Creativity

Innovation

R&D Outcome

Perspectives On Innovation, Globalization and R&D

Impact Factor

By

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Talent

Globalization

Engineering Evaluation

Intellectual Property

Editor: Sachin Jangam

Foreword

Libraries in practically all disciplines are overloaded with voluminous scholarly literature dealing with the study of buzz-word topics such as creativity, innovation, research and development, intellectual property rights, archival publications, impact factors, citation analysis, etc. Authors of such literature are often recognized authorities from academia, typically from business and management schools with non-technical background. Statistics is a tool of choice when a non-technical author analyzes a technical subject, obviously with its inherent advantages but also limitations. What is worrisome is that policy makers in industry, government as well as academia are apt to use such "scholarly" literature to define R&D policies. We believe it is important also to take view points of those who actually define and carry out R&D, and not only those who provide financial, accounting, marketing, and similar support services to R&D.

This compilation of short articles written by Professor Arun S. Mujumdar over the past several years is a result of the aforementioned thinking process. It is intended for leisurely reading by graduate students, faculty members, administrators and researchers in industry, academic as well as government agencies. Often, it gives a unique and very different viewpoint that is worth pondering over. Not everyone is expected to concur with the viewpoints of Prof. Mujumdar but certainly most will want to take a second look at their own ideas on the diverse topics covered; the topics and viewpoints presented here may indeed help develop a paradigm shift that will be beneficial in the long run.

It should be noted, however, that this book focuses on engineering and technology and R&D in these areas. Some of the proposed ideas on R&D may not be applicable to non-technical areas nor even to pure science. This should be borne in mind by the readers to avoid potential confusion or misinterpretation.

The credentials of Prof. Mujumdar to write on the topics of this compilation are impeccable. He has conducted and supervised extensive industrial as well as academic research first at McGill University in Canada and then at the National University of Singapore, both highly reputable and highly ranked institutions of higher learning. He has also been a visiting professor at universities in Japan, China, Brazil, India, Malaysia, etc. He has supervised a massive number of R&D projects in diverse areas over a period of four decades. He has published extensively in the archival literature. His global exposure is evident from the fact that he has lectured in over 40 countries in four continents. He has done successful collaborative and interdisciplinary research with over a dozen institutions in three continents. His industry exposure comes from R&D consulting he did as President of Exergex Corporation, Canada, which included consulting for over 75 corporations, very large to start-ups. His unique and peerless familiarity with global R&D as well as academic institutions and engineering education gives him exceptional credentials to write his viewpoints that readers around the world can benefit from. Prof. Mujumdar is also a prolific reader and covers not only his research areas but also related topics like economics, finance, innovation, creativity, management of technology, climate change, energy crisis, etc.

Foreword (Continued)

Extensive resources are devoted to R&D by both developed and underdeveloped countries, often without commensurate returns. Why does it happen? Is there an optimal and sustainable way of funding R&D? Are there useful guidelines on how not to do R&D? How does one evaluate effectiveness of R&D and return on investment in R&D? Is R&D expense a cost or investment? Should countries compete or collaborate and cooperate in R&D? How does globalization affect R&D? Is fraction of GDP devoted to R&D a meaningful indicator of actual output? Does IP promote or inhibit R&D? Is there an optimal mix of basic and applied research? Should developing countries do R&D at all? What is the difference between innovation, invention and renovation? Why are capital intensive industries less prone to innovation? Should one seek radical or incremental innovation? Is radical innovation always disruptive or game-changing? Is a highly cited paper in a high impact journal really impactful? Why is it that very high impact journals publish very highly cited papers in certain areas e.g. in Cancer Research, and have yet to find a real solution to cancer after many decades of billion dollar research expenditures? Is the basic concept of impact factors valid? Can one truly compare high impact factor papers in sciences with lower impact factor papers in technology or engineering? If these kinds of questions have troubled you, maybe you can find at least partial answers here. If not, at least you will find relevant food for thought!

In agreement with Prof. Mujumdar's expectation, we too hope the reader will not necessarily agree with every idea or suggestion in this thought-provoking, yet easy to read, book. As the old adage goes, "If everyone thinks the same, then no one is thinking." This compilation is intended to stimulate, not terminate, discussion on topics of critical interest globally. The world is eagerly awaiting sustainable solutions to serious problems of the nexus of food, energy and water. Prof. Mujumdar correctly notes the importance of the 3 E's - Ethics, Economics and Environmental Commitment - in education as well as R&D

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What is R&D? : The Multiple Meanings of R&D

Perhaps the most popular definition that covers a lot of ground is: Discovering new knowledge about products, processes, and services, and then applying that knowledge to create new and improved products, processes, and services that fill market needs.

Knowledge itself has several meanings and interpretations. R&D also has a broader definition for tax purposes. Since taxation systems differ widely around the world, R&D expenditures are treated differently by the tax authorities in THE USA compared to those in EU. The objective of this short essay is about R&D as it applies to engineering and science and its use in industrial development. We also exclude market research from this definition without undermining its importance in the marketplace.

There is ample scholarly literature and an abundance of statistical data which confirm a positive correlation between R&D intensity of a country, industry or company to its economic well being. As always, statistical surveys and interpretations are subject to uncertainty levels that can reach rather high values since simple numbers cannot quantify important factors such as efficiency of R&D fund utilization and effectiveness of the effort itself. No amount of R&D dollars will yield a useful outcome if it is spent tackling a wrong problem – the technological equivalent of “barking against a wrong tree”. Definition of the R&D problem is the key to success and yet this is often done by non-experts who are only remotely knowledgeable about the problem and the outcomes expected. It is important to be able to decide the optimal level of funding and human resources and the rate at which the given R&D can be done. Throwing a huge bunch of dollars at a problem does not make the problem go away. It only produces a large hole – and a false hope- to sink the effort with little or no return. Human talent is the important key to success. Technologies today are highly interdisciplinary and complex. To be effective there is a critical mass of talent and a critical mass of material support needed to hope for success. By definition there is a risk element in all true research; how to minimize and manage it is another important issue.

Often we tend to propose or plan research based on published literature or even media reports on what will be in vogue in the near future. This can be misleading as history of R&D has repeatedly shown us. In this globalized –and somewhat flat world- what other parts of the world do can affect the short term future of R&D trends. If someone in Timbuktu solves the R&D problem before you do, then your R&D project needs to be canned for no fault of yours. One must be riding on the information highway all the time. Then there is private sector R&D which is not publicly reported. This can pose even greater risk. As the old adage goes: "Great minds think alike”; we can extrapolate it to not-so-great-R&D-minds and say that they too can think alike and thus work on similar R&D problems elsewhere. Whoever is first to score wins the R&D game and eventually-if all goes well beyond, R&D captures the global market.

R&D usually means Research and Development. During economic downturns, unfortunately it takes on another ugly meaning: Restructure and Downsize. Since R&D returns take much longer to materialize -they do at all- it is convenient for the accounting and finance people to reduce or drop R&D support and yet show no effect on the bottom-line while they are still at the helm. The negative effects may follow well after all bonus figures are computed and disbursed safely. It is a pity that many companies do follow this On-Off policy for R&D and thus may have nothing really innovative to show after decades of heavy R&D expenditures except new superficial designs of headlights, wipers and colors. R&D must be relevant and deployable. Pie-in-the-sky type R&D in industrial settings generally does not represent effective use of funds. Clearly, companies that do in-depth R&D in a sustainable fashion without looking for short term gains or returns will survive the brutal competition. I believe last few years have shown ample big examples of the rise and fall of great industrial empires; at least a part of the reason for the fall has been due to lack of innovation which requires effective R&D as the engine.

Not all R&D happens to be innovative or original. Some are simply of the Read and Delete variety. They try something based on reading literatures and then are forced to quickly delete such projects as they are by definition not innovative and already done! Another possibility for the non-innovative R&D personnel is to Reproduce and Deploy someone else's ideas. This again is bound to fail. How about Reengineer and Design? This too lacks the element of innovation and must head towards failure. R&D scientists and engineers must be reliable and diligent. They must refrain from the policy to "regurgitate and duplicate". In short, successful R&D ventures need talent that is hard to come by. Unless industry and government agencies make it attractive for bright young scientists and engineers to seek higher education and develop superior research skills under excellent mentorship, the shortage of talent will remain a problem. The financial returns for such talented researchers must be commensurate with their value to industry and to society as they are the ones who will drive the national economic engine through manufacturing hard products rather than produce only a service industry that does not by itself create wealth.

A New Avatar Needed for PhD Programs in Science & Engineering

Both empirical and anecdotal evidence shows that the United States has a lion's share of top educational institutions of the world. A recent article by M. Mills and J. Ottino, which appeared in Forbes magazine (http://www.forbes.com/2009/06/3), worries that the graduate programs in the US academia "may be drifting in the wrong direction". While new funding can stimulate higher enrollments in science and engineering, it cannot assure that "skillful innovators (will) emerge from the halls of academia". They blame this on the fact that educational institutions everywhere are producing PhDs that are required to and hence constrained to think with only half a brain. Specifically such programs require use of only the left brain which performs logical, analytical, rational, detailed organizational activities but does not require use of the right part of the brain that is needed to process intuitive, emotional, artistic, creative activities which can result in innovation. It is necessary to combine a dose of humanities with sciences and engineering subjects to produce PhDs that utilize whole brain.

The left and right hemispheres of the brain are known to have specialized functions confirmed using brain scan technique called Positron Emission Tomography (PET). The left side of the brain processes activities involving numbers, sequences, puzzles and analysis. Activities involving music color, imagination, creativity etc are the responsibility of the right side of the brain. The right side sees the big picture while the left side sees the detailed parts. The left side is often termed the Academic Brain and the right side the Artistic brain. Research in neuroscience shows that a balanced involvement of both sides of the brain in thinking processes shows great enhancement in learning and creativity.

While most undergraduate engineering and science programs to include core requirements for a number of humanities and social sciences subjects, there is no such requirement in postgraduate programs. In an effort to seek greater depth in narrower sub-disciplines (which have a strong potential even to disappear given the current rate of change in technologies) there is less breadth and total neglect of right-brain subjects. In the long run this is counter-productive since such programs are not able to produce a crop of innovators despite heavy investment of time and effort by all stakeholders. Of course, as always there are notable exceptions. Despite such left-brain- focused programs a number of graduates have turned out to be great innovators and have excelled in creative activities. As Mills and Ottino point out, there is need to instill both left and right brain activities right from grade and high school days. I could not agree more with their defining statement that "we must avoid bifurcation students into "math-and-no-art" and "art-and-no-math" tracks- a process that is commonly practiced in most countries in the world. I agree with these authors in their recommendation that art, literature and music become part of science and engineering application processes to produce graduates who can utilize the prowess of the whole brain. Today, unfortunately, there is a shortage of whole brain thinkers.

The recent box office hit movie Avatar prompted me to come up with the title of this short article. Indeed, production of this movie, which took four years, required two years' worth R&D! This movie is a monumental testament to the striking result of whole brain thinking processes. Such a record-breaking movie could not be the result of only the left brain or only the right brain thinking processes. Taking on a new Avatar is no mean task since this involves redefining goals of education and research at academic institutions and possibly an even harder task would be to find faculty or mentors who themselves are comfortable with whole brain activities. Doctoral students often try to meet research objectives set by their professors or funding agencies. This naturally limits their ability to be creative and thus apply or develop their right-brain skills during the execution of their research. Successful completion of their PhD depends almost exclusively on their left-brain activity. Clearly major changes are needed at all levels to let the PhD program take on a new Avatar.

Imagine what the world will look like a couple of decades from now if our graduate schools nurtured whole brains of our talented pool of scientists and engineers who could be tasked to solve the enormously challenging problems the nexus of water, food and energy pose to the entire world.

On Industry-Academia Collaboration in R&D

The high level of interest in drying R&D, particularly in the academic institutions around the globe, is evident from the series of successful conferences devoted to drying that were held in 2009. It is heartening for me to note this continuing intense activity even after three decades since the first major conference, the biennial International Drying Symposium (IDS) series was launched in Montreal in 1978. By the nature of R&D, especially in highly specialized areas like drying technology, the half life of any field is rather short as new areas emerge and take up the limited human and financial resources. Despite the rapid emergence of bio-nano-info areas, drying R&D has remained an active area in most parts of the world with notable exceptions, which prove the rule. Of course, the half-life by definition is finite and unless we redirect the effort, while remaining within the drying technology, there is potential for a decline in the global level of this activity.

I have repeatedly noted the need for greater industry participation in drying R&D even if carried out fully in academia. Drying is a multi-disciplinary applied area, which can thrive only as industry introduces new ideas that emerge from academic R&D. In fact, drying R&D can be justified only on the basis of advantages to industrial practice. Improved energy efficiency, reduced environmental impact resulting from reduced carbon or ecological footprint of novel dryers, enhanced product quality, safer operation, etc. are among the advantages drying R&D can offer to industry and indeed to the society at large.

Often there is disconnection between industrial R&D and academic research. This arises partly from the different time scales of the two processes and also the basic approaches and objectives. While industry is rightfully interested in faster turnaround (shorter time scale) motivated by the need to make a profit, academia are charged with the task of educating researchers and producing knowledge typically without the profit motive. While industry is interested in R&D to enhance products and processes, academics must focus on generating knowledge (know-why as opposed to know-how) and on training highly skilled manpower for R&D. This makes active cooperation between universities and industry difficult, but with careful appreciation of the needs of each party, it is possible to develop a win-win strategy. Industry must recognize the limitations of academic research but also recognize that such research is ultimately beneficial for industry, both in terms of the new knowledge generated and also in terms of capable researchers that they can employ. A tangible contribution to academic R&D should be considered as an investment rather than an expense.

As pointed out by an industry colleague of mine, although academic research is typically not driven by the profit motive, recent developments in the higher education sector has seen dramatic change in policy since the well known Bayh-Dole act of the 1980's, which encouraged universities in the USA to seek ownership of IP created as a by-product of their research activities. This can be considered academic research driven by a profit motive, which is traditionally the realm of industry.

The focus on owning IP (often at the expense of effort needed to generate results worthy of IP) can be detrimental in the long run by discouraging interaction with and tangible support of industry. When academic research becomes business, industry participation is reduced and not enhanced due to increased costs of overheads and legal formalities involved. Clearly, this is non-productive. A proper cost-benefit analysis of the current state with regard to IP-focused R&D is not quantified yet, as far as I know. Informal interactions between academia and industry at technical conferences and through journal/book publication thus become especially valuable as a bridge between academics and industry. Even developing countries are now focusing attention on IP and how they can "make money" on their R&D effort. Time alone will show if this policy will trigger innovation or suppress it.

Another stumbling block faced by academics is the need to publish in high-impact journals and seek high number of citations to enhance chances of securing research grants as well as promotion/tenure even at non-research intensive universities. For engineers and applied scientists, this is not a good measure of the true impact of their research; they are eventually forced to deviate from true engineering research to areas that are in vogue, which attract more citations and funding. This widens the gap between industrial needs and academic requirements. Until a good quantitative measure can be found to evaluate the true impact of engineering research, this state of affairs is likely to continue and even spread globally like a pandemic.

As for the key R&D areas that should remain in focus around the world, it is obvious that the nexus of food, energy and water, all inexorably associated with drying, is an obvious prediction. Energy conservation and enhancement of thermal efficiency of all dehydration operations with both incremental and radical innovations are also very important but rather neglected areas of R&D and design. If performance guarantees regarding energy consumption per unit of water removed as well as the associated carbon footprint are enforced by law for drying hardware, I am sure we will see a step jump in both figures in the marketplace since this can be achieved today even without major breakthroughs.

Use of renewable energy sources for drying, particularly in the agro-sector must be encouraged. Today the effort is sporadic and half-hearted. A global scale project by networks of excellence combining the widely dispersed expertise and scattered experience around the world in this area need to be properly consolidated for the common good. Drying systems using solar, thermal, photovoltaic, wind energy as well as sources such as geothermal and tidal energy should be examined systematically. These should also include thermal and electrical storage systems to take care of the inherently intermittent nature of these energy sources. A global scale effort is needed to ensure large scale impact. Greenhouse gas emissions and climate change will also be alleviated if the application is on a global scale.

I hope that future conferences such as IDS, ADC, IADC, NDC, CDC, WFCFD etc., will attract more industry participants. As academic institutions become focused on IP issues, such conferences provide a useful but not ideal platform for useful industry-academia dialog.

In this globalized world industry can benefit from the widely distributed talent participating in these events. This is essential for rapid technology transfer. I also hope these conferences will evolve to meet current and future challenges and thus justify their continuing existence. Strong leadership and vision is needed to accomplish the lofty proposals I have made in this short editorial to stimulate thinking and action by our esteemed readership. There are ample opportunities for personal interactions between industry and academia. I believe that such meetings help promote innovation on a global scale. Are we up to this challenge?

Research Models: University-industry Interaction

It is well known that academic researchers are facing severe compression of funding from public as well as private sources in almost all parts of the world - there are a few exceptions, which only serve to support the rule. Yet, high quality innovative research, both basic and applied, must go on to push the frontiers of knowledge and technology in this era of global competitiveness. Further, research in academia serves another valuable purpose viz. to train highly skilled researchers for academia as well as industry. This key element of training often results in a longer time scale for achievement of research outcomes in universities. Also, academic research results are generally expected to be open and disseminated freely and widely. Indeed, most academic institutions derive their reputation from high quality research outcomes that are globally recognized. These two distinguishing features of academic research are often in conflict with the goals of most industries, leading to poor interaction between the generators of knowledge and the potential users thereof. Another complicating factor is the fact that funding agencies prefer to provide greater support for mission-oriented strategic research while universities expect fundamental original contribution to knowledge that is publishable in high impact factor journals. This is a new challenge that academics must face.

I believe that special effort must be made so that academia and industry can meet halfway for mutual benefit. As an example, in a field such as thermal drying (or applied heat and mass transfer) close interaction between university researchers and industry is essential to make the research relevant and worthwhile. Engineering research differs from basic scientific research in that it cannot be justified as curiosity-driven. The former must resolve a real problem in a co-effective manner. Issues of ethics and economics are often central to effective engineering solutions..

Figure 1, which is clearly a simplistic model of most academic research in engineering, displays its essentially "closed loop" nature; this is undesirable, especially in engineering and technological fields. Research in academia, by academics and for academics is unlikely to lead to technological advances of benefit to the society. Since, in most parts of the world, much of the funding for university-based research currently comes from government sources there is little incentive for academics to seek partnerships with industry. Publication and desire for increased citation of their research papers often becomes the primary goal of such research since these criteria are applied by granting agencies in their evaluation of new grant and renewal applications. Obviously, this is not a good model for engineering or applied scientific research in universities. Academics provide R&D solutions but are not in a position to utilize the outcomes themselves. It is therefore important to ensure that the research undertaken in academia is relevant and useful to industry to improve the bottomline of their operations. This is how society can benefit from funding of academic research in engineering and technology. While basic research can work with a longer term timeline, that too must yield value eventually if it is to be of value to the society at large.

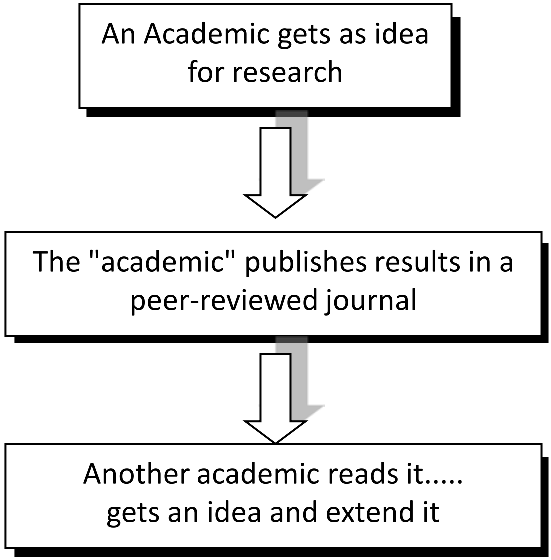

Fig 1: A "closed-loop" model of academic research

Figure 2 presents a model for engineering research in academia; it portrays how industry-university cooperation can lead to useful technology transfer. Aside from tangible research support from industry as well as public sources, it is necessary to maintain interaction between academic researchers and industry personnel throughout all phases of research. If the academic researcher is not included in the final technology application it is unlikely that further interactive research will take place. It is also reasonable to expect that the beneficiary of the R&D results should plough back a part of the benefits accrued directly or indirectly to promote further research and training in academia. It is clearly not fair to pass the entire burden of research and manpower training on to the taxpayer.

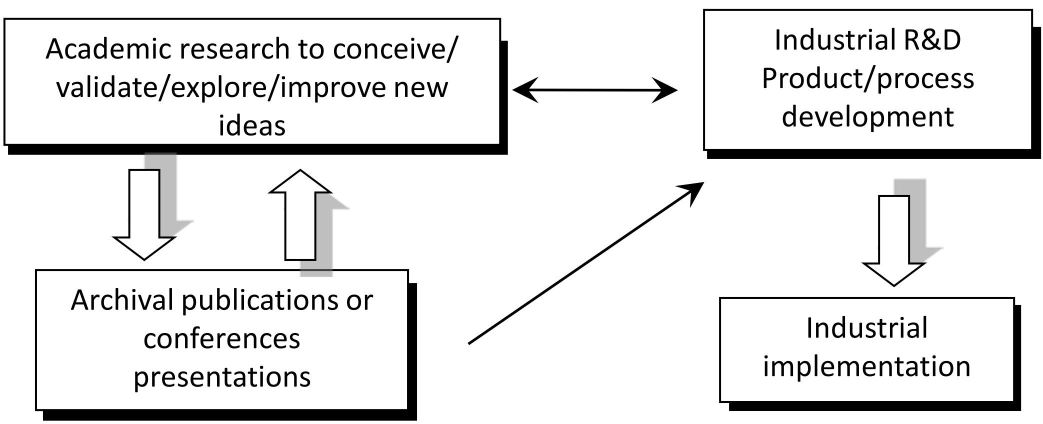

Fig 2: A desirable model for engineering research in academia

Once again taking drying technology as an example, it is a truly inter- and multi-disciplinary field. Without eventual industrial exploitation, engineering and scientific R&D results are of marginal value and often difficult to justify. I hope that many more of the papers published by academic researchers will be read and actually "used" by engineers, technologists and scientists in industry rather than only by other academics to make incremental advances by extending the reported results in another publication. Unfortunately, the current system of evaluation of university-based research places excessive emphasis on "citations" (rather than utilization) of research papers by other researchers (which is almost exclusively in the academic domain) and does little to evaluate the true impact on industrial productivity.

To sum, even academic research, particularly in engineering disciplines should be motivated by near and medium term industrial application rather than long term “blue sky” approach; the latter is clearly unsustainable and places undue burden on limited resources taxpayers are willing to provide for R&D.

Epilog

This mini-book is a compilation of a number of short essays and articles I wrote over the years. Some ideas were included in various plenary and keynote lectures while others appeared as editorials in Drying Technology or guest editorials in other journals and magazines. The goal has been to share my ideas and suggestions for R&D with graduate students, faculty members, as well as professional colleagues around the world. Thus the words globalization, innovation, R&D needs etc. appear repeatedly throughout the book.

As an engineer myself, the focus has been in engineering and technological R&D. Hence, some of the ideas should not be extended to basic scientific research. Just as invention leads to innovation when it is exploited for societal good, basic research is a key to applied and industrial R&D. Without the latter, benefits of basic research do not reach the common man for public good. So, this is a crucial step in all research. I have also had a particularly soft spot for multidisciplinary research. Although educated as a chemical engineer - already discipline with wide breadth - I am now teaching in a mechanical engineering department. I have worked and published with agricultural, food, electrical, pulp and paper engineers as well. This effort has proven to me the need for engineers and scientists to work together in multi-disciplinary as well as multi-cultural and multi-national teams. This requires a different breed of engineer with ability to apply the whole brain - not just left or right brains. Both hard and soft skills are needed for successful execution of complex R&D projects. This theme has been dealt with in several articles in this book as it is particularly important.

One of favorite quotes by Sir Isaac Newton is "If I have seen further than others, it is by standing upon the shoulders of giants." This indicates the importance prior effort for building up new research. Research proceeds in a serial manner. This familiarity with what is already known is critically important for R&D engineers and scientists. This avoids reinventing the wheel and savings in both time and resources. Publication of important results after careful assessment via peer review is extremely important for cost-effective R&D. Authors of follow-up papers must be ethical and recognize and credit prior work relevant to their own work. Claiming credit for others' work is both unethical and detrimental to further progress for obvious reasons. Professional service involved in peer reviews, organization of conferences and editing journals is central to the entire R&D process everywhere. In fact these processes help "flatten" the world as information and knowledge is made available widely on a global scale. It is indeed "professional charity" of invaluable value. It is a pity that most do not fathom the importance and value of such service. Without it, most R&D will simply not even get initiated - in academia as well as industry. Just as most valuable things are priceless, the most truly impactful things cannot be qualified by impact factors or any such numbers. The role of academia in educating highly skilled researchers is central to successful R&D as well. This is different from producing commercializable research. This is like teaching one to fish rather than provide one with fish to survive for short periods

Another point made elsewhere as well is that academic engineering research should not be "for academics and by academics". It must have strategic and industrial relevance to be really impactful. It is good to have faculty members who have industrial experience or continuing industrial consulting practice that influences in a positive manner their definition, execution, dissemination and above all their mentoring of research staff. It is helpful as well if some of the publications appear in trade journals that have much larger readership than academic journals so that the engineering value of research reaches the potential user. Such work needs to be presented in a different manner than a typical research paper that is often inaccessible or neglected by industrial readers. Journals must be selected for their readership pattern and not impact factor which only assesses academic impact-that too in a limited way since it measures to what extent the work is cited by follow-up research regardless of the quality of such citation.

Finally, I acknowledge a number of real and virtual mentors who have helped me in my own academic journey. Indeed I am an "accidental academic" as I never started off with the goal of being an academic. A series of unexpected "accidents" led me to my career; every time I hit a fork with possibility to do something else, I chose the high road of academia. Whether the choices were good - it is hard to tell. In any case, I am glad this provided me with the opportunity to provide some free professional service that is directly or indirectly assisting hundreds of R&D people around the world - many I know of but most I am unaware of. It is a reward in itself. I have also been able to mentor a number of my doctoral and postdoctoral colleagues so that they too can make such contributions to the profession and through this process to the world at large. The impact of this effort is not measurable. Indeed, only most impactful things are not measurable; on the negative side because these cannot be quantified easily, they are often ignored for bodies - animate and inanimate - that influence funding and evaluation of R&D all over the globe.

I am especially thankful to Dr Sachin Jangam for putting together this small compilation. The actual number of individuals, who have shaped my thinking on the matter, so I must avoid naming them all in the fear that I will miss some very important ones. I am sure they will know who they are if and when they come to the last paragraph of this mini-book.

I hope this book will be useful even for those who are too busy to read and study treatises on R&D, innovation, engineering education etc. All comments, criticisms are welcome!

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About the author ….

The name of Professor Arun S Mujumdar is synonymous with Drying R&D on a truly global scale. Author of over 400 journal articles, author of two books and editor of over 60 including a handbook and an archival journals, mentor of over 50 PhD students, keynote and plenary speaker at scores of international conferences etc, winner of numerous international awards for his distinguished contributions to many areas of chemical engineering, Prof. Mujumdar has had a passion with engineering research, industrial R&D, creativity and innovation even from his graduate student days. Over the last decade he has also been interested in R&D policy, management of research as well as implications of globalization and the increasing need for innovation for economic well being of institutions and nations. He has observed personally how engineering research is funded, carried out, evaluated and rewarded in several dozen countries. He has formulated his own ideas about schemes that are likely to succeed and those that are likely to fail. His multi-disciplinary and multi-cultural R&D experience in academia as well as industry from around the world makes his views and opinions worth considering seriously to avoid pitfalls the inexperienced are likely to stumble upon. Prof. Mujumdar holds a PhD in chemical engineering from McGill University, Canada and Doctor Honoris Causa from Lodz Technical University, Poland. He is currently Professor of Mechanical Engineering at a truly global university in Singapore - The National University of Singapore (NUS), following a long stint as Professor of Chemical Engineering at McGill University, Canada. He is a Platinum Award winner of his alma mater, Institute of Chemical Technology (formerly known as UDCT), Mumbai, India.