

# A Search for Directions in Engineering Education Development in a Knowledge-Based Society in Terms of Engineering Ethics Education: An Exploration of Ethics Across the Living Beyond Ethics Across the Curriculum

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## 지식기반사회 공학교육의 발전방향 탐색: EAC를 넘어 EAL로

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### ABSTRACT

The purpose of this research is to search for directions in engineering education development in a 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 accreditation. And engineering ethics education has been a peculiar research field focused on EAC(Ethics across the Curriculum). Therefore, this study has deduced several results by critically reviewing the extant EAC-related literatures. First, accomplishments by various researchers 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 substantial. However, the EAC discussions thus far still raise numerous barriers and unsolved issues. Second, the discussion of EAC thus far comprehends limitations such as a shortage of the recognition of inter-disciplinary study in the field of education and insufficient participation by education majors. Third, the engineering and philosophy field experts who have been leading EAC discussions have been pursuing integrated education courses either consciously or unconsciously. Fourth, EAC discussions may expand by again illuminating the intent of integrated education courses in terms of 'education and the study of education', and this new facet can be summed up with a new term, EAL, which stands for 'Ethics across the Living.'

**Keywords:** Engineering education, Engineering ethics, Engineering ethics Across the Curriculum, Engineering ethics across the Living, Engineering education accreditation

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### 1. Introduction

Today's society can be represented as a knowledge-based society. A knowledge-based society refers to a society where social life is based on the creation and sharing of knowledge. Typically in such a society, the generation and education of knowledge progresses very rapidly. Therefore, education in a knowledge-based

society should emphasize improvement of the situational judgmental power and situational initiatives of societal members. In the engineering field, since the 1980s, improvements of situation judgmental power and situational initiative in the standpoint of ethics education as well as education of major mainly in the US have been emphasized. In particular, attention to ethics education is leading to a unique field for discussion, viz., EAC, which stands for 'ethics across the curriculum', mainly at the collegiate level. And studies and education concerning EAC are being conducted actively, especially in

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the context of engineering education accreditation in countries across the world.

This research is conducted with a sense of agreement that in a knowledge-based society, knowledge is created and phased out very rapidly; therefore, situational judgmental power and situational initiatives are emphasized. In addition, this study 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 also manifest in the educational ideology regarding inter-disciplinary courses that are recently emphasized in engineering education. In such a sense, this study intends to critically examine 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 developmental direction of engineering ethics education in a knowledge-based society in light of the results.

## II. Knowledge-based Society and Engineering Ethics

In terms of philosophy, engineering ethics belongs to applied ethics. Applied ethics, which seeks to address the unethical behaviors of professional workers and ensuing social conflict, is a practical field of study that came into being relatively recently. General individuals can hardly insulate or protect themselves from the unethical behaviors of professionals. Therefore, ethical matters or events that have become social issues these days require intensive coverage in specialized fields that are directly related. Applied ethics has emerged as a philosophical subject since the 1980s. Discussions in earnest are deemed to have started in the 1990s in the US, and since 1996 in Europe, in the case of the western world. Since then, applied ethics has blossomed like never before in the history of philosophy, and in particular, research and discussion on engineering ethics is being conducted the most fervently among the various fields in applied ethics.

The reasons why research and discussion on engi-

neering ethics is the most active can be summed up into two broad respects. First, engineering is a field that draws attention at an ethical level as a concrete manifestation that is accompanied by the loss of property and human life. The second reason is that the engineering community has been undertaking systematic efforts to fulfill its responsibility as a profession that conforms to social changes by executing engineering education accreditation. These two reasons motivate educators who are responsible for engineering education in college; consequently, ethics education, more specifically, engineering ethics education, is taking precedence. As a result, each country that executes engineering education accreditation is committing various efforts to solidify "engineering ethics education" as the ethics of professionals, i.e., a form of applied ethics by forming a unique realm of discussion, EAC, which stands for 'ethics across the curriculum'.

## III. Engineering Ethics Education and EAC

EAC is developed most highly in the US. In the US, inter-disciplinary studies in the engineering ethics-related engineering sphere and philosophy sphere have been conducted since the 1970s. And in 1986, the Challenger incident became an opportunity to draw attention to the subject of engineering ethics throughout the world as well as in the US. Nevertheless, until the late 1990s, not much had transpired by way of systematic discussion and development of engineering ethics at the educational level. According to Herkert(2000), only 8% of US college graduates and 8% of engineering college graduates took ethics-related subjects until the late 1990s. In addition, even the available ethics subjects often times were offered as part of religion or philosophy subjects, and not as a specialized subject. This is the case with ethics education in the field of engineering education throughout the world, not just the US.

In terms of engineering ethics education, the year 2000 marked a watershed. The American Accreditation Board for Engineering and Technology (ABET) emphasized the vocational ethics and social responsibilities of engineers

by releasing EC2000 in 2000. Further, the staff in charge of engineering education in each country included in the Washington Accord (WA) along with the US started to form a unique realm of discussion and show active interest in such discussions. Furthermore, countries included in other accords regarding engineering education accreditation started to participate in such efforts of the US and commit diverse efforts to develop internal engineering education by benchmarking colleges of the US(Chang, 2009; Englehardt, 2009; Fudano, 2009; Hinman, 2009; Mayer, 2009; Pritchard, 2009; Song, 2009; Wueste, 2009).

EAC may refer collectively to all the opinions and measures that variously characterize a series of curricula from an engineering-ethics standpoint, while engineering students undertake college education, and check and improve the purpose, contents, and methods of engineering ethics. The practical success of EAC can be measured based on two aspects: (a) whether students can recognize ethical issues in their field and (b) whether they are able to deal with them in a systematic, reflective, and responsible manner (Wueste, 2009). Ethics education should focus on the improvement of critical thinking. Skill in critical thinking cannot be acquired only by reading a book; it can be also acquired through discussions and case studies on various ethical issues. When EAC research and education directions are set up in such an approach, ideal students will see ethics as a thread that is woven deeply in the fabric of life (Wueste, 2009). Wueste of Clemson University on EAC asserts integrated curriculum and ‘academic’ integrity if expressed in education term. In addition, he suggests comprehensive integrity beyond the ‘academic’ kind by commenting that “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 a trend represents the overall standpoint of engineering ethics-related research institutes or academic research groups established in several universities of the US. Moreover, the trend enables one to conjecture the basic directions and framework of EAC-related educational activities being executed by the Kanazawa

**Table 1 EAC at KIT starting with the Class of 2008 (Fudano, 2009)**

Liberal education	<ul style="list-style-type: none"> <li>▪ Introduction to Engineering I /II/III</li> <li>▪ Japan Studies</li> <li>▪ Ethics for Engineers and Scientists</li> </ul>
Technical / specialized education	<ul style="list-style-type: none"> <li>▪ Engineering Design I /II</li> <li>▪ Core Seminar</li> <li>▪ Human and Nature</li> <li>▪ Engineering Design III</li> <li>▪ Plus micro-insertion</li> </ul>

**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

Institute of Technology of Japan that puts emphasis on designing education and ethics education by benchmarking outstanding engineering education universities of the US. In particular, Kanazawa Institute of Technology is showing excellence in establishing a systematic educational system to consolidate ethics education.

Kanazawa Institute of Technology is showing excellence in developing and utilizing various teaching-learning methods and educational data beyond the aspect that they contribute to the consolidation of engineering ethics education that is simply focused on regular curricula. Furthermore, they appear to be considerably recognizing that all the activities called “education” constitute a process of realizing “ethics” education in practice. Such an inference is based on discussions on the educational direction called “KIT IDEALS” within Kanazawa Institute of Technology.

In terms of EAC, the research efforts of various universities in the US and the education system establishment-related efforts of Kanazawa Institute of Technology may be regarded as model cases so far. However, engineering-ethics experts in the US and concerned staff 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 instance, the practical gap between KIT IDEALS and EAC at KIT suggests that scholars worldwide are aware of the discrepancies between the ideal and the real with regard to engineering-ethics education. If we, Korean scholars, consider that education and research on engineering ethics has been late in coming, it is fair to say that it will be a prolonged and challenging task to substantialize and normalize EAC (ethics across the curriculum) at the level of collegiate education.

#### IV. Limits and Tasks of EAC Discussion

A reflection on the research accomplishments regarding EAC thus far reveals limitations in two aspects as follows. First, EAC discussions thus far have been relatively neglecting the establishment of mid-to-long-term plans for engineering-ethics education. This means that naturally the field of engineering ethics came into being comparatively recently. However, as mentioned from the standpoint of education or the study of education, the limitations may boil down to (a) a shortage of understanding of the relationship between 'education' and 'ethics' and (b) the absence of an educational philosophy on engineering ethics. Limitations from such a perspective may yield a new approach towards EAC discussion through the exploration of the following problems.

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

Second, the EAC discussions thus far highlight various problems throughout the entire process of teaching-learning. Such limitations have been suggested to a certain degree even during the process of EAC discussion. In other words, 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 light of the connotation of EAC itself, though it should be an important content of research on education, EAC has been recognized as an inter-disciplinary research field between

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

	Academic		Non-academic
	Centralized within Philosophy	De-centralized outside of Philosophy	
↑ ↓	Centralized required ethics courses	Centralized service learning course taught by a philosopher	Community outreach; volunteerism; coordinated by philosopher as intern program
	Specialized ethics courses from within philosophy department	Range of service learning courses integrated into ethics courses	
	Team-taught ethics courses with philosopher and non-philosopher	Philosopher works equally with non-philosopher to develop service learning component	Philosophers working in role of administrators to coordinate outreach and volunteerism
	Ethics-component in non-ethics courses with philosopher guest lecturer	Philosopher consults with non-philosophers who are developing service learning components	
	Course components taught by non-philosophers	Service learning component in courses, report to course instructor	Community outreach and volunteerism, coordinated by Campus Ministry, Associated Students, or other organizations

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 responsibility of eng.	Understanding of ethical awareness	* Recognize eng. ethical issues * Solution method	* Understanding conf. * Confucian view of value: prof.	* Engineer's ethical 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

engineering and philosophy. Various issues that should be examined from the perspective of the study of education hover between the domains of engineering and philosophy. The limitation in such a perspective may give rise to EAC discussions through the exploration of the following problems from 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 papers (Table 3, 4). In overall consideration of the contents suggested and the two limitations of

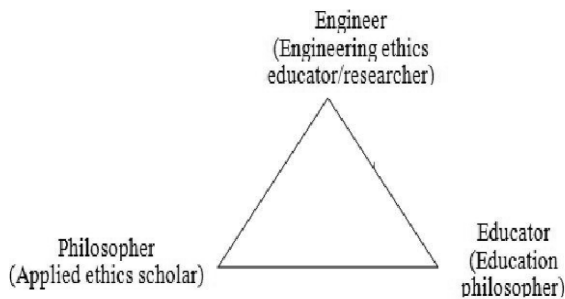


Fig. 1 A possible framework for the establishment of EAC education theory

Table 5 A possible framework for the establishment of EAC education

	Why (education objective)	Who (educator)	What (education contents)	How (education method)	.....
Engineering (experts in the eng. fields)	●	◐	●	◐	.....
Philosophy (Applied ethics scholars)	●	◐	◐	◐	.....
Study of education (Curriculum experts)	●	◐	◐	●	.....
.....	.....	.....	.....	.....	.....

- strongly related
- ◐ moderately related
- weakly related
- not related

EAC discussion mentioned above, EAC can be said to require the preparation of (a) a framework for the establishment of education theory (Fig. 1) and (b) practical composition of education data (Table 5).

After all, the EAC discussion thus far comprehends the limitation, shortage of recognition of inter-disciplinary research in the education field, and insufficient participation of education majors. In fact, EAC examined with focus on the U.S. or Kanazawa Institute of Technology of Japan vividly reflects the theory and practice of particular subject area of the study of education “Integrated Curriculum, Unified Curriculum.”

## V. The Re-conceptualization of EAC

### 1. The orientation of EAC

‘Integrated Curriculum, Unified Curriculum’ that EAC actually intends to explain is an approach that selects and organizes study contents by comprehending the entire curriculum according to certain criteria with no restriction on the 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 courses pay attention to the realization of the integration of personality as all the contents learned are integrated organically with each other from the standpoint of individual learners.

### 2. Various meanings of ‘curriculum’

Curriculum, an educational term which is a part of the subject, EAC, is a word of various meanings that can be interpreted in various senses, and be used in completely different senses depending on the perspective on education. Curriculum, a term that originated etymologically from the Latin word, ‘currere’, means course of the race along which the horse should run in the horse-acing field and route or course that students should follow naturally. If interpreted narrowly based on such etymology, curriculum means the educational content or textbook that comprises regular subjects. On the other hand, if a series of efforts for systematically composing the education process are

seen as the key to curriculum, it will be apparent that curriculum is after all education.

### 3. Ethical perspective contained in education

In essence, education is not an activity that evaluates and determines who does better and who does worse, as in judgment by a judge. Education is an activity that assumes as key growth to a condition that is better than present, whatever the present circumstance is. In such a sense, the ethics connoted in education can be defined as the process itself that pursues and realizes good condition consecutively. In such a case, a process that pursues continuous growth to a good condition is not limited to a certain area among various areas of the personal life of the learner but is most meaningful when it pursues integration across various fields. Such a method of understanding may be in the same line as discussions 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 educational organizations, e.g., colleges, may be realized primarily through education courses with a focus on official education courses, i.e., regular subjects. However, in view of the orientation of EAC, curriculum in a 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 assumes the relationship: "Curriculum = Education = Living."

No matter whether it is ethics in the general sense or ethics of engineering as a form of applied ethics, 'ethics' is realized and implemented by way of the value perspective, life perspective, and worldview of an individual or particular social group. Engineering ethics or vocational ethics, from the standpoint of an individual, can be said to reach the best condition when the value perspective, life perspective, worldview, etc., of that person reach harmony and balance with a focus on his/her vocational philosophy.

Put differently, if the internal theoretical characteristic of EAC is emphasized, EAL will materialize; if the external practical characteristic of EAL is emphasized, EAC will be realized. In particular, it is determined that EAL is a term that is 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. Furthermore, EAL opens up the possibility of meta-evaluation by various subjects or groups. In other words, the term EAL highlights the task of a teacher or learner that each should enhance their ability for meta-evaluation regarding 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 a wide range of domains and pursue ceaseless self-reflection and improvement in terms of their studying ability. In particular, since the world of vocation is maintained based on interests, emphasis on social intelligence, self reflection, and self-study ability in specialized fields of professional activity in various sectors of life may be interpreted with specific explanations on critical thinking, as mentioned earlier.

## VI. Conclusions

The most conspicuous characteristic of a knowledge-based society is that such a society experiences the creation and degeneration of knowledge faster than in any other era. That is to say, a knowledge-based society is in an era of change and speed. On the other hand, discussions on ethics pursue cogency and unification. Therefore, any 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 it is an era of change and speed, the more unified will be the focus needed. This research intended to critically review trends in engineering-ethics education

and research, as summed up in the word, 'EAC', and deduce suggestions for developing engineering-ethics education by clarifying the part that has been overlooked in EAC discussions so far. The results of this research are summarized as follows.

First, the achievements of various researchers in the US that can be cited as a forerunner of engineering-ethics research and education or the educational accomplishments of Kanazawa Institute of Technology of Japan, though considerably stimulating, still raise barriers and unresolved issues.

Second, the EAC discussions thus far involve various limitations: shortage of recognition of inter-disciplinary research in the education field and insufficient participation of education majors.

Third, the engineering and philosophy experts who have been conducting EAC discussions have been pursuing integrated education courses either consciously or unconsciously.

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

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