Challenges of a “Virtual” Biophysics Laboratory during the “Stay home” period caused by COVID-19

Naruki Tamura\textsuperscript{a}, Hisao Taira\textsuperscript{b}, Kazuo Umemura\textsuperscript{a,*}

\textsuperscript{a}Biophysics Section, Department of Physics, Faculty of Science Division II, Tokyo University of Science, 1-3 Kagurazaka, Shinjuku, Tokyo 162-8601, Japan
\textsuperscript{b}Faculty of Education, Hokkaido University of Education, 5-3-1-5 Ainosato, Kita-ku, Sapporo, Hokkaido 002-8502, Japan

biophys@rs.kagu.tus.ac.jp

Abstract. We have recorded our experience of a “virtual” university biophysics laboratory using the Zoom meeting system, from April to June 2020, during the “stay home” period of the COVID-19 pandemic, in Japan. Because the specialty of our laboratory is experimental biophysics, careful planning was necessary for the continuation of research. We set several special research topics for teleworking, although some compromise was inevitable. Frequent meetings, seminars, and lectures using the Zoom meeting system were important to maintain laboratory activity. Meetings were carried out three times per day. Two types of seminars were held, as well as the “meeting-style” laboratory. Lectures by outsiders were also performed. As a result of these approaches, many students succeeded in presenting their telework research in autumn domestic conferences for biophysics and physics education in 2020. Furthermore, some students submitted papers to academic research journals by the end of the teleworking period. Our experiences of the “virtual” laboratory will provide helpful information for many researchers in experimental research fields in science and engineering.

1. Introduction
With the benefit of the continuing development of online technology, the internet is widely used to register for courses at universities and submit assignments. Distance learning universities, such as Cyber University (Japan) and The Open University (United Kingdom), provide all of their lectures via the internet. The recent coronavirus (COVID-19) disease pandemic has changed the lecture style of all universities from face-to-face lectures to online. Cloud meetings or classroom systems such as Zoom (Zoom Video Communications, Inc., San Jose, CA), Cisco Webex (Cisco Systems G.K., San Jose, CA), and LoiLoNote (Loilo Inc., Yokohama), and a massive open online courses (MOOC.org) provide multi-platform software programs for interactive learning. Many universities in Japan have moved to giving online lectures by using the internet or classroom software for the new teaching term in 2020. The lectures provided online can be made available on-demand and are interactive. Reports have been published that discuss how online learning behavior and course design might engage students with a high level of learning [1-7].

Previous studies have developed teaching resources and examined the efficacy of online versus face-to-face experimental classes [8-10]. The American Physical Society posted an article “Moving Physics Courses Online on Short Notice,” [11] which provides some strategies and resources to quickly shift classes online. An excellent crowd-sourced resource is the PhysPort website (http://physport.org), which includes content such as running synchronous online classes, ideas for
what to do during classes, and ideas for moving labs online. Educators can freely refer to this content and learn the principles of taking online classes.

Laboratory education and research activities are major issues for both undergraduate and graduate students, and part of daily learning. Face-to-face and individualized teaching are critical in learning experimental skills. The Japanese government issued an emergency declaration in April 2020, which resulted in university laboratories being shut. This has greatly concerned teachers and made students worry about a delay in graduation. Graduate students need research results from refereed papers and conference presentations in order to be exempted from repayment of scholarship grants from the Japan Student Services Organization. During job hunts, research results are required to obtain a job offer. The issue of non-operational laboratories is more serious than the class itself and has a significant impact on and implications for student life.

The use of a virtual laboratory has been studied [12-16] and deemed sufficient to achieve learning outcomes. However, in the COVID-19, these studies are focused only on classroom lectures, not on the laboratory education. We have taken the use of a virtual laboratory because of the uncertain timespan of the emergency. Although our main field of research is experimental biophysics, we decided to change our research topics to be more suitable for teleworking. In this study, we report the research results of a teleworking study. We conducted regular meetings and shared research reports by students throughout each day and, at the end of the period of closure, students could present their research results at a conference or in a refereed paper. This study is a product of teleworking research, using Zoom, an online meeting system from Zoom Video Communications, Inc., U.S.A.

2. Methods
The teleworking approach was operational from April 2, 2020, to June 31, 2020. In this study, numerical analyses, including the average duration of meetings, were calculated based on recorded data from April 2, 2020, to May 1.

All members belonging to the laboratory attended the virtual laboratory trial. The breakdown of the members was as follows: a professor, two doctoral students (1st and 3rd years), three master’s students (1st, 1st, and 2nd years), and two undergraduate students (4th year). The two students were under Ph.D. course and they were also working in a private company.

For researches at home, experimental data which were obtained by Mar 2020 were shared using the BOX system (BOX Inc., Redwood city, CA). Every student could access the data at home using virtual private networks VPN) in order to analyze the data. Several softwares such as MS office, Adobe ETLA, MATLAB, Mathematica, and ChemOffice were available even at home with subscription. In the case of working students, the companies allowed to use softwares for finite element method (FEM) simulation.

For communication, Zoom Cloud Meetings (Zoom Video Communications, Inc., San Jose, CA) were used for online meetings and other online communications. At the beginning of teleworking, a free version of Zoom (Basic) was used, although there were several restrictions such as a time limit for meetings of 40 min. Then, our university decided to use Zoom for many of the lectures for graduate and undergraduate students. After that, we used the licensed version, at which point all software functions were available for use.

To evaluate teleworking, questionnaires were administered twice (April 17 and May 26).

3. Results and Discussions

3.1. Preparations
The teleworking period due to the COVID-19 started at our university on April 2, 2020. Although the declaration of a state of emergency by the Japanese government was not given until April 7, our university decided that students and staff should “stay home” from April 1.

There was a previous “stay home” situation in the Eastern area of Japan, in March 2011, due to the aftermath of the 2011 Tohoku earthquake and tsunami. However, there were practical differences between the situations in 2020 and 2011. In 2011, the earthquake struck suddenly, railway lines were stopped, and the supply of electricity and water was interrupted in some areas. In that situation,
preparation for teleworking was impossible. In the present “stay home” situation due to the virus, we recognized the possibility of a state of emergency from mid-March 2020, which gave us enough time to prepare for teleworking.

Our laboratory belongs to the Department of Physics, and our specialty is experimental biophysics, although some members use computer simulations. All students usually attend the laboratory each day to undertake experimental work, and teleworking has not been part of the activities.

In the third week of March 2020, we started to arrange special research topics to be conducted at home, which were presented in the final week of March. The notice from our university, to start teleworking, was given without warning on April 1, 2020, and teleworking started the following day. Although there was no grace period, teleworking got underway smoothly.

3.2. Research topics for teleworking to continue practical activities
Our specialty is experimental biophysics, but we were open to compromise at least one of our keywords, such as “biophysics,” “nanobio,” “experimental,” “nanocarbon,” and “single cell,” in order to work remotely. Based on the consensus of the discussion, the professor indicated several research plans to the students in the final week of March 2020.

The research topics for teleworking can be categorized into four types. The first choice was “data analysis and preparation of paper drafts using experimental data.” If a student had experimental data and if the teleworking period was not long, this might have been the best choice. By the end of January, COVID-2019 was already recognized due to mass infection in Wuhan, China. Based on the information from China, in February, the professor recommended that students focus on experiments to hedge the risk against the possibility of a lockdown of cities. Data analysis and preparation of draft papers can be done at home, although specific software might be necessary for analysis. On the other hand, February and March are the end of the fiscal year in Japan when several events including meetings of academic societies are scheduled. Therefore, many students unfortunately did not focus on experiments in February and March 2020, and only one doctoral student took the first choice. His subject was fabrication of a new optical cuvette for measuring near-infrared spectra of bioconjugates of nanocarbons.

The second choice was the analysis of experimental data obtained by previous students. One of the drawbacks of university lab-based research is that students are usually short of time. Thus, some students complete their experiments but graduate without publishing a paper, leaving a stock of unused data. If the current student did not have their experimental data to analyze during the teleworking period, they could analyze such previous data. One master’s degree student opted for this approach. He analyzed microscopic movies of single cell gliding in a Petri dish.

The third choice was a simulation study. Although our laboratory mainly focuses on experimental approaches, some of the working students proceed to use simulations using computers at home or their companies. A combination of simulation and experimentation is expected, but a simulation study can be completed during the teleworking period. However, only one working student, who had already focused on a simulation approach, selected this choice. He simulated dynamics of bioconjugates of nanocarbons.

The fourth choice was to give up “biophysics,” although it is our specialty. If we disregarded “biophysics,” there are many research topics that could proceed at home. Particularly, information about the emerging virus, SARS-CoV-2, is provided daily. If a student analyzes novel data, the potential for research topics is unlimited. Other approaches are also available. We performed international communications with Vietnam, the Philippines, Indonesia, and China. It is possible to report, in the form of a review article, the summary of international communications. However, long delays in international communications due to the coronavirus pandemic is unavoidable, so a new proposal on how to continue international communications in the pandemic era might be a valid topic. Many universities, however, are using the Zoom system, which is a new approach in the field of higher education. We could record the trials of our activity of the “virtual laboratory” using the Zoom system and discuss the advantages and problems of this approach, in relation to the existing literature on online research and remote working practice, in the context of science education. In fact, this study is one of the outputs of the fourth topic, and three students elected to pursue this choice. One student
recorded the virtual laboratory for this work, the second student summarized our previous international communications, and the third student analyzed ten years retrieval data of Ph.D. job opportunities in physics.

3.3. Preparation of online communications using the Zoom system

Before the coronavirus pandemic, the operational timetable of our laboratory was as follows: the “core time” of the laboratory was 11:00 to 17:00 on weekdays. Students were expected to be present during this time for research. Personal discussions between the professor and each student were carried out once per week and details of their research, such as specific problems in experimental work, were discussed. Two types of seminars were conducted; one was on reading English research papers and held every Tuesday from 11:00 to 12:30, while the other was held to report the research progress of each student, on Thursdays (18:00 to 21:10), every two weeks. Additionally, interim reports for graduation theses were performed four times per year.

Table 1. Contents of the virtual laboratory during the teleworking period.

(a) Special research topics for the telework

| Students | Research topics for the telework |
|----------|----------------------------------|
| B4       | Summary and discussions of international communications at our laboratory |
| B4       | Recruitment problem of Ph.D. researches based on ten-years original web search |
| M1       | Trial of online operation of biophysics laboratory using the ZOOM system |
| M1       | Writing budget applications |
| M2       | Analysis of biophysical data of living cells obtained by previous students |
| D1       | Analysis of own data and preparation of paper drafts |
| D3       | Simulation study of bio-nano conjugates and preparation of paper drafts |

(b) Types of online communications

| Types          | Days of week and time | Details |
|----------------|-----------------------|---------|
| Regular meetings | 10:00, 14:30, and 16:00, every day | Those were called (confirmation of the existence). Daily reports were basically carried out on 14:30. On Tuesday and Thursday, schedules were modified. |
| Daily reports | Weekday, 14:30 or 16:00 | Report progress one by one |
| Seminar 1     | 11:00 to 12:30 on Tuesday | Reading English papers |
| Seminar 2     | 18:00 to 21:10 on every other week on Thursday | Progress reports for two weeks. Interim reports for graduation thesis. |
| Lectures      | 10:00, 16:00 (irregular) | One hour lectures by outsiders. |

(c) Lectures by outsiders

| Lecturers                                                                 | Topics and dates                                                                 |
|--------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Yuji Matsukawa, Representative Director of Dangonet Co., Ltd.            | An example of training of new staffs at a company (6th April–10th April)        |
| Hisao Taira, Ph.D., Lecturer, Hokkaido University of Education          | Introduction of molecular dynamics (MD) simulation (22nd April)                  |
| Dan Chen, Ph.D., Assistant Manager, NEC Corporation (~Apr. 2020) Project Research Fellow, National Astronomical Observatory of Japan (May 2020–) | Careers of Ph.D. at a company/Introduction of Astrophysics (13th April) |
| Naoki Tanaka, General Manager, Customer Support Division, Dangonet Co., Ltd. | Description of Information Security Management System (ISMS) (10th June)        |
Based on these “usual operations,” online communications were planned as follows [Table 1(b)]: two seminars were scheduled without change, except for the use of the Zoom system. Instead of personal discussions, regular meetings were planned at 10:00, 14:30, and 16:00 each weekday. From mid-March, many primary, junior high, and high schools in Japan were closed prior to the soft lockdown of cities. However, some students visited busy quarters in Tokyo for shopping or various other purposes because they could not go to school, a behavior criticized by mass media. Considering this problem, we thought the thrice-daily meetings using Zoom might be effective in encouraging the students to “stay home.”

Regular meetings at 10:00 and 16:00 were short (less than 10 min) and termed “confirmations of existence.” Daily reports were usually carried out at 14:30. Sometimes, they were carried out at 16:00 depending on the schedules of seminars and outsiders’ meetings.

### 3.4. Results of online communications using the Zoom system

The history of web meetings at our virtual laboratory, using the Zoom system, is summarized in Figure 1(a). Although the teleworking period continued through May 2020, the graph displays data for most of the month of April. The operation of meetings in May was similar to that in April.

Data revealed that the average duration of regular 10:00 meetings was just 8 min. Interestingly, many notices from our university regarding COVID-19 arrived in the evening (18:00 to 20:00), suggesting that our administration staff had worked outside the usual working hours. The 10:00 daily meetings were a good opportunity to discuss new notices. There was an exception on April 10th and 13th, when we had one-hour lectures by outsiders, the details of which are described later. These were excluded from average time calculations.

The average duration of regular meetings at 14:30 was 38 min because all students gave a daily report of their research subjects. In this meeting, the “share screen” function of the ZOOM system was useful for detailed discussion. Figure 3(a) shows a screen capture during a discussion on microscopy images of cell migration and numerical analysis of images. Numerical values on an Excel document can be shared and seen by all attendees; however, we had some difficulties in discussing the details of microscopy images. Although the resolution of the shared screen was greatly improved compared to previous systems [17], further improvements are necessary for scientific discussions.

The regular meeting at 16:00 was generally short, like that at 10:00. The average duration for the afternoon “confirmation of existence” was 17 min. There were few important topics at this meeting and some students felt that the meeting made no sense (see questionnaire, Figure. 3). On Tuesday, daily reports were carried out at 16:00 because a seminar was performed from 11:00 to 12:30 every week for reading papers, and regular meetings at 10:00 and 14:30 were canceled. In addition, several lectures were conducted at 16:00. The average duration was calculated without including these exceptions, and the average duration of daily reports was 39 min, including those at 14:30 and 16:00.

All students, including the two working students, attended the seminars. The situation of working students has dramatically changed over the past 20 years. The stereotypical working student was a full-time worker who had graduated from high school and joined an evening course at a university/college. Evening courses are popular with working students and the number of students with high-powered jobs has increased. In our laboratory, one working student is the CEO of a company, and the other is an engineer at a research/development company that has a free-time working system. Both are doctoral students and were able to attend daytime seminars on weekdays. Other regular meetings were performed with five students, without the two working students, for whom personal discussion using the Zoom system was conducted once a week.

A seminar for reading papers was conducted from 11:00 to 12:30 every Tuesday. The average duration of this seminar was 92 min. In this seminar, research papers were selected from popular journals such as Nature. Because of the problem of low English ability among Japanese students, all papers were read aloud and then discussed in Japanese. One advantage of the online operation of the seminar was the visualization of various supporting data.

It was difficult to monitor the behavior of each attendee during seminars. Although preparation in order to understand the research topics and English text is expected, it is difficult to evaluate this using the online system. If students made machine translations of papers, using the internet, without
rehearsal, it was difficult to pick this up. Asking specific questions was one way of evaluating their level of preparation. However, in many cases, students could not reply to such specific questions, even if they were prepared, and this did not provide enough information for an evaluation.

Figure 1. Duration of Online Communication. (a) Time history of meetings (b) Total duration of meetings. Blue, yellow, red bars indicate the morning, afternoon, and evening, respectively. Solid fill indicates regular meetings, vertical stripes daily reports, diagonal stripes seminar 1 (reading papers), horizontal stripes seminar 2 (progress reports), and dotted lines lectures.
Another seminar was held from 18:00 to 21:10 on Thursday, every other week, the aim of which was to report a summary of research progress for the two-week period. The average duration was 202 min, including a 10 min coffee break. All members, including the two working students, attended the seminar. In this seminar, all attendees made presentations using PowerPoint® (Microsoft®) without any problems. Figure 2(b) shows a screen capture from the presentation. Attendees could see the graphs with sufficient resolution and participants could modify the presentation files. It was an unexpected Zoom function. One problem observed during the presentations was the use of a “pointer.” In the case of usual meeting-style presentations, the use of a laser pointer is popular. In Zoom presentations, we used a computer mouse to specifically point to a part of the slide, such as ideal cells on a microscopy image or specific curve in spectral data. It proved difficult, with the mouse, to indicate the exact location on the slide. With many academic conferences using the Zoom system this year, it is expected that the problem of the pointer will soon be improved.

In addition, an interim presentation of graduation theses was held using this method in mid-May. Some of the students also prepared presentations for online conferences.

One-hour lectures by four outsiders were conducted, a total of 8 times, as shown in Table 1(c). The topics were varied and some lectures introduced research topics. The importance of career education has been recognized in modern university/college education, and some lecturers were invited from companies to make careers presentations.

We recognize that an advantage of online lectures using the Zoom system is that we do not have to consider the location of the lecturer, who does not lose time in transit to the university. Based on this understanding, we invited a graduate student located in Canada to give a lecture. Furthermore, our professor was invited to join a committee for a doctoral-thesis evaluation at a university in the Philippines. These experiences are described in detail elsewhere.

![Figure 2. Typical screenshots of presentation at the online meetings. (a) A microscopy image of living cells and numerical analysis of cell migration. (b) Spectroscopy data for a presentation in an online academic conference.](image)
Figure 1(b) shows a summary of daily interactions. The average daily duration, including all activities on weekdays, was 105 min. Saturdays and Sundays were excluded from calculations. The total duration for one month was 2213 min for every category. Total duration of regular meetings (10:00), regular meetings (14:30), regular meetings (16:00), seminars (reading papers), seminars (progress report), and lectures were 111, 580, 194, 369, 405, and 554 min, respectively.

Figure 3. Results of questionnaires; (a) and (b) for meetings; (c) for lectures.
3.5. Evaluation of the virtual laboratory

For evaluation, online questionnaires were used in two occasions (April 17 and May 26). A summary of questionnaire results is shown in Figure 3. Because the number of attendees was 8, including the professor, statistical analyses might not be valid.

For meetings and seminars, positive comments were obtained for most questions. However, some students felt that the regular meeting at 16:00 was meaningless. Actually, the meeting at 16:00 was just “confirmation of existence” in many cases. Students have known that this meeting is held as just “confirmation of existence”.

For lectures, positive comments were obtained in all cases. One problem with the questionnaires was that the access log could be analyzed, making blind voting difficult. Thus, many students hesitated to make negative comments.

Our university allowed a return to the campus since June 1, 2020. However, all the students in our lab continued to stay home until the end of June 2020. In July, two students decided to return to hands-on work in laboratories, although others continued from home. Thus, the trial of the virtual laboratory was complete at the end of June. Since July 2020, both face-to-face and virtual laboratories have been running in parallel. In order to decrease the heavy duties of the professor, the number of regular meetings was decreased.

Almost all the students submitted their abstract to present the results of teleworking at autumn domestic conferences such as Physical Society of Japan, and online international conferences. A few students have submitted manuscripts as their product of teleworking to peer-reviewed journals for research publication, while others are preparing their drafts. One is this work, the others were single cell analysis and analysis of Ph.D. job opportunity.

4. Conclusions

We participated in “virtual” biophysics laboratories from April 2020 to June 2020, due to the COVID-19 pandemic. To achieve this, the Zoom system was very useful, although several drawbacks were reported. As a result, many of the students submitted research manuscripts and conference abstracts at the end of the teleworking period. Our trials will provide an effective strategy to continue physics education and researches even for long term battles with covid-19. If the pandemic will be short, the “stay home” could be recognized as a vacation. Students can stay at home without any scientific activities, and then, they can compensate the activity by hard works after the stay home period.

However, if the battle with the virus will be continued longer periods, we cannot stop our educations and researches during the stay home period. Student will be aged, and will have stress due to the less activity at home. Our attempt of the “virtual” laboratory with regard to higher education at research level revealed a possibility of possessing activities of educations and research for long “stay home” periods even in the case of experimental physics such as experimental biophysics.

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