세계경제연구원
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2012년 6월 22일

과학기술연구대학의 발전과 교육, 경제성장

서남표
KAIST 총장

사공일 이사장님,

초대하여 주셔서 감사합니다.

연구대학교의 의무와 책임

1. 사회에서 받는 특혜
2. 인류의 역사적 의무

3. 후손의 교육
4. 지식 창출
5. 인류가 당면한 문제 해결
6. 기술창출
7. 경제발전
8. 평화, 안전, 국방

문제와 목적

1. 문제를 아는것이 제일 어려운 과제
2. 문제를 알아야 목적을 수립할 수 있음.
3. 목적이 분명해야 방법을 강구할 수있음.

학교의 목적을 먼저 명시 해야 함

1. 부산에 가실 겁니까?

2. 보스톤에 가시겠습니까?

목적을 정하면 방법은 많음

- 방법은 다양할 수 있지만
  목적이 확실하면
  많은 방법으로 목적지에 도착할 수 있음.

- 제일 좋은 방법을 잘 선택해야 함.
  (robust design)

많은 목적을 동시에 만족시켜야 하면 어떻게 하나요?

- Water faucet(수도꼭지) problem
- 물의 온도 control(조절) 과
  물의 양 control(조절)

수도 꼭지

Water Faucet Design

경제도 연구대학교도 System 입니다

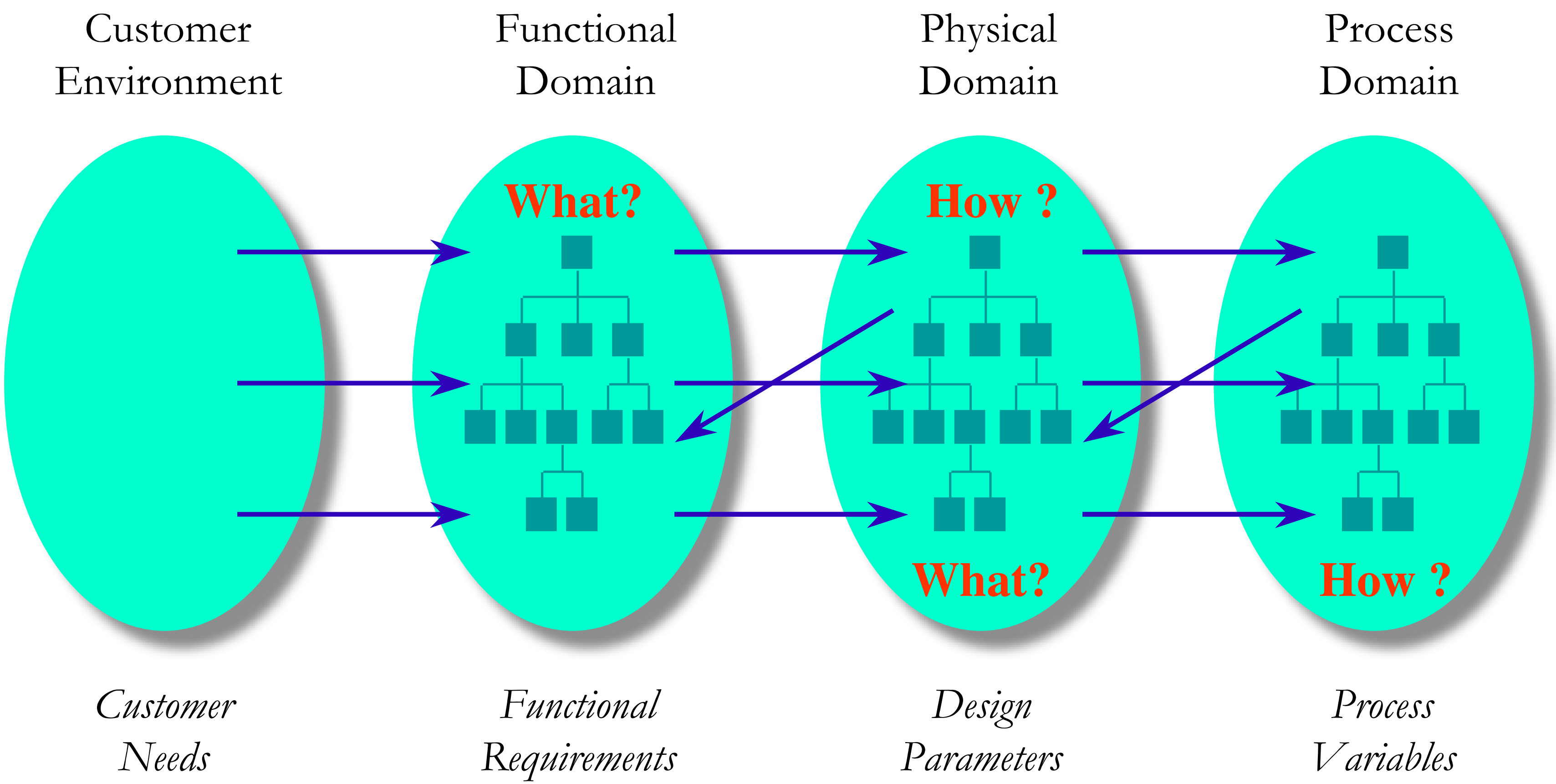
- Many outputs / many inputs
- Constraints
- How can we select the inputs to satisfy the system requirements and constraints?

많은 목적을 동시에 만족시켜야 하면 어떻게 하나요?

- Axiomatic design

- Independence Axiom
- Information Axiom

Axiomatic design:
Mapping, hierarchies, and zigzagging



Design of KAIST policies

- Survey -- department heads
- Established the highest goal
- Established the second level goals
- Chose methods and directions

The Goal of KAIST

- To become one of the best research-oriented universities in the world
- How?
- By solving most important problems the humanity is facing in the 21st century

Specific Changes made since 2006

1. Governance

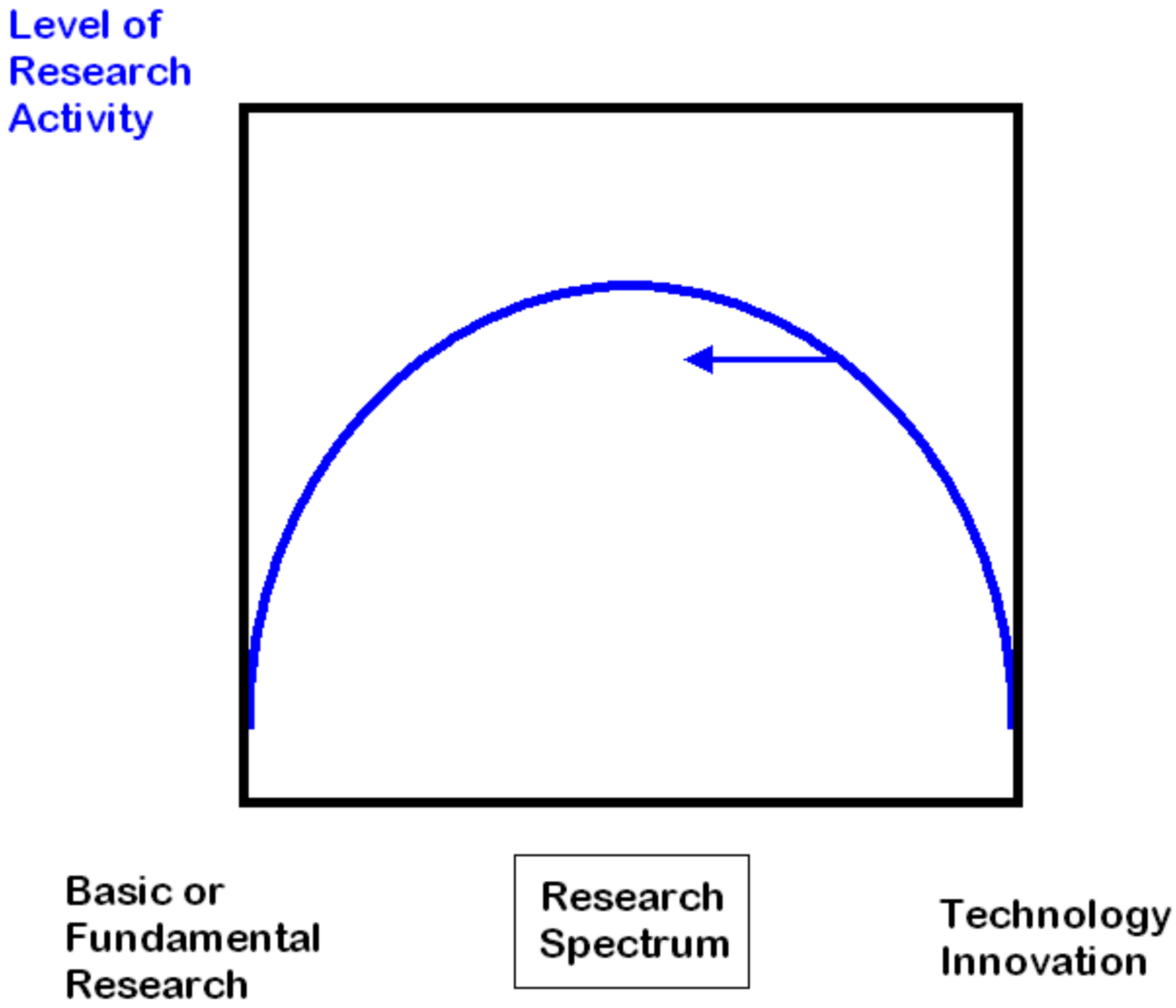
- Department centric ~ All decisions related to personnel, finance, space, promotion, and tenure made by the department head
- Asymmetric decision making
- Merit-based system
- Tenure & promotion policy
- Importance of the role of staff
- Unlimited hiring based on quality of the prospective faculty
- Increased the size of the faculty by 50% in five years from 400 to 600 (about 150 without government support)

Specific Changes

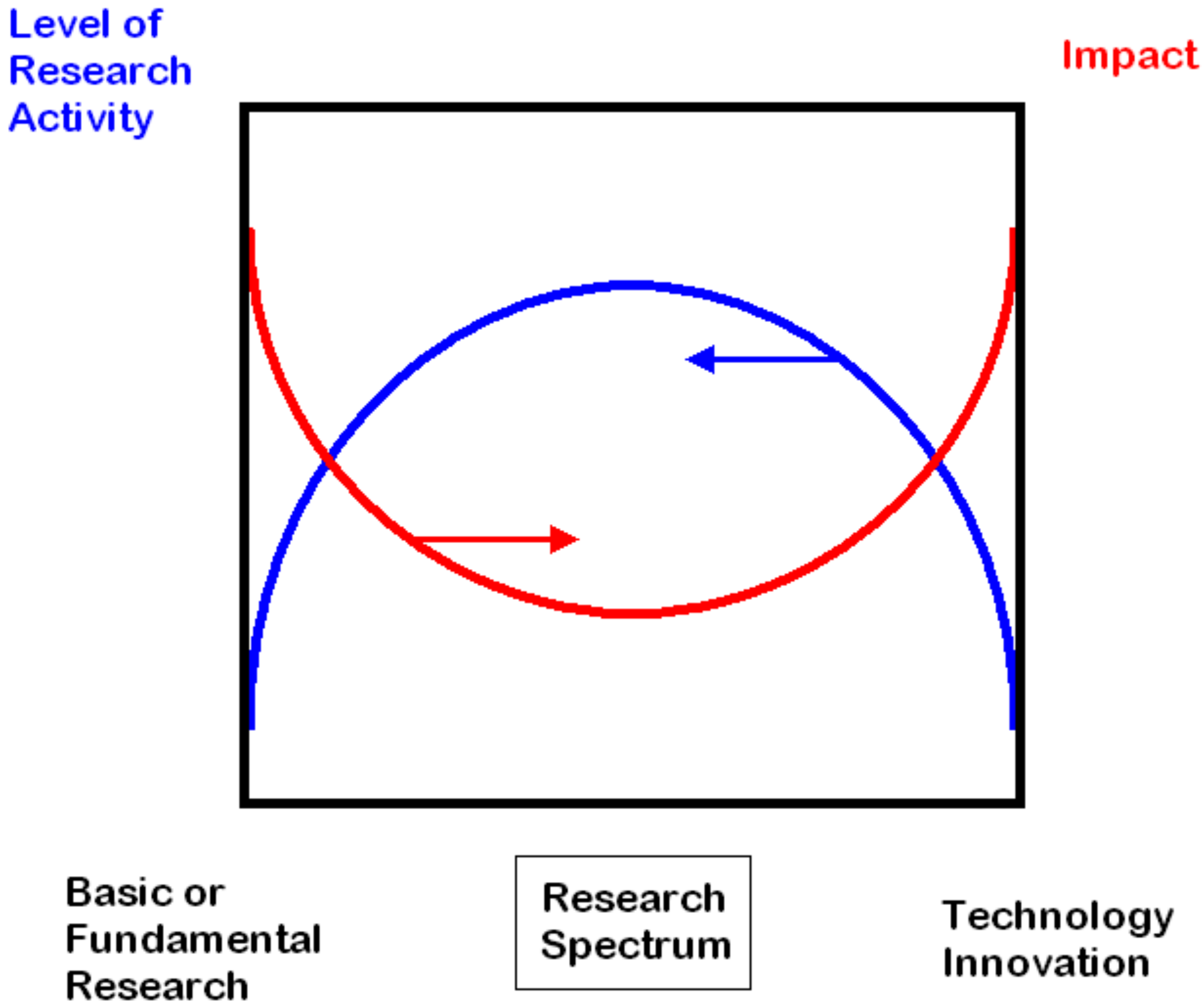
2. Research

- Selection of important problems -- EEWS, HED, HRHR
- Interdisciplinary research -- KI
- Major technology innovation: OLEV, MH
- Support of young professors: start-up funds
- Globalization -- many collaborative research with universities in Europe, U.S., Middle East, Asia, Australia
- Two-ends of the research spectrum, i.e., basic research and technology innovation

Research Spectrum vs Impact



Research Spectrum vs Impact



The Second-Level Specific Changes

3. Education

- New admissions process
- Instruction in English
- Student-centric I-4 education (International, ICT based, independent, integrated)
- Tuition policy
- FDC

4. Infrastructure

- 7 New buildings
- 3 more major buildings
- 3 more smaller buildings

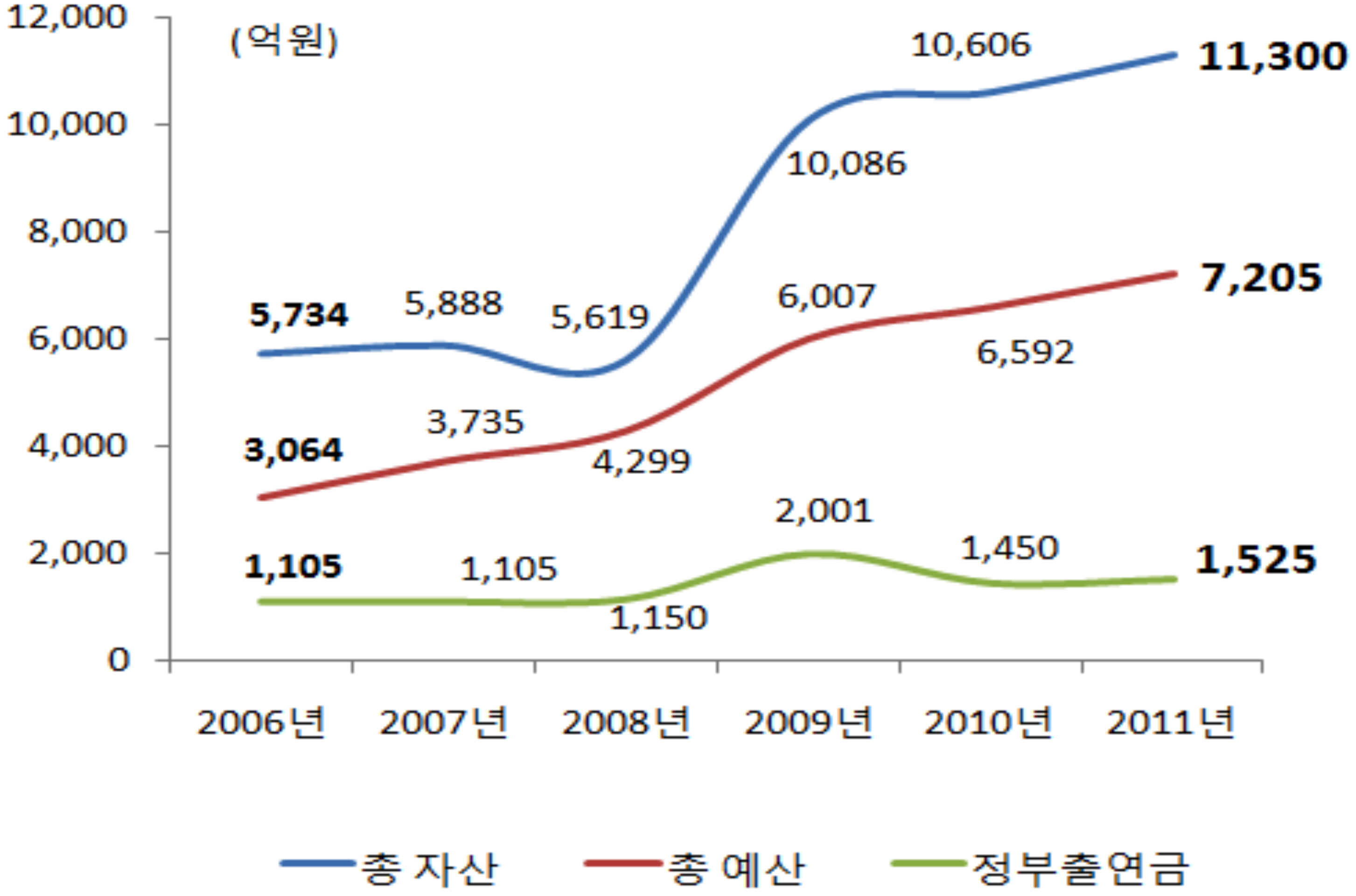
The Second-Level Specific Changes

5. Finance

- Stronger than ever
- Asset over 1 trillion
- Budget increased more than 2 times

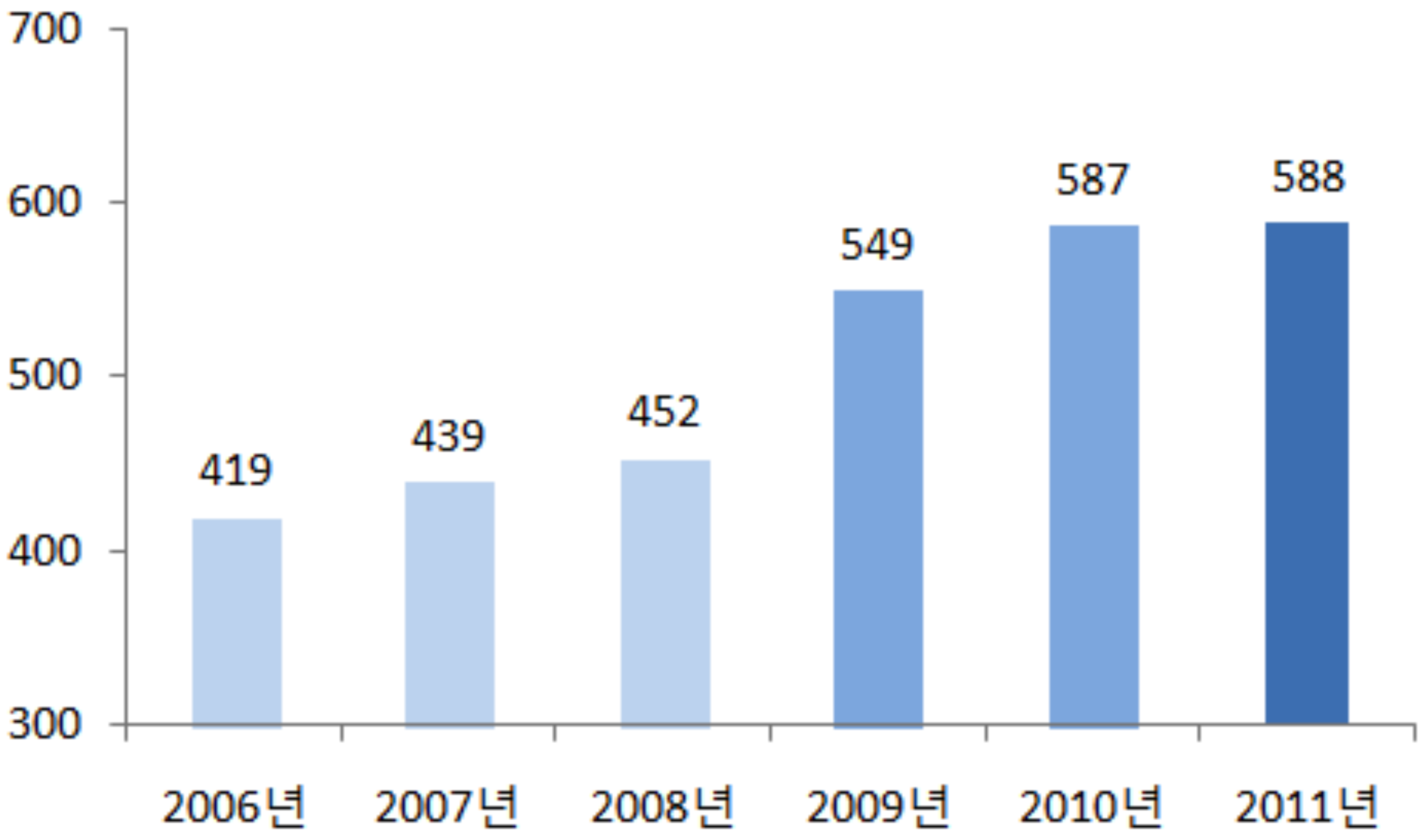
Changes at KAIST (2006~2011)

재정현황 변화



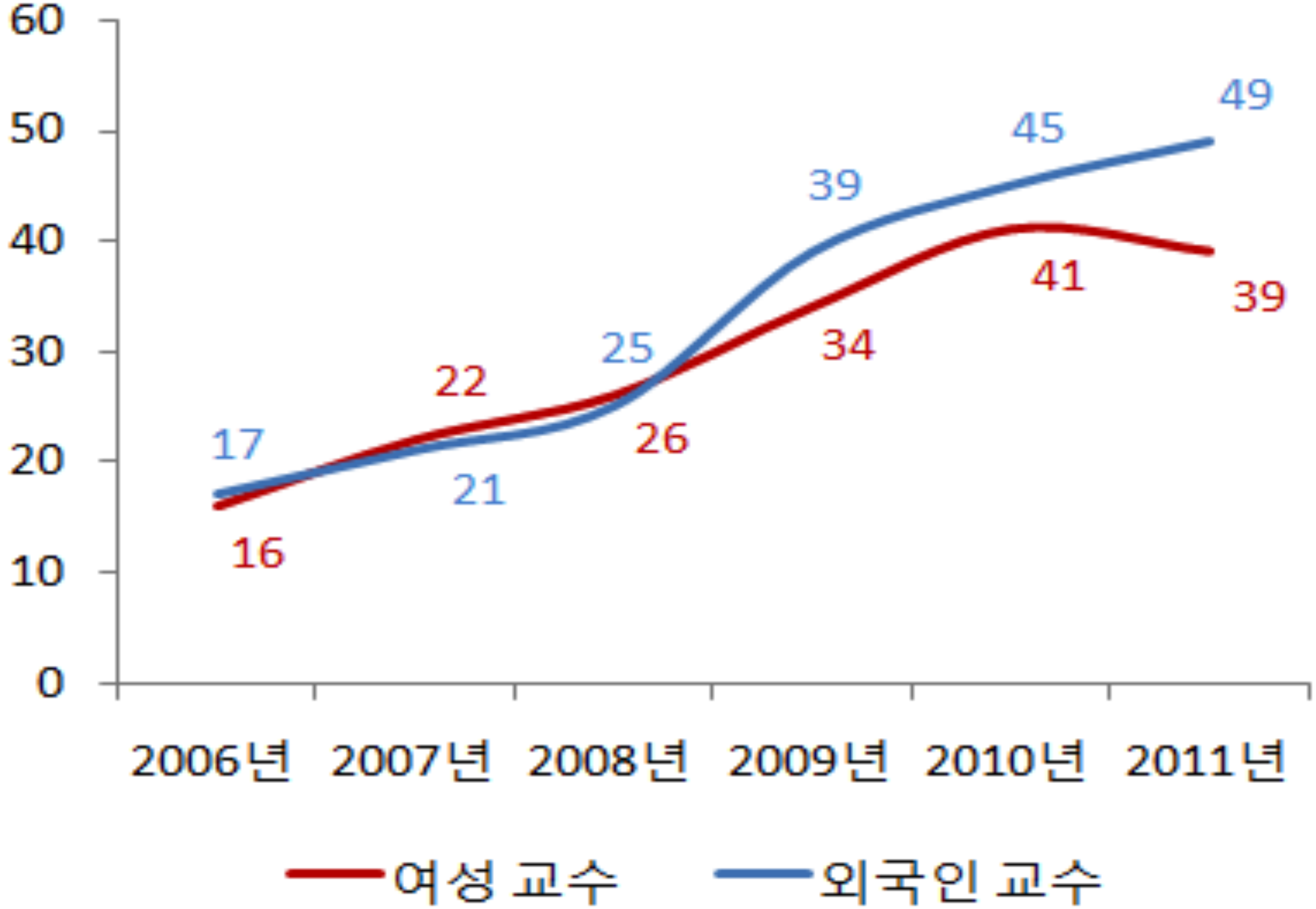
Changes at KAIST (2006~2011)

연도별 교수 수 변화



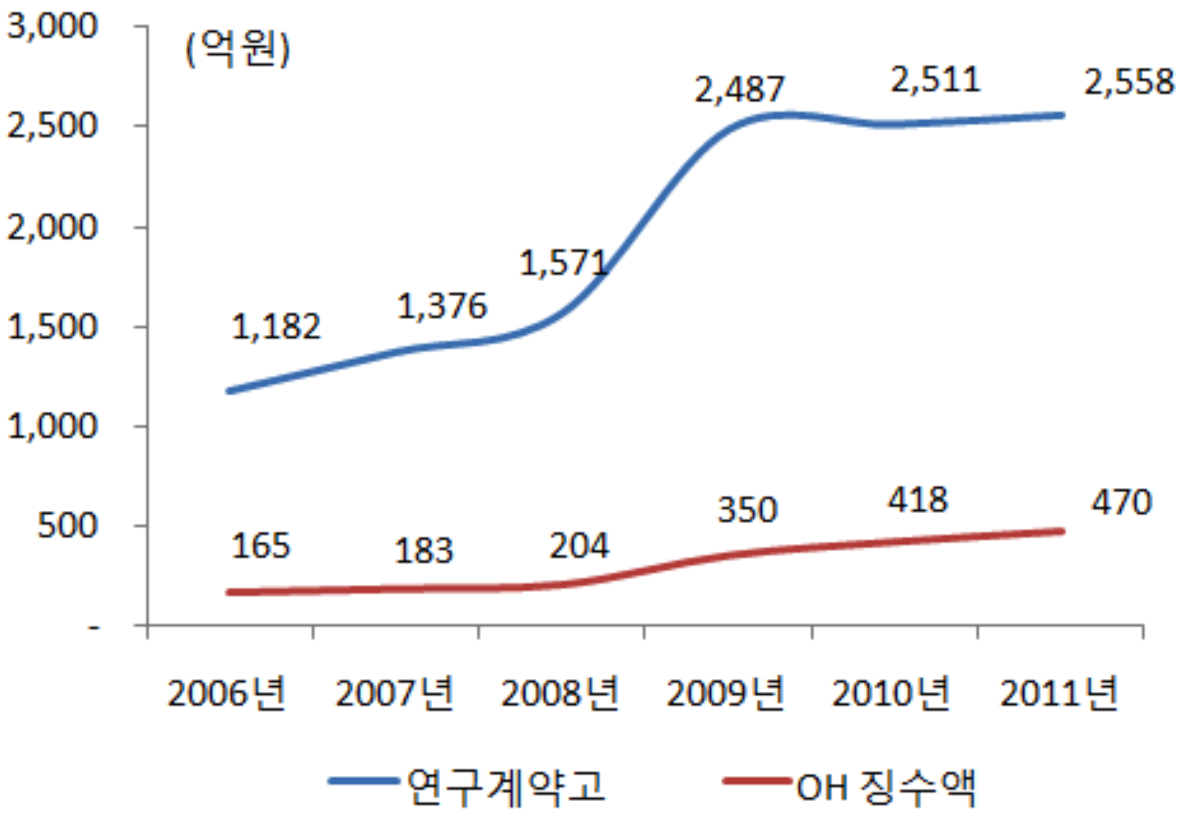
Changes at KAIST (2006~2011)

여성 및 외국인 교수 수 변화



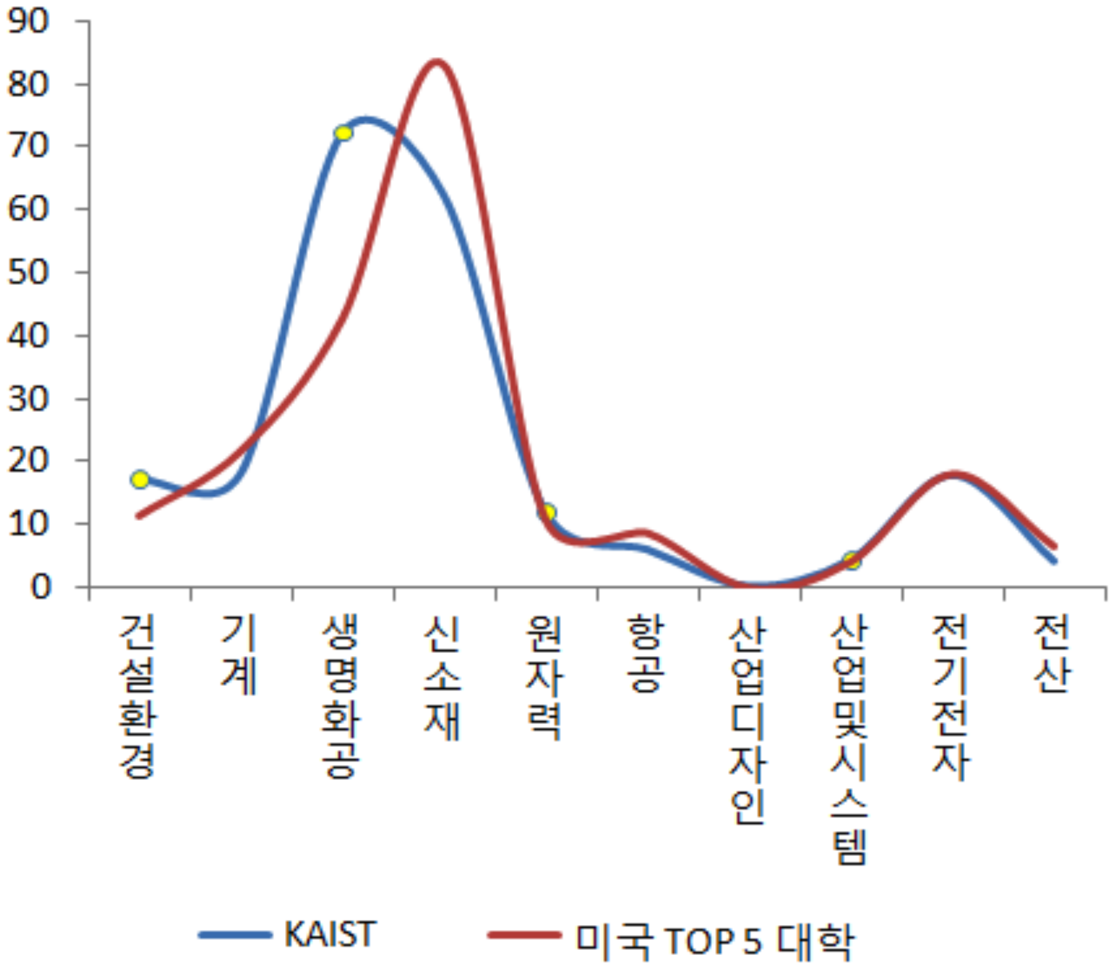
Changes at KAIST (2006~2011)

연구비 및 O/H 증가 추이



Changes at KAIST (2006~2011)

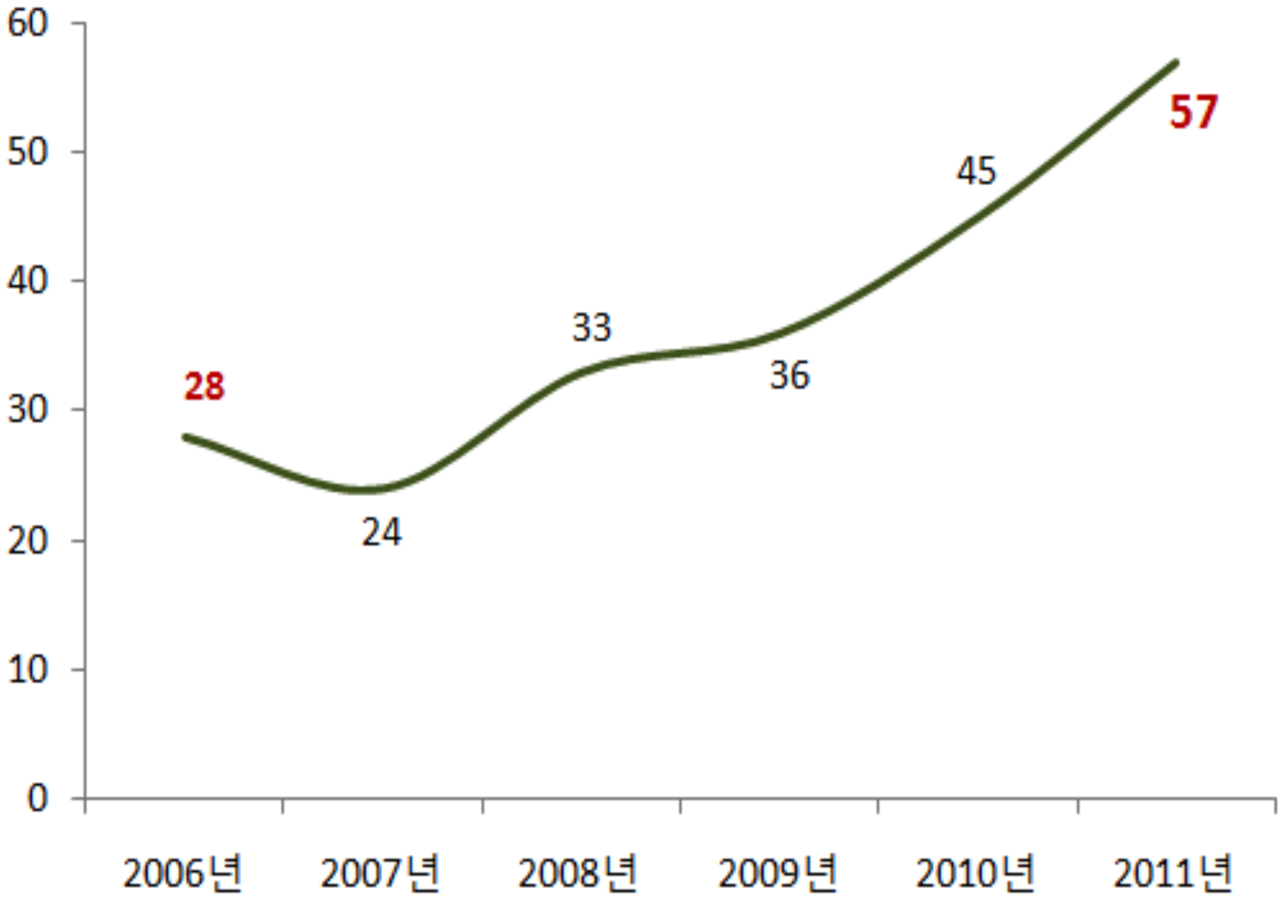
공학·IT분야와 미국 TOP 5대학 JIF 비교



JIF : Journal Impact Factor

Changes at KAIST (2006~2011)

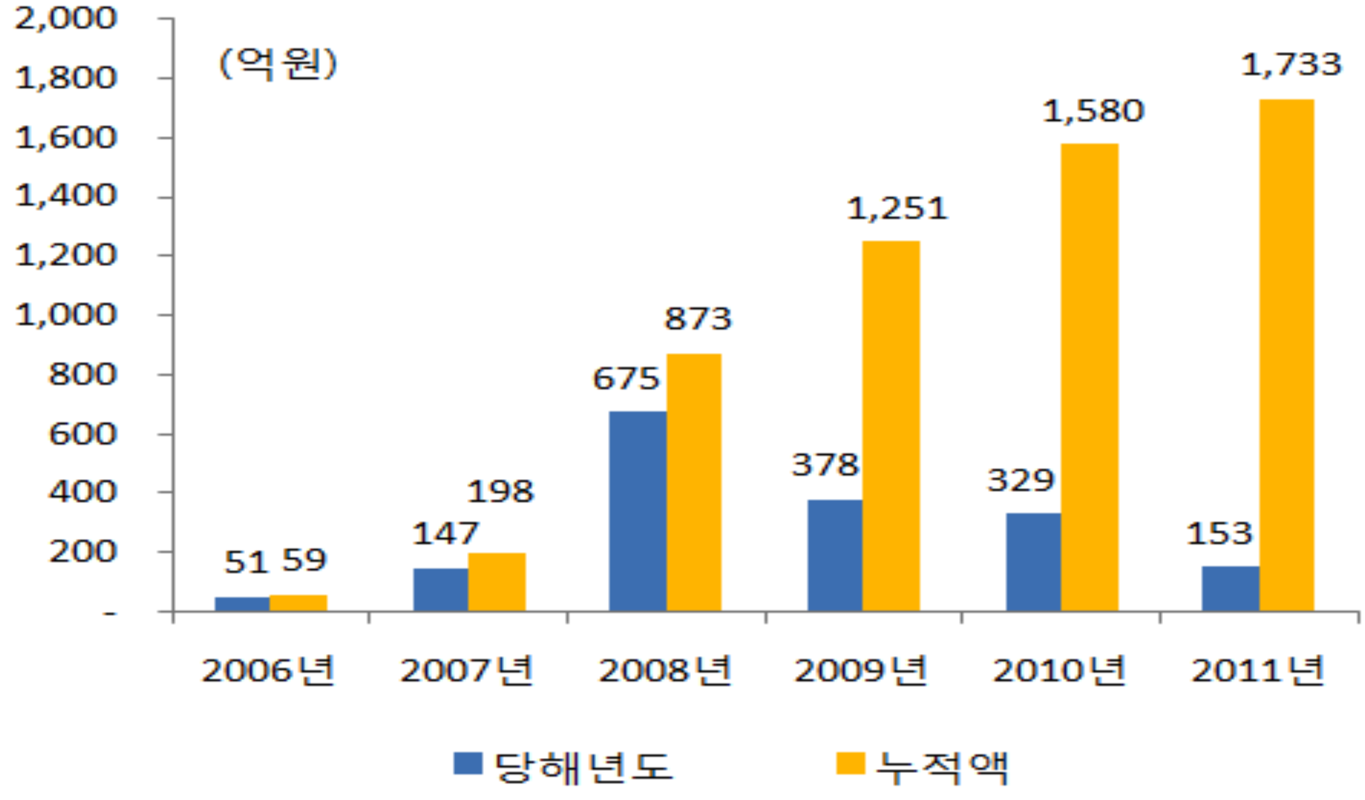
자연과학분야 NSC 논문 수 변화



NSC : Nature, Science, Cell

Changes at KAIST (2006~2011)

기부금 유치현황



Changes at KAIST (2006~2011)

분야별 신축건물

KAIST Institute		Sports Complex		International Center	
 21,124,220㎡	**연구** 2010.02	 14,678,400㎡	**체육** 2010.02	 2,133,260㎡	**국제** 2010.02
KAIST Clinic		**외국인교수 및 석학초빙 숙소**		**학생기숙사(미르/나래)**	
 4,234,000㎡	**의료** 2010.07	 16,566,670㎡	**교수** 2011.01	 12,359,940㎡	**학생** 2011.01

KAIST's 2006 Issues: EEWS

- Energy
- Environment
- Water
- Sustainability

KAIST's 2011 Issues: HED

- Healthcare System
  - Labor intensive
  - High cost labor
  - Systems design solution
  - Scientific advances
- Education
  - Labor intensive
  - High cost labor
  - Systems design solution
  - Scientific advances
- Defense

In the 21st Century university education will change.

- Current lecture format is not efficient.
- Emphasis must be on learning, not teaching.
- More generalized principles should and will be developed to make teaching and learning more efficient, e.g., medical profession.
- Modern ICT-based instruction will replace many professors who only teach -- professors will be needed to do creative thinking and work.
- Teaching, not education, will become more like a business.
- “Teaching simulators”?

The I-4 Educational Program

I*nternational*

IT*-based*

I*ndependent*

I*ntegrated*

Healthcare

Systems Problems

- Delivery
- Diagnosis
- Testing
- Medical care
- Emergency room
- Health insurance
- Infrastructure
- Teaching
- Research
- Training
- Etc.

Healthcare

Scientific and Technological Solutions Through:

- Design of better healthcare systems
- Homecare for chronic diseases
- Basic research (e.g., regeneration of organs, cancer)
- Chip augmentation for Alzheimer's patients
- Preventive medicine
- Nano Science and Technology for medicine
- Novel approach to fabricate porous sponges of poly (d,l-lactic-co-glycolic acid) without the use of organic solvents (Biomaterials, 1996)
- Etc.

Example: Technology Innovation

- EEWS: energy, environment, water, sustainability
- How do we reduce CO_2 level by 50% by 2050?
- On-Line Electric Vehicle (OLEV)

FRs of the On-Line Electric Vehicle (OLEV)

- FR1 = Propel the vehicle with electric power
- FR2 = Transfer electricity from underground electric cable to the vehicle
- FR3 = Steer the vehicle
- FR4 = Brake the vehicle
- FR5 = Reverse the direction of motion
- FR6 = Change the vehicle speed
- FR7 = Provide the electric power when there is no external electric power supply
- FR8 = Supply electric power to the underground cable

Constraints (Cs)

- C1 = Safety regulations governing electric systems
- C2 = Price of OLEV (should be competitive with cars with IC engines)
- C3 = No emission of greenhouse gases
- C4 = Long-term durability and reliability of the system
- C5 = Vehicle regulations for space clearance between the road and the bottom of the vehicle

DPs of OLEV

- DP1 = Electric motor
- DP2 = Wireless power transfer system
- DP3 = Conventional steering system
- DP4 = Conventional braking system
- DP5 = Electric polarity
- DP6 = Motor drive
- DP7 = Re-chargeable battery
- DP8 = Electric power supply system

Design Matrix

{FRs} = [DM] {DPs}

[DM] must be either

Diagonal -- > Uncoupled Design

Or

Triangular --> Decoupled Design

Decomposition of FR2 and DP2

FR2 = Transfer electricity from underground electric cable to the vehicle

DP2 = Power transfer system

Decomposition of FR2

FR21 = Generate an alternating magnetic field

FR22 = Control the power level of the magnetic field

FR23 = Shape the magnetic field to control
the height of the field, H

FR24 = Control the radiation (EMF)

FR25 = On/Off the magnetic field

FR26 = Maximize the pick-up of the power in the alternating
magnetic field created under the ground for use
in the vehicle

Decomposition of DP2

DP21 = Underground power lines with AC field surrounding the magnetic core (ferrite)

DP22 = Electric power level, i.e., current (I) times voltage (V), at a given frequency

DP23 = Width of the magnetic poles established by the magnetic core in the ground

DP24 = Active or passive shields for EMF

DP25 = Switches that turn on/off the underground power

DP26 = Pick-up unit mounted on the car that resonates the frequency of the alternating magnetic field

Design Matrix

{FRs} = [DM] {DPs}

[DM] must be either

Diagonal -- > Uncoupled Design

or

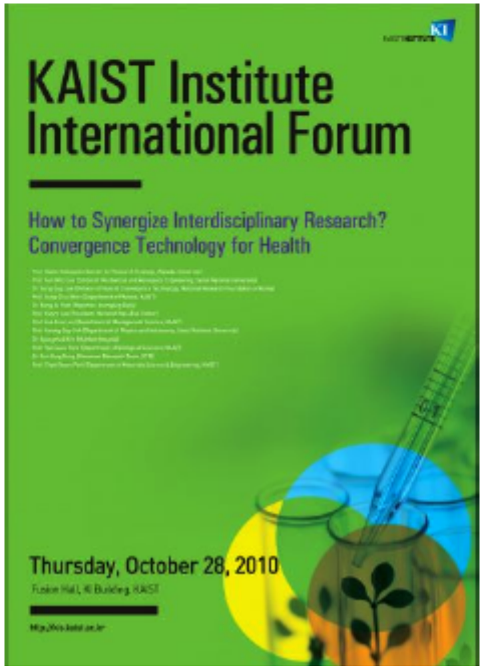
Triangular --> Decoupled Design

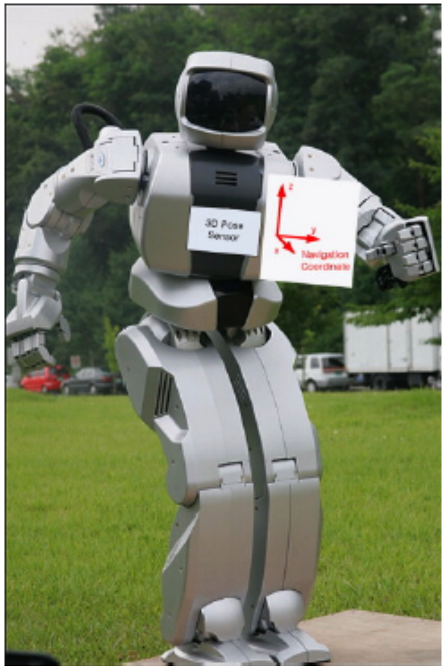
온라인전기차의 디자인

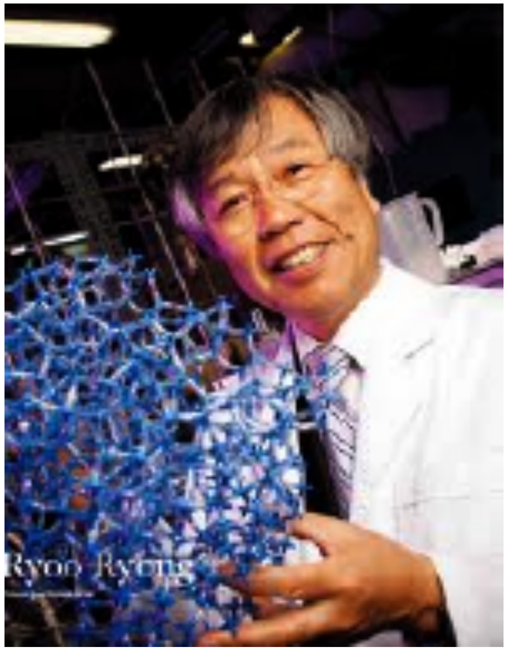
2 년만에 design에서 상용화

PREPARING KAIST FOR THE 21ST CENTURY

- KAIST has become much stronger financially even though it is a tuition-free institution.
- While the faculty size increased by 50 percent from 2006 to 2012, the budget and research volume increased by a factor of 2.4.
- KAIST's assets doubled and it received significant gifts.





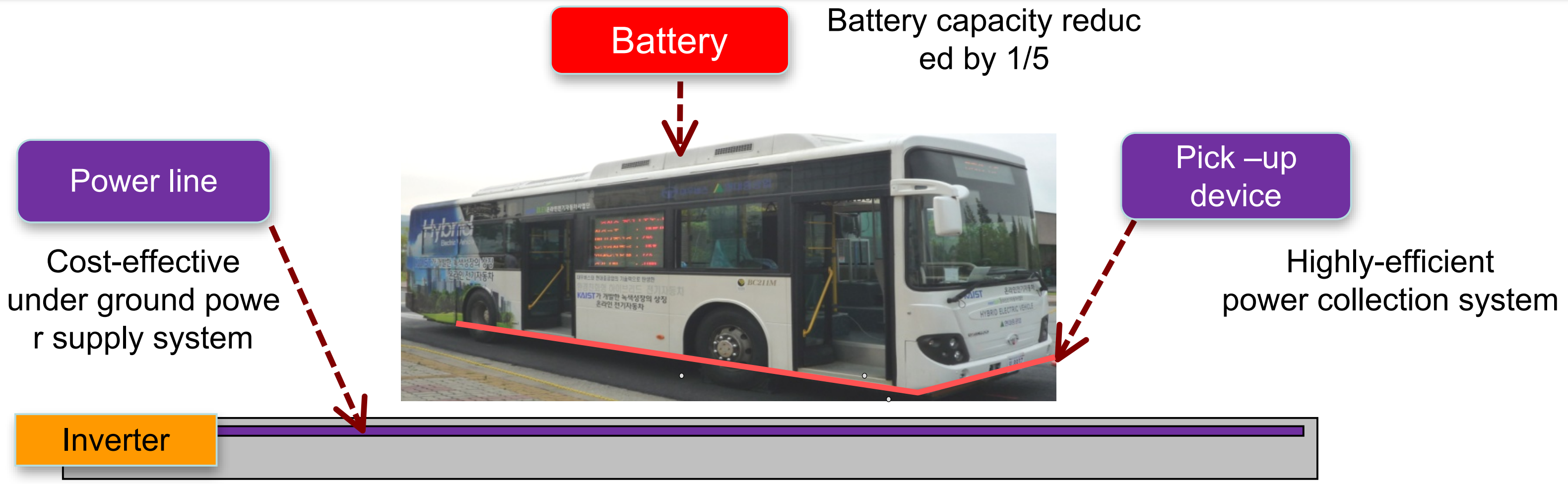


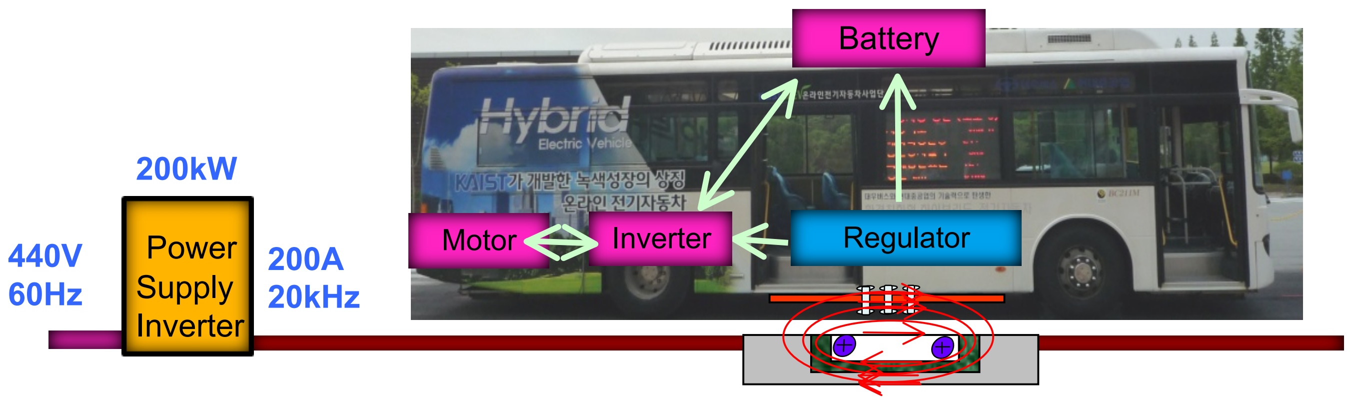
온라인전기차(OLEV)

◈ 급전 인프라 구축구간 : 전체 버스 운행 노선의 약 20% 정도

◈ 시점, 종점, 정류장, 교차로 부근 및 주차장 등에 급전 인프라 설치

Example of Technology Innovation: OLEV



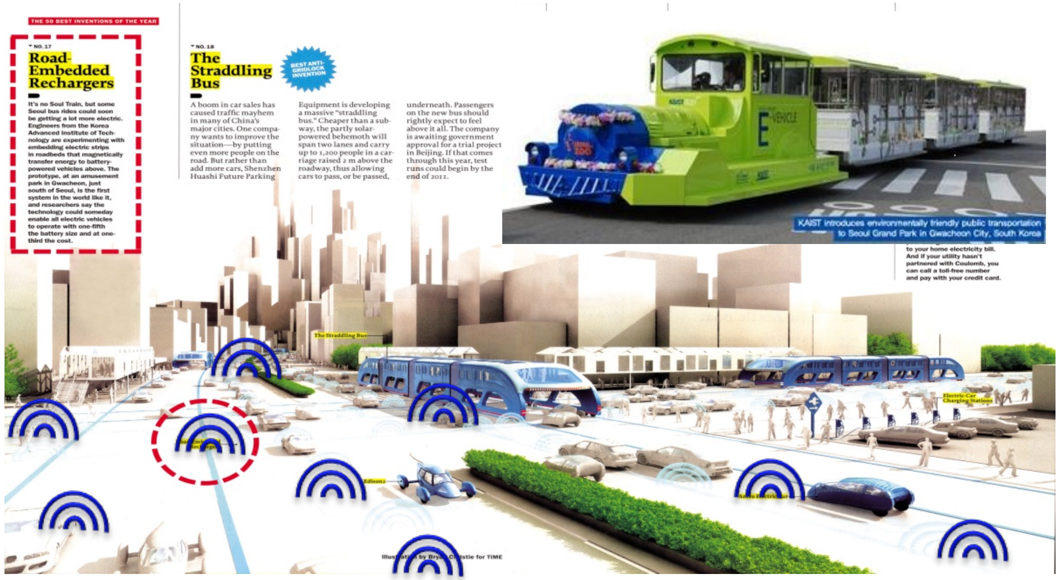


※ KAIST is demonstrating the core technology by using both power supply system under ground and power collection system attached to bus.

Examples of Large Complex Systems Research

- OLEV (On-Line Electric Vehicle)

The 50 Best Inventions of 2010: OLEV



THE 50 BEST INVENTIONS OF THE YEAR

NO. 17

Road-Embedded Rechargers

It's no Soul Train, but some Seoul bus rides could soon be getting a lot more electric. Engineers from the Korea Advanced Institute of Technology are experimenting with embedding electric strips in roadbeds that magnetically transfer energy to battery-powered vehicles above. The prototype, at an amusement park in Gwacheon, just south of Seoul, is the first system in the world like it, and researchers say the technology could someday enable all electric vehicles to operate with one-fifth the battery size and at one-third the cost.

NO. 18

The Straddling Bus

BEST ANTI-GRIDLOCK INVENTION

A boom in car sales has caused traffic mayhem in many of China's major cities. One company wants to improve the situation—by putting even more people on the road. But rather than add more cars, Shenzhen Huashi Future Parking Equipment is developing a massive "straddling bus." Cheaper than a subway, the partly solar-powered behemoth will span two lanes and carry up to 1,200 people in a carriage raised 2 m above the roadway, thus allowing cars to pass, or be passed, underneath. Passengers on the new bus should rightly expect to feel above it all. The company is awaiting government approval for a trial project in Beijing. If that comes through this year, test runs could begin by the end of 2011.

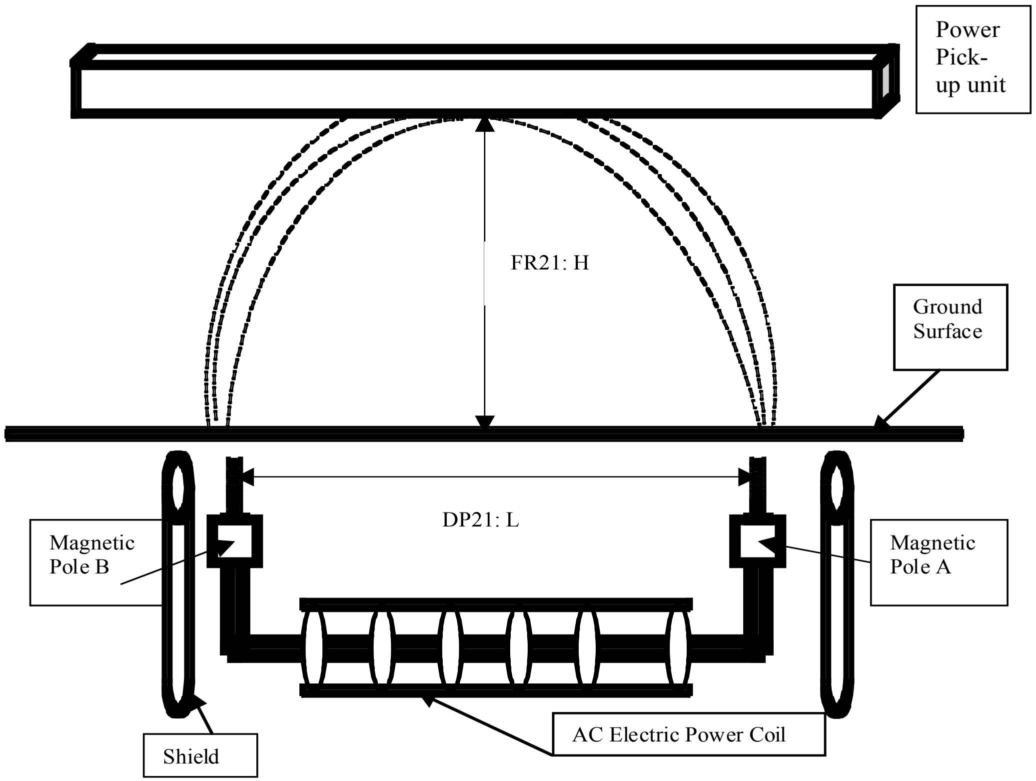
KAIST introduces environmentally friendly public transportation to Seoul Grand Park in Gwacheon City, South Korea

to your home electricity bill. And if your utility hasn't partnered with Coulomb, you can call a toll-free number and pay with your credit card.

Time Magazine selected KAIST OLEV system as one of the 50 best inventions of the year. (November 22, 2010 Time Specials)

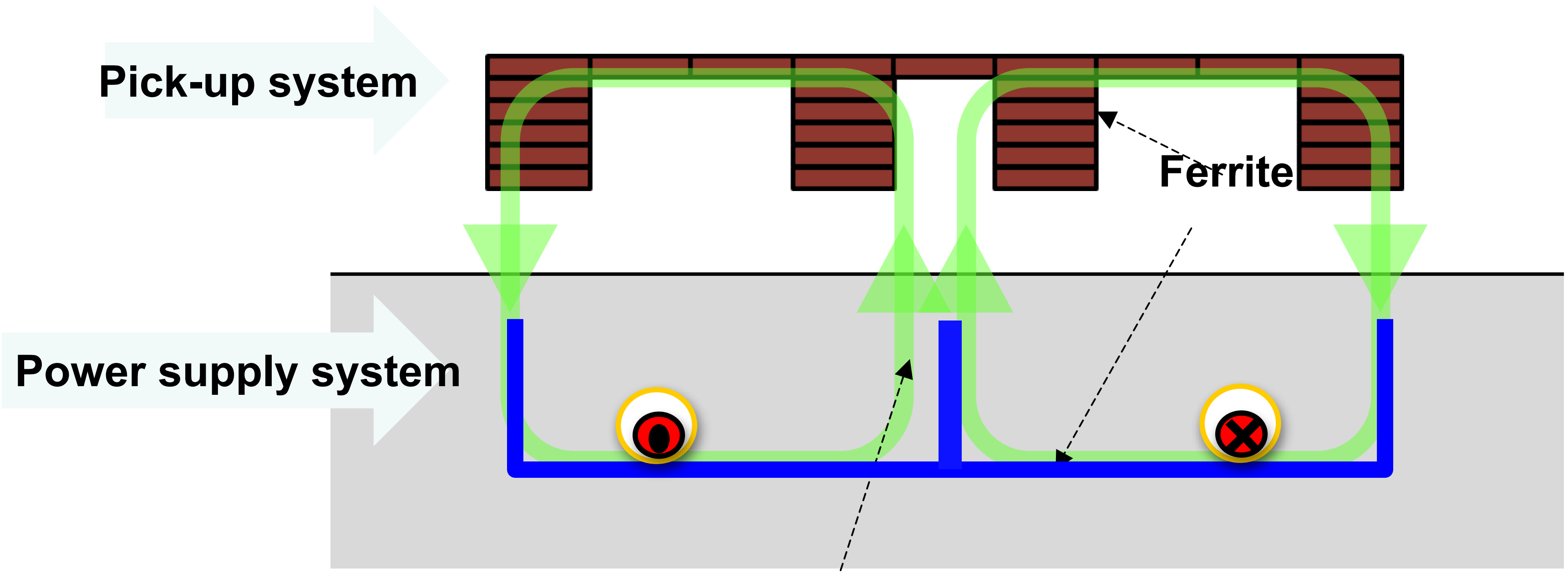
SMFIR

- OLEV (On-Line Electric Vehicle)
- SMFIR (Shaped Magnetic Field in Resonance)



Core Technology: SMFIR

At KAIST, we invented SMFIR, which enables the transmission of a large amount of power (~ 100Kw) over a large distance (>20 cm).



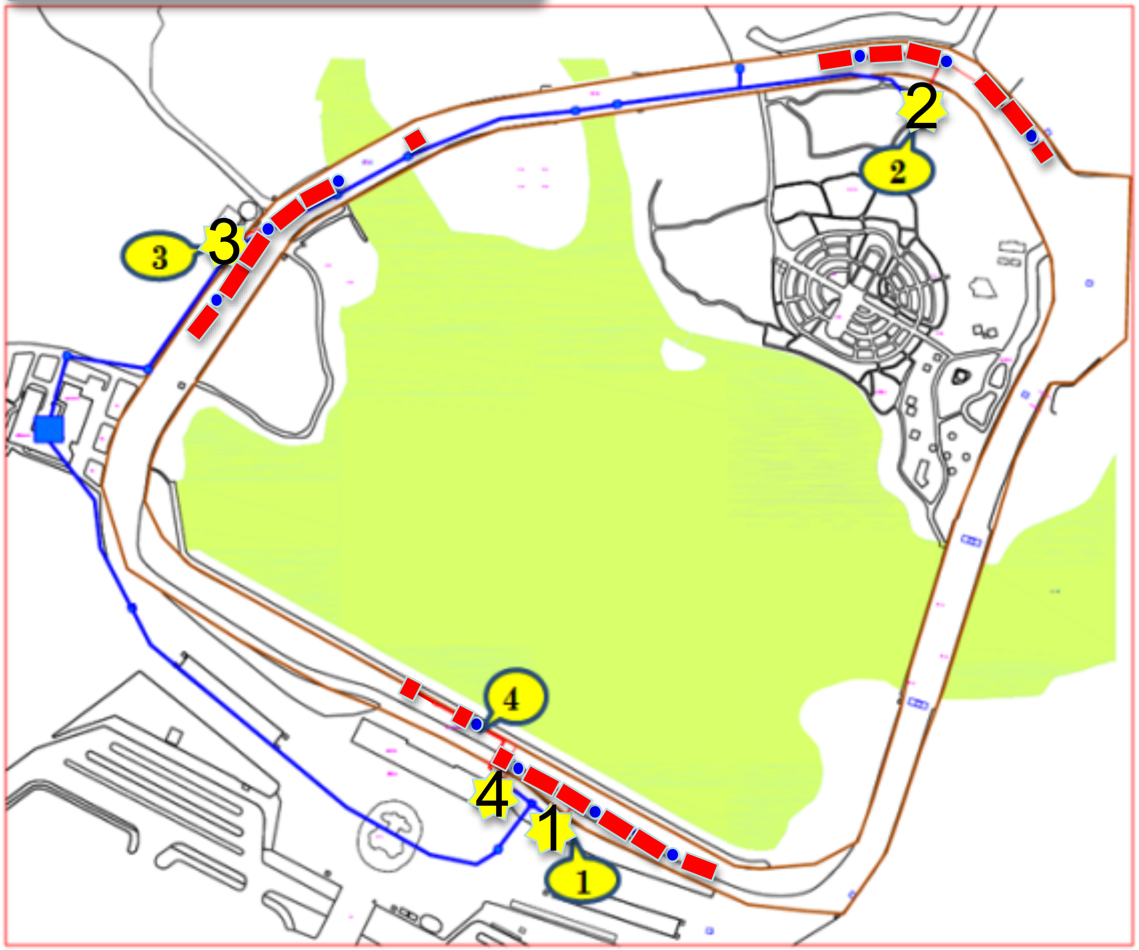
Shaped Magnetic Field in Resonance

서울대공원 OLEV 시스템 개요

급전구간 : 372.5m

구 간	길 이
1구간	122.5m [24mx5+2.5m]
2구간	122.5m [24mx5+2.5m]
3구간	122.5m [24mx5+2.5m]
4구간	5m [2.5m+2.5m]

급전·수전인프라



:인버터 위치 :맨홀의 위치 : 케이블 트랙길이 : 배전선 : 공동구내 배선

여수 2012 EXPO

Another Example of Complex Engineering Systems:

Mobile Harbor (MH)

Chosen as the second most promising innovations of 2011 by an Australian venture firm.

Rate Limiting Process in Ocean Transportation Systems

"Why should ships come into harbor?"

"Why couldn't a harbor go out to the ship?"

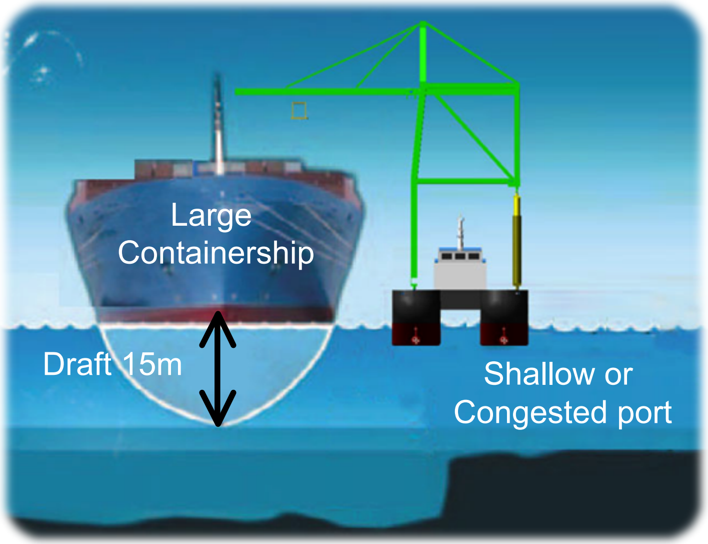
The Concept of a Mobile Harbor

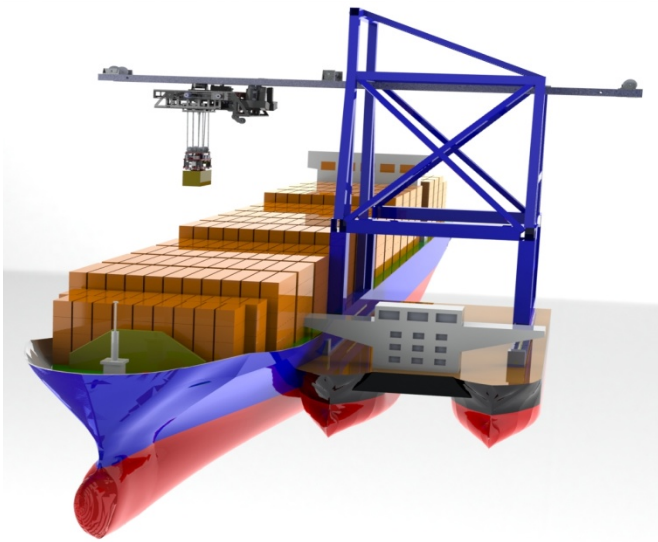
Creativity of KAIST - MH (July 31, 2008 file)

Mobile Harbor (MH)

- "Why should large container ships come into harbor?"
- "Why shouldn't harbor go out to the ship?"

- Execute high speed loading and unloading in the wavy open sea
- Deploy original, advanced technologies





Examples of Large Complex Systems

•Mobile Harbor (MH) : "Why should large container ships come into harbor?" "Why shouldn't harbor go out to the ship?"

Lessons Learned

•It took only two years to design and deploy OLEV and MH.

•Why does it take so long to develop new products?

(Boeing 787, Airbus 380)

•We use “systems”or “system of systems”. Yet we are not teaching the fundamental basis for designing systems. Still, many companies are creating systems by trial and error processes. Universities should do a better job in generating people who can create systems.

결 론

- **KAIST**의 **21**세기 과학, 기술의 무대는 세계로 정했습니다.
- 과학, 기술분야에서 연구하는 사람들이 지향하는 목적은 다양합니다.
  - 기본지식과 원칙을 알아내고 이해하며,
  - 인간사회가 해결해야 할 문제를 발굴하고,
  - 발굴된 문제들을 가장 효과적으로 해결할 수 있는 방법을 찾고,
  - 경제발전에 기여를 하고,
  - 인간사회를 위하여 공헌하고 ...
- 사회의 많은 문제들은 **Complex System**입니다.
  이 문제들은 단순히 주먹구구식의 노력으로는 해결하기 어렵습니다.
  깊은 지식을 탐구함으로써 그 해결책을 찾을 수 있습니다.
- 연구대학의 개혁이 필요합니다.
- 연구대학이 국제화가 되어야만 경쟁력을 갖습니다.

결 론

- What we have to do at universities is simple:
  - educate students well -- knowledge, vision, ethics
  - generate new knowledge and technologies
  - Uphold the highest ethics
  - serve the public.
- Yet, it is a major challenge to achieve these goals because most universities are tradition-bound and it is not easy to introduce changes.

결 론

- We must collectively accept the necessity for change and implement better ways of educating our students and conducting research.
- Education will improve if we transform educational emphasis from teaching to learning, customize education for each individual student.

결 론

What we do at universities will support the progress of human society in many ways:

- enhancing the economic activities of all nations,
- providing healthcare to everyone on the earth,
- dealing with environmental and energy issues,
- making water available to all living beings, and
- providing opportunities to acquire education.

감사합니다.