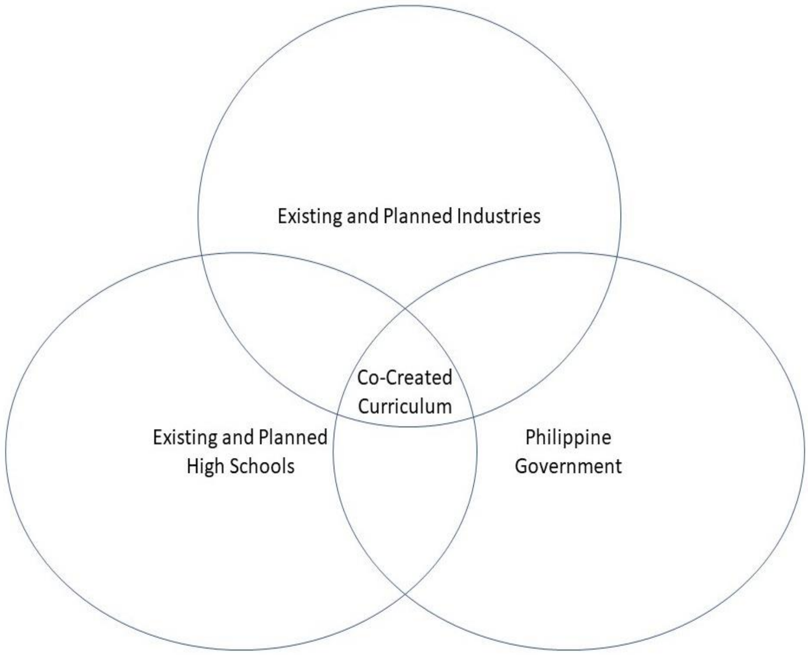

Figure 2. *Co-Creating the Philippine STEM High School Curriculum*

The topmost circle of the Venn diagram in Figure 2 pertains to existing and planned industries. These will provide the actual industry job description and skills required as operationalized for current and future job vacancies (applied science as practiced in industry or required by the job). The circle on the left refers to existing and planned high schools. These schools (major assumption: with Years 11 and 12) will provide the competency component as taught in a particular STEM subject, such as the fundamentals through pure/basic science, but much emphasis will be given to applied science. The curriculum, lecture classes and/or modules of these applied science subjects will be matched or aligned with the apprenticeship component as provided by existing and planned industries. The circle on the right refers to the Philippine government. Its role is to craft the national industrialization strategy at the macroeconomic level with resonance at the regional development level in relation to the local government unit's development plan and land use plan because these will guide the trajectories of existing industries and serve as overarching frame for the curriculum planning of schools.

Since it is assumed that industries, schools and the local government are co-located (in the same city/municipality and/or province), an expected outcome of co-location is a co-created curriculum as shaped by the teaching and emphasis of applied science in the high school STEM curriculum, and as informed by present and future industry job expectations in relation to the Philippines' macroeconomic industrial strategy, regional development policy, and local government plans.

Conclusions and Recommendations

Based on the emerging conceptual framework above, it is imperative to bring back Years 11 and 12 with actual applied science and practical work courses in partnership with automobile industries, chemical laboratories, textile production plants, etc. This would entail provincial and city/municipal level co-creation of STEM (and TVET) curriculum by schools and industries in the same geographical area. Industries can partner with schools if given incentives by the local government unit (LGU) and/or the national government (e.g. as part of corporate social responsibility (CSR), as tax deduction, as part of a human resources inter-agency/institutional program that ensures school to work transition, or as engaging in conscious capitalism – it is a win-win situation for all).

The STEM (and TVET) high school curriculum must give emphasis to the subject matter and content of applied sciences (e.g. accelerator physics, polymer chemistry, marine biology, biotechnology) (might be able to help the Program for International Student Assessment (PISA) outcomes in STEM as well as other international large-scale assessments (ILSAs) that the Philippines participates in). STEM content and pedagogy must be integrated with TVET concepts (e.g. accelerator physics and vehicle mechanics to teach Newton's Laws of Motion through the operation of automobiles) and vice versa. Also, summer STEM workshops should be the norm in high schools through the years by partnering with higher education institutions (HEIs) and industries that are located in the same city/municipality or province (Education Development Center (EDC), 2023). These can be part of the HEIs' training, research and extension programs.

As part of manpower forecasting, there is a need for a standard nomenclature for occupational categories, job descriptions and actual industry skills as used in the private and public sector so that these can be directly embedded in the STEM (and TVET) curriculum and with the exact matching skillset as juxtaposed in the STEM (and TVET) competency and subject taught in high school. There is a need for the following databases to be created for curriculum co-creation that are accessible to both schools and industries/companies:

- Existing industries' labor market needs and actual job openings (city/municipal and provincial level data)
- Existing industries' forecasted manpower needs (future job openings based on each company's strategic plan)
- Industry location plans (municipal and provincial level data by the LGU, JICA, etc.) in relation to location of high schools and HEIs

The Philippine Development Plan of every Philippine President, most especially the national industrial development strategy, must be developed or formulated with manpower forecasting and the secondary education STEM (and TVET) curriculum as major considerations.

Areas for Future Research

Based on the context of the Philippines, the three most relevant future research studies to consider are:

1) Partnership between schools and industries: conduct research to explore effective models for collaboration between schools and industries in the development of STEM and TVET curriculum. This research should focus on understanding the incentives and benefits for industries to engage in partnerships, as well as strategies for co-creating curriculum that meets industry needs. This will help bridge the gap between education and industry, ensuring that students are equipped with the relevant skills for the job market.

2) Integration of applied sciences in the curriculum: conduct research to examine the impact of integrating applied sciences, such as accelerator physics, polymer chemistry, marine biology, and biotechnology, into the high school STEM curriculum. This research should explore how the inclusion of applied sciences can improve outcomes in STEM education and international assessments, and how it can better prepare students for careers in industries that require practical knowledge and skills.

3) Standardization of occupational categories and job descriptions: conduct research to establish a standard nomenclature for occupational categories, job descriptions, and industry skills in both the private and public sectors. This research should focus on creating standardized databases that are accessible to schools and industries/companies. By aligning the curriculum with the exact matching skillset needed in the job market, this research will contribute to improving the relevance and effectiveness of STEM and TVET education in the Philippines.

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