The Improvement of Technology Education for Mechanical Engineering-Practicing of Pre-University Make-Something-Education

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Abstract: Taiwan is an island country of which the economy is built on trade. The development of industrial technologies plays a decisive role of its economy. How to produce good quality and quantity engineers is one of the most important issues for the island's economic development. To improve the technology education of mechanical engineering in university, the authors proposed that the mechanical engineering education is indeed Make-Something-Education and have implemented a new education system that is welcomed and supported by many industries. As the system is carried out, it is found that proper technology education before university is essential to the success of the Make-Something-Education of university stage. For that we investigated the nature of technology education, outlined the principles for pre-university technology education. In this paper, the concept of pre-university technology education is addressed. Experimental courses that the authors developed and the practicing results are also presented.

Keywords: Make-Something-Education, pre-university, make fire by rubbing woods, cotton candy

1.Nature of Technology Education for Mechanical Engineering

Learning technical skill is part of human's everyday life. Our ancestor developed necessary surviving skills and passed them to others who need them. The transferring of technologies occurred naturally and without being noticed. Technology is a combination of experience, knowledge, and skills. Exercising of skills is an important step of technology transfer. In ancient time, transfer of technology is integrated in everyday life. The process was natural and effective. As society become more and more diversified, the places for producing commodities needed for everyday life have become separated from where they are used thus teaching and learning technologies become difficult. The difficulty of technology education has become more serious with the rapid growth of application of automation and information technologies.

For the improvement of the education in science, many educators have studied and proposed a pattern for human learning of science illustrated in Figure 1. Educators proposed that the only fundamental of science learning is that a person must be able to do experiment with hypotheses on natural phenomena that he discovered due to curiosity. Based on this understanding, the educators have designed and implemented a course that integrated abundant materials in few items. The improvement on the learning result using this course is proved effective [2, 3].

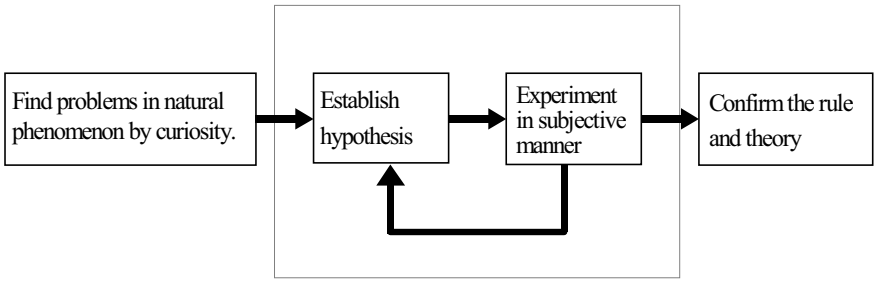

Fig 1. . The pattern of science learning process.

The context of mechanical engineering is a summary of technologies that human has created along the history. It is very to complete the technology education of mechanical engineering within limited school education time. To improve the education for mechanical engineering technology, we need to analyze the common pattern of technology development and to identify the natural of technology education for mechanical engineering so that a feasible and effective curriculum can be established. With the experiences in schools and in industries and concepts from references [4, 5, 6], a complete process for technology development can be described with Figure 2. Figure 2 shows that a technology development process starts with an aggressive attitude, of a person, for solving problems that can not be solve by simple common sense and ends at the completion of the prototype. This attitude originated from one's sense fitness of things. This sense is a gift and is very difficult to acquire through education [4]. So the starting point of the technology education is to find people with such gift, or to design a learning environment so that the gifted people can be identified.

Also, the technology development process ends when a prototype is made. Since direct application of common sense is usually not sufficient to solve technical problems which involves many uncertainties. Besides, many design specifications sometimes are difficult to describe numerically. Usually a good design solution can not be obtained directly with simple calculation. Instead, a good usually need to go through a trial and error process such as shown in Figure 2. In the recursive trial, an engineer uses his drawing techniques to study possible solutions. After his efforts in design manufacturing and testing, the solution may be found unsatisfactory. But new knowledge is generated

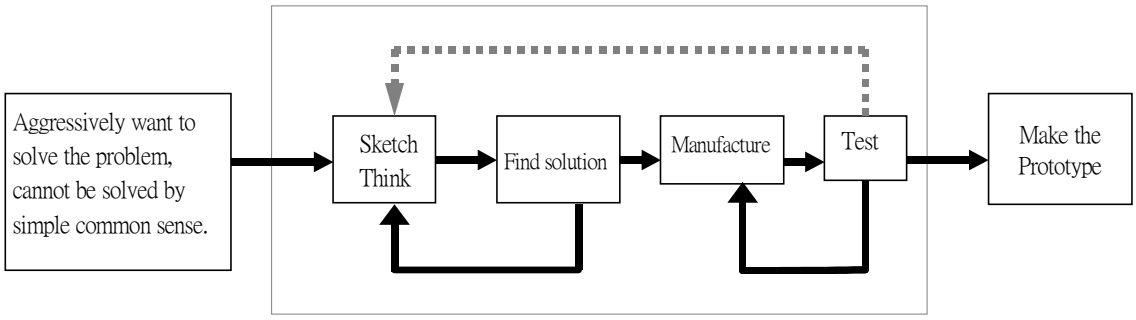

Fig 2. The pattern of technology development process for mechanical engineering

during each trial, and the knowledge is to be applied until a satisfactory prototype is made.

With foregoing description, we know that drawing skill and manufacturing skill of an engineer are what make the trial and error process possible. If the purpose of technology education for Mechanical Engineering is to cultivate technology development engineers, then basic training such as skills of mechanical drawing, manufacturing should be the most important part of the education.

As it is shown in Figure 2, we can say that technology development is creation of problem solving designs and effort of producing the designed goods. Creation of problem solving designs is Invention. Effort of producing the designed goods is what we call Make-something. To be more apparent in expressing the authors' supposition for meaning of engineering technology education, the authors proposed to use " **Invent-and-Make-something Education**" instead of engineering technology education.

2.Need for Pre-University Invention-and-Make-Something-Education

The authors have been studying how to improve the technology education for mechanical engineering. We have proposed and established a long term systemic education program and have

practicing in the proposed way for 10 years [1]. During 10 years of practice, the program has been successful. More than 20 engineers get their master's degrees through our create-design-make oriented program. However, the result is far from comparable with the education for training medical doctors or musicians [1], thus the following study is proceeded.

For an engineer to have the ability to invent and make something, 5 elements are essential, namely: (1)physical strength, (2) general abilities of reading, writing, and calculating, (3) experience and knowledge, (4) basic skills of drawing, machining, (5) Positive attitude toward making things with their hands. The ability of **Invention-and-Make-Something** is a combined expression of the 5 elements. Although with the education system we have implemented, students' ability increase accordingly with the increase in the length of their education, yet the achievement of this 10 years education program is far below our expectation.

To understand the reason for the discrepancy, an observation has been performed on the growth of the 5 elements as functions of age. The result of this observation is illustrated as Figure 3. According to the pattern of technology development process shown in Figure 2, among the 5 elements, item (5): positive attitude toward making things with their hands is the key for all Invention-and-Make-something activities. Without item (5), no invention activity will begin and thus nothing will be invented or made. It is our observation that the ability of Invention-and-Make-Something of a person at any age is the sum of the values of items (1) through (4) multiply by the value of item (5) at that age, where the value of item (5) varies between 0 and 1. According to our study and research results of Dr. Harry Chuguni, PET Center of Michigan Children's Hospital [7], the value of item (5) starts from zero at the birth time and will grow with age of the child. It will reach the maximum value of 1 at about age of 6. And because of various limitation of the current education environment, this value tends to decrease along the time and down to almost zero approximately at the age of 18. In Figure 3, items (1)physical strength, (2) general abilities of reading, writing, and calculating, and (3) experience and knowledge, all increase with the increase of age and are represented by 3 solid lines. Item (4), basic skills of drawing, machining, is represented by solid line before age of 6 and by dotted line after age of 6. This reflects the facts that current education system is quite successful in teaching common knowledge, but as for engineering technologies, the education is far from adequate. Analyzing result of Figure 3 reveals that it is necessary to begin the **Invention-and-Make-Something education** in elementary school, middle school and high school.

The growth and maintain of positive attitude toward making things with their hands depend on the learning and practicing of the skills. Before age of 6, skills such as paper cutting, painting can be properly trained in family. After 6 years old, need to learn more drawing and manufacturing skills, however the society not realizing the importance of the skill learning at this early stage, fail to provide proper teaching facilities, manpower as well as way of teaching. The result is that in current 12 years of grade school and high school education in Taiwan, the teaching of engineering technology is completely blank. That is why the motivation of making things by hand decreases along the age. By 18 years old, a person's physical strength, general skills and knowledge have increased to a certain level, but due to the decrease in his motivation of making things and lack of proper training, his ability to invent and to make something has been completely lost.

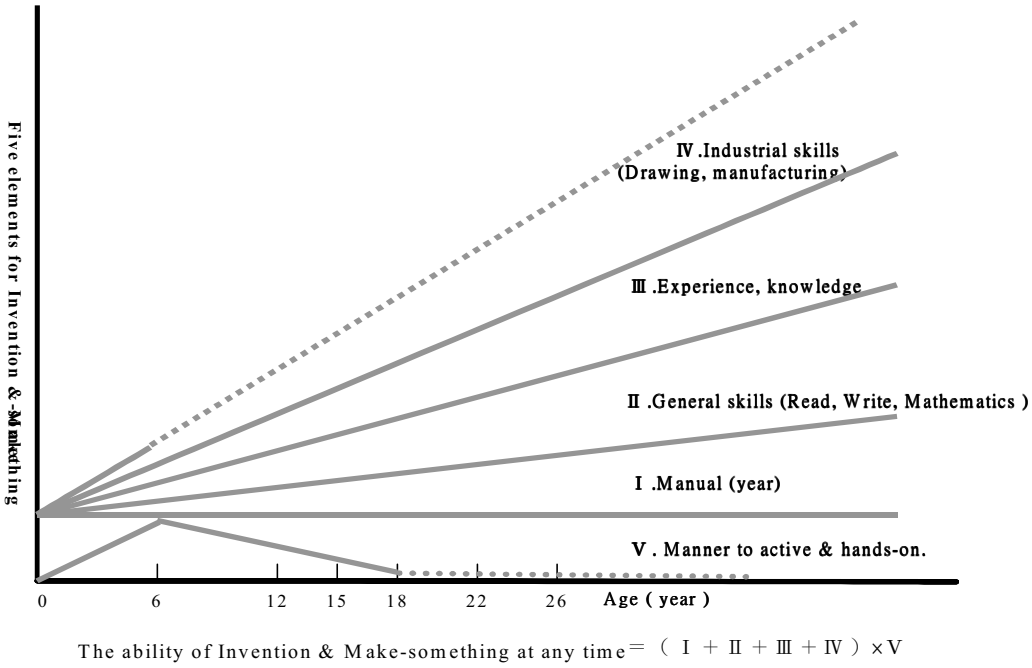

Fig-3, Relationship between the ability of Invention & Make-something and the age.

Learning of skills and exercise are similar. It must start with simple, fundamental moves and gradually increase the complexity. It will take long enough time to master the skills. Learning technical skill is special because the timing to start it is important. In current system, the teaching of technical skill begins at university. In this stage, training of basic skills as well as establishment of motivated attitude are difficult to carry on. This is why current mechanical engineering education is not successful. Also it is why we need to study the contents of our training for general skills and try to include invention-and-make-something education in pre-university stage.

3.Practicing of Pre-University Make-Something-Education

According to the foregoing discussion, I know that Mechanical Engineering Education has to be long-term and persistent to cultivate engineers who can really invent and make things. Engineering educators of universities must extend their service area to pre-university technology education. Through out the years, the authors, with cooperation from grade school and high school teachers, have carried out a series of training courses that we developed experimentally to verify our idea. The Results are reported as below.

To be compliant with current education system, we use summer and winter break and also weekends to promote our education courses. Because the technology education must be long term, courses have to be designed to cover contents suitable for different age groups. In our experiment, three levels of courses are designed to fit children of three age groups: 10 to 12 year-old group (grade 4 to 6), 12 to 15 year-old group (middle school level) and 15 to 18 year-old group (high school level). Three different goals are set for the different age groups. For the first group, the goal is to make students motivated and eager to solve problems faced in everyday life. For the second group, our goal is to teach students the basic skills of drawing and manufacturing. The goal for the third group is to provide students with opportunities for them to carry out a complete process of invention and make-something. Our courses are designed to use only limited time in weekends and holidays so the principle for the designing the courses' context is to make the courses concise but very impressive.

In the elementary school stage, we studied the important inventions in human history. We chose items that are impressive and have great influence to human life and integrated them into a 3 hours course. We hope to make students motivated and have the eager to invent and make things with their hands. Photo 1 shows the experiments that demonstrate the power of atmosphere and why it can lift airplanes. Photo 2 shows how to **make fire by rubbing woods** and how to make **cotton candy** with simple home-made device. Photo 3 shows how egg and arched bridge can support heavy load. The above 3 photos are examples of the course we designed and taught for more than 30 times. Atmosphere, fire and eggs are most natural and familiar things to us in our everyday life. The magic that these things have is most suitable examples for inspiring people to devote himself to invent and make things.

After the elementary school level education, we tried to identify students who have the aggressive attitude for solving problems and with good sense of fitness of things. We invited them to participate in the middle school level invent-and-make-something education course. In preparing the

course contents for this stage of education, the principle of concise but impressive is also applied. We designed a training course that enable use to train students to operate lathe, milling machine, welding machine, and practice other basic manufacturing skills. For a given subject, students learned not only the machining skills but also the physical principle of how this subject works. For example, oscillating steam engine as shown in Photo 4 is one of the subjects employed in our course. Students learned the principle of steam engine, how energy is transformed and the technique needed to build the machine. Currently more subjects such as manufacturing of a mechanical clock, manufacturing of gyro toy are under developing. To ensure the safety and efficiency of this course, a junior level Factory of Dream was set-up. Photo 5 shows a corner of this junior factory[6].

After a student who has good sense of fitness of things go through the 2 stages training addressed above, he should have become a junior inventor before he enters high school. The tasks of the high school level invent-and-make-something education are: 1) to introduce examples of exist inventions to inspire students motivation for invention, 2) to provide equipment and necessary assistance to students in making prototype of their invention, 3) to help students apply patent on their invention, 4) to hold regularly exhibitions for inventions done by junior inventors. Right now our plan on the third stage of invent-and-make-something education is being carried out. A complete records of the experiment results is not yet available. However, we are confident that after the execution of this final stage will conclude successfulness of our Invent-and-Make-Something Education.

4.Conclusion

Technology education for Mechanical Engineering is indeed what we call the Invent-and-Make-Something Education. Invent-and-Make-Something Education is a comprehensive training of spirit, skills and knowledge. This kind of training has to be carried out with persistency and has to be long term. In current education system, in addition to the efforts we put in the university level education, efforts in enhancing the skill training of pre-university level education are also needed. The latter are the key for assuring the successfulness of improvement for technology education. The improvement of technology education requires participation from the society and thus is a social movement. To promote effectively this social movement and to carry out the improvement effectively, formation of special organizations to integrate resources from schools and society is the most important task for the future study on the improvement of engineering education.

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Photo-1 The power of atmosphere and how to

Photo-2 Make fire and cotton candy

Photo-3 Strength of egg and arched bridge

Photo-5 Junior factory

Photo-4 Oscillating steam engine