How Are Students Motivated for Learning Multidisciplinary Field: Biomedical Engineering?

Shigehiro HASHIMOTO
Professor, Doctor of Engineering, Doctor of Medicine,
Biomedical Engineering, Department of Mechanical Engineering,
Kogakuin University, Tokyo, 163-8677, Japan
shashimoto@cc.kogakuin.ac.jp http://www.mech.kogakuin.ac.jp/labs/bio/

ABSTRACT[1]

The academic field has been divided into each specialized field. Many problems in global society (including Coronavirus disease 2019 (COVID-19)) cannot be solved by the single disciplinarian. They are waiting for the multidisciplinarian. For students, it is not easy to find the way to learn a multidisciplinary field: the curriculum, the textbook, the learning team, and the teacher (adviser). "Biomedical Engineering" is one of the multidisciplinary fields, which have many related fields: biology, medicine, informatics, and engineering. The topic includes case studies (education for freshman, undergraduate, master's and doctoral courses) based on the author's experiences. "Finding related subjects to the case study" is effective to motivate students to learn the multidisciplinary field. Multidisciplinary group activities are effective for students to find innovative ideas for multidisciplinary topics. Multidisciplinary conferences give students opportunities to improve their communication ability. Multidisciplinarians are necessary to make bridges over the barrier between global problems.

Keywords: Multidisciplinary Field, Learning, Biomedical Engineering, Motivation, Communication, COVID-19 and Students.

1. INTRODUCTION

The academic field has been divided into each specialized field. The communication tools (internet, and database), on the other hand, develop multidisciplinary academic fields [1]. Artificial intelligence helps humans to select the best answer from big data [2]. Users should understand the background of big data. A "multidisciplinary field" is not just a collection of fields, but a fusion of fields [3]. Many problems in the global society cannot be solved by the single disciplinarian. The global society is waiting for multidisciplinarians. For students, it is not easy to find the way to learn a multidisciplinary field: the curriculum [4-10], the textbook [11], the learning team, and the teacher (adviser).

"Biomedical Engineering" is one of the multidisciplinary fields, which have many related fields: biology, medicine, informatics, and engineering [12-15]. The field also relates to economics, sociology, ethics, and religion [3]. For example, artificial organs should be designed to coexist with natural systems of the human body [2]. The contents of this article are based on the author's experience: multi-doctoral thesis defenses, and variation of affiliations [16].

2. METHODS

Students learn a variety of subjects in interdisciplinary courses (Fig. 1). In the present article, several cases are exemplified: multidisciplinary courses, case studies, and trainings.

1) Finding related subjects.
2) Mechanics of parts of the human body.
3) Fluid dynamics of the human body.
4) Devices for parts of the human body.
5) Case study on coronavirus.
6) Presentation in multidisciplinary conference.

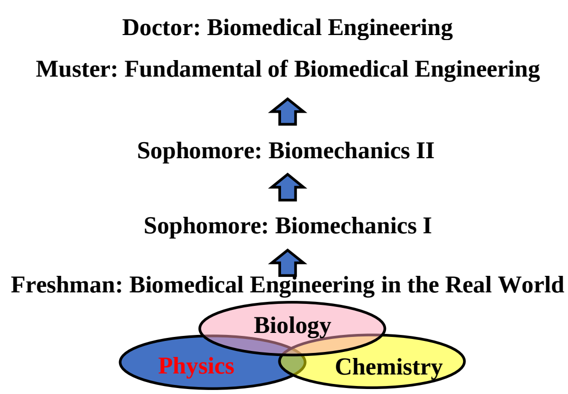

Fig. 1: Sample courses.

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Finding Related Subjects
Many students in biomedical engineering courses" prefer to study biological fields. They should be aware of related subjects, especially of physics. First, students are divided into several groups. During discussion in the group, students imagine a device, which operates as a part of the human body. Next, students imagine problems to be solved to design the device. To solve the problem, students list related subjects (mathematics, physics, chemistry, engineering, etc.).

Mechanics of Part of the Human Body
Students pick a part of the human body. Students analyze deformation or movement of the part by mechanics. Students research backgrounds, devise methods (principle), hypothesis, and numerical models Students add several reports to the topic: equations, and their original drawings.

Fluid Dynamics of the Human Body
Students pick a part of the human body. Students analyze visco-elastic properties of the part by fluid dynamics". Students image backgrounds, devised methods (principle), and numerical model (hypothesis). Students add several reports to the topic: equations, and their original drawings.

Device for Part of the Human Body
Students are divided into several groups. Each group includes graduate students from a variety of bachelor courses: mechanical engineering, electrical engineering, control engineering, materials, informatics, biology, chemistry, medicine, dentistry, and pharmacy. During group discussion, students design a new device, which acts as a part of the human body. They describe the specifications, including their original drawings and numerical descriptions. They report several items: problems to be solved, devised methods, background, references, expected results and the contribution to society.

Fig. 2: Introduction in undergraduate class.

Case Study on Coronavirus
The author had the experience of attending an academic conference on a cruise ship. The coronavirus (COVID-19) has become a global problem in 2020. Students use the clean room for micro-machining. They learn about the cell culture technique. They study immunology.

Presentations in Multidisciplinary Conferences
Presentations at international conferences in biomedical engineering fields give students good opportunities not only to use the foreign language, but also to learn interdisciplinary communications.

3. RESULTS

Finding Related Subjects
Students found that a variety of subjects relate to the biomedical engineering topic (Fig. 2). For example, one student made the report as follows:

1) Device: an emergency life-saving system.
2) Problem to be solved: connection between ambulance and hospital, training of the medical doctor about technology.
3) Related subjects: computer engineering, computer science, mathematics, information technology, communication technology.

Mechanics of Part of the Human Body
Students found that many parts are related to mechanics (Fig. 3). For example, one student made the report as follows:

1) Part: intervertebral disks.
2) Model: vertebras.
3) Equations: compressive forces.

Fig. 3: Active learning in undergraduate class: biomechanics.

Fig. 4: Group work in master's course: design a new device.

Fluid Dynamics of the Human Body

Students found that many parts are related to fluid dynamics. For example, one student made the report as follows:

1) Part: the lymphatic vessel.
2) Model: cells on the vessel wall.
3) Equations: mechanical signals to cells.

Device for Part of the Human Body

Students created new ideas on devices related to biomedical engineering (Fig. 4). For example, the following ideas are related to coronavirus problems:

1) Intracellular oxygen recycling system.
2) Encapsulated enzymes circulate with red blood cells.
3) Synthesis of lymphocytes.
4) Portable artificial lung.

Case Study on Coronavirus

The author attended an academic conference on a cruise ship in the autumn (Fig. 5). The cruise ship has a variety of facilities: bedrooms, conference rooms, restaurants, theaters, swimming pools, and shops. It is a very convenient venue for an academic conference. Infection has been controlled carefully in the closed society of the ship. The ship, however, is not a hospital.

Students experienced using clean rooms. The clean room controls contamination according to the particle size that can pass through the filter, which has a controlled pore size (Fig. 6). If you look at the particle size, a floating particle of cigarette smoke has smaller dimensions than a bacterium. The filter of the sub-micrometer pore size controls passing movement of sub-micrometer particles.Controlling particle size by the filter allows you to prevent contamination that would make it impossible to make devices with very small features, like scaffolds or integrated circuits.

Fig. 5: Conference on a cruise ship.

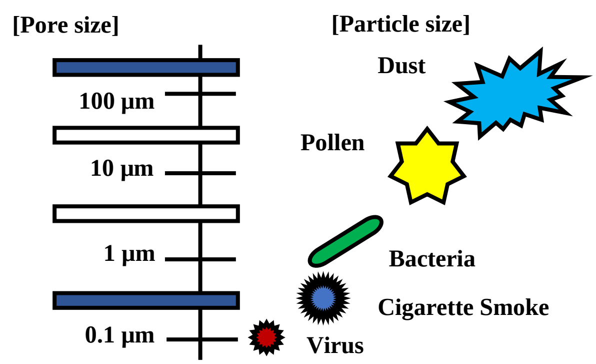

Fig. 6: Pore size of filter vs. particle size.

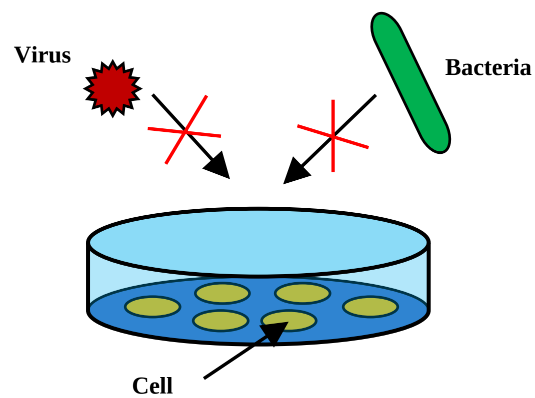

Fig. 7: Cell culture technique.

Students also experienced cell culture techniques (Fig. 7). In a cell culture system without the immune system, contamination has to be controlled so the culture is free of viruses and bacteria. Sterilized tools are used for the procedures of cell culture. The operation is performed in the clean bench. The positive pressure space can prevent penetration of foreign viruses (Fig. 8a). The negative pressure space can prevent release of internal viruses (Fig. 8b). To prevent invasion of contaminants, positive pressure is used in the clean bench. To prevent release of the subjects harmful to the operator, negative pressure is used in the clean bench.

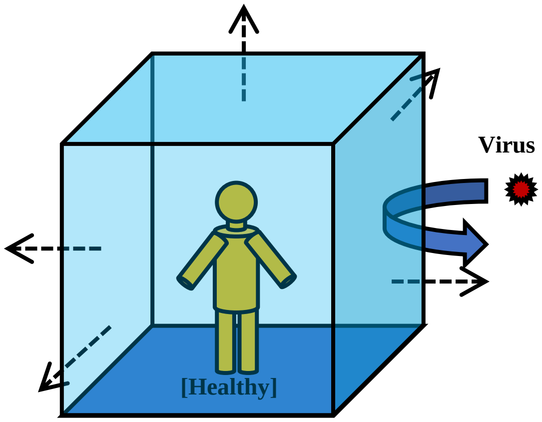

Fig. 8a: Isolation by positive pressure: rejection of foreign enemy.

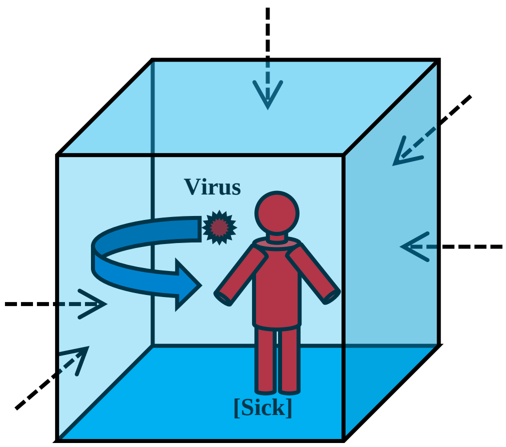

Fig. 8b: Isolation by negative pressure.

Presentation in Multidisciplinary Conference

The cumulative number of students, who participated in the "World Multi-Conference of the International Institute of Informatics and Systemics (IIIS)" was 62 from 2002 to 2020. The topics of the presentations in 2020 are as follows:

1) Effect of Shear Stress on Myoblasts Cultured under Couette Type of Shear Flow between Parallel Disks.
2) Analysis of Cyclic Deformation of Erythrocyte in Couette Type of Pulsatile Shear Field.
3) Effect of Hysteresis of Stimulation of Tangential Force Field on Alignment of 3T3-L1 Cultured on Micro Striped Pattern.
4) Analysis of Dielectrophoretic Movement of Floating Myoblast near Surface Electrodes in Flow Channel.
5) Relationships between Electric Impedance and Orientation of Biological Cells: Control by Micro-stripes Grooves In Vitro.
6) Migration of Cell under Couette Type Shear Flow Field between Parallel Disks: After and Before Proliferation.

Each annual conference of IIIS includes participants from many countries: from 27 to 52 countries. The number is rather large compared with the other international conferences in the specialized fields. It is good stimulation for young students to join in the multi-society. World Multi-Conference on Systemics Cybernetics and Informatics (WMSCI) performs as a multidisciplinary society and a cross-cultural society simultaneously.

Students enjoy a variety of research activities in the multidisciplinary field of biomedical engineering: nano /microsystems, cellular mechanics, biomechanics, biomaterials, bio-simulation, medical robotics, medical systems, biomedical informatics, bio-control engineering, bio-measurement.

4. DISCUSSION

COVID-19 is one of the multidisciplinary topics. Man is mortal. What is the higher risk for you? When you check the number of each cause of death of humans every year in the world, both "road incidents" and "suicide" are big risk factors. For individuals, COVID-19 is just one of factors. Infection is the major problem against the maintenance of human health. The biological system has an immune system to distinguish the inside and outside of the system. For society, a new virus has a high risk of the number of patients exceeding the capacity of the medical system.

There are two ways of isolation from viruses: the positive pressure system (Fig. 8a), and the negative pressure system (Fig. 8b). Which way do you prefer to take? If you think about variations of viruses, it is difficult to contain every virus inside negative pressure systems (Fig. 8b). On the other hand, can you keep yourself in a clean room (Fig. 8a) forever?

The human body has some kinds of viruses inside: symbiosis. The human body has the immune system. Infection is controlled by the immune system (Fig. 9). It is important for health control not only to decrease the possibility of being infected by viruses, but also to improve the immune system.

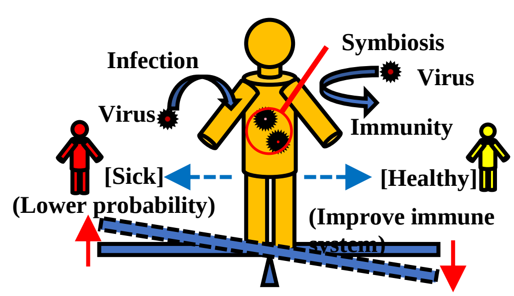

Fig. 9: Immunological balance.

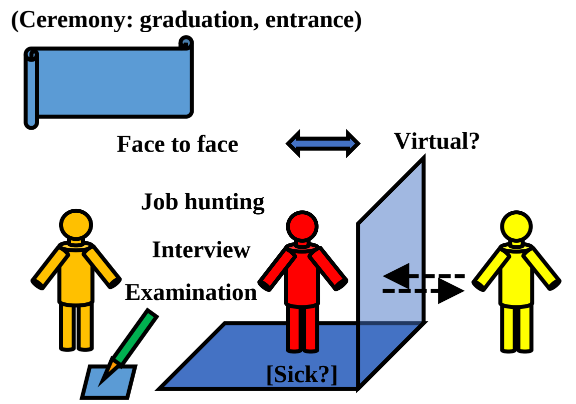

Fig. 10a: Face to face communication.

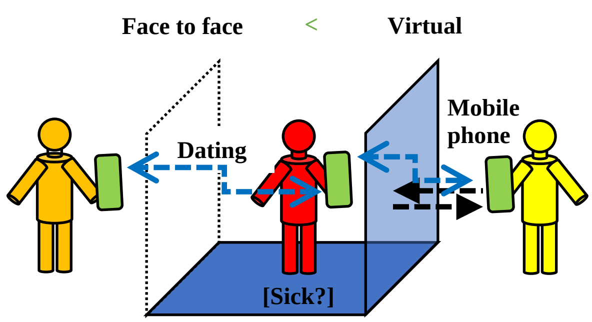

Fig. 10b: Communication technology.

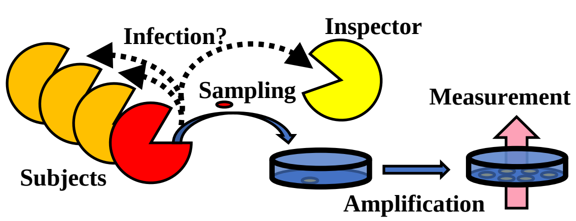

Fig. 11: Inspection.

Students have many things to do in spring: examinations, job hunting, interviews, and ceremonies (Fig. 10a). The traditional way of these things is face to face. Telecommunication technology has improved virtual communications. Even when the partner is facing in front of him during dating, some young persons prefer to make virtual communication by the mobile phone (Fig. 10b). The telecommunication technology can change the control of infection in the society.

During sampling specimens from patients, there is a possibility of the infection spreading from a patient to an inspector (Fig. 11). Biomedical engineers could propose several systems to solve the problem: devices for self-checking, robotics for sampling, and telemetric diagnostics. “Polymerase chain reaction (PCR)” can make copies of a specific DNA sample. The method is convenient to the detect presence of DNA, but it is not enough to confirm the current activity of viruses.

Do we need the barrier between persons (Fig. 12)? Do we make the barrier between different points among people (nationality, language, or culture)?

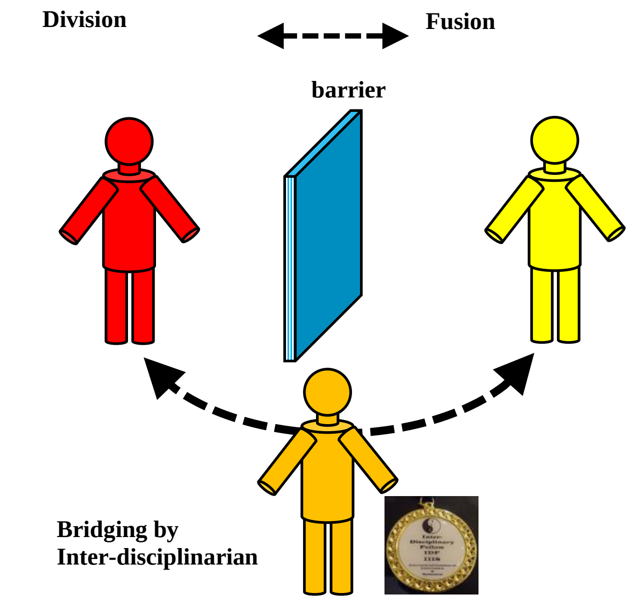

Fig. 12: Barrier vs. inter-disciplinarian.

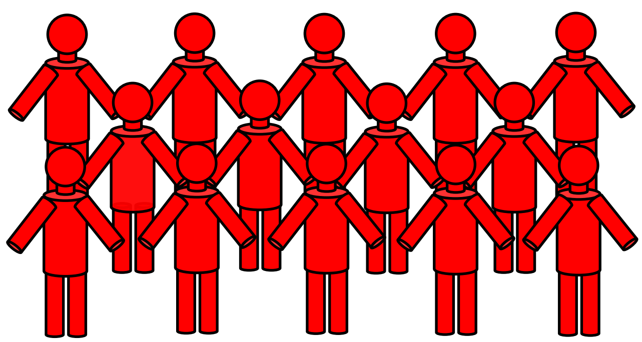

Fig. 13a: Uniformity.

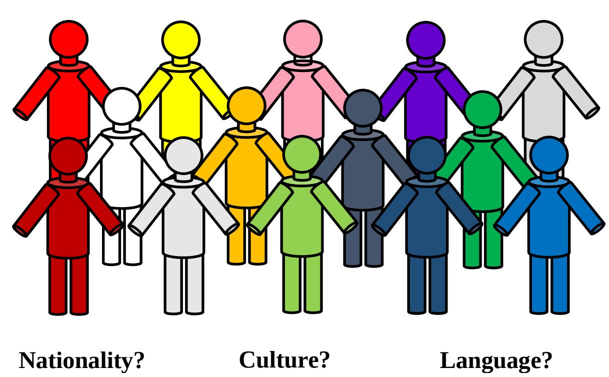

Fig. 13b: Diversity.

Is uniformity the goal of global society (Fig. 13a)? Can we accept diversity (Fig. 13b)? In the biological system against enemies, diversity is stronger than uniformity.

In the global society, we do not have to be in total agreement, but we need collaboration. Interdisciplinarians shall make bridges between disciplines to break through barriers (Fig. 12).

5. CONCLUSION

Finding related subjects to the case study is effective to motivate students to learn multidisciplinary fields. Multidisciplinary group activities are effective for students to find innovative ideas for multidisciplinary topics. Multidisciplinary conferences give students opportunities to improve their communication ability. Interdisciplinarians are necessary to make bridges over the barrier between global problems.

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