

# A Study of Convergence Education Type for the College of Engineering

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### ABSTRACT

Due to the development of science and technology, diversity of fusion technologies has become a major concern. Especially the application of the convergence education became necessary in the curriculum of engineering department. The purpose of this paper is to extract characteristics of convergence education among engineering majors and to present a model of applicable convergence education. The researchers collected studies of past 15 years in domestic and international journals in related themes. Academic research information systems, DBpia, e-article, Academic Search Complete were used for keyword searches. 43 Korean papers and 25 international papers were analyzed for the study. The results showed that the convergence education models for college of engineering can be classified into the three types: the cooperative convergence, multidisciplinary convergence, and transdisciplinary convergence. Based on the results, a convergence education model is suggested for the schools of engineering in Korea.

**Keywords:** Convergence, Fusion, engineering, education, model

## 1. Introduction

With the progress of civilization and required technologies becoming more sophisticated which in turn deepen and complicate problems to be solved, cooperative problem-solving has been continuously developing as an important measure (issue) to solve these complex problems. Collective ability of humans produce greater knowledge and ability than that of individuals and it has attracted attention as an area of sustained development in the future and thus studies have been conducted to graft it into the field of education.(Kim

et al, 2015) Development of technologies has produced new areas and technologies which have not previously existed such as birth of new areas in the field of integration and convergence. Scholars who claim the need of convergence of academic studies emphasize that academic studies have reached a saturation point within the frame of existing academic system and that with the increase of need to combine knowledge of one area with that of other areas, convergence studies away from the frame of specific studies are now appearing.(Choi, 2010)

The emergence of convergence education stems from active development of academic areas themselves, context of unifying knowledge in the brains of humans in epistemological dimension, desire and stimulation to solve

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practical problems in real society and necessity of new social coordination role due to multicultural phenomenon . (Petrie, H. G. ,1992) Seen from recent trend, birth of new areas of this kind occurs by the convergence of more than two areas and early forms of convergences started from engineering areas and now they are spread to convergence of humanities and engineering and one of art and all areas. This happens in education as well as engineering and typically, necessity of creative engineering talents calls for convergence of humanities and engineering.

In Korea, however, although there are some successful cases of convergence technologies and products in industries, due to lack of long-term national goals and philosophy regarding academic convergence, there is more or less confusion in education and cultivation of talents and convergence still remains at early stage and thus active convergence reaction is yet to take place. Though convergence efforts of university spurred by the demand of the time manifest themselves as cooperation among areas and emergence of several of convergence departments, they show forms of combination rather than convergence due mainly to egoism of departments, inadequacy of system and related laws. In addition, although universities are moving toward convergence education and policies by analyzing the strengths of themselves in order to enhance competitiveness and fortify their strengths, it seems that there are many problems to be solved in reality.

Here, convergence means a heterogeneous combination of knowledge, technology and academic studies, mutually beneficial relationship in which expertise of each area compensates for the limitations and problems of other areas and a process which stimulates other heterogeneous areas, eliminates limitations restricted in certain frames and elicits creation of highest level of knowledge through grafting of well-suited areas. (You, 2013)

In addition, in relation to convergence, there are concepts of consilience, combination and integration which are used in academic circles and industries. To sum up the opinions of domestic and overseas scholars so far, consilience can be defined as creativity by biological / neurological / synaptic knowledge in the 4-dimensional brain and combination as 2-dimensional functional complement while integration is

defined as three-dimensional functional connection and convergence as three-dimensional chemical / biological creation. (Lee, 2012)

With the progress of science and technology, new age requires various convergence educations. Though graft of convergence education to school (education) spreads and practical cases are increasing, there is still lack of integrated and systematic analyses. In a study on cultivation of human resources in the field of technological convergence, Min Ah Jung (2009) drew out courses (subjects) of major for convergence of IT and shipbuilding and appropriately fused subjects for the purpose of producing specialized convergence professional workforce by suggesting cross-layer completion system.

Samsung Economic Research Institute (2011) studied quality improvement plan for university education to train talents in technological areas. The study emphasized that in order to attract outstanding talents to IT areas, companies should improve treatment of IT talents and present vision while government should implement systematic and consistent IT talent training policies and investments and other media organizations should strengthen assessment of education and university-industry cooperation. As the economic paradigm has changed into information economy, digital economy and creative economy over the last 2 decades, in order to preemptively respond to the age of creative economy characterized by convergence among knowledge, technology and academic studies, Science and Technology Policy Institute (Kim, 2011) drew out types, areas, growth principle and policy implications of creative convergence talents focusing on convergence of science & technology and art.(Lim et al., 2013)

In the case of convergence education in the universities of the U.S., it turned out that universities with strong engineering colleges are more active in convergence education. Perdue, Carnegie Mellon, Georgia Tech, MIT and Olin College of Engineering were challenging, developing and operating the convergence with other areas of academic studies beyond mere convergence of engineering areas. Franklin W. Olin College of Engineering developed project-oriented education course for engineering major by introducing interdisciplinary problem-solving approach. The

course emphasizes product design education which satisfies customer demand, creative invention education, planning, finance and marketing and senior students are offered a year project leaning in which students solve practical problems of companies. "Engineering Fundamentals" major in Michigan Technological University provides students with most of basic engineering courses and students learn by fusing various areas of engineering based on their individual interests. These preceding studies on convergence area suggest change in university education and consumer-oriented education and emphasize the necessity of effective education methods in the area of convergence.

For this purpose, this study aims to survey and analyze theses on convergence education in engineering field published in domestic and overseas academic journals since 2000 and investigate their characteristics and commonalities. Analysis and organization of preceding empirical studies related in an integrated and systematic manner has its meaning of grasping basic principles and effectiveness of convergence education and obtaining integrated understanding and classifying characteristics. (Park et al., 2013)

This study took the year 2000 as its start since it was the important year for convergence in the educational curriculum of engineering colleges in Korea. In addition, it was the time when balanced regional development policy of the government and university-industry cooperation centering on local universities were vitalized and various experiments on curriculum started mainly by engineering colleges. Thus, this study judged that it was the time when convergence education in engineering areas began to pay academic attention to advanced cases and draw out outcomes of study.

Thus, focusing on engineering areas which require various models of convergence education, this study aims at the followings:

First, investigating the direction of study so far conducted on convergence education in engineering area.

Second, drawing out the characteristics of convergence education in engineering areas from overall perspective and, based on it,

Third, suggesting an applicable model of convergence

education.

This study aims not only to promote understanding on convergence education in engineering areas but also to provide a frame of convergence education which will offer practical support and standard for an educator when he/she is placed under the circumstances which require teaching methodology related to convergence.

## II. Theoretical background

### 1. Definition of convergence

Convergence manifests itself in various forms and levels in various subjects of various areas and its meaning and concept varies depending on scholars and areas actually applied. (Frodman, R, Klein, P., & Olkinuora, E., 2006)

Necessity of convergence has been actively raised as the solution to technological problems. Rosenberg conceptualized convergence as common technological innovative phenomenon of factories of various industries in the process of solving technological problems. (Rosenberg, N, 1963)

In addition, Kodama defined convergence as a method of innovation while breakthroughs of many technological problems take place simultaneously and combine with each other(Kodama, F, 1991) and Gong Rae Lee and Jung Tae Hwang saw it as a phenomenon of technological innovation caused by chemical combination of more than 2 technological factors which exerts new functions not possessed by existing technology.(Lee and Hwang, 2005)

### 2. Definition of convergence technology

Development of civilization accelerates convergence of technology and development of convergence technology promotes further progress of convergence in academic field. Nissan and Niroomand defined convergence as combination of more than two majors or subject components and Duk Hyun Kim viewed it as independent entities creating a new and bigger entity through chemical combinations. Seeing general definitions of convergence in diverse countries, the U.S. regards it as synergic combination of NT-BT-IT-CT while Europe defines it as synergic combination of NBIC, humanities and science. Convergence technology is a major

issue of future society and countries have been competitively conducting researches on convergence technology to create new technological areas through combination of different areas and to secure original technology. From industrial viewpoint, consilience is a creation of knowledge and based on it, knowledge property is formed, based on which combined products and services are created, and then integrated products and services are created which further create new original products and services. Thus, we witness that value chain and value proposition of consilience-combination-integration-convergence are formed. Convergence technologies of this kind have been studied preferentially by the scholars and, recently, analyzing what motivated scholars who paved the way to convergence studies to create academic studies through convergence in a study 'How convergence studies are created?', Heon Seok Oh defined convergence as 'a process of creating new academic areas by combining more than two areas beyond the boundaries of different individual areas and specific academic fields.(Lee et al. 2005)

### 3. Definition of convergence education

Convergence education in historical and theoretical context is rooted in the demand for reform from liberal educators centering on John Dewey who emphasized theme-oriented projects in the problem of real life in the 1920s and 1930s.(Applebee, A. N., Adler, M., & Flihan, S., 2007)

Later, convergence education was vitalized by Piaget in the 1950s and it is coming to a new turning point due to heightened interest in problem-solving and decision-making techniques as well as widespread use of Constructivist educational theories.(Ellis, A. K., & Stuen, C. J., 1998)

Especially, Constructivist educational philosophy which provides theoretical basis of integrated educational curriculum became the foundation of strengthening convergence teaching-learning. In addition, Gardner's multiple intelligence theory justifies integrated approach in teaching-learning.(Park, M., 2008)

In order for Korean economy which adheres to export-led growth model led by high-tech products like semi-conductors and automobile / shipbuilding / heavy and chemical plant to maintain stable and consistent growth, future-oriented engineering and technical workforce should be sufficiently

secured and first foothold for this goal must be based on innovative engineering education acquired by close cooperative relationship between industries and universities. Especially, university-industry cooperation mainly takes the form of research projects as corporations can use high-quality manpower and facilities of the universities cheaply and universities can have the advantage of application of theories to practical problems in the fields of corporations or field practice for job-seeking efforts of students and complementary education for manpower in the fields of corporations. Attempts have been reported that overseas universities verify their system of courses and develop new courses and teaching-learning methods and curriculum so that they can raise technical manpower and motivate students. These innovation plans for engineering education strongly emphasize the fortification of design education and, to support this, establishment of capstone design education system. (Thigpen, L, Hou, C., Fairchild, J., and Nallenweg, R., 1992)

Hence, out of practice of pursuing research project development and new technology development through existing university-industry cooperation model focusing on research, a university and a corporation jointly established a new university-industry cooperation education course model centering on undergraduate course for the purpose of providing corporations with competitive competent manpower.(Lee, D.H, Kang, D. C, and Jung, G. H. 2004)

Other than that, there are also cases of empowering students to undergo design education of convergence major together with general engineering design themselves by having engineering education conducted which consistently implements theories, design and practice for all grades of a department based on creative education system which includes universal engineering design technology and to cultivate experience and competency to draw out creative ideas and produce products which take the value of the products into consideration or cases of creative design education for the purpose of enhancement of practical design ability through experience and application of engineering design process and integrated design course, Creative Design Project(Ji, H. S. 2013), in which, from opinions of industrial design experts, factors of design technology competency are drawn out which in turn are applied to engineering design education.

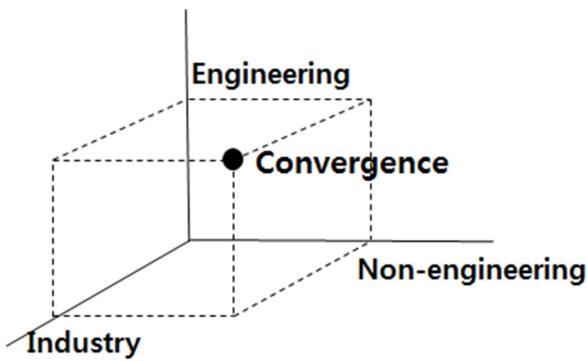


Fig. 1 Meeting point of convergence in engineering area

### III. Study methods

In order to suggest direction for convergence education, especially convergence in engineering field by looking into study trend of convergence education in the engineering field, this study conducted analysis on related academic journals, literature review and content analysis. As the selection of subject theses for analysis is the most important process in the analysis of study trend, this study made effort to enhance the reliability of data for analysis through discussions among researchers and reviews on the selection factors. To collect the theses which conducted empirical studies on the implementation and effect of convergence education, this study performed online search on academic databases. For domestic data, this study acquired related materials by using Noori Media Corporation's DBpia ([www.dbpia.co.kr](http://www.dbpia.co.kr)) and Academic Educational Institute's e-article([www.earticle.net](http://www.earticle.net)) and for overseas data, it obtained materials by using Academic Search Complete ([web.b.ebscohost.com](http://web.b.ebscohost.com)). Analysis of theses went through selection of theses focusing on title and keywords, analysis based on search and conclusion which includes result treatment and drawing-out process as shown in Figure 2.

DBpia and e-article provide academic theses service for 1,500 kinds of domestic journals respectively for whole academic fields and Academic Search Complete is a major overseas academic database which provides over 9,000 journals including science and technology, humanities and social science. As academic trend before 2000 is judged to be different from current one, this study focused on analysis on theses related to this study which have been published from 2000. For literature review, this study researched

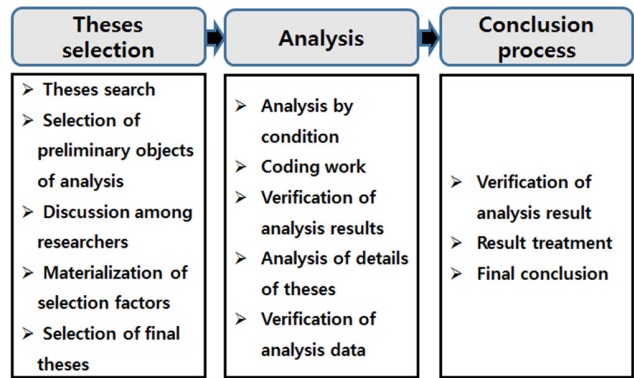


Fig. 2 Study procedure

Table 1 Search condition.

Item	Contents
Database	DBpia, e-article, Academic Search Complete
Period of search	Jan 1, 2000 ~ present (2015)
Search terms	STEAM + ENGINEERING, STEAM + engineering, STEAM + IT, STEAM + design, Convergence education, Integrated education, University-industry cooperation education), Distribution education, Practical education process
Study contents	Reality, development, theory/contents

various materials related to convergence research in engineering field. The word is accounts for more than 90% from the whole number. The keyword are 9 words among 48 words used more than two times in title and keyword of 709 literature in related to department of convergence research. This study aimed to investigate study trend related to convergence education so far and suggest study direction with literature review which collected and analyzed related materials and content, and finally a total of 68 theses were analyzed (32 out of 219 theses published in DBpia, 11 out of 106 theses published e-article, 25 out of 384 theses published Academic Search Complete). Selection of theses for analysis and standard for search are presented in Table 1.

A total of 709 materials on convergence study were primarily collected through online search of titles.

Among the theses searched, only those satisfy selection standards were included in the objects of analysis of this study; First, convergence education should be actually performed in engineering colleges and analysis on its effectiveness should also be included. Therefore, theses on

establishment of theoretical models, model development or proposals for discourse were excluded. Second, what the converged subjects are and how the contents of the subject converged should be discernible in the theses. As the primary focus of this study is on various forms of convergence in the courses and factors of convergence in the engineering colleges and analysis on their effects, only theses which have discernible elements were included in this study. Third, contents, effects and objects of education should be clearly presented. Among the research types which can have effect on convergence education, study selected materials which definitely delineated contents and verification of effects of convergence education. Considering these standards, the study finally selected 68 theses which fit the selection standards by analyzing abstracts and contents out of 709 theses searched.

Two major points of this study were first, subjects of converged education and second, converged forms of education and their effects. Specifically, subjects of converged education means entities which require convergence education, and classification of subjects with active convergence

education and examination on their trend will provide present necessity of convergence education and its future directions. In the cases of convergence education implemented, bigger frame of convergence education can be confirmed although it is not easy to consider quality among courses or technologies. For this purpose, this study, by referring to Drake & Burns' level and degree of convergence are presented in Table 3, classified convergence education into parallel convergence which is not deep in interaction, interdisciplinary convergence in which multi-disciplinary approach and interaction of common goal and concept take place and transdisciplinary convergence in which a new form of single concept takes place.

Although the classification form suggested in above is one considering convergence of courses, it is comprehensive when seen from the concept of learning for students if it is expanded to academic studies and technology among courses, that is, theory and practice, not just convergence among courses being performed in engineering colleges at the present. Therefore, looking at actual application process of classification, cases of convergence education out of

**Table 2 Search result.**

Search words	DBpia	e- article	Academic Search Complete	Total	Remark
STEAM education + ENGINEERING	17	5	10	32	
STEAM education + engineering	14	3	-	17	
STEAM education + IT	6	3	2	11	
STEAM education + DESIGN	42	4	4	50	
Convergence education	34	27	64	125	Classification: Engineering
Integrated education	52	36	85	173	
Cooperation Education	43	15	88	146	
Distribution education	5	12	61	78	
Practical education process	6	1	70	77	
Total	219	106	384	709	

**Table 3 Standard of classification of the level and degree of convergence.**

	Type of classification	Major contents and characteristics
Level and degree of convergence (Drake & Burns, 2004)	Multidisciplinary approach	<ul style="list-style-type: none"> <li>- parallel enumeration of individual courses or majors</li> <li>- maintenance of details of courses and majors in original forms</li> <li>- implementation of classes in sequence, not a shared team teaching</li> </ul>
	Interdisciplinary approach	<ul style="list-style-type: none"> <li>- active course-centered, design integrated into wider scope of educational curriculum</li> <li>- modification of details in courses and majors and implementation of team teaching by teachers</li> <li>- participation of individual teachers as team members in a big team, department or a program</li> </ul>
	Transdisciplinary Approach	<ul style="list-style-type: none"> <li>- subjects based on real life or context while transcending bounds of courses</li> <li>- implementation of courses of in a single curriculum based on learners' demands and interests</li> <li>- embodiment in integrated educational process, integrated study and fusion models</li> </ul>

necessity even with little mutual commonalities were classified as multi-disciplinary convergence and cases with mutual commonalities in curriculum and practice were classified as interdisciplinary convergence. For example, science of machines and devices, automatic control, sensor, communication and software are interdisciplinary convergence. Cases of sharing information and technology through the process of consolidated opinion collection, not individualized knowledge, such as approach to human being in consolidated method and quantum physics were classified as transdisciplinary convergence.

#### IV. Study results and discussion

Though the cases of convergence education overseas date back to 1920s, application in domestic academic studies only started in 1990s by academic circles. As a part of confusion in domestic studies, Dong Joo Shin mentioned in 2012 "Even though consensus is formed for importance and necessity for convergence education in the university with the progress of convergence among industries, full-blown discussion on concept and definition of convergence education still remains an incipient state." This study also set the period after 2000 as the object of research since recognition on importance of overseas convergence began around that time. The results of the search using search words in Table 1 are shown in Table 4. As for the trend in convergence education in engineering field by year, the biggest number of studies on STEAM was conducted during the period of year 2003 through 2005, and since has gradually decreased while many studies on convergence and integration education and

industry participation education have been conducted since 2007. The number of thesis has been on steady decline starting from 2013, when 'industry-university cooperation-focused university project' and 'talent-raising project' ended. It looks that as the government effort to strengthen strategy industries by region centering on universities which began in the middle of 1990s shifted into (the meaning of) restructuring of universities, voluntary efforts of researchers on convergence education gradually decreased.

Convergence studies in engineering area are largely classified into STEAM, convergence among majors and industry-university cooperation convergence. Studies on STEAM have been mainly focused on primary, middle and high schools while STEAM in university showed relatively low frequency. Especially in the case of middle and high schools, unlike primary schools in which a teacher instructs many subjects, STEAM programs were frequently operated in cooperation with teachers of other subjects majoring in technology and engineering by dividing themes into divided sessions, which looks as the result of strengthening of primary and secondary convergence education by national policy. Although convergence of art and science is a useful linking strategy in providing creative ideas (Sung Wook Hong, 2005), in order to actively link diverse areas in STEAM education in the future, it is necessary to provide information and guidelines on various linking strategies such as creative design-based problem-solving skills.

Industry-university cooperation and convergence among majors which accommodates social demand and conditions occupy a large part of university-centered convergence studies

**Table 4 Status of convergence research by theme in engineering field**

Year	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	Sum
STEAM education + ENGINEERING	1	1	3	4	5	6	4	1	1	2	1	-	2	-	1	-	32(4.5%)
STEAM education + engineering	1	-	2	2	3	1	1	-	1	2	1	-	1	1	-	1	17(2.4%)
STEAM education + IT	-	-	1	2	1	1	1	-	-	1	1	-	1	1	1	-	11(1.5%)
STEAM education + design	2	1	2	4	4	6	7	5	2	3	3	2	4	3	1	1	50(7.1%)
Convergence education	5	2	2	4	9	16	10	16	12	10	6	10	9	8	4	2	125(17.6%)
Integrated education	3	4	8	3	8	8	2	16	10	12	28	11	20	34	4	2	173(24.4%)
Cooperation education	-	5	5	2	5	6	7	11	17	13	15	14	24	13	7	2	146(20.6%)
Distribution education	3	1	4	4	5	4	5	6	9	8	2	5	9	6	6	1	78(11.0%)
Practical education process	2	2	3	8	2	2	9	7	8	7	3	2	9	10	3	-	77(10.9%)
Total	17	16	30	33	42	50	46	62	60	58	60	44	79	76	27	9	709(100%)

**Table 5 Analysis on major materials**

Name of thesis	Keywords	Major contents	Classification of forms
Direction for convergence education and suggestion on design of basic convergence curriculum for systemization of convergence education	Convergence education, liberal education ' etc.	Liberal education convergence, basic convergence education	Convergence between engineering and non-engineering
A study on verification and analysis of effectiveness of pro-convergence IT professional workforce training and educational system	Pro-convergence IT professional workforce training and educational system, etc.	Verification of effect of cross education, field training of corporations and team activities among students of different areas	Intra-engineering convergence and convergence with non-engineering studies, corporate participation convergence education
Status of convergence education and future direction-focusing on Hanbat University	Convergence education, cognition, nano-technology, bio-technology	Classification and characteristics of convergence in cognitive science field, nano and bio field, art and technology	Convergence within engineering, convergence of engineering, business administration, humanities and social science
Development of education model for student-led creative convergence project	Creative engineering, convergence, R&D, etc.	Problem-solving through education 3.0-generation students-centered teamwork	Convergence of knowledge, convergence type of technology and humanities
Trend analysis on domestic studies related to convergence and integration science education	Convergence and integration education, domestic study trend, STEAM	Increased until the mid-2000 and later decreased and increased again after 2010, linking was highest in STS and integration area	Convergence within science, linking with other courses
A study on convergence education model of science and engineering for vitalization of creative education	Convergence education, modeling, convergence technology	Convergence of liberal art courses, soft skill training and major courses, necessity of creation of new majors	Convergence of engineering and liberal arts, corporate track type, convergence industry type and growth study type
A study on development of education curriculum for convergence-type educational institutes for the gifted	Convergence education for the gifted, educational courses	Execution of purpose-oriented convergence education and teamwork activities simultaneously by actively fusing STEAM	STEAM-type basic curriculum, professional curriculum, voluntary-research activities type STEAM-A, etc.
A study on creative thinking and convergence education for innovative design	Creative thinking, convergence education, design education	As the result of drawing out design outcomes of convergence group between design and other studies and exclusive design group, convergence group was better	Convergence between design and humanities, engineering and philosophy
Analysis on curriculum and policy of convergence education in domestic universities	Convergence education, curriculum, industry, curriculum, etc.	Convergence education process in domestic universities progressed in line with local specialization project	Convergence within engineering and between engineering and non-engineering
Development and application effect of STEAM program for future promising career based on 5th and 6th grade students of primary schools for the promotion of intention to enter science and engineering universities	Science and technology STEAM, bio-medical technology, design-based, etc.	Search for bio and medical engineering career and simulated experience by integrating possible courses after analysis of curriculum of 5th and 6th grade of primary schools	Convergence education of science, technology, engineering and arts
Designing of STEAM education programs for engineering experience of female students	STEAM, e-textile Engineering education for female students, STEAM, e-textile	Designing of engineering -centered STEAM programs to raise female talents in engineering fields	Convergence education of electricity and electronics, computer science, design and sewing
Analysis of teaching-learning programs of technology and engineering field in STEAM	Technology and engineering in STEAM, education and learning strategies	Strategy establishment of technology and engineering in teaching-learning strategy is strengthened more in middle and high schools than primary schools	Convergence type of technology and engineering, Convergence type of art and mathematics
Design of STEAM convergence education curriculum of project-based learning - focusing on development and utilization of Android-based contents for power transmission leaning contents-	Design of STEAM convergence education, project-based learning, curriculum	Design of STEAM education curriculum of primary school in the form of project-based learning -development of android application	Convergence of math-science-technical subjects



Name of thesis	Keywords	Major contents	Classification of forms
Industry-university cooperation concept model through game-making cases	Game education, industry-university cooperation	Focusing on learners' direct and indirect experience of manufacturing process in the fields of industry, suggestion of industry-university model which suggests role importance of related practice instructor by stage	Application of university education process in the same stage as industrial development process, experience, practice and industry-university cooperation
Regional manpower training policy for social consolidation and symbiotic development -centering on industry-university cooperation projects	Regional manpower training policy, industry-university projects, symbiotic development	Strengthening of industry-university cooperation for balanced regional development and regional talent cultivation policy	Order-based/tailored educational curriculum, field training, internship, career-linked program
Exploration on educational curriculum for the vitalization of industry-university cooperation	industry-university cooperation, educational curriculum, DACUM technique	Analysis of university education curriculum and educational program development by DACUM technique for consumer-centered talent cultivation	consumer-centered, practical use (commercialization), field work, integrated education (students / professor / corporations)
Exploring the Exemplary STEAM Education in the U.S. as a Practical Educational Framework for Korea	STEM education, STEAM education, framework, Science education	This exploratory study is to inform the exemplary framework of STEAM education in the U.S. for Korea and to provide descriptive and analytical accounts on STEAM teaching and learning as an innovative integrated convergence education.	The type of multi- disciplinary convergence
New challenging approaches to engineering education: enhancing university-industry cooperation.	Curricula design, Engineering education, Industrial management Innovation,	Both projects are unique in emphasizing the importance of crossing organizational borders within and outside of traditional engineering education system. The paper also introduces recent initiatives of global ICT industry	Service leadership, organizational development and teamwork. Service delivery and technology architectures.

in engineering areas. Original lexical meaning of convergence is creating a new thing by the union of two completely different things. With the progress and advancement of technology, development through single major has faced limitations and thus necessity of convergence has been taken for granted. In the academic areas, convergence is also defined as education created by various manners from fusion to combination of study areas with different backgrounds and Dong Joo Shin observed, "Convergence education is a concept of combination of two or more subjects and knowledge systems into forming a completely new knowledge structure or course." The purpose of this study was to survey domestic and overseas study cases conducted since year 2000 in relation to convergence studies in engineering colleges, classify convergence education and present education model by types. For this purpose, this study analyzed 709 theses from preliminary literature review and final 68 theses which fitted selection standards and as the result of drawing out meeting point (common ground, consensus, commonalities),

they were classified into several forms as [Figure 3]. First, by searching various theses related to convergence, this study chose 8 search words which suit the purpose of this study and classified 5 convergence areas and three distinct convergence education types through analysis of abstracts and contents. In the case of STEAM among 8 search words, most studies were for primary, middle, high school and thus this study searched theses related to engineering colleges by using related search words and, through this, drew out convergence type within engineering, convergence type between engineering and non-engineering and theory-practice convergence type in which areas of detailed contents of courses and majors were modified and which shows interdisciplinary approach where convergence takes place at the level of teachers. In addition, liberal arts-based convergence type was also drawn out which is a multi-disciplinary approach in which individual courses or majors are arranged in parallel manner and original forms of details in courses and majors are maintained. Due to the meaning

of the term convergence, various convergence areas have been studied and this study was limited to convergence education focusing on engineering colleges. Through analysis on abstracts and contents of selected theses, this study drew out 5 convergence areas of 'convergence type within engineering', 'convergence type between engineering and non-engineering', 'liberal arts-based convergence type', 'theory-practice convergence type' and 'corporation-based convergence type.' Each of these 5 convergence areas has characteristics and commonalities; 'convergence type within engineering' can be divided into engineering area academic convergence type and industry-university cooperation

convergence type, 'convergence type between engineering and non-engineering' into convergence type between engineering and non-engineering academic convergence type and industry-university cooperation convergence type and 'liberal arts-based convergence type' can be divided into convergence type between engineering and non-engineering academic convergence type and industry-university cooperation convergence type. More materialized of these are Type I (convergence type between engineering and engineering), Type II (convergence type between engineering and non-engineering), Type III (convergence type between engineering and industry) presented in below [Figure 4].

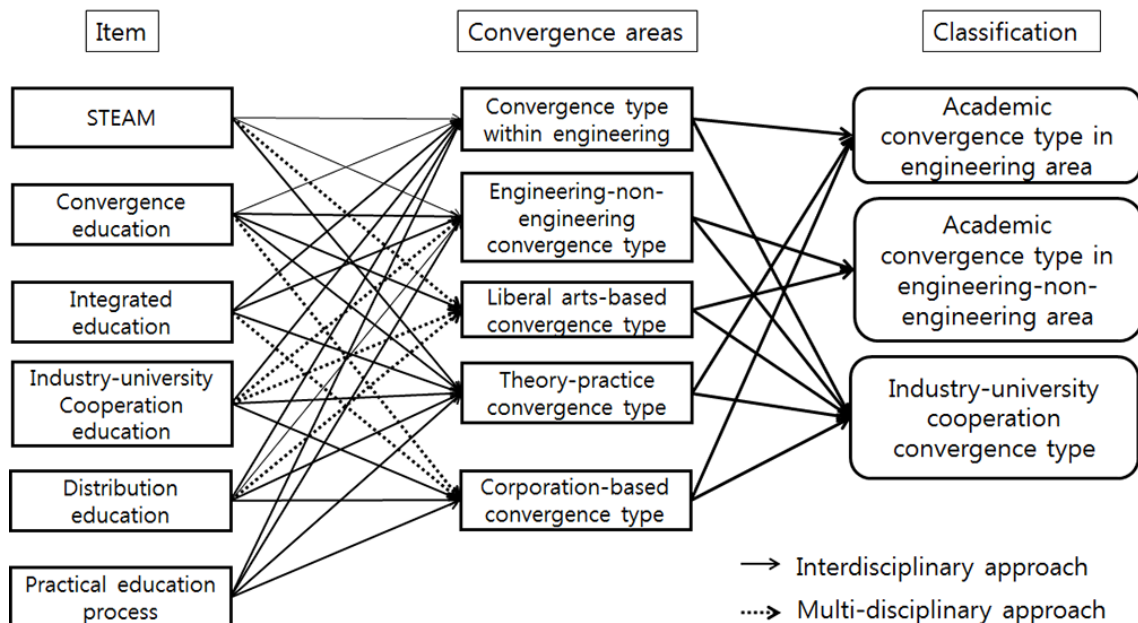


Fig. 3 Convergence areas and classification

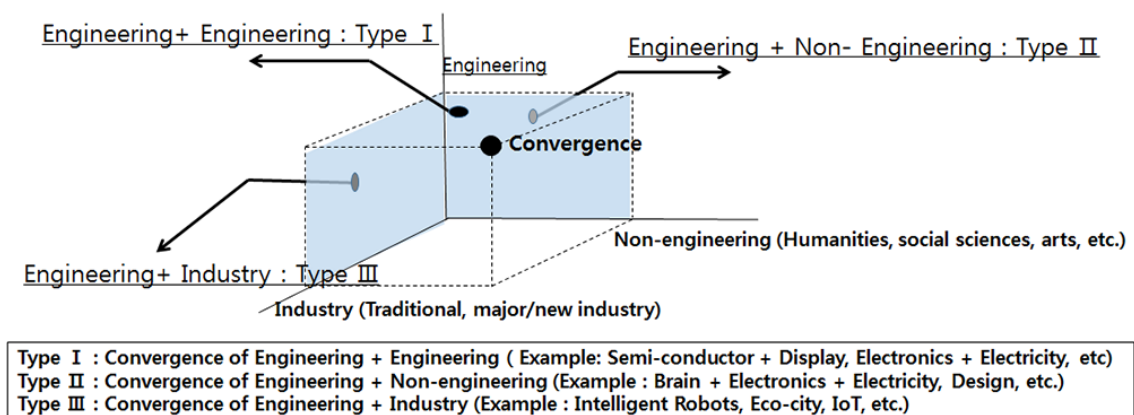


Fig. 4 Model for convergence education in engineering university

## V. Conclusion and suggestions

In order to investigate study trend on convergence education performed in engineering colleges in Korea from year 2000 up to May 2015, this study surveyed related study materials uploaded on academic databases DBpia, e-article and Academic Search Complete, conducted analysis by using 8 search words and engineering, examined study trends related to convergence education in engineering colleges and classified them according to characteristics and commonalities. As the result of analysis on research theses on convergence education by year, number of studies on STEAM had increased until early and middle of 2000s and began to decrease after that period, and convergence and integration education began to increase from the mid-2000, after which industry-university cooperation and collaboration education increased. However, all education related to object of study, convergence, started to decrease drastically from 2014, when government's university support system extended for industry-university cooperation as an external factor shifted to support for restructuring of universities. Especially, what is noteworthy is integration education started to rapidly decreased from 2014, which provides solid implication for convergence education in the future that should be consistently studied and implemented, not as an education which passes by like a fad affected by external factors. three models of convergence education drawn out by this study, which are 'convergence type within engineering', 'academic convergence type between engineering and non-engineering', and 'industry-university cooperation convergence type', include various types of convergence education performed in engineering colleges. Although one of big convergence area, STEAM, has been studied, applied to and practiced in primary, middle and high school since long ago, it is a fact that universities which really need to study convergence technologies required for industries have so far turned away from them and, instead, studies in universities have followed the steps of theoretical and rote-learning type of education of the past. Educational changes in the engineering colleges are still (nothing but) slow. When our industrial ecology enters global system and in a thoroughly

fierce age of competition in which no clearly visible future can be secured and only the law of the jungle dominates, engineering colleges have to squarely face the major premise of convergence. Starting from the discussion on the necessity of convergence education, this study analyzed theses on convergence education in and out of Korea, made comparison analysis on their characteristics and commonalities and presented three convergence education models for engineering colleges. Through this, this study tried to suggest ultimate direction for convergence education of engineering colleges and standards necessary to raise convergence talents required by the industries. Nevertheless, since this study did not analyze all the studies on convergence education and did not conduct study on educational method by classified categories of convergence education, it may be stretching too far to generalize presented limitation of convergence education. Still, this study hopes to play a role to a certain degree as a basic material for classification and methods to be prepared to realize convergence education of engineering universities. As the result of the study, this study presents several suggestions for the study direction for convergence education of engineering colleges in the future. First, as research and analysis on convergence education can provide not only study trend so far but also implications for the study direction in the future, other than theses analyzed in this study, analyses on more diverse kinds of theses are required. Second, together with research efforts for more diverse areas related to convergence education, more scientific classification should be made and realistic educational contents by classification category should be developed. Third, for this purpose, precise assessment on convergence education conducted previously must precede these efforts. As Steve Jobs' words, "All the activities in Apple come out of intersection between humanities and state-of-the-art technologies", convergence between engineering and non-engineering and engineering and industry must be the very core competency for the future. Therefore, convergence in engineering is to raise convergence talents who will become the center of future industry and for this purpose, this study hopes that various convergence educations in engineering colleges will be continuously studied and developed.

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