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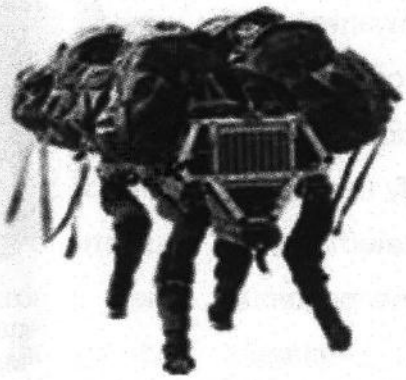


Abstract

Innovation usually occur when there is a better application solution that meet new requirement, inarticulate needs, or existing market needs. One engineering product that bears rich innovation is mechatronics. This occurs, thanks to the multidsciplinary interactions in which new ideas flow out to meet user demands and continously trigger new sub-disciplines to surfaced up. This paper utilizes mechatronics as the vehicle to proceed into a widely concept of development in innovation within the landscape of human life, and can relate to why our country are still lack behind.

Key words : engineering, innovation, interaction, mechatronics, multidiscipline.

General

Mechatronics is a branch of science, originally stemmed from technology disciplines. One can encounters mechatronics in mechanical, electrical engineering, as well as in mathematics and natural sciences within each curriculum setting. Some other programs of education considered mechatronics support important and placed it in their curriculum as well. The effect was that mechatronics spread so widely within the landscape of science and technology, and can even attract other branches of science to join in.

Mechatronics in Engineering

As a multidisciplinary field of engineering, mechatronics, since its

early stage of development rejected the splitting of engineering between Mechanics and Electronics. These two disciplines must again adapt itself with the fast changes of the technological outlook as the systems became more and more complex. Many technical branches, demand close collaboration while the basic phylosophy of mechatronics is continously updated to adjust with the new trend. Mechatronics shifted to the center of gravity of Mechanical, Electronic, Computer, and Control Systems. Intersections of all these discplines have created other branches or sub-disciplines to surface up, like Digital Control Systems, Control Electronics, Electro-mechanics, and Mechanical Computer Aided Design. These basic core disciplines must serve the need of so many applications including : Medical systems, Xerography, Defense systems, Consumer products, Manufacturing, Material processing systems, Automotive, and Aerospace, to mention a few. Fig.-2 portrayed the condition.

At an International Conference of Mechatronic in Warsaw University a couple of years passed mechatronics was redefined, as the combination of enabling technologies brought together to reduce complexity through the adaptation of interdisciplinary techniques in production.

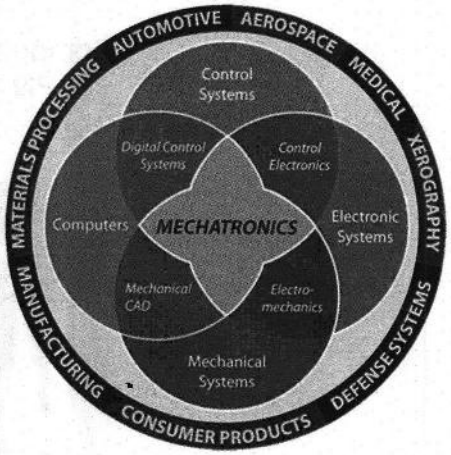


Figure-2 : Multidiscipline in Mechatronics product

Mechatronics cannot exhaustively be analyzed within the domain of mechanical or electronic engineering alone. They are even not mutually exclusive since parts of its whole product involve others, in a variety of levels. One discipline may easily dominates in the design of mechatronics depending on the required function of the designed product that got prime attention. Thus concentrated efforts on the stakeholders of mechatronics so to say, should be emphasized as the strategic aim toward the building of mechatronics' products, requested by so many field of applications. These requirements are commonly considered seriously by the designers with the results that the designed

products are successfully accepted by the targetted users. Why do multi interrelated products more acceptable ? Multidiscipline interplays, enjoy the open minded visions of the participants while in almost all cases each party place high expectations on the users who are going to utlize the output. That is why the most benefit side are the users. This differ from a single source entity which despite all its efforts to embark on the same approach, can not independently enjoy the liberty from the embedded monosectoral influences. Look at the creature that welcome you at the entry part of this paper. No one can claim that it belongs to their domain. Name any branch of discipline, and you will find that it definitely has some share in this robotic creature. Not only Computer, or mechanical engineering are involved but even psychology, behavior science, and even health as well as any branch that you can imagine. And that is a product of innovation. It differs from invention, because invention refers to the use of a better and as a result, novel idea or method, and refers more directly to the creation of the idea or method itself. Innovation on the hand differs from improvement in that innovation refers to the notion of doing something different rather that doing the same thing better.

Decline attractiveness in Engineering

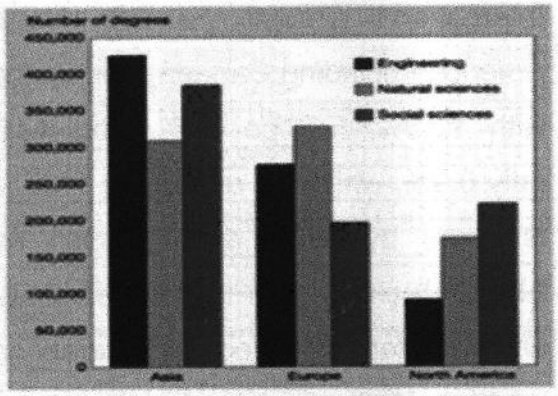
Engineering studies is no doubt the cornerstone of mechatronics. It build the foundation to enhance innovation within the engineering discipline. The basic foundation of mechatronic lies in the appropraite curriculum design of an engineering subject, including teachers and educators. Unfortunately while the demand of business for the product of mechatronics increases, interrests in this field was steadily declining. Some speculated, that the causes being the difficulty of the curriculum, the attractiveness of alternate path to good technical jobs, and the lack of attractiveness of projected employment paths for engineering graduates. Around a decade ago UPN "Veteran" Jakarta has to close its Electrical Engineering program because after 3 years of operation the number of students only reached 20. It followed the technical engineering of the diploma program which was closed a year before. All efforts were then focused to retain the existence of the (undergrad) Technical Faculty, despite

its lack of enrollment below the minimum standard level for several years. UPN "Veteran" Jakarta did not face this problem alone. There were not less than 10 private Universities terminated their technical programs based on similar reasons almost during the same period.

Interestingly, this trend also occured in other countries as well. United states, and some European countries claimed similar issues. Despite the believe of those industrilized countries that the direction will soon reverse, no practical fact of the trend provided any evidence. The optimisms were based on the high demand of engineering products, especially in the application of robotics and automation for industrial movers where such trend will commonly drives the supply sides to react according to the needs, and so equilibrium at the supply side will dictate the balance. However, mechatronics is heavily technology and creativity driven where innovations are its main success factor. When young generations are not attracted to STEM (Science,Technology, Engineering, and Mathematics), the future of mecahtronics will be at stake.

Some Indicators

Statistics in figure-3 shows the difference of higher education in Engineering, Natural Science, and Social Science among the three regions, Asia, Europe and North America. As mentioned obove these are the basic prefoundation of mechatronics development. Asia is clearly leading. However, looking more deeply, one can see that in Asia only some countries dominate the lead. China, South Korea, Japan, India as well as Singapore are dominating. When the United States bachelor's level graduates in engineering reached a peak of 800.000/year in the mid 1980, it then decreased steadily to about 65.000/year (*Engineering Workforce Commission, 2004*). Although it increased again somewhat, still can not keep in pace with the employer's needs, while China currently has 3.7 millions engineers output ambition in her pipeline.



Natural sciences include : physics, chemistry astronomy, and earth, atmospheric, ocean, biological and agricultural sciencesas well as Mathematical and computer sciences. Social Sciences include sociology, psychology, and other social sciences.
Source : Science & Engineering Indicators - 2002

Figure-3 : Higher Education in Science and Engineering

Reasons behind the scene

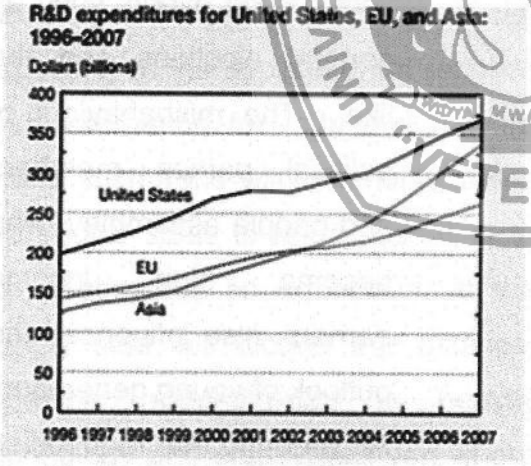
The following points were collected from many surveys on the reasons why engineering are not so attractive by young generations :

1. The curriculum of engineering is difficult. Undergraduate curriculum in engineering, were built on top of strenuous prior preparation requirements in secondary education years. It is heavily loaded with mathematics and science – including calculus, probability and statistics, physics, chemistry and biology.
2. The curriculum is densely packed and not very flexible with respect to its prerequisites.
3. Alternate path for high school students looking at various options may end up with choosing less formidable, where compensation levels may be better.
4. The global interaction which is now easily accessible provides the following lifestyle for young people at high school students ages :
   a. Celebrity life attract many young people. Besides it, celebrities get the most probable opportunity to be popular in the eyes of the society, and can easily granted certain predicates. They get more chances in vote getting events such as general elections and the like. The misbehaviors of political parties members and people assambley, who become high income earners, also influenced the outlook of young generation. Engineering that requires so much energy and investments with minimum compensation is obviously not attractive.
   b. Scarcity of engineers in industrilized countries attract overseas engineers. If their immigration policy is set more

friendly, brain drain from developing countries may be at stake.

The Equilibrium

Figure-3 displays the imbalance of the number of engineers that are produced in North America, Europe and Asia. At a cursory glance, Asia as mentioned earlier dominates the other two regions. If China engineers flood most engineering industries globally, will engineering standards requires reallignment to this Asian flavor? To provide an honest analysis one need to look at Figure-4 that displays the condition of the spending in R&D. Asia is still behind US.



EU = European Union, 27 member states.
Note : Asia includes China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand.
Science and Engineering Indicators 2010

Figure-4 : R&D expenditure for USA, EU and Asia

Projections of research and industrial data from different angle are important to consider. In Figure-5 (the International Patent Family), North America (including Canada) dominates with 72.5%, Europe 15%, and Asia only 0,9%, while the remaining 11,6 % is taken by other regions such as Africa, Australia and the Middle East. Other factors required considerations are that North America is still on the top level with respect to education and industrial standard, due to its homogenous advantage as a single big entity. Canada can easily go along with the United States because of the close cultural relationship, while Europe and Asia consist of so many different cultures that may not so easy to result smooth interactions. Although engineering may possess similar or close standard among the different countries, its detailed breakdowns and educational implementation may be strongly influenced by each national cultural identity and higher education policy applications.

North America

Year	1995	1996	1997	1998	1999	2000	Total
United States	21	45	104	217	247	0	634
Canada	1	0	2	4	1	0	8
Total N. America	22	45	106	221	248	0	642

Europe

Great Britain	1	4	9	9	8	0	31
Germany	1	2	2	9	5	0	19
Finland	1	3	0	5	6	0	15
European Patent Office	2	0	6	5	0	1	14
France	0	1	3	7	1	0	12
Sweden	0	1	6	5	0	0	12
Netherlands	1	1	2	2	1	0	7
Ireland	1	0	0	1	2	0	4
Austria	0	0	0	2	1	0	3
Switzerland	0	0	1	1	1	0	3
Norway	0	1	0	1	1	0	3
Denmark	0	0	1	0	1	0	2
Patent Cooperation Treaty	0	1	0	0	1	0	2
Belgium	0	0	0	1	0	0	1
Spain	0	0	0	1	0	0	1
Italy	0	0	0	1	0	0	1
Total Europe	7	14	30	50	28	1	130

Asia

Year	1995	1996	1997	1998	1999	2000	Total
Japan	4	14	15	14	16	0	63
South Korea	1	1	3	2	3	0	10
China	1	0	1	2	1	0	5
Singapore	0	1	0	1	0	0	2
Total Asia	6	16	19	19	20	0	80

Middle East

Israel	0	0	2	6	3	0	11
Total Middle East	0	0	2	6	3	0	11

Australia

Australia	1	1	2	3	0	0	7
New Zealand	0	0	0	0	2	0	2
Total Australia	1	1	2	3	2	0	9

Africa

South Africa	0	0	1	1	0	0	2
Total Africa	0	0	1	1	0	0	2

South America							
Brazil	0	0	0	1	0	0	1
Total South America	0	0	0	1	0	0	1

Figure – 5: International Patent Family

Source : Realigned from " Science and Engineering Indicators, 2002

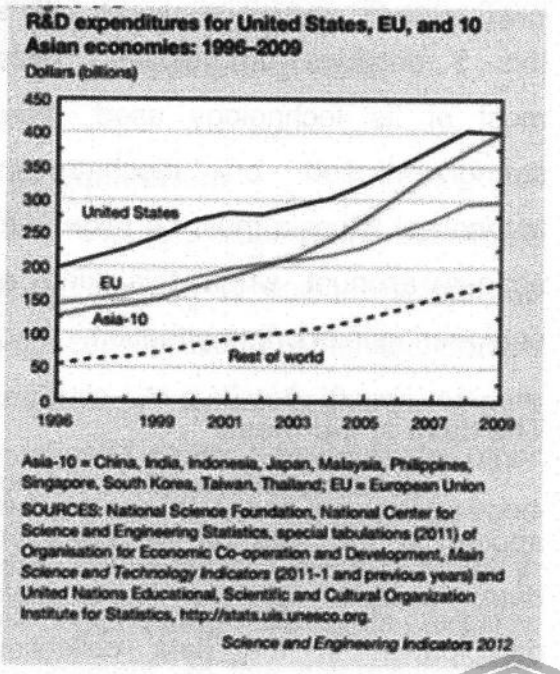
The statistical data of 2010 was already launched, and figure-3 have shows that for five years, United States is still leading in its research endeavour, although China is trying to close the gap.

Other factor that is not covered was the role of Russia, a giant power that due to its rather silent behavior is not so well exposed. But, if we look back to the history of engineering that has put Russia as the first successfull country in the history of space technology, we can easily predict that their education systems and innovative motivation should have been taken them into an advanced state during this 5 decades progression. Since most of its technology used, were strongly based on mechatronics technology, Russia must be taken into serious account when this kind of engineering is of prime attention.

The case of Indonesia

Indonesia, unfortunately did not appear in the lists of the analyzed data, probably of the inappropriate participation in the data collection survey, despite the achivements reached by the young generation of high school in many international competitions of mathematics, science, and technology as well as computer and robotics. Participants almost never return home without any gold medal. Some freshmen and sophomores have also showed good records. Graduates from Indonesian Universities are now seeking jobs in other countries with success. However,

Figure-6 : R & D spending



we must admit that in the field of research and development, Indonesia required hard works and good governance involving higher education management and administration, otherwise we may become first victim of the brain drain. Indonesia are also weak in the academic publication at international level. To make matter worst, in the eyes of the young generation, our political systems despite its democratic jargons, may become one weak element, what corruptions are concernerned. As a legislative body they have demonstrated that many legislative products put most of the benefit to their own advantages rather then the strategic interest of the country. Member of the legislative body are the high paying citizens of the country despite the fact that no innovation or even creativity have been presented. Even with minor things despite the technological progress of IT that have made data collections and analysis easier, they still relying on the "comparative study" just to formulate a certain legal product. This is strongly opposed by the principle of innovation, and because of their high position project the prototype character of the country. Despite these facts, some available statistical data may provide us with optimisms that Indonesia still have the opportunity to play some roles in the global driving seat in the years to come. Fig-6 shows a tremendous increase in the allocation of budget for R&D for Asia-10 so that in 2009, the number of allocation for R&D match with that of the United States. Asia-10 group consists of China, India, Indonesia, Japan, Malaysia, Phillippines, Singapore, South Korea, Taiwan and Thailand. We can predict how many Indonesia shares in this Asia-10 achievement. Possibly belonging to the lowest percentage. However, with reference to the achievement of our hich school's students performance in the international competitions and the

chance as member of Asia-10 the opportunity still looks bright, although seemingly not to occur within a decade and must wait for our new generation to take the lead of the country when they become mature.

What should be done

1. The declining interest in engineering and thus mechatronics application need serious attention. It is not just a simple issue of inatractiveness of the engineering subject, but involve more on the changing character of the young generation in adaptations toward consumptive lifestyles in this global competettive era. Without any dedicated effort from the government – ministery of national education - to reverse this situation, Indonesia will loose the opportunity to exploit the talents of the young generation who have shown high achievements in the international recognized competitions involving engineering and mechatronics. Continious flow of the best graduated engineers from good Indonesian higher institution will occur, leaving the Indonesian industries remaining in the passenger seat without any chance to move to the driver seat.
2. Indonesia need to take the initiative to share the drastic progresses of some leading Asian countries that placed Asia as the next decisive power in economic and technological development. With the relatively high number of human resources Indonesia should share the progressive name of Asia. To utilize this opportunity, Elective subject to learn one of the Asian language should be considered. Either Japanese, Korean or Chinese might be feasible to add into the curriculum subject.
3. The following strategies and initiatives are important to achieve all the above points
   a. Revisit and if necessary redesign the education policy at high school with proper emphasis on mathematics, physicst, biology, and subjects that will support the future outlook of the students at those level. Projects initiated by Dr. Yohannes Surya has shown that most

young people from remote areas of Indonesia (like those living in rural mountaineous areas) like Papua, have shown talents in math if providing attractive ways of learning. And this have also retained their interest until reachning the freshmen and even sophomore ages.

b. Redesign the curriculum of the basic science and technology such as mathematics, physiscs, statistics, and the like, to be more adaptive with the real application. Improper handling of the strategic plan in education setting currently, can only be corrected after 5 years later.

c. Engineering subject commonly trigger one's motivation in increasing self awareness in mastering a knowledge which may become the foundation of selftrust and initiative rather than depending on what is alredy available. These, characterizes the will to become productive person rather then consumtive.

d. Innovation can only blossom in a multi disciplinary interactions. The achievements shown by the Indonesian young generation in various international comptetions gave some hope that potential talents exist in young generation. Unfortunately the new cuurriculum setting which combined some important basic STEM subjects require testing for 5 years, before we will know its real effects.

e. Continue and upgrade the engineering competetion projects, such as math competitions, robotics and the like. Without it self trust will cease in our young generation and our industries will mostly absorb overseas engineers, while on the contrary our own best engineers will seeks jobs outside. Such condition will stay at statusquo state for a long time, although as part of Asia we bear the productive name of Asia, but only follow the trend which are set up by

our neighbour China, India, Taiwan, Singapore and even Malaysia. Some our their products may stem from the works of our own best engineers who work in other countries.

Conclusion

1. Mechatronics products has become the high demanding commodity of the global industry, but on the contrary, engineers that belong to the design and production sides of mechatronics become scarce as the consequencies of continuing decline of interest of the young generation to choose engineering as the subject of their future competence.
2. Asia played steady increase in filling the gap of scarcity. Onfortunately, only relatively small numbers of the Asian countries belong to this group mostly dominated by the North Eastern part of Asia, including India, and Singapore. Indonesia does not play any significant role in this advantage, despite the evidence that among its large numbers of population, some young generations have demonstrated high competetive power in several international competitive events in science and technology including robotics. By being aware of the situation and set up a strategic and sound plan, for education as well as systems and industry, windows of opportunity will still open to share the driver seat together with the leading Asian countries.
3. Mechatronics lay the fundamental road map of innovation where multidiscipline interaction provides feasible mapping on how to understand and plan its utilization toward the best wellness of the country.

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