A HISTORY OF SCIENCE AND TECHNOLOGY IN THE PHILIPPINES

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Introduction

The need to develop a country's science and technology has generally been recognized as one of the imperatives of socioeconomic progress in the contemporary world. This has become a widespread concern of governments especially since the post-world war II years.

Among Third World countries, an important dimension of this concern is the problem of dependence in science and technology as this is closely tied up with the integrity of their political sovereignty and economic self-reliance. There exists a continuing imbalance between scientific and technological development among contemporary states with 98 per cent of all research and development facilities located in developed countries and almost wholly concerned with the latter's problems. Dependence or autonomy in science and technology has been a salient issue in conferences sponsored by the United Nations.

It is within the above context that this paper attempts to examine the history of science and technology in the Philippines. Rather than focusing simply on a straight chronology of events, it seeks to interpret and analyze the interdependent effects of geography, colonial trade, economic and educational policies and socio-cultural factors in shaping the evolution of present Philippine science and technology.

As used in this paper, science is concerned with the systematic understanding and explanation of the laws of nature. Scientific activity centers on research, the end result of which is the discovery or production of new knowledge. This new knowledge may or may not have any direct or immediate application.

In comparison, technology has often been understood as the "systematic knowledge of the industrial arts." As this knowledge was implemented by means of techniques, technology has become commonly taken to mean both the knowledge and the means of its utilization, that is, “a body, of knowledge about techniques." Modern technology also involves systematic research but its outcome is more concrete than science, i.e. the production of "a thing, a chemical, a process, something to be bought and sold."

In the past, science and technology developed separately, with the latter being largely a product of trial and error in response to a particular human need. In modern times, however, the progresses of science and technology have become intimately linked together. Many scientific discoveries have been facilitated by the development of new technology. New scientific knowledge in turn has often led to further refinement of existing technology or the invention of entirely new ones.

Precolonial Science and Technology

There is a very little reliable written information about Philippine society, culture and technology before the arrival of the Spaniards in 1521. As such, one has to reconstruct a picture of this past using contemporary archaeological findings, accounts by early traders and foreign travelers, and the narratives about conditions in the archipelago which were written by the first Spanish missionaries and colonial

officials. According to these sources, there were numerous, scattered, thriving, relatively self-sufficient and autonomous communities long before the Spaniards arrived. The early Filipinos had attained a generally simple level of technological development, compared with those of the Chinese and Japanese, but this was sufficient for their needs at that period of time.

Archaeological findings indicate that modern men (homo sapiens) from the Asian mainland first came over-land and across narrow channels to live in Palawan and Batangas around 50,000 years ago. For about 40,000 years, they made simple tools or weapons of stone flakes but eventually developed techniques for sawing, drilling and polishing hard stones. These Stone Age inhabitants, subsequently formed settlements in the major Philippine islands such as Sulu, Mindanao (Zamboanga, and Davao), Negros, Samar, Luzon (Batangas, Laguna, Rizal, Bulacan and the Cagayan region). By about 3,000 B.C., they were producing adzes ornaments of seashells and pottery of various designs. The manufacture of pottery subsequently became well developed and flourished for about 2,000 years until it came into competition with imported Chinese porcelain. Thus over time pottery making declined. What has survived of this ancient technology is the lowest level, i.e., the present manufacture of the ordinary cooking pot among several local communities.

Gradually, the early Filipinos learned to make metal tools and implements -- copper, gold, bronze and, later, iron. The Iron Age is considered to have lasted from the second or third century B.C. to the tenth century A.D. Excavations of Philippine graves and work sites have yielded iron slags. These suggest that Filipinos during this period engaged in the actual extraction of iron from ore, smelting and refining. But it appears that the iron industry, like the manufacture of pottery, did not survive the competition with imported cast iron from Sarawak and much later, from China.

By the first century A.D., Filipinos were weaving cotton, smelting iron, making pottery and glass ornaments and were also engaged in agriculture. Lowland rice was cultivated in diked fields and in the interior mountain regions as in the Cordillera, in terraced fields which utilized spring water.

Filipinos had also learned to build boats for the coastal trade. By the tenth century A.D., this had become a highly developed technology. In fact, the early Spanish chroniclers took note of the refined plank-built warship called caracoa. These boats were well suited for inter-island trade raids. The Spaniards later utilized Filipino expertise in boat-building and seamanship to fight the raiding Dutch, Portuguese, Muslims and the Chinese pirate Limahong as well as to build and man the galleons that sailed to Mexico.

By the tenth century A.D., the inhabitants of Butuan were trading with Champa (Vietnam); those of Ma-i (Mindoro) with China. Chinese records which have now been translated contain a lot of references to the Philippines. These indicate that regular trade relations between the two countries had been well established during the tenth to the fifteenth centuries. Archaeological findings (in various parts of the archipelago) of Chinese porcelains made during this period support this contention. From the Sung (960-1278) and Yuan (1260-1368) Dynasties, there are descriptions of trade with the Philippines, and from the Sung and Ming (1360-1644) Dynasties there are notices of Filipino missions to Peking.

The most frequently cited Chinese account in Philippine history textbooks is that of Chao Ju-Kua in 1225. He described the communities and trading activities in the islands of Ma-i (Mindoro) and San-hsu (literally three islands which present-day historians think refer to the group of Palawan and Calamian Islands). The people of Ma-i and San-hsu traded beeswax, cotton, true pearls, tortoise shell, medicinal betelnuts, yu-ta cloth (probably jute or ramie?) and coconut heart mats for Chinese porcelain, iron pots,

lead fishnet sinkers, colored glass beads, iron needles and tin. These were practically the same commodities of trade between the islands and China which the first Spanish colonial officials recorded when they came to the Philippines more than two centuries later.

The Filipinos in Mindanao and Sulu traded with Borneo, Malacca and parts of the Malay Peninsula. This trade seems to have antedated those with the Chinese. By the time the Spaniards reached the archipelago, these trade relations had been firmly established such that the alliance between the rulers of Manila and Brunei had become strengthened by marriage. It was through these contacts that Hindu-Buddhist, Malay-Sanskrit and Arab-Muslim Cultural and technological influences spread to the Philippines. There have also been some references (by early travelers during the precolonial period) to trade relations between Japan and the Philippines. To date however, Philippine historians have not found any prehispanic references to the Philippines in Japanese literature of the period.

By the time the Spaniards came to colonies the Philippines in 1565; they found many scattered, autonomous village communities (called barangays) all over the archipelago. These were kinship groups or social units rather than political units. They were essentially subsistence economies producing mainly what they needed.

These communities exhibited uneven technological development. Settlements along the coastal areas which had been exposed to foreign trade and cultural contacts such as Manila, Mindoro, Cebu, Southern Mindanao and Sulu, seem to have attained a more sophisticated technology. In 1570, for example, the Spaniards found the town of Mindoro "fortified by a stone wall over fourteen feet thick," and defended by armed Moros -- "bowmen, lancers, and some gunners, linstocks in hand." There were a "large number of culverins" all along the hillside of the town. They found Manila similarly defended by a palisade along its front with pieces of artillery at its gate. The house of Raja Soliman (which was burned down by Spaniards) reportedly contained valuable articles of trade -- "money, copper, iron, porcelain, blankets, wax, cotton and wooden vats full of brandy." Next to his house was a storehouse which contained: much iron and copper; as well as culverins and cannons which had melted. Some small and large cannon had just begun. There were the clay and wax moulds, the largest of which was for a cannon seventeen feet long, resembling a culverin...

These reports indicate that the Filipinos in Manila had learned to make and use modern artillery. The Spanish colonizers noted that all over the islands, Filipinos were growing rice, vegetables and cotton; raising swine, goats and fowls; making wine, vinegar and salt; weaving cloth and producing beeswax and honey. The Filipinos were also mining gold in such places as Panay, Mindoro and Bicol. They wore colorful clothes, made their own gold jewelry and even filled their teeth with gold. Their houses were made of wood or bamboo and nipa. They had their own system of writing and weights and measures. Some communities had become renowned for their plank-built boats. They had no calendar but counted the years by moons and from one harvest to another.

In the interior and mountain settlements, many Filipinos were still living as hunters. They gathered forest products to trade with the lowland and coastal settlements. But they also made "Iron lance-points, daggers and certain small tools used in transplanting."

On the whole, the pre-colonial Filipinos were still highly superstitious. The Spaniards found no temples or places of worship. Although the Filipinos knew how to read and write in their own system, this was mainly used for messages and letters. They seem not to have developed a written literary tradition at

that time.(20) This would have led to a more systematic accumulation and dissemination of knowledge, a condition that is necessary for the development of science and technology. Because of the abundance of natural resources, a benign environment and generally sparse population, there seemed to have been little pressure for invention and innovation among the early Filipinos. As governor Francisco de Sande observed in 1575, the Filipinos do not understand any kind of work, unless it be to do something actually necessary -- such as to build their houses, which are made of stakes after their fashion; to fish, according to their method; to row, and perform the duties of sailors; and to cultivate the land...

Developments in Science and Technology

During the Spanish Regime

The beginnings of modern science and technology in the Philippines can be traced to the Spanish regime. The Spaniards established schools, hospitals and started scientific research and these had important consequences for the rise of the country's professions. But the direction and pace of development of science and technology were greatly shaped by the role of the religious orders in the conquest and colonization of the archipelago and by economic and trade adopted by the colonial government.

The interaction of these forces and the resulting socio-economic and political changes must, therefore, be analyzed in presenting a history of science and technology in the Philippines.

Spanish conquest and the colonization of the archipelago were greatly facilitated by the adoption of an essentially religious strategy which had earlier been successfully used in Latin America. Known as reduccion, it required the consolidation of the far-flung, scattered barangay communities into fewer, larger and more compact settlements within the hearing distance of the church bells. This was a necessary response to the initial shortage of Spanish missionaries in the Philippines. This policy was carried out by a combination of religious conversion and military force.

The net result of reduccion was the creation of towns and the foundation of the present system of local government. The precolonial ruling class, the datus and their hereditary successors, were adopted by the Spanish colonial government into this new system to serve as the heads of the lowest level of local government; i.e. as cabezas de barangay. The colonial authorities found the new set-up expeditious for establishing centralized political control over the archipelago -- for the imposition and collection of the tribute tax, enforcement of compulsory labor services among the native Filipinos, and implementation of the compulsory sale of local products to the government.

The Filipinos naturally resisted reduccion as it took them away from their rice fields, the streams and the forests which were their traditional sources of livelihood and also subjected them to the onerous economic exactions by the colonial government. Thus the first century of Spanish rule brought about serious socio-economic dislocation and a decline kin agricultural production and traditional crafts in many places. In the region surrounding the walled city of Manila, Filipinos migrated from their barangays to the city in order to serve in the convents and thus avoid the compulsory labor services in the shipyards and forests. Over the centuries, this population movement would greatly contribute to the congestion of Manila and its suburbs.

The religious orders likewise played a major role in the establishment of the colonial educational system in the Philippines. They also influenced the development of technology and promotion of scientific research. Hence, these roles must next be examined.

Various decrees were issued in Spain calling for the establishment of a school system in the colony but these were not effectively carried out. Primary instruction during the Spanish regime was generally taken care of by the missionaries and parish priests in the villages and towns. Owing to the dearth of qualified teachers, textbooks and other instructional materials, primary instruction was mainly religious education. Higher education was provided by schools set up by the different religious orders in the urban centers, most of them in Manila. For example, the Jesuits founded in Cebu City the Colegio de San Ildefonso (1595) and in Manila, the Colegio de San Ignacio (1595), the Colegio de San Jose (1601) and the Ateneo de Manila (1859). The Dominicans had the Colegio de San Juan de Letran (1640) in Manila. Access to these schools was, however, limited to the elite of the colonial society -- the European-born and local Spaniards, the mestizos and a few native Filipinos. Courses leading to the B.A. degree, Bachiller en Artes, were given which by the nineteenth century included science subjects such as physics, chemistry, natural history and mathematics.

On the whole, however, higher education was pursued for the priesthood or for clerical positions in the colonial administration. It was only during the latter part of the nineteenth century that technical/ vocational schools were established by the Spaniards.(26)

Throughout the Spanish regime, the royal and pontifical University of Santo Tomas remained as the highest institution of learning. Run by the Dominicans, it was established as a college in 1611 by Fray Miguel de Benavides. It initially granted degrees in theology, philosophy and humanities. During the eighteenth century, the faculty of jurisprudence and canonical law was established. In 1871, the schools of medicine and pharmacy were opened. From 1871 to 1886, the University of Santo Tomas granted the degree of Licenciado en Medicina to 62 graduates. For the doctorate degree in medicine, at least an additonal year of study was required at the Universidad Central de Madrid in Spain.

The study of pharmacy consisted of a preparatory course with subjects in natural history and general chemistry and five years of studies in subjects such as pharmaceutical operations at the school of pharmacy. At the end of this period of the degree of Bachiller en Farmacia was granted. The degree of licentiate in pharmacy, which was equivalent to a master's degree, was granted after two years of practice in a pharmacy, one lof which could be taken simultaneously with the academic courses after the second year course of study. In 1876, the university granted the bachelor's degree in pharmacy to its first six graduates in the school of pharmacy. Among them was Leon Ma. Guerrero, who is usually referred to as the "Father of Philippine Pharmacy" becuase of his extensive work on the medicinal plants of the Philippines and their uses. The total number of graduates in pharmacy during the Spanish period was 164.

There were no schools offering engineering at that time. The few who studied engineering had to go to Europe. There was a Nautical School created on 1 January 1820 which offered a four-year course of study (for the profession of pilot of merchant marine) that included subjects as arithmetic, algebra, geometry, trigonometry, physics, hydrography, meteorology, navigation and pilotage. A School of Commercial Accounting and a School of French and English Languages were established in 1839.

In 1887, the Manila School of Agriculture was created by royal decree but it was able to open only in July 1889. The School was designed to provide theoretical and practical education of skilled farmers

and overseers and to promote agricultural development in the Philippines by means of observation, experiment and investigation. Agricultural stations were also established in Isabela, Ilocos, Albay, Cebu, Iloilo, Leyte and parts of Mindanao. The professors in the School were agricultural engineers. The School was financed by the government but it appears that its direction was also left to the priests. The certificates of completion of the course were awarded by the University of Santo Tomas or the Ateneo Municipal. It seems that the School was not successful as Filipinos did not show much inclination for industrial pursuits.

In 1863, the colonial authorities issued a royal decree designed to reform the existing educational system in the country. It provided for the establishment of a system of elementary, secondary and collegiate schools, teacher-training schools, and called for government supervision of these schools. The full implementation of this decree, however, was interrupted by the coming of the Americans in 1898.

Higher education during the Spanish regime was generally viewed with suspicion and feared by the colonial authorities as encouraging conspiracy and rebellion among the native Filipinos. For this reason, only the more daring and persevering students were able to undertake advantaged studies. The attitude of the Spanish friars towards the study of the sciences and medicine was even more discouraging. As one Rector of the University of Santo Tomas in the 1960s said: "Medicine and the natural sciences are materialistic and impious studies." It was not surprising, therefore, that few Filipinos ventured to study these disciplines. Those who did were poorly trained when compared with those who had gone to European universities. Science courses at the University of Santo Tomas were taught by the lecture/recitation method. Laboratory equipment was limited and only displayed for visitors to see. There was little or no training in scientific research. Sir John Bowring, the British Governor of Hongkong who made an official visit to the Philippines in the 1850s wrote:

Public instruction is in an unsatisfactory state in the Philippines--the provisions are little changed from those of the monkish ages.

In the University of Santo Tomas... no attention is given to the natural sciences... nor have any of the educational reforms which have penetrated most of the colleges of Europe and America found their way to the Philippines.

In spite of the small number of Filipino graduates from the UST in medicine and the sciences they still faced the problem of unemployment. This was because the colonial government preferred to appoint Spanish and other European-trained professionals to

At the start of the American regime, a German physician of Manila submitted a report to the authorities on the conditions at UST's medical college. The report mentions, among others, its lack of library facilities, the use of outdated textbooks (some published in 1845), that no female cadaver had ever been dissected and the anatomy course was a "farce", that most graduates "never had attended even one case of confinement or seen a case of laparotomy" and that bacteriology had been introduced only since the American occupation and "was still taught without microscopes!" Many of these graduates later joined the revolutionary movement against Spain.

With the opening of the Suez Canal in 1869 and the consequent ease in travel and communications that it brought about, the liberal ideas and scientific knowledge of the West also reached the Philippines. The prosperity that resulted from increased commerce between the Philippines and the rest of the world enabled Filipino students to go to Europe for professional advanced studies. These included Jose Rizal who

was able to pursue studies in Medicine and specialize in ophthalmology in Spain and Germany; Graciano Apacible who studied medicine in Madrid; Antonio Luna who obtained his Ph.D. in pharmacy in Madrid and later worked with renowned scientists in Ghent and Paris; Jose Alejandrino who took up engineering in Belgium, and others. It was this group of students which set up the Propaganda Movement in Europe that eventually led to the Philippine revolution against Spain.

The religious orders provided most of the teaching force and institutions of learning in the colony. This was similar to the situation that had earlier prevailed in Europe (where they had come from) during the medieval ages. Inevitably, members of the religious orders also took the lead in technological innovation and scientific research. This involvement invariably arose from their need to provide for basic necessities as they went around the archipelago to perform their missionary work of propagating the Catholic faith and to finance the colleges, hospitals and orphanages that they had established.

The Spaniards introduced the technology of town planning and building with stones, brick and tiles. In many places, religious (such as Bishop Salazar in Manila) personally led in these undertakings. Because of the lack of skilled Filipinos in these occupations, the Spaniards had to import Chinese master builders, artisans and masons. The native Filipinos were drafted, through the institution of compulsory labor services, to work on these projects. In this manner, the construction of the walls of Manila, its churches, convents, hospitals, schools and public buildings were completed by the seventeenth century.

Towards the end of the sixteenth century, the religious orders had established several charity hospitals in the archipelago and in fact provided the bulk of this public service. These hospitals became the setting for rudimentary scientific work during the Spanish regime long before the establishment of the University of Santo Tomas (UST) college of medicine. Research in these institutions were confined to pharmacy and medicine and concentrated on the problems of infectious diseases, their causes and possible remedies. Several Spanish missionaries observed, catalogued and wrote about Philippine plants, particularly those with medicinal properties. The most notable of these was Father Fernando de Sta. Maria's Manual de Medicinas Caseras published in 1763 which was so in demand that it had undergone several editions by 1885.

By the second half of the nineteenth century, studies of infectious diseases such as smallpox, cholera, bubonic plague, dysentery, leprosy and malaria were intensified with the participation of graduates of medicine and pharmacy from UST.(45) At this time, native Filipinos began to participate in scientific research. In 1887, the Laboratorio Municipal de Ciudad de Manila was created by decree. Its main functions were to conduct biochemical analyses for public health and to undertake specimen examinations for clinical and medico-legal cases. It had a publication called Cronica de Ciencias Medicas de Filipinas showing scientific studies being done during that time.

There was very little development in Philippine agriculture and industry during the first two centuries of Spanish rule. This was largely due to the dependence of the Spanish colonizers on the profits from the Galleon or Manila-Acapulco trade, which lasted from 1565 to 1813. It was actually based on the trade with China which antedated Spanish rule. The galleons brought to Latin America Chinese goods -- silk and other cloths, porcelain and the like -- and brought back to Manila Mexican silver. When the Spanish and Portuguese thrones were united from 1581 to 1640, goods brought to Manila by ships from Japan and Portuguese ships from Siam, India, Malacca, Borneo and Cambodia were also carried by the galleons to Mexico. During the time, Manila prospered as the entrepot of the Orient.

The Filipinos hardly benefited from the Galleon trade. Direct participation in the trade was limited to Spanish inhabitants of Manila who were given shares of lading space in the galleons. Many of them simply speculated on these trading rights and lived off on their profits. It was the Chinese who profited most from the trade. They acted as the trade's packers, middlemen, retailers and also provided services and other skills which the Spanish community in Intramuros needed.

Spanish preoccupation with the Manila Galleon eventually led to the neglect of agriculture and mining and the decline of native handicrafts and industries in the Philippines. The deleterious effects of the trade on the archipelago's domestic economy had been pointed out by some Spanish officials as early as 1592. But this seems to have been largely ignored by colonial policy-makers. Only the local shipbuilding industry continued to prosper because of necessity -- to build the galleons and other ships required for internal commerce and the defense of the archipelago. This had become quite well developed according to a French visitor in the nineteenth century. He observed:

In many provinces shipbuilding is entirely in the hands of the natives. The excellence of their work is proof that they are perfectly capable of undertaking the study of abstruse sciences and that mathematical equations are by no means beyond their comprehension....

Agricultural development was left to the resident Chinese and the Spanish friars. The latter saw in the cultivation of their large estates around Manila a steady source of financial support for their churches, colleges, hospitals and orphanages in Intramuros. The friar estates profited from the expanding domestic food market as a result of the population growth of Manila and its suburbs. But the friars contribution in the development of existing agricultural technology was more of quantitative than qualitative in nature. The profitability of their estates was largely derived from the intensive exploitation of native technology and their free compulsory personal services.

Successive shipwrecks of and piratical attacks on the galleons to Mexico led to declining profits from the trade and triggered an economic depression in Manila during the latter part of the seventeenth century. This situation was aggravated by increasing restrictions on the goods carried by the Manila Galleon as a consequence of opposition coming from Andalusion merchants and mercantilists in Spain.

At the beginning of the eighteenth century, the Bourbon dynasty ascended to the Spanish throne and brought with it political and economic ideas of the French Enlightenment. This paved the way for more government attention to the economic development of the Philippines. Enterprising Spaniards began to exploit the mineral wealth of the islands, develop its agriculture, and establish industries. These efforts were further encouraged by the need to promote economic recovery after the British Occupation of Manila in 1762-1764.

Research in agriculture and industry was encouraged by the founding of the Real Sociedad Economica de los Amigos del Pais de Filipinas (Royal Economic Society of Friends of the Philippines) by Governador Jose Basco y Vargas under authority of a royal decree of 1780. Composed of private individuals and government officials, the Society functioned somewhat like the European learned societies during the eighteenth and nineteenth centuries and a modern National Research Council, It undertook the promotion of the cultivation of indigo, cotton, cinnamon, and pepper and the development of the silk industry. During the nineteenth century, it was endowed with funds which it used to provide prizes for successful experiments and inventions for the improvement of agriculture and

industry: to finance the publication of scientific and technical literature, trips of scientists from Spain to the Philippines, professorships; and to provide scholarships to Filipinos.

In 1789, Manila was opened to Asian shipping. This inaugurated an era of increasing Philippine exports of rice, hemp, sugar, tobacco, indigo and others and rising imports of manufactured goods. In 1814, Manila was officially opened to world trade and commerce; subsequently other Philippine ports were opened.

Foreign capital was allowed to operate on an equal footing with Spanish merchants in 1829. By this means agricultural production particularly of sugar and hemp, was accelerated and modernized. Local industries flourished in Manila and its suburbs -- weaving, embroidery, hatmaking, carriage manufacture, rope-making, cigar and cigarettes-making. Much of the finished products of these industries were exported. Yet although Philippine exports kept rising during the nineteenth century, imports of manufactured goods also rose and foreign, particularly English capital dominated external trade and commerce. This partly because of short-sighted Spanish colonial trade policies and the relative inexperience and lack of capital of Spanish colonial trade policies and the relative inexperience and lack of capital of Spanish and Filipino merchants.

The prosperity arising from expanded world trade and commerce in the nineteenth century led to Manila's rapid development as a cosmopolitan center. Modern amenities -- a waterworks system, steam tramways, electric lights, newspapers, a banking system -- were introduced into the city by the latter half of the nineteenth century. Undoubtedly, commercial needs led to the Spanish governments establishment of a Nautical School, vocational schools and a School of Agriculture during the nineteenth century. Various offices and commissions were also created by the Spanish government by the Spanish government to undertake studies and regulations of mines, research on Philippine flora, agronomic research and teaching, geological research and chemical analysis of mineral waters throughout the country. However, little is known about the accomplishments of these scientific bodies.

Meteorological studies were promoted by Jesuits who founded the Manila Observatory in 1865. The Observatory collected and made available typhoon and climatological observations. These observations grew in number and importance so that by 1879, it became possible for Fr. Federico Faura to issue the first public typhoon warning. The service was so highly appreciated by the business and scientific communities that in April 1884, a royal decree made the Observatory an official institution run by the Jesuits, and also established a network of meteorological stations under it. In 1901, the Observatory was made a central station of the Philippine Weather Bureau which was set up by the American colonial authorities. It remained under the Jesuit scientists and provided not only meteorological but also seismological and astronomical studies.

The benefits of economic development during the nineteenth century were unevenly distributed in the archipelago. While Manila prospered and rapidly modernized, much of the countryside remained underdeveloped and poor. The expansion of agricultural production for export exacerbated existing socio-economic inequality that had been cumulative consequence of the introduction of land as private property at the beginning of Spanish rule. There was increasing concentration of wealth among the large landowners -- the Spaniards, especially the religious orders, the Spanish and Chinese mestizos, the native Principalia -- and poverty and landlessness among the masses. This inequality, coupled with abuses and injustices committed by the Spanish friars and officials gave rise to Philippine nationalism and eventually the Revolution of 1896.

At the end of the Spanish regime, the Philippines had evolved into a primary agricultural exporting economy. Progress in agriculture had been made possible by some government support for research and education in this field. But it was largely the entry of foreign capital and technology which brought about the modernization of some sectors, notably sugar and hemp production. The lack of interest and support for research and development of native industries like weaving, for example, eventually led to their failure to survive the competition with foreign imports. Because of necessity and the social prestige attached to university education, medicine and pharmacy remained the most developed science-based professions during the Spanish regime.

Science and Technology during the First Republic

There was very little development in science and technology during the short-lived Philippine Republic (1898-1900). The government took steps to establish a secular educational system by a decree of 19 October 1898; it created the Universidad Literaria de Filipinas as a secular, state-supported institution of higher learning. It offered courses in law, medicine, surgery, pharmacy and notary public. During its short life, the University was able to hold graduation exercises in Tarlac on 29 September 1899 when degrees in medicine and law were awarded.

Developments in Science and Technology

During the American Regime

Science and technology in the Philippines advanced rapidly during the American regime. This was made possible by the simultaneous government encouragement and support for an extensive public education system; the granting of scholarships for higher education in science and engineering; the organization of science research agencies and establishment of science-based public services.

The Americans introduced a system of secularized public school education as soon as civil government was set up in the islands. On 21 January 1901, the Philippine Commision, which acted as the executive and legislative body for the Philippines until 1907, promulgated Act No. 74 creating a Department of Public Instruction in the Philippines. It provided for the establishment of schools that would give free primary education, with English as the medium of instruction. This was followed by the setting up of a Philippine Normal School to train Filipino teachers. Secondary schools were opened after a further enactment of the Philippine in Commission in 1902. The Philippine Medical School was established in 1905 and was followed by other professional and technical schools. These were later absorbed into the University of the Philippines.

The colonial authorities initially adopted a coordinated policy for the promotion of higher education in the sciences and government research institutions and agencies performing technical functions. The University of the Philippines was created on 18 June 1908 by Act of the Philippine Legislature. Among the first colleges to be opened were the College of Agriculture in Los Baños, Laguna in 1909, the Colleges of Liberal Arts, Engineering and Veterinary Medicine in 1910 and the College of Law in 1911. By 1911, the University had an enrollment of 1,400 students, Four Years later, its enrollment had almost doubled (to 2,398) and the University included two new units, a School of Pharmacy and a Graduate School of Tropical

Medicine and Public Health. In 1916, the School of Forestry and Conservatory of Music were established; and in 1918, the College of Education was opened.

Except in the College of Medicine, where there were already a number of Filipino physicians who were qualified to become its faculty members when it was opened in 1907, most of the early instructors and professor in the sciences and engineering at the University of the Philippines were Americans and other foreigners. Qualified Filipinos were sent abroad for advanced training and by this means foreign faculty were gradually replaced by Filipinos. For example, in 1920, Filipino Ph.D. graduates of U.S. universities took over the Department of Agriculture Chemistry in the College of Agriculture. By December 1926, the university's enrollment in all colleges had reached 6,464 and out of a total teaching staff of 463, only 44 were Americans and other foreigners.

Before 1910, the American colonial government encouraged young men and women to get higher professional education as much as possible in American colleges. In 1903, the Philippine commission passed an Act to finance the sending of 135 boys and girls of high school age to the United States to be educated as teachers, engineers, physicians and lawyers. One third of these were chosen by the governor-general on a nation-wide basis and the rest by the provincial authorities. In exchange for this privilege, the pensionados, as they came to be called, were to serve in the public service for five years after their return from their studies. Between 1903 and 1912, 209 men and women were educated under this program in American schools. After the establishment of the University of the Philippines, scholarships for advanced studies of a scientific or technical nature in American Universities were given only in preparation for assignment to jobs in the public service.

The Philippine Commission introduced science subjects and industrial and vocational education into the Philippine school system but they found that industrial and vocation courses were very unpopular with the Filipinos. When the Manila Trade School was opened in 1901, the school authorities found it difficult to get students to enroll in these courses. Because of their almost 400 years of colonial experience under the Spaniards, middle class Filipinos had developed a general disdain for manual work and a preference for the prestigious professions of the time, namely, the priesthood, law and medicine. Education in these professions came to be regarded as the means of making the best of the limited opportunities in the Spanish colonial bureaucracy and thus of rising from one's social class. Hence, even at the newly-opened University of the Philippines, it was difficult to get students to enroll in courses which required field work such as, for example, agriculture, veterinary medicine, engineering and other applied science. Scholarships were thus offered by the government to attract a sufficient number of students to enroll in courses that were needed to fill up the technical positions in the government service.

In the field of medicine, the Philippine Commission provided for as many scholarships as there were regularly organized provinces in the Islands. These were awarded by the school departments after competitive examinations in the provinces. A recipient of these scholarships was required to return to the province from whence he came and to serve as a physician for as many years as his medical education was paid for by the government. This policy was adopted not only to assure the medical school a continuing supply of carefully selected students but also to ensure a balanced geographical distribution of physicians in the different provinces and to counteract their tendency to settle in the large urban areas.

Selected graduates of the schools of medicine and nursing were also sent on government scholarship to universities in the United States for postgraduate courses and training in special fields. In 1921, the Rockefeller foundation provided for six fellowships for qualified Filipinos in universities in the United States and Europe, two each in he fields of public health (preventive medicine), public health laboratory work and teacher training in nursing education. Over several years, the Foundation provided more than thirty of these fellowships and also financed shorter observation trips of many other health officials.

It also greatly aided in the establishment and development of the Graduate School of Public Health and Hygiene in the University of the Philippines.

When the Bureau of Public Works was created in 1901, the Americans found that there were no competent Filipino engineers, and American engineers had to be imported. As a consequence, a special effort was made to attract Filipinos to pursue advanced studies leading to careers as engineers. In many cases government financial assistance was provided to enable them to complete their professional studies in the United States. Upon achieving their professional qualifications they were employed as junior engineers in the Bureau of Public Works. Many of them rapidly advanced in their positions. Their career progress can be seen from the fact that whereas in 1913 there were only 18 Filipino engineers out of a total of 145 engineers in the Bureau of Public Works, the rest being American; by the end of 1925, out of 190 engineers in the Bureau, only 16 were Americans and 174 were Filipinos.

The establishment of the University of the Philippines satisfied the short-run needs for professionally trained Filipinos in the colonial government's organization and programs. What the authorities did not recognize was that by providing for an extensive public school system at the elementary and secondary levels they had increased tremendously the social demand for professional education. The University of the Philippines remained the only publicly-supported institutions for higher education, and, since it could not meet the increasing social demand for universities was left to the initiative of enterprising Filipinos. For many Filipinos, private education became the alternative for professional education.

Many of the existing private nonsectarian universities were organized during the early period of the American regime to help meet the increasing demand for professional education and the country's need for trained manpower. At the same time, these schools remained distinctively Filipino in orientation as they were conceived by their founders as a means to conserve the national heritage and prevent the complete Americanization of the Filipinos.

At the outset of the American regime, there was no definite government policy on private schools. Because of the widespread disorganization that followed a more of these schools were set up, government regulation and control was found necessary. The first attempt to regulate private schools was through the Corporation Law (Act No. 1459) enacted by the Philippine Commission in 1906. In effect, it treated the schools like commercial firms or business enterprises except that they would be under the supervision of the Department of Public Instruction rather than the Department of Trade and Industry.

In 1917, Act No. 2076 (Private School Act) was enacted by the Philippine Legislature. The Act recognized private schools as educational institutions and not commercial ventures. It required the Secretary of Public Instruction to "maintain a general standard of efficiency in all private schools and colleges so that...(they shall) furnish adequate instruction to the public..." and authorized him to "inspect and watch" these school and colleges. The supervision of these schools was entrusted to a staff

of four within the Department of Public Instruction -- a superintendent, an assistant superintendent and two supervisors.

The number of private colleges increased rapidly. In 1925 a survey of the educational system of the Island was authorized Survey which was headed by Paul Monroe made a comprehensive investigation of all public and private institutions of learning in the country. The Monroe Survey found most private schools substandard. It reported that most of these were physically ill equipped and with more part-time than full-time faculty members. Among the private colleges and universities, it found out that: "The equipment of all these institutions is owefully inadequate, the laboratory for the teaching of science being but a caricature of the real thing".

As a consequence of the findings of the Monroe Survey, the Government took steps to improve the machinery for the supervision of private schools. The Philippine Legislature created the Office of Private Education to look into such matters as physical plant, school facilities, libraries, laboratory equipment and student load, and administrative work such as enforcement of relevant government regulations, evaluating credits taken by students, managing admission of foreign students and the like. As a result of the increased outlay for supervision of private schools, their standards were improved.

During the American regime, the development of science gained more government support along with efforts to establish an old extensive public school system and public health programs. The old Laboratorio Municipal was absorbed by the Bureau of Government Laboratories created by the Philippine Commission in 1901. In 1905, the latter was reorganized and renamed Bureau of Science. It remained the principal government research establishment until the end of the Second World War. It had a biological laboratory, a chemical laboratory, a serum laboratory for the production of vaccine virus, serums and prophylactics, a library. Most of the senior scientists in the Bureau were initially Americans but as Filipinos acquired the necessary training, they gradually took over their positions.

The Bureau of Science served as a valuable training ground for Filipino scientists. It performed the needed chemical and biological examinations for the Philippine General Hospital and Bureau of Health and manufactured the serums and prophylactics needed by the latter. Pioneering research was done at the Bureau of Science on such diseases as leprosy, tuberculosis, cholera, dengue fever, malaria and beri-beri. Results of these studies were readily available to the Bureau of Health for use in its various programs. Studies on the commercial value of tropical products, tests of Philippine minerals and roadbuilding materials, the nutritional value of foods, and other were similarly done at the Bureau of Science. From 1906, it published the Philippine Journal of Science which reported not only work done in local laboratories but also scientific developments abroad which had relevance to Philippine problems.

The American colonial authorities organized other offices which, by the nature of their operations, contributed further to the growth of scientific research. These were the Weather Bureau (1901), the Board (later Bureau) of Health (1898), Bureau of Mines (1900), Bureau of Forestry (1900), Bureau of Agriculture (1901), Bureau of Coast and Geodetic Survey (1905), Bureau of Plant Industry (1929) and Bureau of Animal Industry (1929) (82) From 1927, there were proposals from professional societies for the creation of a National Medical Research Council and a National Research Council similar to those in the United States, Canada, and Australia. The Philippine Legislature passed an extensively emulated abroad."

Act in 1933 creating the National Research Council of the Philippine Islands (NRCP). Aside from working for the promotion of scientific research, the NRCP actively participated in the deliberations and drafting of provisions affecting science and industry in the 1934 Constitutional Convention.

Educational and science policy during the American regime was not coordinated with colonial economic policy. While Filipinos were provided opportunities for higher education in the sciences and engineering, the economy remained basically agricultural. To a great extent, Philippine economic development was determined by free trade relations established in 1909 between the Philippines and the United States, and these continued long after independence was achieved in 1946. As a result of this policy, the Philippine economy became tied to that of the United States, remaining primarily an exporter of agricultural crops and raw materials and an importer of American manufactured goods. Undoubtedly this delayed Philippine industrialization. The relative underdevelopment of the physical sciences vis-a-vis the medical and agricultural sciences may be traced to this policy. Basic and applied research in the medical, agricultural and related sciences received much greater government support during the American regime than did industrial research.

Science and Technology

During the Commonwealth Period

In 1935, the Philippine Commonwealth was inaugurated and ushered in a period of transition to political independence. The Constitution acknowledged the importance of promoting scientific development for the economic development of the country by incorporating a provision (Article XIII, Section 4) declaring that "The State shall promote scientific research and invention, Arts and Letters shall be under its patronage..."

The government, which was by this time completely under Filipino management, continued to expand its public school system to accommodate the increasing number of schoolchildren. The Government abolished Grade VII as the terminal grade in the elementary curriculum and also instituted the "double-single session" plan thus reducing the time allotment or dropping certain subjects in the elementary school. The government also enacted Commonwealth Act No. 180 (13 November 1936) reestablishing the Office of Private Education which had been abolished in 1932.

On the whole, higher education was provided mainly by the private sector. By 1936, there were 425 private schools recognized by the government, 64 of which we institutions at the College level and 7 were universities. These were Centro Escolar University, Far Easter University, National University, Philippine Women's University, Silliman University, University of Manila and the University of Santo Tomas. Together with the University of the Philippines these had a total of 19,575 college students in all universities in the country. The combined significant increase in trained scientists and engineers in the Philippines before the Second World War.

The Commonwealth government worked towards the development of economic self-reliance which would be necessary to sustain genuine political independence. It created the National Economic Council to prepare an economic program and advise the government on economic and financial questions. Several

government corporations were reorganized and new ones were created to perform such varied functions as the exploitation and development of natural resources (e.g., the National Power Corporation); the development and promotion of local industries (such as the National Development Company (NDC) and its subsidiaries, the National Abaca and Other Fibers Corporation); promotion of agricultural production and marketing; and the like. The NDC was especially mandated to undertake the development of successful researches of government science agencies (such as the Bureaus of Science, Animal Industry and Plant Industry) for commercial production.

The Commonwealth government likewise adopted measures to encourage and provide assistance to private Filipino businessmen in the establishment of industries and manufacturing enterprises. For example, it created new agencies, such as the Bureau of Mines, to provide assistance to businessmen undertaking mining exploration and development. It also increased appropriations for the Bureaus of Science, Plant and Animal Industry, and thereby encouraged more scientific research for industrial purposes.

In spite of all these efforts, the Commonwealth government was unable to achieve its goal of economic self-reliance. This was primarily because foreign trade and tariff policies remained under the control of the American government. Free trade relations also continued and thus perpetuated the preferential treatment of exports of agricultural raw materials. Moreover, the Pacific War broke out in 1941 and the Philippines was occupied by Japanese troops.

The occupation of the Philippines by the Japanese during the War brought educational and scientific activities practically to a halt as able bodied citizens joined the resistance movement. Worse still, much of the country was reduced to ruins during the battles ought for the liberation in 1944-45. Manila, which was the center of all educational and scientific activities, was razed to the ground, destroying everything that had been built up before. It was in this condition that the Philippines became an independent state. The government had to contend with economic reconstruction, normalization of operations as well as the task of planning the direction of economic development.

Science and Technology since Independence

The underlying pattern of education and training of scientists, engineers and physicians established during the America regime, as well as the direction of government support for scientific research and development, has basically remained unchanged since independence in 1946. State support for education continues to be concentrated at the elementary school level; private colleges and universities provide education for the majority of the collegiate population.

The number of state universities and colleges has been increasing since 1946. However, their growth has not been based on a rational plan. Partisan political considerations often determined the creation, location and staffing of these institutions. Hence, many of them were ill-equipped and ill-prepared to provide quality higher education particularly in the sciences and engineering. State universities and colleges vary in standards arising largely from the uneven distribution of faculty development programs. The University of the Philippines System remains the most developed with extensive graduate and undergraduate degree programs in the sciences and engineering. It receives over half of the national budget for state universities and colleges.

Private universities and colleges have similarly increased in numbers since 1946. However, these vary in standards. Most non-sectarian universities and colleges are organized and managed like business enterprises and are heavily dependent on tuition fees. To operate profitably, they tend to concentrate on low-cost courses like business administration, liberal arts and education, and encourage large enrollments in these. Sectarian universities and college tend to be financially better endowed. Hence, they have been able to impose selective admissions, lower faculty-student ratios and provide laboratory and library facilities requires for science and engineering program. The large number of private colleges and universities to be supervised and the limited Department of Education and Culture (now the Ministry of Education, Culture and Sports) staff to do it has hampered effective government supervision and control of their standards.

The number of college students and graduates from public and private universities and colleges has shown tremendous increases since 1946. Nevertheless, the proportion of those in agriculture, medical and natural sciences, and engineering has remained relatively low. There are very few graduates in the physical sciences. Most students (and graduates) in agriculture come from state institutions while most of those in engineering and medical sciences come from private institutions. In both, the majority of college students and graduates continue to be in teacher training/education and commerce/business administration courses. This situation results from the fact that students tend to enroll in courses where there are perceived employment opportunities and which their families can afford. Engineering and science courses entail longer periods of study and have generally been more expensive to pursue.

The rise of professional organizations of scientists and engineers followed closely the growth of higher education in the Philippines. The earliest organizations were in medicine and pharmacy, professions which were the first to be introduced during the colonial era. As the number of graduates in a particular discipline increased, associations were formed to promote professional interests and regulate standards of practice and these were modelled after their counterparts in the United States. Self-regulation by professional associations was eventually institutionalized in government laws which established professional examining boards and licensing procedures.

In certain cases, professional organizations initiated changes in the collegiate curriculum for their specialization and worked for improvements in educational standards. The Philippine Medical Association (PMA) actively worked to improve standards of medical education by limiting enrollment in medical colleges and adding courses required for the medical degree. Academic members of the profession have led in questioning the relevance of Western-oriented medical curriculum to Philippine conditions. This has resulted in recent innovations in medical training such as more exposure of students to community medicine and the experimental curriculum to produce doctors for rural areas. In the field of engineering, the Philippine Institute of Chemical Engineers initiated a series of conference to discuss curriculum revisions for its profession. Results of these conferences were then endorsed to the Department of Education and Culture (DEC) for official adoption. In other branches of engineering, the government through DEC convened meetings of educators, members of professional examining boards, representatives of professional organizations and the private sector to update and adopt uniform core curricula for all universities and colleges to follow. These developments took place in 1973-1974.

On the whole, there has been little innovation in the education and training of scientists and engineers since independence in 1946. This is in part due to the conservative nature of self-regulation by the professional associations. Because of specialized training, vertical organization by disciplines and

lack of liaison between professions, professional associations have been unable to perceive the dynamic relationship between science, technology and society and the relevance of their training to Philippine conditions.

Paralleling the increasing number of state colleges and universities has been a rise in government science agencies since 1946. In 1947, the Bureau of Science was reorganized into an Institute of Science.(95) In the same year, an Instituter of Nutrition, and in 1952, the Science Foundation of the Philippines (SFP) were created and placed (along with the Institute of Science) under the Office of the President.(96) The Institute of Nutrition was to perform research, advisory and extension functions while the Science Foundation was to stimulate research in the sciences and engineering and promote science consciousness among the people. In 1952, the Commission on Volcanology was also created and placed under the National Research Council of the Philippines (NRCP). Its function was primarily basic research on volcanology.

Scientific work in government suffered from a lack of support, planning and coordination during the early postwar years. The U.S. Economic Survey Mission to the Philippines in 1950, noted in its Report the dearth of basic information needed by industries of the country, the neglect of experimental work and the meager appropriation in the national budget for scientific research, including the low salaries of government scientists. The Bell Mission recommended, among other things, the systematic exploration of the country's natural resources to determine their potentialities for economic development.

Following the Bell Mission's Report, the Institute of Science was reorganized in 1951. Renamed Institute of Science and Technology, it acquired the status of a government-owned corporation and was placed under the office of Economic Coordination. Added to its former functions of resources survey, testing and standardization, were the responsibility for improving industrial processes and stimulating technological development.

In 1957, a report was submitted to the President pointing out the deterioration of Philippine science since the early years of the American regime. The report analyzed the causes of this decline -- the lack of government support; dearth of scientists of high training and ability; low morale of scientists and a lack of public awareness of Science. It made several recommendations towards a long-range development of science in the country. Consequently, Congress enacted the Science Act of 1958.

The Science Act created the National Science Development Board (NSDB) to formulate policies for the development of science and coordinate the work of science agencies. The Act also created the Philippine Atomic Energy Commission (PAEC) and the National Institute of Science and Technology (NIST) and placed these, along with the NRCP, under the NSDB.

In the 1960s additional science agencies were created by law which thereby expanded NSDB's organization and functions. These were the Philippine Inventors Commission (1964), Philippine Coconut Research Institute (1964), Philippine Textile Research Institute (1967), and Forest Products Research and Industries Development Commission (1969).(102) Several existing agencies were also attached to NSDB for policy coordination -- the NRCP, Metals Industry Research and Development Center (MIRDC), the SFP, Philippine Science High School (PSHS) and Philippine Council for Agriculture and Resources Research (PCARR).

The creation of these science agencies undoubtedly shows increasing government concern and support for the development of Philippine science and technology. In 1974, a national science

In 1982, NSDB was further reorganized into a National Science and Technology Authority (NSTA) composed of four research and Development Councils; Philippine Council for Agriculture and Resources Research and Development; Philippine Council for Industry and Energy Research Development; Philippine Council for Health Research and Development and the NRCP. NSTA has also eight research and development institutes and support agencies under it. These are actually the former organic and attached agencies of NSDB which have themselves been reorganized.

The expanding number of science agencies has given rise to a demand for high calibre scientists and engineers to undertake research and staff universities and colleges. Hence, measures have also been taken towards the improvement of the country;s science and manpower. In March 1983, Executive Order No. 889 was issued by the President which provided for the establishment of a national network of centers of excellence in basic sciences. As a consequence, six new institutes were created: The National Institutes of Physics, Geological Sciences, Natural Sciences Research, Chemistry, Biology and Mathematical Sciences. Related to this efforts was the establishment of a Scientific Career System in the Civil Service by Presidential Decree No. 901 on 19 July 1983. This is designed to attract more qualified scientists to work in government and encourage young people to pursue science degrees and careers.

Summary and Conclusion

This paper has shown that the development of science and technology in the Philippines has been greatly influenced by its historical experience as a colony of Spain and the United States. Colonial policies, particularly those on economic development and external trade, have over the centuries fostered a primarily agricultural, export-oriented economy dependent on the outside world as market for its products and a source of manufactured goods. This has led to a neglect and lack of support for industrialization.

This problem of colonial development has effected the historical development of Philippine science and technology. The agricultural science generally tended to receive more funding and support compared to the physical sciences. This pattern of support persisted despite the introduction of the other sciences into the country's educational system during the American regime.

The continuing dependence of the Philippine economy on the United States even after independence in 1946, as a result of the free trade relations and the virtual imposition of the "parity" amendment to the Philippine Constitution by the US Congress has perpetuated the predominantly agricultural and rural character of Philippine economy and society. This dependent development of Philippine society and economy has had serious repercussions for the advancement of Philippine science and technology. Increasing social demand for higher education has led to the growth of highly-trained professional manpower, particularly scientists, engineers and physicians. However, because of the underdeveloped state of the economy, many of these science-based professionals have either been unemployed or underemployed. Consequently, many of them have been forced to migrate to

developed countries, thus creating a "brain drain" or loss of valuable human resources for the Philippines. (108) Worse still, this "brain drain" helps to perpetuate Philippine dependent development as many of those who leave are highly educated and better trained professionals who are needed in the country's development efforts. There is thus a need for the government to critically reexamine the interrelations between past and present education and science policies with those of its economic development policies in order to be able to redirect these towards the goal of attaining a strong, self-reliant economy and society. A well developed national science and technology is a critical factor in the achievement of this goal.