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Issues in the Science and Engineering Education in Indonesia: How to Improve Competitiveness Through STEM Mastery

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ABSTRACT

The rapid advancement of technology and information in Indonesia over the last few decades has provided great benefits to all around its citizen. However, this is not accompanied by the availability of skilled workers in the fields of Science, Technology, Engineering, and Mathematics or what is more commonly abbreviated as STEM. Countries such as the United States have taken rapid steps to reduce the human resource deficit of Pam Sam's country with various incentives in the STEM field. Unmitigated, America opened more than one million new job openings in 2018, the majority (71%) of which were STEM-related jobs. This essay will discuss the urgency of mastering STEM aspects in Indonesia. Several case studies from several developed countries will be provided. In addition, suggestions for the development of STEM that can be done by the government will also be presented in this essay.

Keywords:
Science; engineering; education;
Indonesia; STEM

1. Introduction

Science and engineering sectors play a pivotal hidden role in the economy of every nation. The skills and knowledge possessed by scientists and engineers are unquestionably needed in various industries, from automotive to IT sectors and everything in between. Despite the importance of engineers role, the dearth of science and engineering talent in Indonesia is prevalent across the workforce. To help increase the development of Indonesian economy, more engineers who are educated through excellent education system are needed.

Many believe that concrete infrastructure is the country's top priority. Yet, even with the unceasing supply of graduates from Indonesia's best universities like ITB, ITS, UGM, and UI, the shortage of engineers is still in the tens of thousands. For many businesses, expanding and adding more branches are relatively easy. They just need to obtain the money, build the office, and attract customers to come in, but the most challenging part to do is to fill the organisation with qualified people. The case is not easy when the term qualified employees refer to skilled engineers.

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According to The Indonesian Engineers Association (PII), there are currently 750,000 Indonesian engineers [1]. Unfortunately, 60 percent of them are working in non-engineering sector. With Rp 5,500 trillion (US$393 billion) infrastructure projects coming up in the next half decade, 65,000 new engineers are needed annually. However, all graduates in the country combined with foreign workers could only contribute 35,000 engineers per year. What the government would do to get the extra 30,000.

In the United States, the Governor of Kentucky, Matt Bevin proposed a fairly controversial idea. He wants students who are taking STEM majors to get education subsidies from the government [2]. What is controversial is that Bevin prohibits the subsidy from being given to those studying in non-STEM majors such as literature and social sciences.

Batt Bevin is not alone in his country, Florida Senator Marco Rubio has even publicly stated that America needs engineers more than philosophers. The lack of resources in the STEM field is indeed a serious problem in several developed countries, where the heart of their economy is very dependent on continuous innovation. If the supply of innovation stops, the country is in danger of dying.

Aspects of science, technology, engineering and mathematics are the foundation of modern technological progress. Germany, America, and Japan have long ruled the world with their superior technological products, ranging from modern vehicles, sophisticated production machines to world-class medical equipment. As a result, those countries managed to become global players with strong dominance thanks to their mastery of STEM.

Indonesia can take lessons from what developed countries are doing to become a global player in the STEM field. These countries are competing to attract the interest of their citizens to study in the STEM major. If a country wants to compete globally, the government must be able to give birth to experts in the STEM field. Also, the government should educate, raise, care for, and build homes for STEM graduate students. Because if not, other developed countries are ready to adopt them.

2. Science Vs Engineering

The bond between the world of science and engineering has experienced love-hate style for centuries. Some scientists are still carrying superior attitude towards engineers. Engineers, as a result, actively blame the media for the lack of coverage. Most people believe that the word “science” is generally a substitute for “engineering” and vice versa.

In most part of the world, engineers and scientists do not unfortunately receive the respect from general public. The role of engineers is often armpitted by a higher hierarchy in a company. The social status of engineers and scientists in many asian countries is even alarming. Majority undergraduates who have degree in scence are happened to be the second-class students in their previous school. Many will later work as teachers, only a few pursue their further education to be “real scientists”. Regrettably, most of them are out of the country and never back.

Some say that no difference exists between a scientist and an engineer. Others argue that the two terms are entirely poles apart. Although both encompass inventing, formulating, and humanizing important matter for mankind, scientists are perceived to be the one who formulate theories while engineers create products using these theories.

An engineer usually goes through series of professional training who work in a company focusing on efficiency and making money. A scientist, on the other hand, receive scientific training who work in the sciences looking for “what is possible”. Simply speaking, the dissimilarity lies in their educational degree and job descriptions in the workplace. Both, of course, are monetary oriented by turning a scientific invention into real money leading to financial success.

Moreover, scientists begin a question with the word “why” to pinpoint the truth of unknown worlds in order to formulate conclusions, knowing little what the result might be. Scientists create their own problems which in turn they themselves who solve the problems. Starting with a question of how, engineers, on the contrary, solve real-life problems that are not created by them. They use known theories and models to work in the direction of a known result. They solve the problem and get paid. It is, therefore, engineering is sometimes considered more directly significant to the creation of wealth compared to science.

Either science or engineering actually makes an essential contribution to solving practical problems today. A combination of those two capabilities will greatly bring considerable number of benefits to one nation. Although, in reality, there is substantial intersection between science and engineering, they still bring numerous benefits to a development of a country. We will sometimes find an engineer being the one who responsible to make considerable scientific discoveries and a scientist who put on the knowledge to resolve real-world problem.

3. Government's Role in Promoting STEM

Indonesia really needs a lot of STEM graduates. This is because there is a significant shortage of STEM human resources to meet the infrastructure targets planned by the government. Approximately Rp 60 - Rp 100 trillion in infrastructure budgets was issued by the government in the last three years [3]. Unfortunately, such a large budget is not matched by qualified domestic experts.

The number of Indonesian engineers is the lowest in ASEAN. Indonesia only has 3,038 engineers per million inhabitants [4]. Let alone compare with Singapore which has 28,235 engineers per one million population, with the Philippines and Vietnam alone the country loses. The Philippines has approximately 5,170 engineers where Vietnam is at 8,917 engineers per one million population.

A study conducted by the Organization for Economic Co-operation and Development's (OECD's) found that a nation's technological progress is determined by children's mastery of mathematics and science from the age of 15. Reflecting on these findings, it is fitting that Indonesian economic and educational policy agenda should focus on improving the quality of their human resources in the STEM aspect.

Engineers and graduates of STEM science themselves have accompanied the journey of the Indonesia as a nation. Even the first President (Ir. Soekarno) and the third (Dipl. Eng. BJ. Habibie) graduated from technical schools and held engineering degrees. Not to mention the important officials and stakeholders who are also many STEM alumni. This is because STEM requires students' ability to solve problems systematically and logically.

Especially with the existence of the ASEAN Economic Community (AEC), excellence in the STEM field is an absolute necessity that must be realized immediately. To be able to excel in the field of sports, PSSI (Indonesian football association), for example, requires fields of international standard. And who built the stadiums if not STEM graduates in civil, mechanical, and electrical engineering.

Excellence in the STEM field has domino effect. This means that it will be able to initiate excellence in other fields such as sports and health. We can see the success of advanced countries in the Olympics such as the United States and European countries that are dominating such competition. Likewise, the life expectancy of the population in most developed countries can reach more than 70 years. The benefits of STEM are felt in various aspects of life.

With its important role, STEM requires collaboration with other scientific fields. We can look at the case of Steve Jobs, for example, this Arab-blooded man has dominated the technology world for decades, but he is not an IT graduate. Without a background in computer science, Jobs managed to position himself in the midst of the big players in the technology field. Why? Because Steve Jobs

managed to give a touch of art in every product he created, one thing that is often forgotten by many technocrats around the world.

Steve Jobs once said that the success of the company he founded was not solely due to the technological aspect. Apple can be a pioneer in the world of smartphones, computers, and tablets because Apple has succeeded in marrying technology and art. Coupled with a touch of humanity, it is a product that is loved by millions of people around the world. Nevertheless, we still have to remember, that Apple's core-business remains in the field of technology.

Apple's case above is similar to the dilemma faced by many engineering companies today. Many technical school graduates in Indonesia are not able to convey their ideas clearly coupled with limitations in mastering foreign languages. Communication and language issues are clearly not the realm of the STEM field. Therefore, interdisciplinary science is still needed, whether it is a combination of STEM and Language, STEM and Design, or STEM and other fields of science.

In addition to collaboration, deep mastery in the STEM field must still be a top priority if the government wants to increase the competitiveness of its younger generation in global competition. The government's efforts to provide scholarships both domestically and abroad are also to be applauded. Moreover, the STEM field should be included in the priority list. Imagine if these scholarship recipients managed to graduate and return to their homeland. In the next 10-20 years, they will collaborate positively with each other.

Related to Indonesian students who study abroad and do not return. Indonesia can learn a lot from Japan. Japan and its neighboring country Korea have both sent many of their citizens to Europe and America to study STEM science. However, unlike the case with many Koreans who choose to stay in the country where they study, many Japanese scientists actually return to Japan to collaborate in building their home country.

Japan's success above should be taken as an example, to keep the nation's best graduates who have been educated by the government from being hijacked by foreign countries. Of course, the government must take appropriate steps. Several efforts have been made, ranging from providing contracts that bind scholarship recipients to return and serve Indonesia to providing clear guarantees for alumni of STEM graduates.

If we examine the reasons for not returning the Indonesian diaspora abroad. The biggest factor in their reluctance to go home was not salary, but more about career certainty and how much knowledge they have learned in developed countries can be applied in their home country. When studying abroad, they are faced with sophisticated tools and a very neat system. This is the government's biggest homework if they want to ensure that Indonesia's great human resources do not run abroad.

4. Attracting High School Graduates

Although its conventional teaching method has been heavily critised by several body of education, engineering education in Indonesia remain unchanged throughout history. The change only occur from “chalk and talk” to “whiteboard and powerpoint”. With current technology development and industrial growth, industries should be more adaptive and flexible to remain competitive. It is why most engineering companies are more likely to employ candidates who can easily adapt to changing conditions, generating innovations from newly available technologies.

Naturally, engineers in their real life often face with insufficient data, uncertainty, and demanding clients. In order to produce qualified engineers that could meet the demand set by the industry, the dominant pedagogy for engineering should incorporate project-based learning method. Academic world has been developing for hundred of years. As a result, it has deeply-rooted impact that is not easily to revolutionise. Engineering jobs in the labour force, on the other hand, are relatively younger

profession due to the industrial revolution that occurred in England. It is, thus, engineering education could contribute to the modern-day industrial need.

Engineering education predominantly focus only on science and technical lesson taught in the classroom, failing to deliver an integration with industrial practice. Student do not get sufficient exposure to design experiences. In the existing engineering curricula, teachers are the busiest person in the class, not the students. This is outdated and the method should be student-centred. In addition to their professional practice, today's engineers should also integrate social skill into their technical expertise. It is, therefore, social aptitude and practical knowledge are two set of skills that are required.

Indonesia's current STEM education curriculum has not been able to create student characters to be ready to face global competition. To produce superior quality students, an interdisciplinary approach and its application are needed along with problem-based active learning. STEM-based education actually provides space for students to develop critical skills and form logical thinking to solve a problem well.

STEM-based education will form human resources who can think critically, logically, and systematically. Even though it focuses on the exact sciences, not mastering the STEM aspect will have an impact on other fields of science such as social and economics. That is why many STEM graduates are widely employed in fields that are not related to technology. Because the logic of critical and systematic thinking has a positive impact on the progress of a company or organization.

However, to build quality human resources that are able to compete at the global level, the current curriculum is not qualified to achieve this goal. The problem-solving model by memorizing formulas is no longer in accordance with the current competition needed. Students should be given more space to be creative in solving science problems around them. So the learning pattern focuses on problem-solving where various approaches need to be respected and one single answer is not an absolute answer.

5. Attracting Young Women

Studies in the US have revealed that interest in engineering for young women reaches a peak during middle school years. The trend then fall gradually since then. These young women fail to believe that engineering jobs are relevant to their nature, thinking that engineering degree will never suit their career goals. The tendency is not any better in Indonesia.

Although the number of Indonesian female engineers is increasing in the last decade, engineering is undeniably a male dominated playground. A handful of male engineers consider their female co-workers are talkative individuals with high pithced voice who often create the drama in the workplace. Young Indonesian women has seen from the previous generations that female engineers find it hard to identify their roles in technology-based activities. Such reality is caused by relatively fewer opportunities to grow their motoric and spatial competency – two vital elements involved in most engineering day to day tasks.

Although young females are, in reality, as competent as their male counterparts. The typical reason why some women have huge interest in engineering is because their father is an engineer. It is their father who provide the two vital engineering competencies mentioned above – motoric and spatial skills. The rest of the pool do not have such luxury.

6. Conclussion

STEM has been able to make war-losing countries like Japan to change and transform into a developed country to be reckoned with. Mastery in the STEM field is an important factor for Indonesia to leave its status as a developing country to become a developed country.

Indonesia must be able to excel in the STEM field. With the provision of scholarships, positive collaboration between various disciplines, reform of the STEM curriculum, firmness and clear work guarantees from the government, the positive effects of STEM will be able to contribute positively to the progress of the Indonesia as a country.

Conventional engineering education in Indonesia needs some reformation. In their future day to day job, engineering students should be equipped with the concept project and problem solving. To satisfy industry requirements, the government must combine project-based learning methods with the existing courses that are taught traditionally. In doing so, the fundamental of engineering principle would not be sarificed. The industry would also be more than welcome to hire them as young engineer graduates that are ready to step up the ladder.

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