A Search for Directions of Engineering Education Development in Knowledge Based Society in Terms of Engineering Ethics Education : An Exploration of Ethics across the Living beyond Ethics Across the Curriculum

Song, D.J.[1], Pyun, K.H.[2]

[1,2]Yeungnam University, South Korea

djsong@yu.ac.kr[1], edu4u@kongju.ac.kr[2]

Abstract

The purpose of this research is to search for directions of engineering education development in knowledge based society in terms of 'engineering ethics education'. Engineering ethics education, having been recognized as an inter-disciplinary research field between engineering and philosophy, is a field that has been a major issue in countries that execute engineering education certification. And engineering ethics education has been a peculiar research field focused on EAC. Therefore, this research deduced several results as follows by critically reviewing precedent EAC related researches. First, accomplishments by various researchers in the U.S. that may well quoted as the leader of engineering ethics study and education or the educational achievements of Kanazawa Institute of Technology in Japan are considerably spurring, however the EAC discussions so far involve still numerous impediments and unsolved tasks. Second, the discussions of EAC so far comprehend limitations -- shortage of recognition on inter-disciplinary study with education study field and insufficient participation by education study majors. Third, the engineering and philosophy field experts that have been leading EAC discussion have been pursuing integrated education courses either consciously or unconsciously. Fourth, EAC discussion may enter new facet by illuminating the intentions of integrated education course again in terms of 'education and the study of education', and this new facet can be summed up with the new term, EAL.

Introduction

Today's society can be represented as knowledge based society. Knowledge based society refers to a society where social life is based on the creation and sharing of knowledge, and is highly characteristic that in such society, generation and evacuation of knowledge progress very fast. Therefore, education in knowledge based society should emphasize the improvement of situation judgmental power and situational initiative of social members. In engineering field, since 1980s, there have been emphasized improvements of situation judgmental power and situational initiative in the standpoint of ethics education as well as education of major mainly in the U.S.. In particular, a turn of attention to ethics education is forming a unique field of discussion, EAC that stands for 'ethics across the curriculum' mainly in college. And researches and education on EAC are being conducted actively specifically in the course of executing engineering education accreditation in each country of the world.

This research is conducted with a sense of agreement that in knowledge based society, knowledges are created and phase out very rapidly, so situation judgemental power and situational initiatives are emphasized. In addition, this research sees that since knowledge changes so rapidly these days, general thinking power and flexible judgmental power should be emphasized more than ever before. Such emphasis is in the same context as the educational ideology comprehended in the inter-disciplinary courses recently emphasized in engineering education. In such sense, this research intends to critically check what has been overlooked in the course of EAC related education and research so far with relative emphasis on the terms 'education' and 'ethics' in discussing engineering ethics, and to propose the development direction of engineering ethics education in knowledge based society in light of the results.

Knowledge based society and engineering ethics

In terms of philosophy, engineering ethics belongs to applied ethics. Applied ethics, which pursues to solve unethical behaviors of professional workers and the social conflicts by them, is a practical field of study that came into being relatively recently. Unethical behaviors of professionals are something that general individuals can hardly get themselves prevented or protected from. Therefore, the ethical matters or events that become social issues these days fell on a category that requires intensive coverage in specialized fields directly related to applicable problem or events primarily. It was since 1980s that applied ethics emerged as philosophical subject. Discussions in earnest are deemed to have started since 1990s in the U.S., and since 1996 in Europe, in the case of western world. Since then, applied ethics boomed up like never before in the history of philosophy, and in particular, the circle of philosophers sees that researches and discussions on engineering ethics are being conducted the most fervently among applied ethics fields.

The reasons researches and discussions on engineering ethics are the most active can be summed up into two broadly: First, it is because engineering is a field that draws attention as visible event that is accompanied by loss of property and human life when it becomes an issue at ethical level. Second reason is because engineering community has been doing systematic efforts to fulfill the responsibility as a profession that conforms to social changes by executing engineering education accreditation. These two reasons served to arouse alert to educators that are responsible for engineering education in college consequently beyond the matter of precedence. on ethics education, more specifically engineering ethics education. And a result, each country executing engineering education accreditation is pouring out various efforts to solidify “engineering ethics education” as ethics of professional, an applied ethics by forming unique space of discussion, EAC which stands for ‘ethics across the curriculum’.

Engineering ethics education and EAC

The country that plays the most advanced and central role in EAC matters is the U.S. In the U.S., inter-disciplinary researches among engineering ethics related engineering arena and philosophy arena have been conducted since 1970s. And in 1986, Challenger incident became an opportunity to draw attention to the subject, engineering ethics throughout the world as well as in the U.S. Nevertheless, until late 1990s, there has not been much accomplishments for systematic discussion and development of engineering ethics at educational dimension. According to Herkert (2000), only 8% of the U.S. college graduates and 8% of engineering college graduates have taken ethics related subjects until late 1990s. In addition, even the opened ethics subjects oftentimes were opened as part of religion or philosophy subjects, not as specialized subject. Such reality represents the reality of ethics education in the field of engineering education throughout the world let alone in the U.S.

In terms of engineering ethics education, the year 2000 is a considerably meaningful year. American Accreditation Board for Engineering and Technology(ABET) emphasized the vocational ethics and social responsibility of engineers by releasing EC2000 in 2000, and the staffs in charge of engineering education in each country included in Washington Accord(WA) along with the U.S. started to form unique space of discussion and show active interest in such discussions. Furthermore, also in case of countries included in other agreement bodies other than WA regarding engineering education accreditation, they started to participate in such efforts of the U.S. and pay diverse efforts to develop internal engineering education by bench-marking the colleges of the U.S.(Chang, 2009; Englehardt, 2009; Fudano, 2009; Hinman, 2009; Mayer, 2009; Pritchard, 2009; Song, 2009; Wueste, 2009).

EAC may be referred collectively to all the opinions and measures that diversely illuminate a series of curriculum in engineering ethics standpoint while engineering students follow along college education and check and improve the purpose, contents and methods of engineering ethics. In view of the practical process of education, success of EAC can be measured based on two aspects: (a) if students can recognize ethical issues in their field; and (b) if they are able to deal with them in a systematic, reflective and responsible way (Wueste, 2009). Ethics education should focus on the improvement of critical thinking. Skill in critical thinking cannot be acquired by reading a book only, but can be acquired through gaining skill in critical thinking by inducing student engagements through discussions and case study on various ethical issues. When EAC research and education directions are set up in such method, ideal students will see ethics as a thread woven deeply in the fabric of life”(Wueste, 2009). The opinion of Wueste of Clemson University on EAC asserts integrated curriculum and that, ‘academic’ integrity if expressed in education term. In

addition, he suggests comprehensive integrity beyond 'academic' one by commenting "Integrity is an achievement and an ongoing project; it's the project that cuts across all aspects of one's life and lasts for as long as one lives."
Such trend represents the overall standpoint of engineering ethics related research institutes or academic research groups established in several universities of the U.S. Moreover, the trend enables conjecture of basic directions and framework of EAC related education activity being executed by Kanazawa Institute of Technology of Japan that puts emphasis on designing education and ethics education by benchmarking outstanding engineering education universities of the U.S. In particular, in the case of Kanazawa Institute of Technology, they are showing excellence in establishing systematic education system to solidify ethics education (Table 1).
Kanazawa Institute of Technology is showing excellence in developing and utilizing various teaching-learning methods and education data beyond the aspect that they contributed to solidification of engineering ethics education simply focused on regular curriculum. Furthermore, they appear to be considerably recognizing that all the activities called "education" are process of realizing "ethics" education in practice. Such inference is based on the discussions on the educational direction called "KIT IDEALS" within Kanazawa Institute of Technology (Table 2).
In terms of EAC, the research efforts of various universities in the U.S. and the education system establishment related efforts of Kanazawa Institute of Technology may be regarded as model cases so far. However, engineering ethics field experts in the U.S. and concerned staffs of Kanazawa Institute of Technology confess that still there are numerous impediments and challenges related to EAC (Englehardt, 2009; Fudano, 2009; Hinman, 2009; Mayer, 2009; Pritchard, 2009; Wueste, 2009). For an instance, the practical gap between KIT IDEALS and EAC at KIT gives sufficient conjecture on the agonizes and problem consciousness of concerned individuals currently paying interest in engineering ethics throughout the world let alone in the U.S. If we, Korean scholars, consider the fact that the commencements of our education and study on engineering ethics are significantly late, it is fair to say that it is a distant and tough mission to substantialize and normalize EAC(ethics across the curriculum) in the college education level.

Limits and tasks of EAC discussion

In reflective view of research accomplishments on EAC so far, the discussions face limitations in two aspects as follows: First, EAC discussions so far have been relatively neglecting establishment of mid-long term plan for engineering ethics education. This means that it is natural the field of engineering ethics came into being comparatively recently. However, mentioned in the standpoint of education or study of education, limitations may boil down to (a) shortage of understanding on the relationship between 'education' and 'ethics', and (b) absence of education philosophy on engineering ethics. Limitations from such perspective may be given new approach on EAC discussion by exploring the following problems:

- What is the purpose of engineering ethics education?
- What are the common points and differences between ethics education of general meaning and that of engineering sense?
- What is the reasonable and desirable scope of engineering ethics?

Second, the EAC discussions so far comprehend various problems throughout the entire process of teaching-learning. Such limitations have been suggested to certain degree even during the process of EAC discussion. In other words, the interest in engineering ethics, a new field of philosophy, arose between the booming phenomenon of applied ethics and the task of establishment of identity as professional career of engineering. Therefore, in consideration of the word itself of EAC, though it should be an important content of research task of the study of education, EAC has been recognized as an inter-disciplinary research field between engineering and philosophy. Various matters that should be illuminated rightly in the perspective of the study of education in this course hover between the domains of engineering and philosophy. The limitation in such perspective may give rise to EAC discussion through exploration of the following problems in the standpoint of 'education':

- Who should teach this subject?
- What should be taught?
- How they should teach?
- What is the scope of engineering ethics education?

Such problems have been suggested also in several prior research documents (Table 3, 4). In overall consideration

of the contents suggested and the two limitations of EAC discussion mentioned above, EAC can be said to require preparation of (a) framework for the establishment of education theory(Fig.1); and (b) practical composition of education data (Table 5).
After all, the EAC discussion so far comprehends the limitation, shortage of recognition on inter-disciplinary research in education study field and insufficient participation of education study majors. In fact, the EAC examined with focus on the U.S. or Kanazawa Institute of Technology of Japan vividly reflect the theory and practice of particular subject area of the study of education "Integrated Curriculum, Unified Curriculum".

The Re-conceptualization of EAC

1. The orientation of EAC

'Integrated Curriculum, Unified Curriculum' that EAC actually intends to explain is the approach method that selects and organizes study contents by comprehending the entire curriculum according to certain criteria with no restriction of subject or major area. Most of the education courses that emphasize experience assume a type of integrated education course in practice. In addition, integrated education course pays attention to the realization of integration of personality as all the contents learned are integrated organically each other in the standpoint of individual learner.

2. Various meanings of curriculum

Curriculum, an education study term which is a part of the subject, EAC, is a word of various meanings that can be interpreted in various sense, and can be used in completely different meanings depending on the perspective on education. Curriculum, which term originated from the Latin word 'currere' etymologically, means course of race along which horse should run in horseracing field and route or course that students should follow naturally. If interpreted narrowly based on such etymology, curriculum means education contents or textbook that comprise regular subjects. On the other hand, if a series of efforts for systematic composition of education process are seen as the key to curriculum, a relationship will stand such that curriculum is after all education.

3. Ethical perspective contained in education

In essence, education is not activity that evaluates and determines who does better and who does worse like a judge. Education is an activity that assumes as key the growth to a condition better than present whatever the present circumstance is. In such sense, the ethics connoted in education can be defined as the process itself that pursues and realizes good condition consecutively. In such case, The process that pursues continuous growth to good condition is not a growth limited to certain area among various areas of personal life of the learner but is most meaningful when it pursues integration among various fields. Such method of understanding may be in the same line with the discussion on the pursuit of the aforementioned integrated education course that EAC declares and the curriculum of wide sense.

4. Possibility and necessity of EAL

The engineering ethics education conducted in the education organization, college, may be realized primarily through education course with focus on official education course, i.e., regular subject. However, in view of the orientation of EAC, curriculum of wide sense and the ethical aspect connoted in the essence of education, the aspect of Ethics Across the Living (EAL) of EAC stands out. And EAC assume a relationship: "Curriculum = Education = Living".
No matter it is ethics of general meaning or ethics of engineering as applied ethics, 'ethics' is realized and implemented by way of the value perspective, life perspective and world view of an individual or particular social group. Engineering ethics of vocational ethics, in the standpoint of an individual, can be said to reach the best condition when the value perspective, life perspective and world view etc of that person reach harmony and balance with focus on his/her vocational philosophy.
It may seem like a juggle of word but in fact if the internal theoretic characteristic of EAC is emphasized, EAL will come and if the external practical characteristic of EAL is emphasized, EAC will be. In particular, it is determined that EAL is a term effective in establishing plan on mid-long term engineering ethics education and in properly emphasizing the intentions of engineering ethics education as a form of ethics education. Furthermore, EAL opens

the possibility of meta evaluation by various subjects or groups. In other words, the term EAL highlights the task of teacher or learner that each should enhance the ability of meta evaluation on their own life and their own specialized field in their present situation and place. That is because life is made up of various elements and domains, so harmony between each element and domain is not easily attained. Therefore, if harmony of life is the goal, each subject should exercise and improve their social intelligence in wide range of domains and pursue ceaseless self reflection and improvement of studying ability. In particular, since the world of vocation is maintained based on interests relation, emphasis on social intelligence, self reflection and self study ability in specialized professional activity fields among various sectors of life may be interpreted with specific explanations on critical thinking aforementioned.

Conclusions

The most conspicuous characteristic of knowledge based society is that such society experiences creation and degeneration of knowledge faster than in any other era. That is to say, knowledge based society is in an era of change and speed. On the other hand, discussion on ethics pursues cogency and unification. Therefore, implementation of the grand subject "direction of development of knowledge based society engineering education" in terms of "engineering ethics education" comprehends paradoxical aspect in itself. However, this research assumed the basic standpoint that the more the time is an era of change and speed, the more unified focus is needed. This research intended to critically review the trend of engineering ethics education and research, summed up in the word 'EAC' and to deduce suggestion for development of engineering ethics education by clarifying the part that has been overlooked in EAC discussion so far. The results of this research are summarized as follows:

First, the achievements of various researchers in the U.S. that can be quoted as forerunner of engineering ethics research and education or the educational accomplishments of Kanazawa Institute of Technology of Japan, though considerable stimulative, still comprehends impediments elements and unsolved tasks.

Second, the EAC discussions so far involves limitations: shortage of recognition on inter-disciplinary research with education study field and insufficient participation of education study majors.

Third, the engineering and philosophy field experts that have been conducting EAC discussion have been pursuing integrated education course either consciously or unconsciously.

Fourth, through a review of the intention of integrated education course in terms of 'education and the study of education', EAC discussion may enter new phase, and such new phase can be summed up with the term 'EAL'.

Tables and figures

<Table 1> EAC at KIT Starting with the Class of 2008(Fudano, 2009)

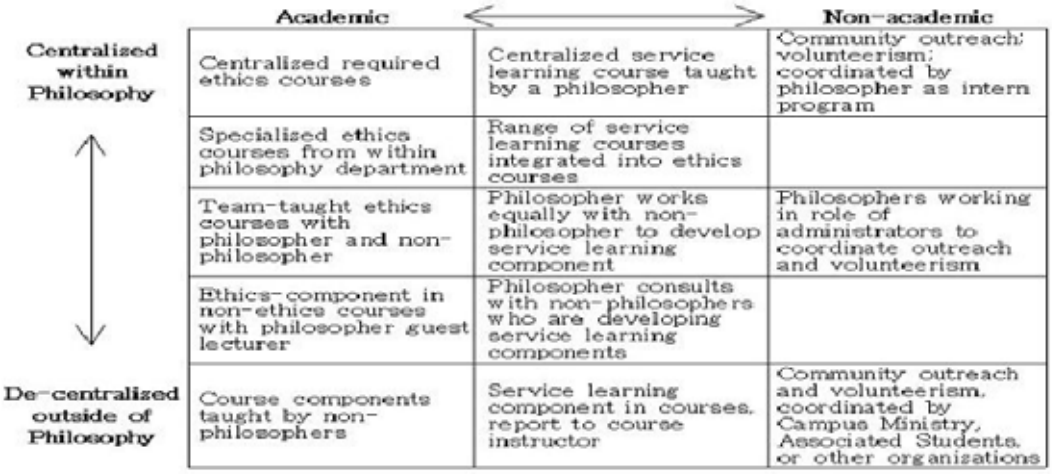
Liberal Education	_ Introduction to Engineering _/_/_ _ Japan Studies _ Ethics for Engineers and Scientists
Technical/Specialized Education	_ Engineering Design _/_ _ Core Seminar _ Human and Nature _ Engineering Design _ _ Plus micro-insertion

<Table 2> KIT IDEALS(Fudano, 2009)

K	Kindness of Heart
I	Intellectual Curiosity
T	Team Spirit
I	Integrity
D	Diligence
E	Energy

A	Autonomy
L	Leadership
S	Self-Realization

<Table 3> EAC Grid: Mapping the Possibilities(Hinman, 2009)



<Table 4> Comparison of Stand-alone Engineering Ethics Course Syllabus of some universities in Korea(Song, 2009)

	Yeungnam Univ.	**KunKook Univ.**	**Pusan Nat' l Univ.**	**SungKyunKwan Univ.**	**Inha Univ.**
Course Name	Science & eng. Ethics	Modern society & ethics	Engineering ethics	Confucianism & Prof. ethics	Engineering Ethics
Lecturer's dept.	Philosophy	Philosophy	Mechanical eng.	Confucianism (Philosophy)	Education
objectives	Ethical responsi-bility of eng.	Understanding of ethical aware-ness	* Recognize eng. ethical issues * Solution method	* Understanding conf. * Confucian view of value: prof.	*Engineer's ethi-cal dilemma. *Engineer's leadership
Related PO	*Team work *Understanding prof. *Prof. ethics	*Understanding prof. *Communication skill *Prof. ethics	*Prof. ethics *Communication skill *Understanding effect	*Team work *Prof. ethics *Communication skill	*Prof. ethics

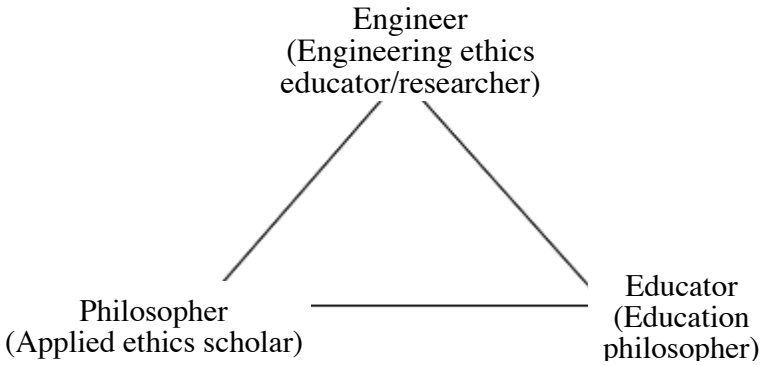
<Table 5> One Possibility: Framework for the preparation of practical establishment of EAC education

	Why (Education Objective)	**Who (Educator)**	**What (Education contents)**	**How (Education method)**	**.....**
Engineering (experts by the engineering fields)	—	–	—	–	.....
Philosophy (Applied ethics scholar)	—	–	–	–	.....
Study of education (Curriculum expert)	—	–	–	—	.....

.....	.....	.....	.....	.....	.....

Legend	—	strongly related
	_	moderately related
	O	weakly related
		not related

[Fig. 1] One Possibility: Framework for the establishment of EAC Education Theory



References

01. Chang, P. F.(2.009). Internationalization of Engineering Ethics in Taiwan. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
02. Englehardt, E. E.(2009). Ethics across the Curriculum and Critical Thinking. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
03. Fudano, J.(2009). Interim Report on the Project on "Engineering Ethics Education through Values-Sharing : EAC at Kanazawa Institute of Technology". In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
04. Herkert, J. R.(2000). Engineering Ethics Education in the USA: Contents, Pedagogy and Curriculum. European Journal of Engineering Education, 25(4), 303-313.
05. Hinman, L. M.(2009). Implementing Ethics Across the Curriculum. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
06. Mayer, T.(2009). The Singapore Story : Integrity and Ethics in Research. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
07. Pritchard, M. S(2009). Engineering Ethics Across the Curriculum: USA. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
08. Song, D. J.(2009). Engineering Ethics and EAC in Korea. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.
09. Wueste, D. E.(2009). Ethics Across the Curriculum: Varying Approaches, Similar Challenges. In the 1st International Symposium on "The Perspectives on Engineering Ethics Across the Curriculum", Organized by the Applied Ethics Center for Engineering and Science, Kanazawa Institute of Technology, Japan.