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Sciences and inter-disciplinary research

Good afternoon, everyone! I'd like to first thank the Faculty of Arts for organizing such a great event to talk about multidisciplinary and cross-disciplinary studies. I strongly believe, as a scientist, that we have to have a liberal arts and science type of education in this country, because it enhances the overall cross-disciplinary knowledge and the strength of other fields as well. That is my personal view. I try to address all five questions in one go. If I get more time, I will address further things according to those questions.

Let me first take the first question that Kaushalya wants me to ask, 'what are the acceptable, typical methodologies in your discipline?' We have various methodologies, but I will probably touch on the fundamental and applied methodologies in research. I'm going to specifically address chemistry and technology. Fundamentals explore the real nature of the subject and curiosity comes from fundamental studies. The applied sciences, especially applied research, goes more towards the product development and commercialization. So, it's a balance between these two areas, which is a key challenge nowadays to a scientist. Because the funding organizations are demanding outcome-based research; but at the same time, as a scientist, and as a disciplinary specialist, we have to keep this subject going through new discoveries and new sciences. The five technologies that will shape up the planet in the next 20 years are nanotechnology, biotechnology, artificial intelligence, robotics, and the internet of things. Therefore, it is a very difficult task for us to manage these technologies. But I am fortunate to be part of nanotechnology research even though this was not my initial field of study. My PhD was on gas phase kinetics and laser-induced fluorescence. I moved into material science and nanotechnology after completing postdoctoral studies. Nanotechnology encompasses all major fields, such as medicine, engineering, chemistry, physics, and biology. So, we have a great opportunity for strong interdisciplinary collaborations through this technology.

The next question I have to answer is 'what are accepted research output?' Output is the first level of information. Some people argue that outcomes are more important than outputs, but as a scientist, both are important. Some projects will have outcomes, and some projects will end up in output as a first level of results. That will end up in publications.

I will quickly go through how we measure acceptable research output. In my discipline, the output is measured through patents and the peer reviewed publications. When we have innovations, we prefer to file patents. But it is very difficult these days to file a patent. The reason is that patenting in the USPTO [United States Patent and Trademark Office] or any other patenting body is absolutely expensive. It's about ten

to thirty thousand dollars for the patenting process. Then you have peer reviewed publications, and conference abstracts. These will help to increase your citations and h-index. There is a possibility of selling the patent if the patent shows promising preliminary results to support commercialization. This will transform to innovative products. You create a situation to launch a spinoff using the developed product; however, the culture of spinoffs is a rare commodity in our university system. Even though we are in an innovative science, we have a bottleneck there, because as a scientist I have no way of getting a spinoff by convincing the venture capitalist or other shareholder on it. Such rules are not yet staged in our university system but I'm sure this will come into the picture very soon. Even though we do innovative science, it is impossible to convince investors including venture capitalists to invest in spinoffs mainly due to the lack of policies developed in the country. One such example is, there are no policies for me to become an executive director or the chairman of a company producing a spinoff from my research.

Ranking is a very difficult thing to do uniformly across various disciplines. I greatly respect the humanities, and the problem with this ranking is, the ranking positions are compared across disciplines and favor some areas. Therefore, you have to be very careful with rankings. As an example, the person with the highest h-index in the world is from Harvard University, and he is a medical expert. Out of all natural sciences, only physics appears on top because in physics, the CERN [the European Organization for Nuclear Research] collaborations and particle acceleration projects produce multi-author papers. CERN collaborative research produces papers with 2000-3000 authors per paper, so impact increases exponentially with self-citations because of the multi-author papers. If you consider the humanities, it is very difficult to get into these league tables because the citations may be low. Or for example, if you take aerospace engineering, the best journals have less citations because the number of people who read are less. So we need to be very careful when we compare cross-disciplinary research, using an all-in-one matrix. If you look at Sri Lanka, in the natural science field, a particle physicist from the University of Ruhuna tops the list, with an h-index of 166, which is connected to the CERN collaborative projects. That is why some global rankings now consider the ranking lists without CERN publications because the number of citations will not reflect their true contributions to papers. If you look at a paper from Prof. N Wickramage or any other particle physicists with CERN collaborations there are about two thousand authors in that paper. So inevitably the citations go up because of the cross-citable literature. These scientists should not be compared with other scientists or any other researcher in other fields.

The younger generation is advised that if you want to have a linear increase in your citations, you need to maintain continuous publications. You cannot have

a break in your career in publications. In our case, our research group normally publishes ten papers per year: you can see the linear relationship when you take our citations. But, if you reduce the number of publications, the h-index or citation curve changes. When we are approaching retirement, our citations come down due to lesser number of publications. This will further aggravate due to the administrative roles that we play at the latter stage of our academic career.

I will give you an example of outcome-based research. It was circulated in the University website with a flashing headline that Sri Lankan scientists have found the materials responsible for the CKDu problem. As scientists, neither the Peradeniya group nor our group believes that arsenic was the problem for this CKDu issue, because there is no arsenic in our groundwater or surface water. The problem is due to the fluoride and the hardness of water. So, we have come up with a solution related to water purification in the area. We tried to make synthetic clay filters using advanced materials in our Centre for Advanced Materials and Devices. I am talking about the commercialization aspect where the scientists are interested in outcome-based research. But unfortunately, we didn't have much funds to proceed to commercialization. Due to this situation, we published this work in a top journal, in *American Chemical Society*. This is a 2021 paper and already has many citations and a readership of 1011. The team consisted of my wife, Rohini [Prof Rohini M. de Silva] and myself, Professor Dhammike [Dissanayake] and three of our PhD students, as well as Prof Koswattage from Sabaragamuwa University and two more collaborators including Prof. Gareth Williams from University College London which is the seventh ranked University in the world. So, our research team is a multi-disciplinary team. We have multi-authored peer-reviewed publications which have an added advantage for citations.

And then at what stage is the research published? We normally publish in peer-reviewed indexed journals after patenting. If it is not patentable, we publish in peer reviewed journals just after we have tangible results with double verification. As and when the scientists believe that our results address our research questions, we publish.

The last question: the threat. For many, the threat is the fundamental versus applied research issue. Globally there is less funding for fundamental research and more funding for applied research. However, there should be a synergy between the fundamental and the applied. The moment you kill fundamental research, there will be no applied research. My personal view is, if the policy makers push our National Science Foundation and National Research Council towards funding only for applied outcome-based research, we are heading towards a dead-end. Rather, the fundamental and the applied should strike a balance between these two areas where the fundamental research can reach outcome-based research. From Sri Lanka's point

of view, I have a sad story about that resulting in poor decision making. I always believe that politicians should not intervene with appointing people to scientific bodies because that creates biases in thinking, appointing poor ineffective leadership, people with lack of vision, and no meritocracy. This is mainly due to either political gains or the ignorance of policy makers. And talking about the field of science and technology in Sri Lanka, my personal view is that we will be heading for a crash landing very soon. Of course, I am happy that the University of Colombo is pushing very hard to promote science and technology through our internal leadership. Thank you very much.

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