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Musings of an experimentalist

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Good morning everyone and thank you to the organizers for allowing me to deliver this talk. In this talk, I'm not going to discuss any technical or any other special work of mine. Rather I would like to share with you my experience as an experimentalist.

At the outset let us first understand who is an experimentalist. An experimentalist is a person or the researcher who performs the experiment. But when we say performing an experiment it doesn't mean that the experimental setup is made ready by someone already, the experiment will perhaps come, switch on the power, perform the experiment, and then go. The experimentalist will in fact do much more than that. So to define what is an experimental or who is an experimentalist it is important to first define what an experimentalist actually does.

First of all, there should be an idea that the experimentalist would like to try. There may be some hypothesis or there may be some theory that needs to be proved or that needs to be checked or some other formula, some other law that needs to be proved. So the basic idea that needs to come to the mind of the experimentalist that something is to be proved. Then the experimentalist will have to come up with a design, that outlines what sort of experiment, what sort of instrument, which phenomenon, etc, to be used in order to prove the law or to validate the hypothesis. Therefore it is also the responsibility of the experimentalist to come up with a design. Once the experimentalist designs an experiment then it is to be converted to the actual experimental setup. Now you, the experimentalist, will need to think about what components, such as electrical, mechanical, electronic, and optical ones are required to complete the experimental setup. Here the experimentalist needs to be a bit pragmatic and should first find out which components are already available, and preferably use those components first. You should prepare a list of which components are to be fabricated and which components are to be purchased. If a component is not available in the existing pool of components then the experimentalist will either try to make it or buy it.

Once all the components are ready or available, you will then have to build the experimental setup. Your next task after building the experimental setup is to perform a proof of principle experiment. Making or fabricating the component is also part of the job of the experimentalist if a certain essential component is not available to purchase. You need to verify the working

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of each and every component, verify the working of the software, and so on. If the software is not there then it is also the job of the experimentalist to develop the software for the purpose of performing the experiment. And finally to perform some very simple measurements or make some very simple observations just to ensure that the experimental setup is working perfectly and only then you will have to perform the actual experiment. After performing the experiment, the experimentalist will record the data and then will analyze the data to see if a particular law or a particular hypothesis is validated by the experimental data or not.

All these tasks stated above are, in principle, the jobs of the experimentalist. While performing these jobs the experimentalist will encounter a large number of challenges, many of these challenges are global in nature while some are local in nature. A challenge of a global nature is faced by a scientist all over irrespective of whichever country he or she belongs to. One major global challenge is that even after understanding the principle, the working of the components, the working of various devices, a certain device may not be giving the result as specified or as expected. Now it is also the job of the experimentalist to figure out why this particular component or this particular device is not working in the expected way. However, even when the component or the device is working in the expected way even then the result obtained with the component or the device may not agree with that expected .result. This is because perhaps the theory was not complete or the theory or the phenomenon was not properly understood. So the experimentalist will have to go back and think whether something is missing or there are other sets of factors affecting the experiment which was not taken into account, requiring something in the experimental setup to be modified. The experimentalist may need to come up with more trial experiments till it is found that the device is working properly. Therefore it seldom happens that the experimentalist will simply switch on the power of the experimental setup, the experiment will run and the results will come which will agree with the expected result or as suggested by the theory.

There are other sets of challenges that are local in nature. As we have discussed already in order to make a setup ready, one will require a large number of components, some of these components can be locally available whereas some other components need to be imported from outside. Now while purchasing components from outside one has to follow a certain procedure. Especially if the funding is by a government agency then the purchase process needs to follow the existing rules and regulations. Therefore the purchase process will involve a certain amount of paperwork to be done and certain formalities to be followed besides ensuring that the items procured are of the requisite quality. Therefore as far as the duty of the experimentalist is concerned there has to be a good balance between the paperwork and the actual experiment. Moreover irrespective of the amount of time to be spent on the paperwork, the experimentalist cannot afford to lose sight of the actual scientific objective of the experiment.

Another local challenge is when some component has gone wrong, which is to be repaired but there is no local technical expertise to repair the same.

Thus there are both global and local challenges to be met and addressed while performing the job as an experimentalist. Perhaps that is why experimental subjects are less preferred by

students for research especially when the students have other options. For example, if a student has done the graduation and has the option of choosing either experimental or theoretically oriented subjects, from my experience I find that in most of the cases the students choose a theoretical or a computational subject. However in spite of the above-discussed challenges, end of the day, I think as an experimentalist you achieve multifaceted accomplishments which provide you with a lot of pleasure and satisfaction. As an experimentalist, I draw pleasure and excitement from three different occasions. The first occasion is even before performing the experiment itself. Before performing the experiment you have to think about the entire problem at hand, you have to think about the entire phenomenon associated. Then you have to design the experiment, you have to think about which components are needed and which components are available. All these will require a deep understanding on the part of the experimentalist of the entire phenomena or the entire requirement. That way your concept or understanding about the whole problem gets improved giving you in return a significant amount of satisfaction.

Then you will check the working of each and every component. Some of the components you are familiar with, some of the components you may not be familiar with, and some of the devices you may be working with for the first time. So you'll also have to figure out the working of the devices as well. While figuring out how the devices work, you may have to design certain small trial-and-error experiments. In the process of figuring out how the various devices or components work, you will develop a deep level of understanding.In fact, you develop such an amount of understanding, even the manufacturer or the technical person associated, at a given time, with a particular device may not be aware of the same. The kind of understanding the kind of confidence, the kind of expertise you develop while figuring out the working of various devices gives you a lot of pleasure and satisfaction.

During the experiment, to ensure that every component is behaving correctly, you have to develop a logical approach. You have to trust your logic, trust your logical understanding, because any time the experiment may behave in a random or haphazard manner. Nevertheless, you have to trust the logical understanding that will allow you to do the experiment again and again till you figure out what is going wrong with the experiment. Finally, you will figure out what is the fault and then you will find a way to correct it.

The experiments teach us to be sincere. You have to follow certain rules & regulations both temporal and logical while working with the setup. The experimentalist cannot afford to make a single mistake. So it definitely teaches us to be sincere.

During the analysis of the result, to get everything as required and to validate the theory will require a complete understanding of all the processes or steps. Starting from the basic idea and setup design to performing the actual experiment, all these will require a holistic approach. So you develop a full or complete understanding of the entire problem. This experience, where you start from scratch, you understand the theory, you do the design, you may fabricate the device, you buy components or you manage it from somewhere, you test it, you perform the experiment, then you analyse the result, incorporate error, understand how the actual system is behaving, understand how the phenomena are taking place, how different external phenomena, which were

previously not taken into account are coming into play, altogether gives you very good learning, develops your understanding and gives you a comprehensive knowledge or comprehensive idea of everything. Such an amount of experience will not be available to anyone else other than an experimentalist.

However, as I said already not many students are drawn to the experimental areas. I am from optics and I see brilliant students not coming to experiments. However, technology cannot be developed without performing experiments. Today's experiment or something that is coming out from the experiment today may become technology tomorrow. So, if we want to excel in technology one day, more and more students with imagination, and good analytical skills should come to the experimental areas.

Then what can be done and what lies ahead ? One important point to be taken into account is breaking the stereotype. There seems to be some kind of a narrative or some kind of opinion that experiments are easy or experiments are boring. Both narratives may be running at the same time, as a result, talented students will buy this narrative, will think experiments to be uninteresting, or think that to perform an experiment one does not require any talent or does not require imagination. Although the truth is that experiments require talent, imagination, sincerity, and hard work. A talented student, one with imagination will able to achieve a lot as an experimentalist. So this stereotype needs to be broken. And this should be broken in such a way that the new talent gets attracted towards the experiments.

In order to achieve that the communication modes of people like us who have been doing experiments, need to be changed. There is a need to focus through communication on what is the pleasure or what is the fun in spite of the challenges, and what are the scopes to the younger generation in a manner that is understandable to them. So we should have better communication only then we will be able to attract the younger generation.