Hand-On Engineering Experiences by The PICEE Engineering Camp

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Abstract

A rich quality of life in contemporary society is deeply tied with technical innovation. It is basically based on the foundational knowledge in engineering such as mathematics, science, etc. However, many students may regard this foundational knowledge as difficult things which cannot be easily accessible. So we need to help students to reduce burden of this knowledge through the ordinary and hand-on engineering experiences. By a part of this efforts, PICEE(Pusan Nation University, Innovation Center for Engineering Education) held an Engineering-Camp(EC) twice. The students made a simple robot using a electronic control system in the first camp in 2008 and experienced the principles of energy generation by natural resources in the second camp in 2009. EC provides students to the concept of engineering in everyday life experience. The participation and satisfaction of students are very high and they evaluate engineering as a very interesting thing. In recent situation which excellent students avoid the field of engineering, we hope that EC provides students to acquiring a positive attitude for engineering as well as to increasing opportunity to recruit future excellent students in the field of engineering.

I. Introduction

The rich life of contemporary society is tied directly to technical innovation. Nevertheless, many competent students who are suitable for technical innovation are not inclined to choose the engineering field. This situation is occurring in most developed nations including South Korea. However, avoiding the engineering field will have a deleterious effect on future society. A simple error in the entire system may have a significant and long-lasting effect because our modern society becomes connected with each part of it through complicated contemporary technologies. In order to achieve a safe and rich future, we need to motivate smart and excellent students preparing for college entrance to have interest in the engineering field, and should take various and diverse steps to develop and motivate school-aged children to have creative interest about the engineering field.

The PICEE (Pusan National University Innovation Center for Engineering Education) held an engineering camp twice for the purpose of making engineering comfortable, easy and exciting to elementary students and to cultivate their creative talents that are beneficial for future technology. This paper explains the engineering camp in connection with K-12 engineering education which has been supported nationally by the US government and Howard Gardner's theory of Multiple Intelligences promoting the ability to cope with the future context of engineering.

II. The Social Context of Engineering in the Future

Engineering is an important academic field in contemporary society. It is a practical field that promotes a safe and convenient life by applying highly abstract principles. The technical advances of engineering lead to changes in social environments, which in turn are linked with innovative engineering. In particular, intense competition from the effects of globalization and the extension of the market economy reinforce profit motives. Those motives encourage people to promote technological innovation, which rapidly change societies. In order to decrease the social risks and defend the safety, health, and well-being of the public, human resources that can understand and cope with the rapid social change are necessary to prepare for the future environment.

Therefore, in order to educate competent persons to respond with future situations adequately, we need to understand the current of change of the world. A report presented by the National Academy of Engineering in the U.S. summed

up the social context of the future which current students would encounter.[1] The world's population expected to reach 8 billion at around 2020, will be a big challenge for a future society. This increasing population, which is occurring mainly in Africa and Asia, will cause serious deficiencies in housing and food. In addition, the youth workforce in developed countries will decrease due to the low birth rate. Furthermore, an increase in the elderly population will aggravate the economic burden of the youth workforce. The demand for health and health care as well as life expectancy will increase through the development of innovative medical technology. The expectation of life extension will help increase the tax-burden on the youth workforce. On the other hand, the increase in the unemployment rate of youth in under-developed countries becomes a serious social problem. The discontents of these young people can be expressed to joining fundamentalist camp and terror which may lead to social unrest. The development of communication systems, such as the internet, will expand the scale of the global market and intensify the competition based on the logic of the market economy. Many companies will manage teams that are bound to people from various regions of the world in order to respond to these broad and rapid changes of social context. Therefore, there is a great demand for engineers who can understand the culture, religion, and economy of the other regions and can consider effects of their activities on economy.

This report deals with the professional context of a future engineer. It is difficult to solve technical problems with the technology of single field because future technology will be complex and diversely converged. Therefore, a suitable approach with systems perspective will be needed, in which engineers from a variety of fields are involved in an issue as a team. With the rapid information processing, the gap between buyers and companies is decreasing. As a result, the scheme of buyer-centric strategies will come out and there will be an increase in the interactions between buyers and engineers. In this way, the society needs customizing engineers to communicate with buyers and produce the products fitting their demand. In a future technology-depending society, engineers will play a role in enhancing public policy determination for safety, well-being and health of the public. And we need to make efforts for the smarter students apply for engineering field through improving the public understanding of the engineering field.

Considering the above information, we can find that engineering itself is at the heart of the problem from a variety of social changes in the future. However, because many excellent students avert the engineering field, considerable difficulties are expected when encountering future challenges. As mentioned in the introduction, many advanced nations including South Korea have a similar experience. There are many reasons for outstanding young students to avoid engineering profession; the contribution that engineers make to society is relatively less known, a low reward and low professional reputation compared with their hard works, in particular, the prejudice that engineering needs a high level of skill in mathematics and science which many young students regard as difficult subjects. Among them, low social refutation, low reward and the instability of engineering jobs due to rapid innovation of technology can be regarded as a significant factor that hinders students getting into the engineering field.
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n this regard, the problems that need to be solved can be summarized into two factors. On one hand, it is important to create an environment that would encourage excellent students to enter an engineering field. On the other hand, it is important to develop innovative teaching methods that would encourage present and future students to assume the responsibility of the coming society. For these purposes, we are going to consider the K-12 Engineering Education supported by the US government and Howard Gardner's theory of Multiple Intelligences.

III. K-12 Engineering Education

K-12 Engineering Education is supported by the US government to improve the image of engineering through marketing of engineering fields to K-12 students and create an interest in engineering through hands-on experience. Based on these activities, the United States is striving to maintain a national security system in the technology-depending society of the future, and lining up a demand for engineers of many ethnic backgrounds for national economic prosperity and who are proficient in technology as well as in promoting the environment.

With relation to this purposes, the Engineering K12 Center of ASEE in the U.S. submitted in Nov. of 2004 "Engineering in the K-12 Classroom-An Analysis of Current Practice & Guidelines for the Future" which suggested 6

guidelines that are necessary to improve the K-12 engineering education as follows:

- Hands-on learning: Make the K-12 science curriculum less theory-based and more context-based (hands-on), emphasizing the social good of engineering and demonstrating how it is relevant to the real world
- Interdisciplinary approach: Add a technological spin to all subjects and lessons, and implement writing guidelines in mathematics and science courses
- Standards: Involve engineering in K-12 lessons that state the standards for mathematics and science. In addition, the states should follow Massachusetts and enact state standards for engineering
- Use/Improve K-12 Teachers: Engage more K-12 teachers in outreach efforts and curriculum writing, and increase the teacher salaries to attract the best technological minds to teaching
- Make Engineers "Cool": Outreach to urban schools and females more aggressively, and create more mentors and role models to attract these constituencies
- Partnerships: Create better incentives for all groups to engage in K-12 outreach (particularly from higher education and industry)[2]

The core of these guidelines is to express and teach engineering concepts, in the more familiar concepts of everyday life. In other words, the aim is to explain engineering based on materials that students can experience directly in everyday life to encourage curiosity as a way of dealing with engineering instead of relying on abstract and hard mathematics and science concepts. In addition, it is important to attract the attention of the public by fairly compensating members who participate in the K-12 engineering education, by informing how engineering contributes to society and by presenting role models of engineer.

Policy implications might be different in Korea but it essential for people to understand that the role of engineers is very important by increasing the public's interest in engineering. In addition, engineering should be presented as being exciting through everyday context. Therefore, by making it known to society that engineering is an activity not only to produce economic profit through technical innovation, but also to prepare for the risks that a future society will encounter, we can improve the social status of engineers. This makes engineers work as a social role model for young students and nurture their interest in engineering.

IV. The Theory of Multiple Intelligences

Currently, teaching methods will need to be improved in order to recruit and educate excellent students. In the future, it is difficult to solve complex problems with only knowledge of a major field. Although in many areas, intellectual ability based on interdisciplinary knowledge and flexibility is required, the actual educational conditions do not meet this standard. Rather, the education system has not kept up with the new changes in educational environment bounded by traditional educational methods. Therefore, it is important to encourage those involved in educational innovation to incorporate innovations in education for the future society.

Let's consider several approaches for teaching students. First, the future engineer must have comprehensive thinking ability in a given task. In particular, the engineer needs to approach mechanical production processes in the context of collaboration and supportive interaction. In addition, the engineer should be able to participate in public policies, and consider the effect of their task on the safety, health and well-being of the public. Intellectual ability is also important for coping with urgent situations with self-judgment. In this regard, Howard Gardner suggested five aspects of internal ability: a disciplined mind; synthesizing mind; creative mind; respectful mind; and ethical mind.[3]

The five aspects of the mind have their own unique meaning. The disciplined mind originates from a thinking capacity as a professional based on the full training in his/her field. The synthesizing mind indicates an ability to identify a new problem by integrating current knowledge. The creative mind has an ability to identify a new solution by examining current problems from a different angle. The respectful mind has an ability to respect differences among other groups. The ethical mind has an ability to understand that one's role is consistent with one's status and that one takes responsibility for his/her role and its meaning related to everyday life. An engineer equipped with all five dimensions

of the mind should take a role of a leader in the community, society and nation.

Howard Gardner suggests that educational methods based on the Multiple Intelligences work better than the current system of education to develop human potential abilities.[4] He created the theory of Multiple Intelligences to develop the latent abilities of each individual in a variety of ways. He divided human intelligences into seven aspects: musical intelligence, bodily-kinesthetic intelligence, logical-mathematical intelligence, linguistic intelligence, spatial intelligence, interpersonal intelligence, and intrapersonal intelligence. According to Gardner, these intelligences do not work independently but collaboratively, i.e. different parts of the intelligences are salient according to each individual. As mentioned above, these intellectual abilities are very important because the future environment is changing rapidly and diversely, and because the existing uniform method of evaluation cannot cope appropriately with the future. When access to information is constrained by time and space, those who can memorize knowledge and resolve problems within given conditions are recognized as being competent. However, when storage of information and intercommunication are not limited, people who can search and synthesize information then offer a new solution based on creative and flexible thinking will have greater competency.

Currently, the PBL(Problem-Based Learning) teaching method, which is stressed in engineering education, may have significant relevance to these contexts. As mentioned in the previous section, K-12 engineering education projects, which are sponsored by the NSF(National Science Foundation) in the U.S., are aimed at attracting prospective students. This attempt aims to encourage students with an interest in engineering by deviating from the traditional education paths, which have a strong emphasis on mathematics and science. It also links engineering education with diverse social contexts.

V. The PICEE Engineering Camp

The PICEE held two engineering camps for elementary school students during the winter vacation in 2008 and 2009. The camp in 2008, which was named the Robot Experience Camp, gave students experience in the basic principles. Another camp in the winter of 2009 provided an opportunity to experience generating energy from natural resources (i.e., water, wind, solar, hydrogen, and chemistry) as a response to the depletion of fossil fuels. The PICEE program aimed to stimulate interest by applying engineering to everyday life. It also promotes an atmosphere of productive competition between teams rather than simply transmitting knowledge to students.

The two camps aimed to improve the understanding and interest in engineering by play. In the first camp held in 2008, the participants assembled robot module trials. The PICEE was divided into two groups: lower grade and upper grade. The lower grade group experienced robot soccer and the upper grade one participated in line tracing, in which robot follows a specific line. The robot soccer game determined the winner based on the scores in a given time, whereas line-tracing competition was determined based on how each individual program assembled the modules. A follow up survey showed that most participants were quite satisfied with the program.

The second camp held in 2009 provided the students with hands-on experience of generating energy by natural resources. The programs gave the participants an opportunity to understand how electricity is generated by water-power, wind power, chemical battery, solar energy and hydrogen power. Based on this principle, the participants assembled a playing electric car driven by solar energy in the final step of the program. Furthermore, participants played with their own assembled car and studied the engineering principle through hands-on experiments.
The programs helped encourage the participants' interest in engineering principles through hand-on activities. This is based strongly on the theory of multiple intelligences by Gardner. The programs helped the participants to develop multiple intelligences through hand-on activities. An understanding of the engineering concept with play gives the participants a positive attitude to engineering. Consequently, the participants are more likely to understand the effects of engineering in everyday life. In short, it is important to design a program for students to develop multiple intelligences through an innovative curriculum. Furthermore, there is a need to develop an innovative educational model, as Gardner proposes, which focuses on practical context derived from real life.

VI. Conclusion

This paper reviewed the social contexts that engineers should confront in the future. A suitable number of competent engineers will be needed to prepare for future society. In addition it is important to educate engineers to prepare for the future. As one of the efforts to respond to the problems, this paper reported the outcomes of the PICEE which held engineering camps. Although these camps were not completely satisfied with the innovation of engineering education, the PICEE believes that these efforts will help improve the status of engineering in South Korea. Recently, the efforts to implant engineering mind in the young students attract the South Korean government concern. And government has made efforts to improve engineering education. It is hoped that this governmental effort will succeed in improving the recognition of engineering and attract K-12 students to engineering for a better future.

References

01. The National Academy of Engineering. (2004). The Engineer of 2020, pp. 27-39. The National Academies Press.
02. Josh Douglas, Eric Iversen, & Chitra Kalyandurg. (2004). Engineering in the K-12 Classroom – An Analysis of Current Practices & Guidelines for the Future, The American Society for Engineering Education, p. 18, http://www.engineeringk12.org
03. Howard Gardner. (2006). Five Minds for the Future. Harvard Business Press.
04. _____. (2006). Multiple Intelligences: New Horizons, pp.8-18. Harvard Business Press.