Journal of Systemics, Cybernetics and Informatics (2021) 19(9), 1-6
https://doi.org/10.54808/JSCI.19.09.1

Does Learning Multidisciplinary Field of Biomedical Engineering Help Pandemic of COVID-19?

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

The global community has accelerated the spread of the virus. Medicine alone cannot solve the pandemic. The change of the lifestyle by new technology helps to coexist with viruses. The academic field has been divided into each specialized field. The modern communication tools (internet, and database), on the other hand, promote multidisciplinary academic fields. The multidisciplinary field is not just a collection of fields, but a fusion among fields. Many problems in global society cannot be solved by a single disciplinarian. The global society is waiting for a multi-disciplinarian. 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 (the adviser). “Biomedical Engineering” is one of the multidisciplinary fields. It has many related fields: biology, medicine, informatics, and engineering. The topic includes case studies related to COVID-19 (education for the undergraduate and the graduate courses) based on the author’s experiences: from cross cultural to symbiosys.

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

1. INTRODUCTION

Infection is an unavoidable problem for humankind. They are one of main causes of death. For human society, there is a danger of becoming a pandemic. Viruses are transmitted from person to person. The Public health as an academic discipline recommends limitation of the face-to-face communication in the pandemic [1]. Group activities of students also are limited in universities. Students feel inconvenience under restrictions. Students design the way how to take campus life under pandemic by themselves. The design is related not only to improvement of the lifestyle, but also to project based learning [2]. The learning leads students to their future work. It inspires innovation of the lifestyle [3] after a pandemic.

Biomedical engineering is one of the interdisciplinary fields [4-15]. It has many related fields [4]. Biomedical engineering is also closely related to infectious diseases. The extracorporeal membrane oxygenator (ECMO) is one of the artificial organs [3]. It is the fruit of biomedical engineering as an assist device for the oxygen deficiency due to respiratory disorders. Biomedical engineering as an academic discipline that supports healthcare is deeply related to infectious disease control.

COVID-19 was picked up as one of the topics in the study of biomedical engineering [16]. Students considered on the topic, while answer questionnaires on infectious disease. Students make reports on the topic: the problem to be solved, methods to solve the problem, expected results, and contributions to the society.

2. METHODS

The learning course of “Biomedical Engineering” welcomes undergraduate and graduate students every year. The textbook of “Biomedical Engineering” includes the following contents (with case studies) [17]:

1) Organism and Machine.
2) Unit and Measurement.
3) Material（Hemolysis）.
4) Flow（Blood circulation）.
5) Energy（Oxygenator, Dialyzer）.
6) Movement（Joint prosthesis）.
7) Design and Machining（Artificial organs）.

In the course, students answer several questions related to COVID-19. It is a disease caused by a new type of coronavirus (SARS-CoV-2). The virus has caused a pandemic. The pathology has not been elucidated. Several treatments have been tried. While the unique answer to each question has not be decided yet by specialists, the questions give motivation to students to find topics of global multidisciplinary problems.

Questions

(1) The following effects of vaccine: “True” or “False”.

   1) Antibodies to the virus are produced?
   2) The vaccine makes infection?
   3) Preventing viruses from invading a cell?
   4) Stops infection?
   5) Reduced chance of infection?
   6) No more transmittance of virus to your neighbors?
   7) After infection, condition does not become severe?
   8) Will side reactions happen?
   9) The effect lasts?
   10) Vaccination proof is more effective than PCR negative proof?

(2) Select your behavior in the past two weeks to be “free of COVID-19 infection”.

1) Asymptomatic; I have been facing others in the normal life.
2) Facing others in the normal life, I have been paying attention to disinfection: masks, and distancing from others.
3) I have been managing my own health by measuring body temperature without facing others.
4) Facing others in the normal life, I have been checking for the negative sign of COVID-19 infection by PCR (polymerase chain reaction) test every day.
5) I have been facing others in the normal life, taking medications to control COVID-19 symptoms.
6) I have been facing others in the normal life, after receiving the vaccine against SARS-CoV-2 virus.
7) I have been facing others in the normal life, after confirmation of negative signs by a PCR test after the recovery from COVID-19.

(3) Select three effects of everyday-masks on COVID-19.

1) Prevent the outflow of the virus.
2) Enhance the immune capacity by maintaining humidity in the oral cavity.
3) Reduce splashing of water droplets including virus accompanied with sneezing.
4) Prevent elevation of the body temperature.
5) Prevent the inflow of the virus.
6) Prevent direct touch by your hands to the mouth (or the nose).

(4) Choose three answers related to COVID-19 as a method to directly reduce your chances of infection.

1) Wash your hands frequently.
2) Do not eat with bare hands without washing hands.
3) Disinfect the area you touch with alcohol.
4) Do not get together with many people.
5) Do not eat meals, which are exposed to the space of everyone’s conversation, at the buffet.
6) Do not stay in a place with poor ventilation.
7) Keep a distance from others.
8) In a room with multiple people, refrain from the following action: talking, deep breathing, and singing a song.
9) Do not shake hands with others.

(5) Choose three answers to directly reduce the probability of the movement of COVID-19 virus from yourself to others.

1) Wash your hands frequently.
2) Wear a mask when singing.
3) Use alcohol to disinfect your hands, and to disinfect the areas you touch.
4) Do not go into the crowd.
5) For sneezing and coughing, cover the mouth and the nose with sleeves and a handkerchief.
6) Do not stay in a place with poor ventilation.
7) Keep a distance from others.
8) Wear a mask when speaking.
9) Do not touch where many persons touch.

(6) Which is the effect of virus test? Select two choices.

1) To find positive for isolation.
2) For statistics.
3) To find infection route.
4) Negative check for occupation: medical care, nursing.
5) Certificate for negative.
6) Infection during test: contact with patient.

Topic selection
The problem of COVID-19 includes many topics to be solved. Students try to find a new idea related to the topic, after questions.

(7) Choose multiple answers from the following future technologies related to COVID-19 that you would like to realize.

1) Automatic generation of vaccine.
2) Automatic determination of effectiveness of vaccine without clinical trials.
3) Detection of cytokine (substance secreted by cells) release syndrome.
4) Diagnostics without facing the patient.
5) High-speed diagnosis of inspected data by artificial intelligence.
6) Prediction of infection.
7) Portable respirator.
8) Implantable oxygenator.
9) Technology that reduces oxygen consumption in living tissues.
10) Face-to-face communication technology without vocal conversation.
11) Telemedicine.
12) Medical robot.
13) Remote care.
14) Nursing robot.
15) Remote childcare.
16) Childcare robot.
17) Barber robot.
18) Artificial reality.
19) Remote sports.
20) Self-driving car.
21) Everyday activity tracking technology.
22) Everyday behavior monitor.

Your proposal
In relation to COVID-19, students make a report. Students select topics in relation to biomedical engineering. They discuss quantitatively on their own ideas, using illustrations for explanation. The report should include following items: an informative title, the motivation, methods, and contributions to society.

Presentation in a multidisciplinary conference
Students make presentations in the “World Multi-Conference of International Institute of Informatics and Systemics (IIIS, http://www.iiis.org/)”.

3. RESULTS

Distributions of answers of students for each question are shown in Figs. 1-8, respectively.

Several kinds of vaccination have been started in the world. Higher percentage of effectiveness is shown in each kind of vaccine. Neutralizing antibody is expected to be produced after every vaccination (Fig. 1(1)). There are individual differences.

Most of vaccination is rehearsal for infection. Antibodies may be produced faster after the rehearsal. Results show that the probability of infection is statistically reduced. Before invasion, virus can be moved from person to person during asymptomatic. Side reactions may occur: allergic reactions, etc. Japanese students do not believe the long-term effectiveness of vaccine. The effect might change against mutant viruses. Vaccination is fact, while the results of test might have error.

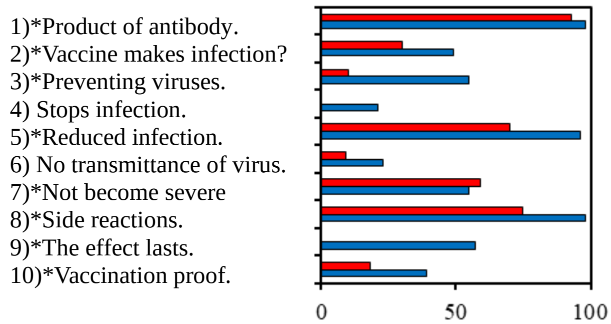

Fig. 1: Effect of vaccine: ratio (%) of "True": red, Japanese (number of samples, 56); blue, Thai (51): *recommended.

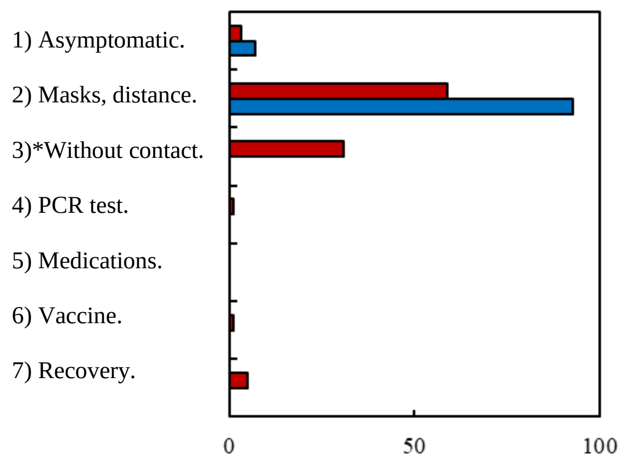

Fig. 2: Select your behavior in the past two weeks to be "free of COVID-19 infection": ratio (%): red, Japanese (56); blue, Thai (51): *recommended.

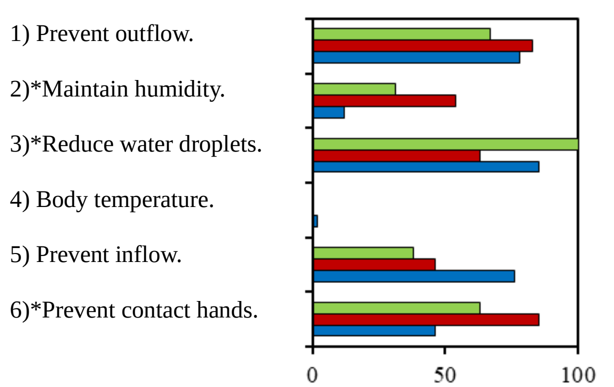

Fig. 3: Select three effects of everyday-mask on COVID-19: ratio (%): green, Japanese graduate (16); red, Japanese undergraduate (80); blue, Thai undergraduate (41): *recommended.

While every answer appears to follow precautions for COVID-19, no answer can guarantee that someone is virus-free. Because virus moves from person to person, "without facing others" is preferred (Fig. 2). There are several patients who are asymptomatic. While many students (especially in Thailand) follow the rule of the mask, the virus can pass through the normal mask. The results of PCR test depend on the timing and the sampling. Some medications mask the symptoms. A vaccine has several points for discussion: the efficacy to the virus, the acquisition rate of antibodies, and the duration of immunity. More information is necessary on several points about the patients: the recurrence, and after-effects.

Many students expect the effect of the mask to be a barrier for the virus (Fig. 3). To stop the virus with a size smaller than 0.1 µm, a mask with a smaller pore size is necessary. Keeping humidity in the oral cavity helps the immune capacity. Most of students understand that the droplets can be captured by the mask. The virus can move from your hand to your oral cavity by direct touch.

We have several social rules recommended against infection in Japan. Students follow the rules: hand-wash, ventilation, and distancing (Fig. 4). We have few reports about infection in the crowded quiet space of public transportation. Virus can get into the oral cavity during eating with chatting. Ventilation is important during chatting.

Many students agree to the rule of distancing (Fig. 5). Making barrier against droplets including the virus is effective to directly reduce the probability of the movement of COVID-19 virus from yourself to others. Japanese students follow disinfection with alcohol. Both touching and gathering do not cause infection without the route to inhale into the body.

The risk of infection during the test procedure is low, because the test is conducted under the specially controlled manner to prevent infection. In Japan, the cluster tracking is the first choice (3) in Fig. 6). Vaccination is the fact, so that the vaccination can be a proof of the fact than PCR test.

Topic selection

Popular topics to students were as follows: "Automatic generation of vaccine", "Diagnostics without facing the patient", "Prediction of infection", "Telemedicine", and "Medical robot" (Fig. 7).

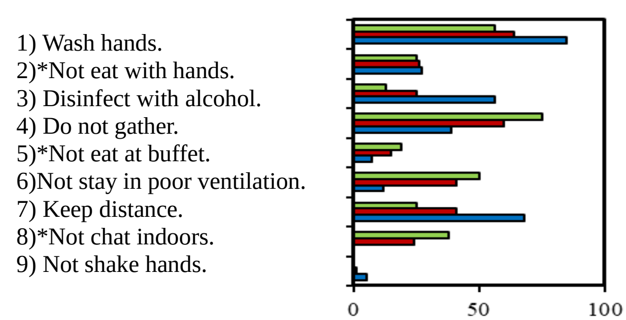

Fig. 4: Choose three answers related to COVID-19 as a method to directly reduce your chances of infection: ratio (%): green, Japanese graduate (16); red, Japanese undergraduate (80); blue, Thai undergraduate (41): *recommended.

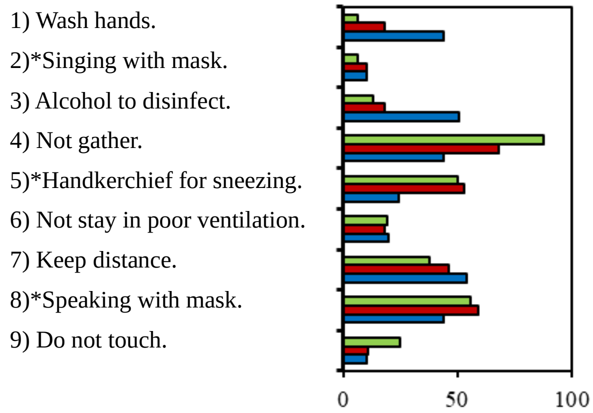

Fig. 5: Choose three answers to directly reduce the probability of the movement of COVID-19 virus from yourself to others: ratio (%): green, Japanese graduate (16); red, Japanese undergraduate (80); blue, Thai undergraduate (41): *recommended.

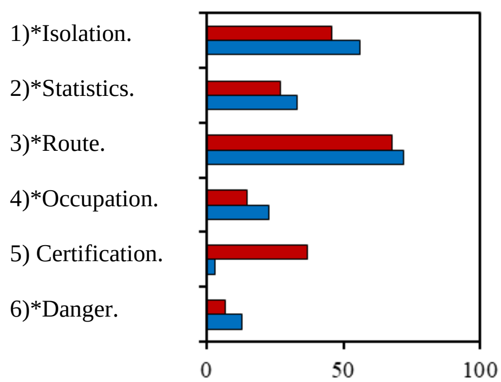

Fig. 6: Which is the effect of virus test? Select two choices: ratio (%): red, Japanese (80); blue, Thai (29): *recommended.

Your proposal

Many topics proposed by students were related to tests for virus detection (Figs. 7 & 8). Minimized artificial organs were also popular to students. Some students proposed innovative ideas related to multidisciplinary background (Table 1). Many problems related to biology can be studied in the field of informatics with the big data of genomics.

Table 1: Examples of ideas proposed by students.

1) Sport-able face mask
2) Self-cleaning sanitary mask
3) Thermometer face mask
4) Alert face shield
5) The bubble
6) Air stroller
7) Chameleon headband
8) Antibodies tester
9) Remote wristband
10) Real time polymerase chain reaction
11) Portable virus detector
12) Temperature tracking system
13) Alert COVID-19
14) UVC-254 toilet
15) Scanning virus screen
16) Smart bus door
17) Mask sterilization machine
18) Hand sanitizer bracelet
19) Spray bracelet
20) Disinfection gloves with thermometer
21) Stanchions sheet cover changing machine
22) Dental robot
23) Telemedicine robots
24) Portable artificial lung
25) Smart security for lungs
26) Emergency auto-ventilator
27) Artificial epithelial stem cells for organs
28) Removing fluid from the lungs
29) Health screening machine in one step
30) Automatic safety-first machine
31) Blood-testing robot
32) Delivery drone
33) Friendly chair
34) Information filter

Presentation in multidisciplinary conference

The cumulative number of participating students from author's program in the "World Multi-Conferences of IIIS" is 74 from 2002 to 2021. The topics of presentation in the spring conference in 2021 are as follows:

1) Behavior of Cell on Micro Ridge Pattern after Continuous Stimulation of Tangential Force.
2) Effect of Contact between Myoblasts on Making Orientation of Cells under Shear Flow Field.
3) Effect of Shape of Cell on Dielectrophoretic Movement in Flow Channel.
4) Effect of Cell Type on Behavior of Cell under Shear Flow Field Before and After Division.
5) Effect of Activity of Cell on Division under Shear Flow Field.
6) Tracking of Deformation of Cell during Passing through Micro Gap.
7) Effect of Shape of Cell on Movement over Micro Groove in Flow Channel.
8) Experiment of Music Therapy Conducted at a Classical Music Recital: Measurement of Pulse Wave, Blood Pressure and Cardiac Orientation.
9) Experiment of Music Therapy Conducted at a Classical Music Recital: Measurement of Saliva Amylase, Hand Sweat and Muscle Hardness.
10) Construction of a Music Database for Earphone Hearing Loss Prevention and Music Therapy.
11) Basic Research on Music Therapy: Proposal on Timbre Comparison Experiment Method.
12) Earphone Hearing Loss: Discussion of Accuracy of Ear Age Conversion Method.

The annual conference of IIIS includes participants from a large number of countries: from 27 to 52. The number is rather large compared with the other international conferences on specialized fields. It is good stimulus for young students to join in the multi-disciplinary society. IMCIC (International Multi-Conference on Complexity, Informatics and Cybernetics) gives a chance for each participant to experience a multidisciplinary society and a cross-cultural society, simultaneously [18].

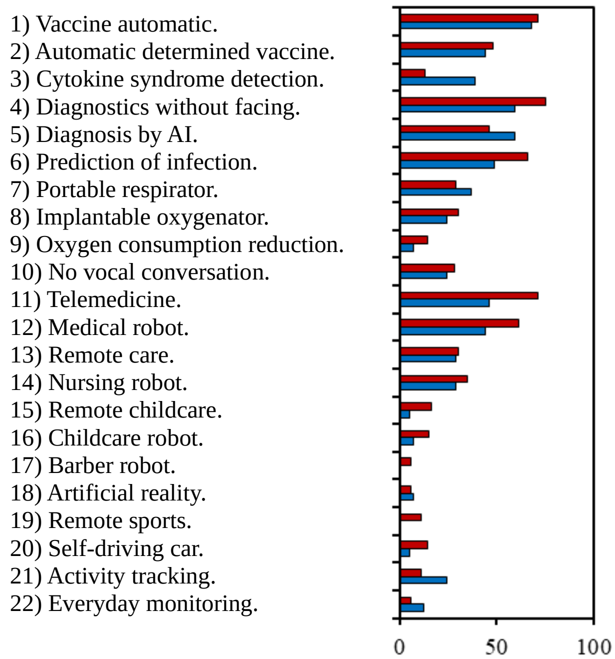

Fig. 7: Choose multiple answers from the following future technologies related to COVID-19 that you would like to realize: ratio (%): red, Japanese (80); blue, Thai (41).

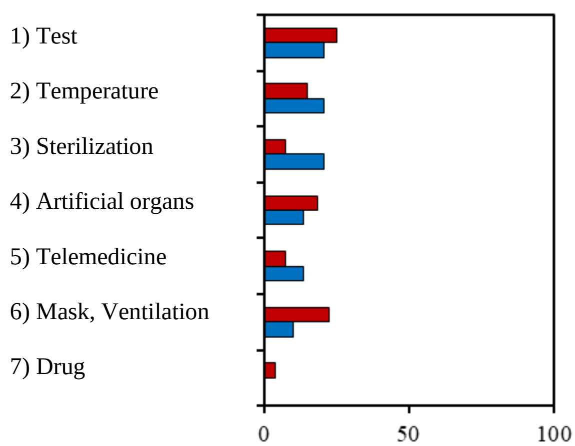

Fig. 8: Category of topics proposed by students: ratio (%): red, Japanese (80); blue, Thai (29).

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

4. DISCUSSION

Students of Biomedical Engineering Department are using the clean room for micro machining. They also learn about cell culture techniques. They are familiar with the clean space, and sterilization. With interdisciplinary learning, students should not blindly follow the rules on COVID-19, but understand the purpose of the rules. Active contribute to society will lead students to their future works.

As a particle, dimension of the virus is as large as the cigarette smoke [1]. They will pass through a fine filter. Adsorption is also available to trap the virus. Once released into the space, the virus continues to drift like the cigarette smoke. It is not easy to remove by the ventilation. A mask is effective to reduce the amount of viruses released from a human. On-time sensitive detect of viruses is expected. Animals can sniff viruses with the nose. When you infected by COVID-19, chatting is similar to smoking. Do you blow cigarette smoke to your neighbors at a short distance? You might refrain from smoking during eating. The image of cigarette smoke will help you to refrain from making the close contact with a person in everyday life.

The author allows students to be relaxed during class except chatting and smoking. It is general rule that smoking is prohibited in the classroom. Why is chatting prohibited? Both of actions affect your neighbors. The passive smoking can be a risk of carcinogenesis. Chatting interferes with the concentration of your neighbors. These rules can also control infection. Prohibiting chatting has the effect of reducing the amount of virus released from the respiratory tract of an asymptomatic patient during class.

The number of people infected with COVID-19 in Japan is higher than that in the other East Asian countries. In Japan, increase in suicide has been warned, but the increase is not so great. The overall death toll is declining. It is considered that control of COVID-19 has the effect of reducing general infectious diseases. Flu is also decreasing.

The virus repeats mutations. There is no almighty permanent antibody. Vaccines cannot solve everything. The role of medical devices is important: respirators, diagnostic equipment, medical equipment, and artificial organs. Sequela of COVID-19 is related to thrombus formation. Thrombus formation is important research topic in blood circulatory assist devices [3].

Engineered systems that physically and mentally support daily life form a society resistant to infectious diseases. It is not easy to complete those complex systems only by studying in specialized fields [19]. Fusion of academic fields realizes innovation. Infectious disease control may promote the formation of a barrier between people. Inter-disciplinarian shall make bridges between disciplines to break through barriers [1].

Sterilization is big issue for the medical equipment. Every object with the virus will be sterilized and safely disposed. Syringes used for infectious disease are disposable. Waste management is important for the sustainable society. Every material should be recycled. For disposable items, attention should be paid to the materials. The disposable mask can lead to the environmental pollution. Plastics are not decomposed immediately. They will remain in the environment for a long time. Microplastics cause a problem in the global environment. With a view of degradation, plastics is different from radioactive materials which have a half-life of radioactivity.

Repeating the same thing is hard to be emotionally accepted to people for a long-term strategy. Concentrated items are preferable [16]. “Do not inhale virus into the respiratory system.” “Reduce the amount of discharge of virus (chatting prohibited without mask).” It is easier to motivate people to prepare for new threats (mutant virus). Is this time practice for pandemic? Is the next wave by mutant strains (increased infectivity?)? Flu virus has more variation of mutation.

Vaccination is training for infection. Some treatments use antibody itself. Additives in the vaccine fluid can cause accidents. Allergies such as pollinosis should be carefully examined related to individuality in the immune response. It takes time to establish herd immunity. In Japan, vaccination is no longer mandatory due to the history of serious adverse reactions to vaccines. The only way to maintain the health care system of society is to reduce the number of patients or reduce the number of people who depend on health care. Individual declaration affidavits (wills) are also useful when it comes to aggravation and funerals.

5. CONCLUSION

After learning the course of "Biomedical Engineering", students have realized that engineering related to many special fields of study. As a case study, students have studied on COVID-19, and found several key points related to pandemic. The multidisciplinary learning inspired students to find innovative topics for the new society. Many global problems are waiting for a multi-disciplinarian.

ACKNOWLEDGMENT

The author is thankful to Dr. Jackrit Suthakorn and Dr. Norased Nasongkla of Mahidol University for collaboration to the student education program.

REFERENCES

[1] S. Hashimoto, "How Are Students Motivated for Learning Multidisciplinary Field: Biomedical Engineering?", **Journal of Systemics Cybernetics and Informatics**, Vol. 18, No. 7, 2020, pp. 42–49.

[2] S. Hashimoto, et al., "Parallel Curriculum between Application and Fundamental Subjects with Rotational Experimental Project for Multidisciplinary Study Field of Biomedical Engineering", **Proc. 12th World Multi-conference on Systemics Cybernetics and Informatics**, Vol. 2, 2008, pp. 98–103.

[3] S. Hashimoto, "Cross Cultural Seminar Inspires Multidisciplinary Learning: from Biomedical Engineering to Gerontechnology", **Journal of Systemics Cybernetics and Informatics**, Vol. 16, No. 4, 2018, pp. 1–7.

[4] S. Hashimoto, "How to Learn Multidisciplinary Design: Biomedical Engineering in Cross Cultural Seminar", **Journal of Systemics Cybernetics and Informatics**, Vol. 14, No. 5, 2016, pp. 22–27.

[5] S. Hashimoto, et al., "Parallel Curriculum of Biomedical Engineering Subjects with Rotational Experimental Project for Interdisciplinary Study Field", **Proc. 11th World Multi-conference on Systemics Cybernetics and Informatics**, Vol. 4, 2007, pp. 39–44.

[6] S. Hashimoto, et al., "Bridging-Charge System for Sustained Improvement of Curriculum of Biomedical Engineering Courses", **Proc. 13th World Multi-conference on Systemics Cybernetics and Informatics**, Vol. 2, 2009, pp. 191–195.

[7] S. Hashimoto, "Bridge-Curriculum with Rotational Experimental Projects for Multidisciplinary Courses on Biomedical Engineering", **Proc. 14th World Multi-conference on Systemics Cybernetics and Informatics**, Vol. 2, 2010, pp. 261–264.

[8] S. Hashimoto, "Bridge-Curriculum System for Multidisciplinary Courses: Application to Biomedical Engineering", **Proc. 15th World Multi-conference on Systemics Cybernetics and Informatics**, Vol. 2, 2011, pp. 108–111.

[9] S. Hashimoto and A Nakajima, "Role of Bridge-Curriculum for Multidisciplinary Courses: Application to Biomedical Engineering", **Journal of Communication and Computer**, Vol. 8, No. 12, 2011, pp. 1117–1122.

[10] R.A. Linsenmeier, "What Makes a Biomedical Engineer: Defining the Undergraduate Biomedical Engineering Curriculum", **IEEE Engineering in Medicine and Biology Magazine**, Vol. 23, No. 4, 2003, pp. 32–38.

[11] R.A. Linsenmeier and A. Saterbak, "Fifty Years of Biomedical Engineering Undergraduate Education", **Annals of Biomedical Engineering**, 2020, pp. 1–26. https://doi.org/10.1007/s10439-020-02494-0

[12] S. Hashimoto, "Multidisciplinary Learning Extends Communication Skill, and Helps Cross Cultural Understandings: Biomedical Engineering", **Journal of Systemics Cybernetics and Informatics**, Vol. 15, No. 6, 2017, pp. 106–112.

[13] S. Hashimoto, "Cross-Cultural Student Seminar for Communication Training in Multidisciplinary Field of Study: Application to Biomedical Engineering", **Proc. 16th World Multi-conference on Systemics Cybernetics and Informatics**, Vol. 2, 2012, pp. 87–90.

[14] S. Hashimoto, "Interdisciplinary Area of Research Offers Tool of Cross-Cultural Understanding: Cross-Cultural Student Seminar for Communication Training on Biomedical Engineering", **Journal of Systemics Cybernetics and Informatics**, Vol. 11, No. 9, 2013, pp. 17–22.

[15] S. Hashimoto, "Cross-Cultural Communication Training for Students in Multidisciplinary Research Area of Biomedical Engineering", **Journal of Systemics Cybernetics and Informatics**, Vol. 12, No. 5, 2014, pp. 43–48.

[16] S. Hashimoto, "Does Multidisciplinary Learning Help Global Problem: Covid-19 by Biomedical Engineering?", **Journal of Systemics Cybernetics and Informatics**, Vol. 18, No. 7, 2020, pp. 1–6.

[17] S. Hashimoto, "**Introduction to Biomechanical Engineering**", Corona Publishing Co. Ltd., Tokyo Japan, pp. 1–151, 2013.

[18] S. Hashimoto, "How to Learn Multidisciplinary Ideas", **Journal of Systemics Cybernetics and Informatics**, Vol. 13, No. 6, 2015, pp. 1–7.

[19] S. Hashimoto, "Communication Training in Multidisciplinary Field: Biomedical Engineering and Symbiosis Engineering", **Journal of Systemics Cybernetics and Informatics**, Vol. 17, No. 5, 2019, pp. 106–111.