Academic research during and after the COVID-19 pandemic

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Albert Einstein tried hard for many years to complete the general theory of relativity which generalized his own special theory of relativity published in 1905. His effort finally paid off, and at the end of 1915, a historic paper containing Einstein's gravitational field equations was published [1]. This history is familiar to most students of physics. Yet, not so many people pay attention to the fact that 1915 was a year when World War I, which broke out in 1914, was fiercely underway in many European countries, including Einstein's homeland, Germany. Einstein's paper, despite the war, was known to physicists in many countries and particularly attracted the attention of the German physicist Karl Schwarzschild. At the time, Schwarzschild was serving on the Russian front as an officer of the German army. In his spare time during the war, he tried to solve Einstein's field equations, and for a particularly simple case, succeeded in doing so and obtained a solution which is now known as the Schwarzschild black hole. This was an important result showing the existence of a black hole for the first time. Schwarzschild wrote a paper containing this result, which was published in 1916 [2]. Meanwhile, he became seriously ill and was released from the army in March 1916. He died two months later. I think this story shows that human beings can be highly resilient and that no matter how harsh the environment is, they can do what they truly love to do.

The pandemic situation caused by the outbreak of the coronavirus disease 2019 (COVID-19) is, of course, much less serious compared to World War I. Nevertheless, COVID-19 has had a very significant impact on everyone around the world over the past year and a half and is continuing to do so. Institutes and universities were naturally affected when lockdowns were taking place around the world last year and research, especially experimental research, is presumed to have been directly affected. However, judging from the papers published during that period, it can be confirmed that academic research continued to be strong and active and the impact of COVID-19 was not so great.

Fig. 1 is a graph showing the number of papers posted on arXiv, a representative preprint site for physics and mathematics, in half-year intervals over the past five years. Meanwhile, Fig. 2 is a graph showing the number of downloads of arXiv papers during the same period. Comparing the data from the past year and a half with those before that, it is possible to notice that there has been some impact from the pandemic. Nevertheless, the numbers of submissions and downloads during that period have increased substantially compared to before. Judging from this result, I think we can say that researchers have become well adapted to the pandemic

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Fig. 1. Number of papers posted on arXiv from 2017 to 2021 in half-year intervals. a (b) designates the first (second) half of a year.

Fig. 2. Number of downloads of the papers posted on arXiv from 2017 to 2021 in half-year intervals. a (b) designates the first (second) half of a year.

situation and are conducting research activities that are not significantly different from before the pandemic. In addition, according to the recently announced 2021 Journal Citation Reports, it can be verified that the impact factors of a large number of major journals have increased significantly compared to the previous year. This result can also be an evidence that research activities have returned to normal.

In quantitative aspects such as the number of published papers, the impact of the pandemic appears to have been overcome. However, there has been some suggestion that a closer look points out that a qualitative setback in research activity, such as a decline in the proportion of researchers starting new

research projects or new collaborative studies, is still continuing [3]. For obvious reasons, the organization of in-person conferences and seminars, which are a representative way of mediating the interaction among researchers, has been extremely reduced. More recently, however, online conferences and seminars have been actively held in many academic fields. These conferences often focus on highly specific topics, invite researchers from all over the world by e-mail, and are often free of registration fees. I have recently participated in several online workshops. I felt that there were not great differences from attending an in-person seminar, but rather felt that there were many advantages. It is perhaps a development

that has opened up a new chapter in academic exchange. Now researchers are able to listen to presentations, which, in the past, could only be accessed at a specific time in a specific place in a distant foreign country, easily from anywhere in the world in a comfortable environment. It is expected that this type of academic exchange will continue to expand quantitatively and qualitatively even after the pandemic is over, since many researchers would probably agree with the advantages of online seminars and meetings.

The pandemic has had a huge impact not only on research but also on education and training. Many universities in Korea are still conducting most of their classes online and it has been clear that this significantly reduces the quality of education. However, similarly to online seminars, online classes have considerable advantages as well as disadvantages and there are some portion of students who prefer them over in-person classes. As more and more people realize these advantages, the proportion of online education and training is expected to grow even after the pandemic is over. Furthermore, in the near future, the so-called metaverse technology, which will allow many human activities, including education, training, discussion, presentation, conference, etc., to be done online in a much more realistic environment, is expected to develop very rapidly. Such technological advances may change the shape of future research activities very differently from those of today.

It is beyond my capacity to accurately predict the future of society, including that of academic research. However, it is not difficult to predict that the changes to the online platform will continue and expand. In the future, academic research will

continue to be active and exchanges among researchers will become more active due to the rapid expansion of online technology. I hope that all of these changes will be made in a way that maintains the essence of academic research, which is the creation and dissemination of knowledge for the benefit of human society.

Conflict of Interest

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