J. Indian Inst. Sci.
A Multidisciplinary Reviews Journal
ISSN: 0970-4140 Coden-JIISAD

Editor's Desk

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We often talk about scientific temper but seldom about engineering temper, or for that matter, business temper, legal temper, literary temper, aesthetic temper, and so on. There is something about scientific temper that cuts across different domains of human endeavours. A businessperson could have a scientific approach to a problem. A lawyer or a judge would certainly use scientific reasoning in arguing a case or delivering a judgement, respectively. An artist might use scientific thinking to convey one's inspiration though a chosen medium. Therefore, scientific temper is not just about science per se. Jawaharlal Nehru said this eloquently in his book, *The Discovery of India* (Religion, Philosophy, and Science):

> *"Science deals with the domain of positive knowledge but the temper which it should produce goes beyond that domain."*

Nehru advocated and popularised the idea of scientific temper to help a young nation prosper. He wrote a long passage to explain what scientific temper meant to him. Two excerpts should suffice for our purpose:

> *"The applications of science are inevitable and unavoidable...But something more than its application is necessary. It is the scientific approach…the* **search for truth and new knowledge**, **the refusal to accept anything without testing and trial**, *the* **capacity to change previous conclusions in the face of new evidence**, *the* **reliance on observed fact and not pre-conceived theory**…"
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> *"…the scientific approach, the adventurous yet critical temper of science, should be, a way of life, a process of thinking, a method of acting and associating with our fellowmen...It is the temper of a free [wo]man…"*

It is useful to examine the etymology of "temper". The Latin root "temperare" means "mingle" or "restrain". Old French root "temprer" denotes "moderate". Old English's "temprian" implies "brings something into the required condition". Current connotation of "temper" indicates the state of mind, mood, or one's habitual way of thinking, behaving, or acting. Thus, it is not surprising that scientific temper, which embodies four generic traits highlighted in bold in the excerpts from *The Discovery of India*, goes beyond science and concerns all human endeavours.

Now, I wonder: Is there a general spirit of engineering? Is there an equivalent general interpretation of engineering as one that exists for science? Is there engineering temper that we can talk about? I think we can, and I feel that we should. Let us consider four general traits of an engineering mind that parallel those of a scientific mind:

- Disquiet about inadequacies that can be improved.
- Fortitude to solve problems by finding viable solutions.
- Ability to apply and extend scientific concepts.
- Reliance on one's endeavours and not ineffective prior solutions.

Let us examine these one by one to assess if they are distinctly different from the traits of a scientific mindset.

Science, as it is generally interpreted, is about observing and understanding what is already there. Therefore, a scientific mind may perceive an inadequacy and try to analyse the causes and consequences. An engineering mind, on the other hand, would want to overcome that inadequacy and thereby change the status quo. For instance, a politician might engineer a new legislation to address inequity in society. Thus, a person with engineering temper would be uneasy when something could be made better but has not been attempted.

Engineering, as it is generally interpreted, is about solving problems. Therefore, a person with engineering temper would have the resolve to find solutions to problems. A judge with engineering temper, bothered by the delays in the judicial system, might look for a new

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solution to expedite legal processes. Engineering is one's predilection to create things that do not exist before or to modify the existing ones.

Engineering temper should also include the ability to solve problems. Businesspersons would not sit quietly when market demands change. They would seek new ways to retain their edge in the market. They would need to engineer a new tactic. The intrinsic ability or cleverness to solve a problem in any domain is also engineering. The Latin root of engineer as a verb is "ingeniare" (to contrive, to devise) and the noun is "ingenium" (cleverness). Etymologists assert that engineer (*v*) arose in a political context in the middle of the nineteenth century to imply figuratively "to arrange, contrive, guide, or manage using ingenuity or tact". Therefore, having engineering temper amounts to being clever in solving a problem. That is why perhaps strikingly good solutions are often called clever solutions. They are all engineered, be it in literature, art, politics, business, or any other domain. It is not unlike what professional engineers do in developing new technologies by applying and extending scientific theories. Who have imagined umpteen ways lasers are used today since the first laser was built in 1960? Ingenious people with engineering temper, of course. It is not only the plethora of clever applications of lasers that should amaze us but also the processes that produce lasers of specific wavelengths and intensity, and at affordable cost. The ability to extend science for useful application goes hand in hand with engineering temper.

Just like people with scientific temper would rely on observed facts and not on pre-conceived notions, those with engineering temper would rely on their own effort in finding a new solution rather than accepting existing solutions that are ineffective for a context. An extreme example, I would argue, is Mahatma Gandhi's *ahimsa*—the principle of nonviolence. It is deemed to be a philosophy or a strategy to bring about social change. Gandhi not only contemplated achieving peace through nonviolence but also engineered a new strategy for gaining independence using nonviolent means. We can all recollect many profound to mundane solutions that were found when past methods did not work. All those in any sphere of life were found by people who had the engineering temper. Inventions occur to people who think creatively. Marvellous inventions arise from original thinking. Innovations too come about when people improve upon existing solutions. This is universal in all fields and not just in professional engineering.

Thus, there are certain qualities associated with an engineering mindset. When engineering temper becomes a way of thinking in society, it will help overcome many of the problems we face, both at an individual and social levels. This kind of temper will gainfully complement the scientific temper, which serves to better understand the world around us, to make our society more rational and prosperous.

Here is why I write about engineering temper in this editorial: after research on space biology was contemplated in a faculty retreat of the new centre for Biosystems Science and Engineering in 2015, we began to pursue it slowly. At that time, a colleague had asked me why we are calling it space biology (a science) and not space bioengineering. I had not considered this question then, perhaps because I believed that understanding how conditions in space (e.g., radiation and microgravity) influence living organisms needed observations and experiments. But as we made progress, it became clear that engineering solutions are also needed to conduct the experiments in space, and on earth by simulating microgravity conditions. Researchers with a larger measure of scientific temper than engineering temper would tend to buy instruments off the shelf, whereas those with a larger measure of engineering temper would work on building their own instruments.

One such engineering colleague of mine, Prof. Aloke Kumar in Mechanical Engineering, has developed a process to make brick-like structures in extraplanetary environment using bacteria that survive in extreme conditions. He has thus embarked on a journey that does not stop at understanding something but goes further using that knowledge for gainful outcomes. Of course, one cannot venture into research in a new domain without the help of scientists. Therefore, we reached out to two JPL (Jet Propulsion Laboratory, Pasadena, USA) scientists, Dr. Kasturi Venkateswaran and Dr. Murthy Gudipati. They visited IISc, taught newly formulated courses on astrobiology and astrochemistry along with Prof. Aloke Kumar, Prof. Varsha Singh, and Prof. E. Arunan from IISc, and helped us organise a conference on the subject. It is most appropriate that the two JPL scientists and Prof. Arunan are also guest-editing this issue. I thank these guest

editors, numerous authors, and reviewers who made this issue possible.

IISc is also working with ISRO in space research that will help in future missions and the imminent Gaganyaan mission of ISRO, which aims to send Indians to space in a couple of years using mostly indigenous technology. Scientific and engineering tempers are integral to these efforts.

Publisher's Note

Data availability

Not applicable to this regular editorial article.

Published online: 2 September 2023