

# SEG Based Engineering Education Innovation: A Case Study on GNTECH-ICEE

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## ABSTRACT

GNTECH-ICEE, which this study seeks to investigate and evaluate, demonstrates a new system of training innovative engineers. An essential component of this operation is a Small Engineering Group (SEG) that links professors, students and industrial experts together, to study and apply different techniques in determining the processes and products that relate industrial sectors needs. As an education program, SEG also provides a right direction for educating students, and generates industry-university link based human resources. Through these efforts, GNTECH-ICEE has effectively trained creative, professional, and practical engineers, by operating a variety of programs for meeting industrial needs and enhancing engineering education. SEG has many merits that have influenced its success so far, but the program also faces some challenges. The merits include; strong group bondage, practical ability incubation, and efficient administrative support. In terms of demerits, it is evident that sufficient theoretical education and local small-middle size enterprises (SMEs)' sustainable participation cannot be warranted. Thus, we propose that initiative strategies have been helpful to maximize GNTECH-ICEE's goal of making students into multi-player engineer, but continuously financial and administrative strategies be put into place in order to guarantee SMEs' long-term devotion to the program, and to help create a sustainable network between students and the companies involved.

**Keywords:** Innovation Center for Engineering Education, Small Engineering Group, multi-player engineer, local SMEs

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## 1. Introduction

The rapid spread of globalization across the world has led to the expansion of customers' needs for new products and services. Therefore, engineering schools in different universities are pressed to train effective engineers and professionals who can develop new products and provide efficient services to meet consumers' demands. A simple look at the pressure on domestic enterprises' engineers to develop new products and services makes us realize how urgent the issue is. Korean companies producing semiconductors, steel, automobiles and ships are not only among the top five industries in the country, but are regarded as the best in the world. However, several global assessments rank Korean universities' engineering schools among the top 50.[14] This trend shows that Korean universities' engineering schools have failed to keep

pace with the quality of engineers required by companies. Innovation in the universities' engineering schools are certainly needed.

Another need for innovation in engineering education can be traced to the rapid global changes in the economic and social environment.[3] Due to the fast growth of scientific and engineering knowledge, which has made it possible to address global issues related to population growth, food, water, natural resources and environmental problems, the role of engineers and engineering as a whole has become extremely important.

Korean universities make every effort to train professionals to meet the needs of companies, and address changes in the social and economic environment, but many of them are not so successful in terms of practical aspects of academic-business cooperation or performance-oriented education. First, let's look at the engineering accreditation system, which was introduced in Korea in 2001.[8] Even though engineering programs are approved by the accreditation system, there are great variations between

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Received 4 October, 2011; Revised 12 June, 2012

Accepted 10 September, 2012

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universities and departments. In 2009, engineering education accreditation programs were adopted by 243 departments in 36 universities. This demonstrates that the engineering program is increasing exponentially in number. However, the Accreditation Board of Engineering Education of Korea (ABEEK) has limits in evaluating candidate departments and universities, and is also not connected to the increase of practical skills that are demanded in companies. Besides this accreditation system, university–industry collaboration is also nominal and joining companies cannot expect practical help for the growth of their businesses. For these reasons, small–middle size enterprises (SMEs) feel uncomfortable participating in any programs that are based on university–business cooperation.

Under these circumstances, Innovation Center for Engineering Education, Gyeongnam National University of Science & Technology (GNTECH–ICEE) has achieved a goal of local based industry–university linkage and has led to a need for objective evaluation and effective advertisement. This study was initiated based on information obtained from published literature and laboratory investigations as well as discussion with staff of GNTECH–ICEE. The major goals are to publish the results of this study, and to spread the innovative case of GNTECH–ICEE to domestic and international academics.

Innovative strategies and programs for engineering education and research on the process at home and abroad have been very active.[1,3,4,10–12,14] Looking at these studies by type, some of them deal with engineering education accreditation and others look at special education for engineering.[5,6,8] These studies emphasize successful stories of engineering education innovation through the introduction of engineering accreditation system. Another similar approach focuses on engineering education innovation through interdisciplinary education and its models. [4] Ertas (2000) stresses interdisciplinary education's effectiveness to develop research logic and research method from its historical background.

A large portion of other research claim that active academic–industrial cooperation will bring about innovative engineering education.[2,6,15,16] They further argue that joint academic–industrial laboratories, academic–industrial

networks, and academic–industrial eco–systems will lead to educational innovation in engineering. In a similar context, Lassig (2009) also contends that practical approach to education develops creativity, which influences engineering education innovation. Most researches on engineering education innovation are relevant to a theoretical meaning and practical application of specific programs or individual departments. Thus, case studies that focus on one university's innovative engineering education are rare.

## II. Methods

Two objectives are outlined for this study: First, it examines the goals and projects of GNTECH–ICEE, including its advantages and disadvantages. The first objective demonstrates the direction and range of the study. Second, we try to figure out the process of human resource production by demonstrating ‘core group’, ‘core engineer’, and ‘core strategy’. GNTECH–ICEE's core group is not a simple process, but it contains the philosophy and mission of ICEE.[7,9,11]

The study framework is as follows: First, we investigate SEG as a ‘core group’ of the study. Specifically, we look at its responsiveness to enterprises' needs and contribution to students' employment or job matching. Second, we study the ‘core engineer’ and determine if it is working as a multi–player technical worker for local SMEs, in terms of creativity, specialty, practicability, and sustainability. Third, we explore the ‘core strategy’ and demonstrate GNTECH–ICEE's strategy and evaluation program. Fourth, we evaluate SEG's ‘core group’ of the study, in terms of its strengths, weaknesses and prospects, in order to give a proper insight for GNTECH–ICEE itself and its programs.

The study mainly concentrates on SEG that enables innovative engineering education in GNTECH. Specifically, there are five main details in the study.

### 1. GNTECH's Innovation Case through ICEE

This case has two separate aspects. First, GNTECH–ICEE has a definite goal of local embedded industry–university cooperation model. Second, it operates SEG so

as to bring innovation to the engineering school. SEG is a specialization strategy to raise multi-player engineer for local SMEs. This is a very innovative case that builds up education, research, and industrial application.

## 2. GNTECH-ICEE's Programs

Programs are closely related to SEG. SEG system provides local SMEs' profile and needs to GNTECH-ICEE and the latter assigns one professor to one enterprise to satisfy its needs. That is, the university's engineering education programs and classes are able to reflect the needs of local SMEs, and evaluate and improve them. SEG designs practical student-initiated programs that produce global scale engineers in the long-term.

## 3. SEG's Education Programs

SEG operates the following training programs effectively. First, SEG carries out a multidisciplinary Capstone Design program. In each SEG, students gain practical skills by playing a major role in planning, designing, and production. The final outputs are demonstrated to the relevant personnel, alumni, and students. Second, SEG-based professor-industry technical guide system supports the program above. Third, GNTECH-ICEE operates the SEG-based Mentor Program. Each SEG contacts professors, industry professionals and graduates (alumni) as mentors.

## 4. Workforce Training System

The system includes on-the-spot/job training program, internship program, soft-skill program, and so on. The goals of the system are achieved by SEG's establishment, growth, expansion, stability, and settlement, where SEG students can improve their abilities for the standards required at local SMEs. GNTECH-ICEE focuses on local industrial clusters such as shipbuilding parts & Machinery cluster, eco-friendly environmental technology cluster, and bio tech & design cluster, and links them to SEGs. Also, GNTECH-ICEE builds up industry-university committees based on three local industrial clusters to train an industry-university linked workforce.

## 5. Evaluation and Administrative System

GNTECH established a faculty recruitment and achievement evaluation system based on industrial experience and industry-university cooperation. GNTECH-ICEE conducts an incentive and competitive system in SEG program, gives a lot of financial and beneficial advantages to professors and students participating, and establishes a computer network and homepage.

## III. Body

Since 2007, GNTECH-ICEE has received a project for engineering education innovation from the Ministry of Education, Science and Technology (MEST), and financial supports from many different organizations such as local governments and SMEs (Fig. 1), which means that it has made a strong linkage with them. In the innovation of GNTECH's engineering education, it is a core organization and has made a strong network with many different organizations and SMEs shown in Fig. 2. Shortly, GNTECH

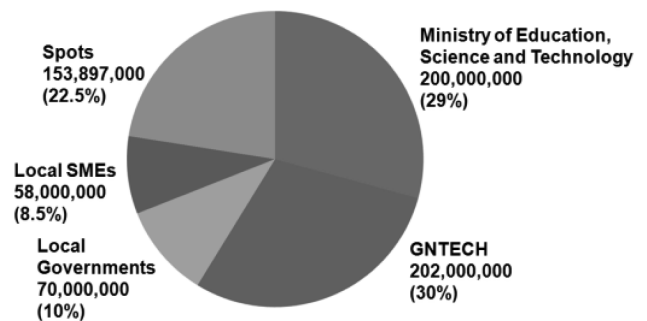


Fig. 1 The budget of GNTECH-ICEE project in 2011: the total cash and spots were 530,000,000 KRW and 153,897,000 KRW respectively

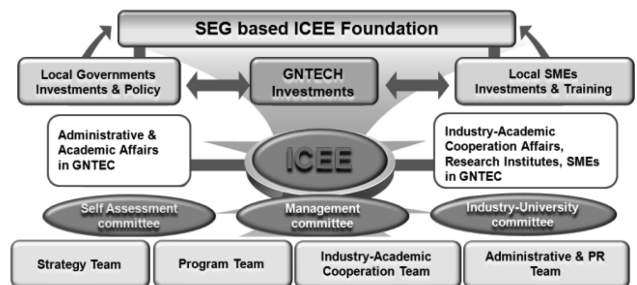


Fig. 2 The structure and network of GNTECH-ICEE

is close to industrial clusters including aviation, shipbuilding, robot, machinery, smart home, and green technology, and GNTECH-ICEE has linked to 523 SMEs as partnership.

GNTECH-ICEE's innovation can be explained with Core Group, Core Engineer, and Core Strategy. And the strengths, weaknesses, and prospects of the three elements should be assessed for the continuous innovation.

## 1. Core Group, SEG

### A. Concept & Function

SEG is GNTECH-ICEE's Core Group (Fig. 3). It brings the University (professor)-Student-industry into one small group in accordance with the industry's needs and human resources training program, which stipulates that executive ability can be achieved through research and practical application of knowledge. Each SEG consists of one professor, 3-5 undergraduate students, and 1 or 2 local SMEs, and carries out 1 or 2 small lab experimental projects and 1 or 2 capstone designs. SEG members can also join different clubs such as R&D clubs and Job creation clubs. Total system of SEG is carried out through an industry-based education in four-step system to perform self-development after graduation. A SEG involved student can get 2 credits per a small lab experimental project and also get maximum 8 credits. While the students carry out the projects, they can have a chance to work together with SMEs' experts.

GNTECH-ICEE constitutes SEG Council to enhance efficiency in the program. It has regular meetings for analyzing industries and students' needs and checking out

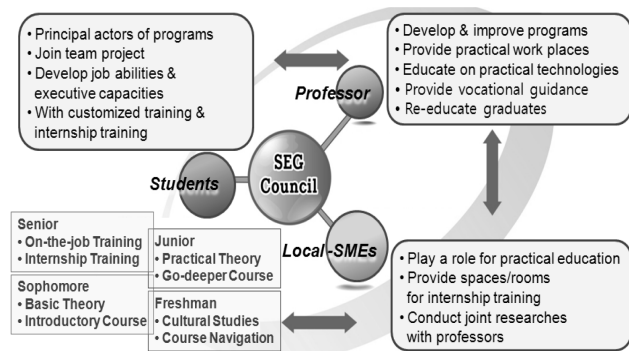


Fig. 3 The concept and function of SEG

students' projects such as capstone design. It also develops different projects, and reviews the progress of existing ones.

### B. Faculty (Professor) & the University

The University as a whole and the professors, who research and lecture there, play different roles in the SEG system. They develop and improve various programs and act as the main agents that provide spaces for practical work as well as the equipment. At the same time, they educate students on practical technologies. Through their relationship with GNTECH-ICEE, professors take an intermediary role and the university takes on a promoter's role. Also, both of them have responsibility for providing vocational guidance and graduate re-education.

### C. Student

University students in SEG are the principal actors of the program. Specifically, students join the team project and develop job abilities and executive capacities. Through custom-education and internship training, they develop their skills to be technical professionals and industrial specialists who have executive abilities.

### D. SMEs

SME's which join the SEG program play their role in providing the enabling environment for practical education. They also provide spaces/rooms for students' internship training (or practical on-the-spot/job education) and for professors' R&D. In addition, they conduct joint research with the university, which results in product development and commercialization. In return, SMEs take advantage of the local-based excellent professionals from the university.

## 2. Core Engineer: Multi-player Engineer for SMEs

SMEs need multi-talented engineers who are practical, creative and specialized to sustain ongoing projects (Fig. 4). Such engineers can play a major role in developing and improving the operations of SMEs. The programs implemented by GNTECH-ICEE, help to train core engineers in the following ways.



Fig. 4 The education scheme of core engineer for SMEs

#### A. Creativity

Creativity is a core value that helps to improve engineering processes and develop new products. To enhance students' creativity, GNTECH-ICEE supports capstone design program (Team Project), and engineering accreditation programs. In capstone design program, students propose and develop team projects that help to develop their creativity and professional skills. And engineering accreditation program is a system that ensures and guarantees that graduates have the necessary expertise and capabilities to be effective in the industry. The accreditation system suggests program standards and guidelines, which universities are supposed to use as benchmark for their engineering education. The system's goal is to train and develop students' talents to acquire high level engineering skills through the accreditation and with professors' advices.[13] This process also trains and prepares students to gain knowledge in the humanities (such as sociology, politics, economics, culture) and environmental issues.

#### B. Specialty

To develop students' specialty skills for SMEs' needs, GNTECH-ICEE develops an industry-university cooperation education system, which guarantees specialized knowledge for students, and equips them with executive capabilities in the field. This is done through research activities, mutual laboratory operations, industrial guidelines and the professors' practical training. Also, it also supports on-the-spot/job training, collaboration with SMEs, and extra-curricular activities for jobs creation.

#### C. Practicability

As an important element, this is especially accomplished through the cooperation with SMEs. Industry-university cooperation committees are organized in shipbuilding parts & Machinery cluster, eco-friendly environmental technology cluster, and bio techs & design cluster. Since March 2008, GNTECH-ICEE has developed internship programs (or on-the-spot/job training) with local SMEs. Undoubtedly, it operates practice-based approaches to engineering education in different ways, and the programs' impacts have been shown in the practical ability improvement of the participant students.

#### D. Sustainability

The Innovation Center has a specific goal to promote talent sustainably. To reach this goal efficiently, the center focuses on practical research and development (R&D) at the industry level, and invigorates the local industry through a customized education system. Examples of R&D programs that can be commercialized include: Capstone Design programs, job creation clubs and engineering club projects.

### 3. Six Core Strategies with Evaluation

#### A. Establish Specialization Strategy

The differentiation strategies are established in two aspects. First, long-term strategies have the goal of building local SMEs-university cooperation. A number of engineering schools are connected to local SMEs or pursue cooperative R&D to gain practical experiences. This cooperation is a very innovative idea since it gives both sides lots of benefits to train qualified engineers. Second, the strategy of SEG's system & program is very innovative, and provides the university with competitive advantages. SEG's outcomes and the participant students' responsiveness are very vigorous, and reflect the strategy efficiency.

#### B. Develop Education Program for SEGs

Innovative education programs for improving students' practical abilities are developed to meet local SMEs' needs: multidisciplinary capstone design, small lab experimental project, R&D club, job creation club, on-the-spot/job

training, internship programs, soft-skill programs etc. These programs are said to motivate students and professors to pursue ongoing studies, and closely connect them to local SMEs where they gain plenty of practical experiences.

#### C. Improve the Methods of SEG Education

GNTECH-ICEE has regularly assessed the methods, and then modified and improved them according to the assessment. The reform includes the SEG industrial practice, job creation supports, SEG-based recruitment system, faculty-industry-alumni joint mentoring system, and engineering education accreditation system. Actually, through the engineering education accreditation system, the methods have continuously been improved.

#### D. Workforce Training System for SMEs

GNTECH-ICEE endeavors to enhance an industry-university linked workforce training system. This is accomplished through this following: local SME-university Memorandum of Understanding (MOU), industry-university cooperation seminar, industry-university R&D collaboration, SEG units' industrial experts' guide & on-the-spot/job training, and SEG-based job linking system. These programs are very effective and useful for students and professors.

#### E. Evaluate Innovation Outcomes of Faculty

The evaluation is conducted under total administration system, which reflects the education accomplishment of industry-university cooperation. The survey report of the other universities' evaluation systems is made for benchmarking and GNTECH-ICEE's homepage has been updated with the related contents. These are embodied by a network system connected to GNTECH's homepage.

With the recognition of needs between the university and industry, GNTECH revises its regulations to contain industry-university linking elements, which affect the promotion, reemployment, and tenure track of the faculty. Through this system professors who work hard towards enhancing the industry-university cooperation are given high evaluation ratings. This compels the professors to strive to achieve the required goal, and also results in a better cooperation with local SMEs.[7]

#### F. Advertise GNTECH-ICEE's Outcomes

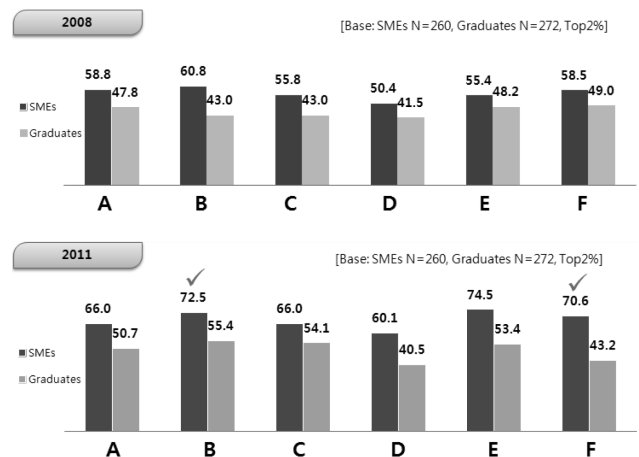
Through maximized innovative outcomes, the GNTECH's honor can be exalted. GNTECH-ICEE accomplishes its goals through innovation outcome fairs, Capstone Design fairs, and departmental club competition events. Also, it organizes local SMEs-university seminars to explain the annual plan & outcomes, which are effective for advertising itself.

#### 4. SEG's Strengths, Weaknesses, and Prospects

In 2008 and 2011, social statistical survey & analysis of local SMEs and the graduate has been carried out to assess SEG based engineering education innovation and the graduates' engineering performance abilities

The education for students' problem solving in the field and team task performance as a member has received high assessments for last 3 years (Fig. 5). It means that the engineering education innovation has been successful and effective in the curricula and also the methods.

Most SMEs are putting a high valuation on the performances (Fig. 6). The abilities to solve new problems,



**Fig. 5** SMEs & graduates' assessment of SEG based engineering education innovation: A=enough curriculums; B=lecture for students' understanding the process, calculation, theory, and method to solve technical problems; C=lecture for students' interpreting experimental data and application; D=lecture for students' using engineering tools; E=offering opportunities to work out team tasks as a member; F=developing social and moral responsibility in the field.

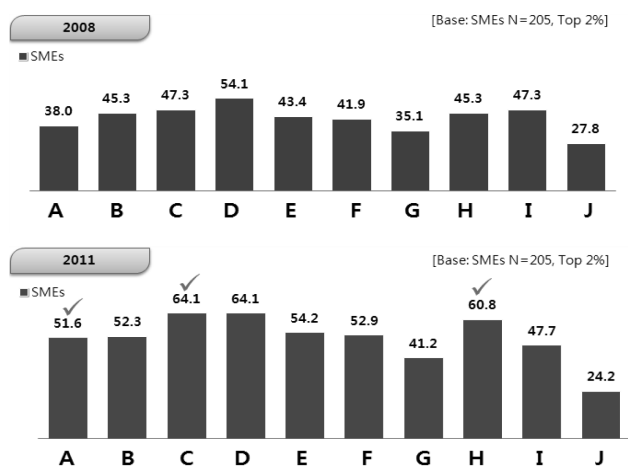


Fig. 6 SMEs' assessment of the graduates' engineering performance abilities: A = solving new problems; B = engineering ability; C = capability of computing & reporting; D = problem solving by using computer; E = technical abilities satisfying SMEs' needs; F = skillfulness for using tools & equipments in the field; G = application ability of basic engineering theories; H = team task performance; I = oral presentation skill; J = foreign language skill.

capability of computing and reporting, and team task performances are evaluated to be improved highly. Many different experiences from SEG's multidisciplinary capstone design and small lab experimental projects make students to improve their abilities by themselves.

According to the two surveys & analysis, the strengths, weaknesses and future prospects are discussed on SEG based engineering education innovation. These mainly reveal SEG's important role in the innovation.

#### A. SEG's Strengths

SEG's strengths are grouped into three main aspects. First, the program has a very strong internal solidarity, because the group sizes are small, and they are managed by the university during the school period. Second, it improves the students' practical abilities. Through SEG, local SMEs' needs are directly addressed by professors and students. Students involved in SEG can conduct their study and program along with the needs, which makes this system very effective. Third, through GNTECH-ICEE, administrative support and financial aids are offered effectively to all parties involved in the program. In this regard, SEG is helpful to students, professors and SMEs.

#### B. SEG's Weaknesses

Two main issues can be raised in terms of SEG's weaknesses. First, as students tend to concentrate on practical experiences in the field rather than familiarizing themselves with basic engineering theories with priority, they can be unfamiliar with engineering theories. Second, since local SMEs will participate in SEG only when they profit from the program, GNTECH-ICEE cannot be so sure about their continuous participation.

#### C. SEG's Prospects

For SEG's continuous development, professors, students and local SMEs should devote themselves to the program at all times, and GNTECH-ICEE should also focus on familiarizing students with basic theories in MSC as well as teaching them practical skills. The program's continuous development should be considered in terms of university systems and local SMEs. When the mentioned above are satisfied, SEG will keep being successful.

### IV. Conclusions

As highlighted in the introduction, globalization and technological advancement in today's environment continue to influence consumers' quest for new products and services. Innovative engineers are able to develop products and services to meet this demand. Thus, companies need more of such qualified and capable professionals in order to satisfy society's emerging needs. GNTECH-ICEE has introduced a new and unique method of training such engineers through SEG program, which this study set forth to investigate and evaluate. The most essential part of the program is the SEG that links professors, students and local SMEs together, to study and apply what local SMEs need in their products and processes. SEG provides the right direction for engineering education innovation, and generates industry-university link-based human resource.

GNTECH-ICEE has effectively trained students as multi-player engineer with creativity, specialty, practicability, and sustainability by operating a variety of programs for meeting industry needs and enhancing engineering education. These following prove it was successful. GNTECH's

employment is 67.4% according to 2011 data and the best among the universities in Gyeongnam province. Also, the students supplement is 101.5%, which means that the number of student enrollment was more than the number of total student quota.

SEG has many merits including, strong bondage in groups, practical ability incubation, and efficient administrative support. However, it also has some hidden demerits such as lack of theoretical engineering education and un-sustainable partnership with local SMEs. Based on the identified weaknesses, new initiatives and strategies will be helpful to maximize the goal of training students as multi-players engineer. We also suggest that effective financial and administrative strategies be put in place in order to guarantee local SMEs' long-term devotion to the program, and to promote the network continuously.

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