How to Learn Multidisciplinary Design: Biomedical Engineering in Cross Cultural Seminar

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ABSTRACT

The way to learn multidisciplinary design has been discussed. "Biomedical engineering" is exemplified for multidisciplinary field. "Biomedical Engineering" makes the multidisciplinary research area, which includes biology, medicine, engineering, and others. The cross-cultural student seminars on biomedical engineering have been exemplified as the case studies. In the group work, students are divided into the small cross cultural groups. Each group finds a problem, methods to solve the problem, and contribution to the society. Presentations are made referring information on the internet. They have learned how to communicate with students, who have variety of cultural backgrounds. The training awakes students to several points: thinking from a different point of view, and variation of communication tools. The process is effective to learn multidisciplinary design.

Keywords: Multidisciplinary Design, Biomedical Engineering, Learning, Students and Cross-cultural Seminar.

1. INTRODUCTION

Multidisciplinary design is effective for innovation of technology. Biomedical Engineering is one of the multidisciplinary fields, which have connection to a lot of disciplines: mechanics, electronics, materials, biology, medicine, pharmacy, economics, sociology, ethics, religion, etc. (Fig. 1).

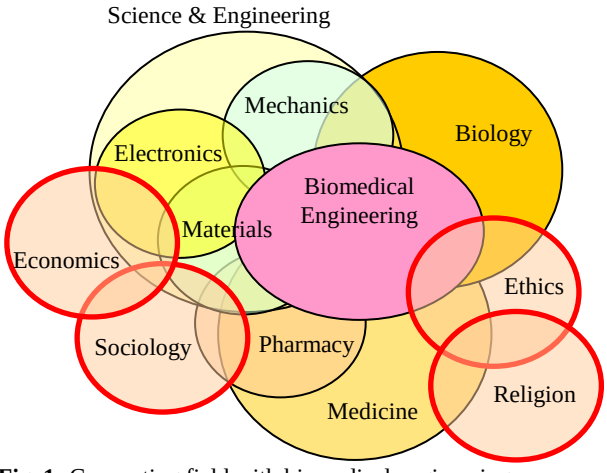

Fig. 1: Connecting field with biomedical engineering.

In biomedical engineering, a living body inspires bio-mimic systems. Engineered device, on the other hand, is designed for prosthesis of the living body (Fig. 2).

Let us think about "Surgical Robots" (Fig. 3). A robot can realize multi-movement (including multi-rotation) more than a human operator. A robot can continue movement for longer time than a human operator. "Big data" are available for the control of the robot. A robotic surgery can be controlled by artificial intelligence (AI). AI can learn new data without preconception. AI can process data with high speed. Do we need a human surgeon? Do you think about emotional aspect of patients?

Let us think about "Artificial Intelligence" for medical data. Can artificial intelligence make diagnosis and prescription with "Big Data"? Do we need a human physician? Do we need legal restrictions?

Let us think about "Gene Technology". Does gene technology contribute to the human health care? Is statistical analysis on relationships among data of patients useful? The huge memory of the computer combined with the high speed of data processing has realized the big data world.

Let us think about "Telemedicine". Information technology has changed health care world. Man can check his own medical data at his mobile terminal. Man can receive medical treatment at home. Do you think about control, security, or privacy?

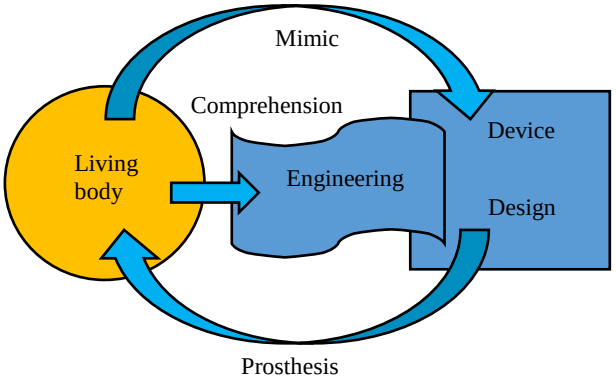

Fig. 2: Biomedical engineering bridges between living body and device.

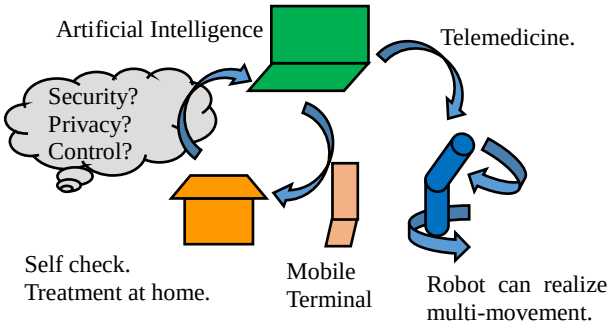

Fig. 3: Surgical robot, artificial intelligence, gene technology, and telemedicine.

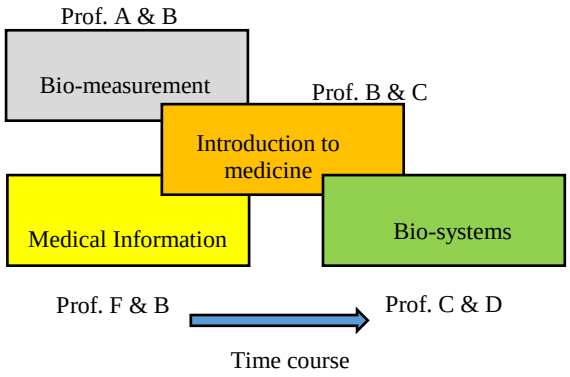

Fig. 4: Bridge curriculum.

The idea of cross cultural multi-disciplinary seminar for students is based on author's experience.

I experienced a technical internship abroad in the field of biomedical engineering in the artificial heart institute in Berlin, when I was a student. The research project of the artificial heart had been supported by collaboration between engineering and medicine. The cross cultural experience as well as interdisciplinary field of study stimulated my brain.

I found different disciplines, when I was reviewed in two kinds of PhD theses: one for medicine and the other for engineering. The research in the field of biology is based on individuality and time dependent, so that statistical processing is indispensable. The research in the field of engineering, on the other hand, is based on homogenization, so that the experimental condition should be controlled. Statistics is important discipline in medicine, although standardization is important in engineering. The referee of medicine requested number of experiment with keeping the protocol. The referee of engineering, on the other hand, requested the sophisticated condition of the experiment: temperature, homogenization, etc.

I also found different disciplines, when my affiliation changed: school of medicine, electronics, biomedical engineering and mechanical engineering. Each special field of study develops own discipline including the style of education. Each discipline has one's own technical terms. For example, "control" means "comparison" in medicine, although it means "regulation" in engineering.

Creating the first department of "Biomedical Engineering (including bachelor, master, and PhD courses)" in Japan was a big challenge. A lot of pioneers in the world (Case Western Reserve University, Northwestern, UIC, UC Berkley, Boston, MIT, and UNSW) helped me for the new discipline [1]. I created a new concept for the interdisciplinary department, which includes the "Bridge Curriculum" (Fig. 4) [2-7]. In the multidisciplinary department, the professor himself should be a multidisciplinarian with the multiple academic backgrounds. The charge system of each class by multi-professors keeps thinking from multi-views.

In the present study, the cross cultural multidisciplinary seminar for students has been exemplified, and the way how to learn multidisciplinary design has been discussed.

2. METHODS

Group Work

The annual cross-cultural student program of Biomedical Engineering between Kogakuin University and Chulalongkorn University in Thailand has been started in 2011 (Table 1) [8-11]. Students, who participate in the program, divided into several groups. Each group includes Thai students and Japanese students. The backgrounds of students have variations: pharmacology, nanotechnology, medicine, mechanical engineering, computer engineering, biology, material science, and biomedical engineering. Each group has to make a report, and to make a presentation at the final session. Two days are available to make the report and the presentation.

Your Proposal

Each student made a report for the training of multi-disciplinary design in the course of "Fundamental of Biomedical Engineering" (Fig. 5). The title is "Proposal on a new implantable device, which acts as a part of the human body".

Fig. 5: Lecture in Mahidol University in 2016 (top & left), in National Technical University of Athens in 2015 (right).

Fig. 6: Group work in Chulalongkorn University in 2015.

Each report should describe the specifications, including drawings and numerical description within one page of A4 paper. The description should include following items: problem to be solved, devised methods, background, expected results, contribution to the society, and reference.

Laboratory Visit

Several universities in the world have programs on biomedical engineering. The author has communicated with several coordinators of the programs. Some of them supported to create a new department of biomedical engineering in Japan in 2006 [1-10]. Some of them agree to collaborate with our group: Stanford, Harvard, Caltech, TU Vienna, Keel, and TU Athens. Some of them have welcomed our students for the laboratory visit since 2006 [8-10]. In 2015, eleven students of Biomedical Engineering Laboratory visited two universities in Thailand, and five students visited two universities in USA.

Presentation Training

The annual cross-cultural student program of Biomedical Engineering between Kogakuin University and Mahidol University in Thailand has been started in 2012.

Every student made a presentation on the topic of his own research plan in English. After each presentation, students discuss on the topic at the seminar and at the laboratory tour in Mahidol University in Salaya. Several students also joined in symposium in UIC.

Presentation in International Research Conference

Students of "Biomedical Engineering Laboratory" have attended the annual international multidisciplinary research conference, and made presentations [8-10]. They have made the oral presentations in the World Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI) since 2002.

3. RESULTS

Group Work

In the group work in 2015, the students were divided into five groups (Fig. 6). "Magnesium" was selected for the theme of the group work. Each group selected the following topic.

1) Measurement of magnesium.
2) Molecules of magnesium used for intravenous supplementation to avoid phosphate precipitation
3) Magnesium-based metallic material and magnesium ion detection method
4) Detection of magnesium level in alcohol drinker.
5) Magnesium and human body

Magnesium is a cofactor in action in Human body. They studied on symptoms of magnesium deficiency. They found that magnesium is applied to a transdermal patch. Magnesium is measured by the ion chromatography.

The impression of the students was as follows:

1) Though presentation was serious, the discussion was interesting. I got a lot of information from the member.
2) I do not forget the activity with you.
3) It was a very valuable experience.
4) I will join in the program again.
5) Group activity was very exciting.
6) This trip of Biomedical Engineering seminar in Thailand is third time for me. It gives us power. I worried about travel to Thailand before, but I am looking forward to coming to Thailand the next year now.
7) It was very meaningful experience for me. I am very thankful that we were able to collaborate with everyone. Biomedical Engineering gives technology between patients and medicine.
8) I learned a lot of things from extracurricular lessons.
9) It was a very good experience, which stimulates me to study English.
10) It was a lot of fun talking with the many students.
11) I depended on the web too much.
12) It is difficult to summarize the ideas.
13) I have found different background of thinking.

Table 1: Annual cross cultural seminar for students on biomedical engineering in Chulalongkorn University.

Year	Number of Students
2011	3
2012	6
2013	5
2014	10
2015	11

Your Proposal

Each students made a report on the following topic.

1) Wireless capsule endoscopy.
2) Micelles nano-carrier for cancer.
3) Retinal prosthesis.
4) Method of vascular graft implantation.
5) Stress measuring implant.
6) Coating on bone fixation implant.
7) Development of total artificial heart of centrifugal pump: based on magnetic and hydrodynamic techniques.
8) Glucose sensor implantable for continuous glucose monitoring.
9) Designed intra-spinal micro stimulation based on biphasic pulse stimulation.
10) Artificial blood vessel network.
11) Development of a skin-contact sensor for monitoring of glycogen depletion condition during the endurance exercises.
12) Development of the implanted device for reduce the appetite.
13) Tendon prosthesis from natural rubber.

14) Implantable lower esophageal sphincter contraction control system for gastroesophageal reflux disease prevention.
15) Artificial vision (tracing of visual line).
16) Micro robot for intra-body surgery.
17) Application of shell structure of abalone to bio-prosthesis.
18) Application of fluid diode to bio-fluid flow control.
19) Cavity of surface of heat exchanger of blood flow.
20) Texturing of the surface of artificial joint for lubrication using laser.
21) Biomimetic surface morphology of the wall of blood vessels for lubrication of flow.
22) Notch of stent to control vortex for occlusion of blood vessel cavity.
23) Damping of noise of medical instrument.
24) Modeling of spine for force analysis.
25) Rolling for bio-durability of metal for implant.

Although it was not easy for student to find originality, the report gave students opportunity to learn about multidisciplinary design (Fig. 7).

Laboratory Visit:
Students joined in the laboratory tour (Fig. 8), and gave comment as follows:

1) I thank you for discussion and introduction of your laboratory. I was surprised to your advanced technologies. I won't forget your passion as a researcher. Communication is not easy between people of different cultural background.
2) Laboratory tour shows important studies. Because I am an engineer, I am interested in every field.
3) I appreciate your support and great help at the university. Thank you for showing us the laboratory.
4) Visiting the various laboratories was very informative.
5) In the laboratory visiting, we could see very high level researches, which stimulate me to continue my research.
6) I learned a lot of things from laboratory tour: essential expression, and direct representation.
7) I want to study English and more about Biomedical Engineering.
8) Thank you for the comments on my research. Language is not only the tool for communication.
9) Laboratory tour gave me new idea.
10) I was able to participate in the experiment and discussion.
11) I have found similar project to mine.

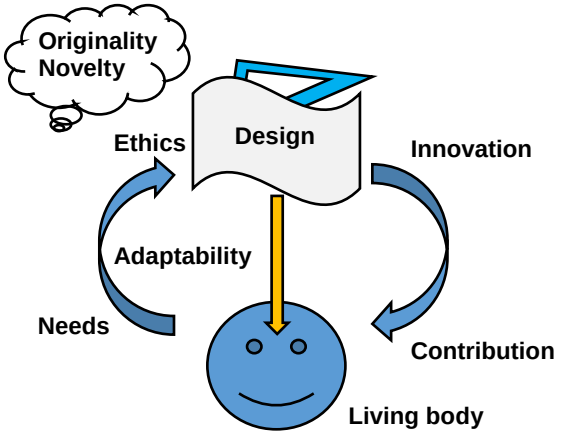

Fig. 7: Your proposal.

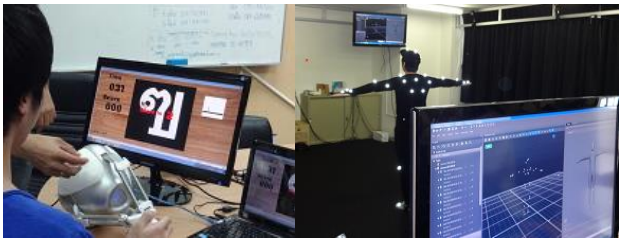

Fig. 8: Laboratory visit in Mahidol University in 2015.

Fig. 9: Presentation in Mahidol University in 2015.

Presentation Training 1
In 2015 (Fig. 9), the topics of presentation in Mahidol University in Thailand were as follows:

1) Micro Groove for Trapping of Flowing Cell.
2) Behavior of Cell on Vibrating Micro Ridges.
3) Deformation of Cell Passing through Micro Slit.
4) Micro Structure of the Solid Surface for Cell Sorting.
5) Measurement of Intercellular Force Using a Micropattern.
6) Effect of Micropattern on Cell Orientation.
7) Effect of Electric Current Stimulation on Cell on Titanium Thin Film.
8) Measurement of Contractile Force of Cultured Myotube.
9) Micro-Fabricated Device for Measurement of Cell Membrane Potential.
10) Behavior of Muscle Cells by Gravity Stimulus.
11) Development of Eareeg (hearing aid) and Its Application.
12) A Mathematical Model of Soft Tissue Using Wave Equation for Realistic Visualization in a New Laparoscopic Virtual Reality Training System.
13) Efficient Audio Visual Speech Recognition for Thai Therapeutic Robot.
14) DEP Microfluidic Chip for X and Y Chromosome Spermatozoa Separation.
15) Rationally Designed NIR Fluorescent Silver/PAA Nanoparticles for Biomedical Imaging.

The presentation also gave a Japanese student a good opportunity to express himself to the person of the first meeting. After the seminar, communication among students continues to the sightseeing in the traditional places. Some students keep in touch with the participants by e-mail.

Presentation Training 2
Six Japanese students joined in the joint seminar between

Kogakuin University and University of Illinois at Chicago (UIC) in UIC in 2015 (Table 2).

The titles of presentations in the seminar were as follows:

a) Micro groove for trapping of flowing cell.
b) Behavior of cell on vibrating micro ridges.
c) Deformation of cell passing through micro slit.
d) Effect of ultrasonic vibration on proliferation of myoblast.
e) Culture of myoblast on gold film sputtered on polydimethylsiloxane disk.
f) Rotating disk to apply wall shear stress on cell culture at microscopic observation.

Table 2: Annual cross cultural seminar for students on biomedical engineering in UIC.

Year	Number of student
2013	4
2014	5
2015	6
2016	5

After the seminar, students gave the following comments:

1) High level researches stimulate me to continue the research.
2) I learned essential expression, and effective presentation.
3) Communication is not easy between people of different cultural backgrounds.
4) Language is not the only tool for communication.
5) Eye contact is important.
6) I should accept more questions.
7) Topic on common background is easy to understand.

Presentation in International Research Conference

Students of "Biomedical Engineering Laboratory" have made presentations in WMSCI from 2002. The cumulative total number of participating students was 53 from 2002 to 2016 (Table 3).

Table 3: Presentation in World Multi-conference on Systemics Cybernetics and Informatics.

Year	Number of students
2002	1
2004	3
2005	5
2006	3
2007	4
2008	5
2009	4
2010	5
2011	2
2012	1
2013	4
2014	5
2015	6
2016	5

Five students made oral presentation in 2016 (Fig. 10). The topics are as follows:

1) Design of Slit between Micro Cylindrical Pillars for Cell Sorting.
2) Electric Stimulation for Acceleration of Cultivation of Myoblast on Micro Titanium Coil Spring.
3) Cell Behavior around Surface-Electrode with Electric Pulses.
4) Design of Scaffold with Array of Micro Projections to Trace Intra- and Inter-cellular Behavior.
5) Effect of Aspect Ratio of Checkered (Ichimatsu) Convexo-concave Micro-pattern on Orientation of Cultured Cells.
6) Deformation of Cell Passing through Micro Slit between Micro Ridges.
7) Design of Cross Type of Flow Channel to Control Orientation of Cell.
8) Effect of Surface Morphology of Scaffold with Lines of Micro Ridges on Deformation of Cells.
9) Behavior of Cells in Excess Gravitational Field: Using Centrifuge.
10) Effect of Ultrasonic Vibration on Proliferation and Differentiation of Cells

Every student has positive impression after participation of the seminar. Every student wanted to join the seminar again. The seminar has given a heavy shock to their brain. The seminar has given motivation to change their mind and brush up their skill for the innovative design.

4. DISCUSSION

The World Multi-Conference on Systemcs, Cybernetics and Informatics (WMSCI) gives good opportunity to learn multidisciplinary design, because it welcomes not only variety of special fields of study, but also variety of researchers from variety of cultural backgrounds. Most of academic conferences are concentrated into special field so that the number of participating countries is limited. Although the specialized group is convenient for peer review, it is not almighty for the global design. The single discipline is not enough for the application to the global design. Multidisciplinary design breaks through the global problem, and creates innovation.

It is good opportunity for young students to join in the multi-conference. WMSCI supplies multidisciplinary society and cross-cultural society, simultaneously.

Fig. 10 WMSCI2015.

The multidisciplinary field makes students learn several things: logical thinking, and flexibility without prejudice. The shocking experience of the cross cultural seminar makes students notice that "It is important to understand the background of thinking to learn the multidisciplinary field of study".

The view from another side is important in biomedical engineering. In the view of mechanical engineering, for example, cells may tilt along the stream line (passive reaction). In the view of biology, cells may tilt perpendicular to the stream line to minimize the internal stress (active reaction) [12].

Constructing model is important for design before statistics. Enough number of samples makes difference between mean values of two groups, but the difference between mean values of two groups is not enough for design. For creative engineering design, quantitative data are necessary.

A common base is necessary for communication. Similar experiences develop the common base. When common rules are defined, the communication becomes easier. That is the reason why you learn language, mathematics, SI unit, etc. When a student of engineering goes abroad, he founds that he has many tools for communication besides language: mathematics, drawings, and figures.

The technology should contribute to the society. The number of global problems is increasing in the society recently. Multidisciplinary design is important for young students in engineering department to break through the cross cultural boundary.

In an international project, you may experience misunderstandings, which depend not only on the language, but also on the cultural background. In a research project in the multidisciplinary field, you may also experience misunderstandings, which depend on the methodological backgrounds. In this point of view, both international projects and multidisciplinary projects have the common problem. The problem supplies a good chance for training on design.

5. CONCLUSION

The cross cultural multidisciplinary seminar for students has been exemplified, and the way how to learn multidisciplinary design has been discussed. Students from a variety of backgrounds of research area and culture have joined in the program. Through the training, students realized another way of thinking, which stands on another base of discipline. The process is effective to learn multidisciplinary design.

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