

TECHNOLOGICAL vs SCIENTIFIC Research

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Summary:- *Technological and Scientific research are, in some sense, duals of each other. Ignoring this duality can lead to incorrect decisions in research management and consequent loss in the quality of research.*

Introduction

The aim of technological research is *utility*. Utility in a given situation is sought to be maximised by exploiting the *specificities* of the given situation as much as possible. However, one is prevented from complete exploitation of specificities due the threat of *obsolescence*- the situation might change slightly and one can't afford to throw away the earlier solutions. One is then forced to look for *generic* solutions.

Dually,

The aim of scientific research is *insight*. Insight is sought to be obtained by looking for *generalities*-i.e properties of phenomena which remain invariant over a wide variety of contexts. One wants to extract from the diverse phenomena some general laws sufficient to explain the apparent diversity. However, one is prevented from over generalisation due to the threat of *weakness of theories* - A weak theory is one in which one can derive seemingly powerful statements, but when particularised to interesting cases can yield only trivial statements. One is then forced to pay attention to the specificities of situations.

But, the fact that both technological and scientific research necessarily have facets in each other *doesn't mean that they are interchangeable!* The intellectual ambient, motivations of the persons involved, infrastructural requirements both physical and managerial- are rather different. Ignoring this difference leads to incorrect policy decisions in research management and leads to situations in which very competent researchers- technological or scientific- are deployed in unproductive ways.

As an aside let us remark that we have identified technological and scientific research **not** with subject matter, but with **attitudes**. Under this view, it is possible to identify situations in which a scientist works in a 'technological mode' (for example when he undertakes a thorough case analysis of a concrete instance of a general theory which he is trying to develop) and vice versa. Such temporary changes of modes are necessary due to reasons given in the beginning of this note.

A nice example which illustrates this difference is given below: This example shows that even within pure sciences one can detect this difference (This difference is related to the 'Computation vs Concept' made by McLane). This also shows that, in general, 'Computations' precede 'Concept formation' and Technology precedes Science; Technology provides the 'experimental' knowledge; rational reconstruction of this knowledge is then attempted by the 'Science'. (Insert here the details of Fermat/1640, Euler/1736 Ivory/1806, Dirichlet/1828 Lars Garding Ch.2).

One might say that these are obvious facts. Why then, should research seem to make decisions which are inconsistent with these facts? Some of the potential reasons are given below:-

1.The carrot and the carrot

Why are 'obviously' incorrect decisions not avoided?

In the Indian context, research is done mostly in Government organisations. A characteristic of these organisations is that people who make bad decisions never have to face the consequences of their decisions. If at all anybody does face such consequences, they are typically from the lower parts of the organisational hierarchy who do not have any say in the decision making process. Therefore there is no incentive for the decision makers to *avoid* making bad decisions.

2.WE can do it policy

Why does an organisation built for Scientific research get into Technological Research? There are many reasons: One of them is elaborated here:

Sometimes a misguided zeal is at work: typically an Institute meant for Scientific research takes up Technological research because 'the guys who are supposed to be doing it are not and the country needs it'.

3.The Caste Factor

Conversely, why does an organisation built for Technological research try to get into Scientific research? There are many reasons: One of them is given below: A technological institute wants to get into scientific research because it is more 'respectable'. This in turn is caused by a misconception that technological research is easier! Such a misconception tends to overlook the fact that technological research has to be done in a fuzzy and unpredictable world whereas scientific research can restrict the degree of freedom of the entities it studies by 'axiomatisation' resulting in simplifications. ('axiomatisation' is a phrase used in Theoretical sciences. In the context of Experimental sciences, we use the phrase 'controlled experiment' instead. Here one might remark that even in engineering one demands certain 'environmental control' for the designed artifacts to work properly. The difference between this demand and that of the experimental sciences lies in the cost ratios involved: one would not mind setting up an elaborate infrastructure for experimental sciences, whereas an engineering

artifact whose cost of environmental requirements far outstrips the cost of its functional component can hardly be called a good engineering solution!)

4. The Ambient mismatch

Each type of research needs a different ‘ambient’. In the case of **technological** research, since *utility* is the ultimate test there must exist a *serious* user (defined as an user who will be in serious trouble if the research project doesn’t succeed!) of the research output who constantly evaluates the project and gives appropriate feedback. In short, technological research is a Two-person (hopefully a +ve sum) Game. One doesn’t expect a simulation of such a game by One person to produce anything worthwhile! (In the Indian context this fact places an *upper bound* on the *attainable* quality of technological research, especially those involving high technology. It also makes any (real) breakthrough in high technology research in the Indian context all the more remarkable.)

What about **scientific** research? This too is a Game between two communities, but with a twist. Both the communities are the same! In detail: We pointed out earlier that insight is the main goal of this type of research. But due to the sophistication of the concepts employed in this type of research (sometimes merely due to ‘jargon’) no **other** community can correctly evaluate the claims of excellence in the area of scientific research. There is no concrete or visible product which a ‘outsiders’ can behold and admire. In this situation how does one evaluate and ensure the quality of ‘insight’? The only possible solution is an extreme self critical attitude of the community towards its own work. This needs, not only *intellectual honesty*, but also lot of *scholarship* to avoid the danger of ‘patting oneself in the back’ too early. (Lack of these qualities within the community leads to unseemly squabbles. Lack of these qualities at the decision making level leads to the end of any serious research). To complicate matters, all this has to be achieved in the context of ‘one-upmanship’ typical of the community.

On the other hand, contrary to the case of technological research, one doesn’t have to live with a constraint (of the availability of a serious user community) which externally imposes an upper bound on quality.

What determines the quality of research?

In the light of the above discussion, one can ask- what are the parameters which determine the quality of research? Earlier, we have compared both types of research activity to Games. The answer to the question above thus lies in asking ‘What parameters control the quality of these games?’- and then interpreting the answers. Lopsided teams (the extreme case of this is complete absence of one team), Inappropriate playing conditions, Non-existent or improper umpiring, Inappropriate training of the players etc..all can adversely affect the

quality.

Conclusion

The requirements on the ambient for carrying out technological research and scientific research are rather different. Attention has to be paid to this aspect for building a high quality research group. Conversely, ignoring this aspect can only result in a mediocre research group- whether it is technological or scientific. In my view, there has been insufficient discussion about these issues within our research community. Either the bodies who are supposed to be thinking about these issues do not realise the important of these issues or they think these issues are too abstract to worry about or We seem, as a community to be responding merely to local fashions or so intent on doing 'local optimisation' that we do not care about the long range impact of our decisions on research management and quality.

Finally, to avoid misinterpretation, I would like to make the following remark: I am not trying to argue for the superiority of either scientific or technological research. I wish to point out, however, about the different requirements of the ambient. Since at least part of this ambience is a property of the organisations set by tradition, it's people and managerial structures, and is 'incubated' over a long period of time, it has a large 'time constant' of change. These facts have to be kept in mind while taking decisions which determine the structure and orientation of research groups.