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Research Design & Methodology: Embedding Creativity and Innovation

by

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Dear Professors, Students, industry executives and Fellow Researchers:

Good morning.

We all know what it takes to attend an early morning session. I presume we have missed some of them or arrived late for a session or two in our college days. Can I recall one such experience of a bright student?

One day he came late to the statistics class by about ten minutes and noticed that the professor had already written the details of two problems on the blackboard. Assuming that these are home work assigned already, he copied them diligently into his notebook and worked on them at home over the next few weeks; He was somewhat disturbed that it took him so long to solve them; but equally dismayed when the professor took six weeks to revert.

But the professor seemed to be excited as he returned the assignment sheet. He could not believe that the two long-standing unsolved problems have been cracked now! He took so much time because he needed to verify that the proof given was correct.

Now it was the student's turn to be astonished. What he perceived as a home assignment was indeed a set of unsolved problems so far and he has found the solution. And this story has a happy ending too. Six months later, his professor asked him to submit these solutions as his doctoral thesis!

Do we know who this student was? Yes it was George B Dantzig, who is the father of the Simplex Method that solves the Linear Programming problem.

I don't know how many of us would be this brilliant or lucky. But when I narrated this story in a class, many years ago, the students tried to convince me that there is a high correlation between coming late to class and getting creative sparks. However I ventured to suggest that the problems were solved because the student did not know that they were unsolved

problems. Then there is no fear of failure. Incidentally, Sir Thomas Alva Edison was deaf from a young age and it didn't seem to matter since he is the inventor of phonograph and thousand other innovations.

The same set of students of mine, bright as they are, stated that high achievers like Michael Dell, Bill Gates, Steve Jobs and even our Azim Premji are college drop outs. They construed that their sample size was adequate and unbiased. Thoroughly convinced by this logic, but too late to drop out from college, I resigned from college instead. I gave up my teaching position and took up an industry job. As they say the rest is history.

But as a graduate student at Purdue, I was searching for a thesis topic for about a year. I was good at theory but had a strong preference for solving practical problems. My guide asked me to look into the Goal Programming model as it is the earlier avatar of multi criteria decision making (MCDM), in which I had a strong interest. I spent more than six months in my research and found out that it is a special case of Linear Programming; hence can be solved using any LP algorithm such as the Simplex Method. Then I decided that there is not much I can add and moved on to other topics.

A friend and co student, named Jeff Arthur, heard about goal programming and showed interest to study it further. He was able to identify the special structure, which is native to all Goal Programming problems. He worked on it to come up with a new algorithm called Partitioning Algorithm for Goal Programming (PAGP) and demonstrated its superiority over regular simplex method. Needless to say that my professor was delighted and encouraged him to write his thesis. He graduated

with a doctorate within a few months; also almost one year before I could!

There were at least three lessons in it for me. That not to give up on a topic too soon. And never be fixated on theory verses practice oriented thesis. Be good enough to tackle both and latch on to any good and early opportunity. I further realized that any topic is good enough for Ph.D. as long as it can make a significant impact on theory or practice. Since then I judge any research effort not by its mathematical elegance, how hard this problem has been, nor how novel the solution is. The relevant question to ask is "Does it make a significant impact? " on theory or practice.

Then watch out for the Choice of tools used. This can be a real danger zone. For example, Regression analysis is a powerful tool that helps us to find the significant factors that relate to any event, provided, we can enumerate exhaustively all the factors apriori, show that they are independent and locate unbiased and comprehensive data sets.

This is a tall order by itself. Even then a strong correlation does not prove cause effect relationship. For that matter none of the tools we use, Optimization, simulation etc can be a validator of cause and effect relationship between two variables observed.

Many a productivity analysis done in shop floor or manpower intensive service industries have suffered from incorrect use of this tool as practitioners can vouch for it. The most famous and recent of such failures is the Gaussian Copula Model used in pricing derivative products in the financial services world that lead to the global recession of 2008. We are yet to recover from this.

What were the two major issues here? First that the data set used to validate the model contained data points for a ten year period when the real estate prices were going up and up only. Secondly the strong correlation found was construed as a proof for product pricing.

It is my belief that if you search with certain preliminary notions they become so preemptive that you find only those examples that fit into your theory. Any thing contrary does not appear in your radar easily or gets discarded as an outlier. We easily become victims of our own beliefs.

Let us say you have to optimize the inventory in a departmental store. The normal practice is to do a FSN analysis coupled with ABC analysis (so that you pay more attention to those products that contribute more to your profit) and weed out some and stock more of the profitable and fast moving items. I reckon there is a flaw in this analysis. What if certain items would sell more or move faster if the package size was different or price was more competitive? Unfortunately that information is not easy to obtain and that thought does not occur easily. The contrary notion does not strike soon.

It is common knowledge that many studies are undertaken where study objectives have been defined with narrow boundaries; so narrow that they miss out on one of the fundamental principles of nature that for every action there is an equal and opposite reaction; that whether it is matter or energy there has to be a equilibrium at the system level; that accounting entries on the asset side need to tally with the entries on the liabilities side in totality. We often claim that our brief is comprehensive. How can we then embark on a study of expense control or cost minimization without considering its impact on revenue generation? Can we assign people to tasks based on skills to optimize their utilization without any reference to their individual preferences or needs?

The final issue I wish to touch on today is the stickiness that we exhibit. Our likes and dislikes, preferences and hates are rather too strong and too heavily pronounced. It is more than 30 years since the world economy switched gears from being predominantly industrial to service orientation. Today manufacturing accounts for less than 25 % of GDP or employment compared to 70 % for the services sector in every developed country in the world. (USA GDP distribution is 1 %, 19 %, and 80 % for agriculture, manufacturing and services respectively. Its corresponding labour distribution is 1 %, 20 %, and 79 %) (World GDP 6 %, 31 % and 62 % Labour 37 %, 21 %, 42 %) Developing countries too are exhibiting similar trends. It is so in China (GDP 10%, 46 %, 43% Labour 38 %, 28 %, 34 %)) and in India (GDP 17 %, 26 %, 56 % Labour 52 %, 14 %, 34 %)), the two largest emerging markets of 21st century.

As industrial Engineering professionals we are the champions of quality and productivity in every enterprise. Be it the study of ergonomics to design machinery that go to reduce human effort or enhance human comfort, The shop floor production planning and control initiatives or Operations Research studies to extract more juice out of any given system, our primary endevour is to improve quality and productivity and hence value. Be it the Machine, Material, Man or Money, for all factors of production, we took custody of their efficiency and effective utilization. We are the value engineers who bridge the technical advancements in laboratories with the needs of customers in mass markets.

We know that whether a firm is in manufacturing sector or in Services, it has to deal with similar factors of production, focus on similar challenges of quality and productivity and is amenable to similar inventory, logistics, capacity planning, SCM, scheduling and resource optimization concepts and tools. Yet our inertia in embracing the services sector within the fold

of traditional IE, our hesitation in changing the name of our profession to be inclusive, our reluctance to spend research efforts on significant man management issues of the services sector are all too embarrassing. Financial Services, Health care Delivery, Hospitality, Hotels, Entertainment, Software Services, Education and Government Services are all major segments of the services sector and are growing at a much higher pace than manufacturing; yet we lag far behind other professionals in extending our reach and applying our tool sets to the services sector. I don't know why.

Don't you think that we ought to be studying the human motivational factors that impinge heavily on the quality of services offered? Shouldn't the capability to learn on one's own initiative and hence improve productivity continuously in services functions be subject to intense study by us? The factory floor called for transferring more tasks from the human being to the machine so that consistency of quality can be enhanced. We achieved this goal of automation very successfully. Hasn't the time come to turn it around and device machinery that make human being perform their services with higher level of consistency and to greater customer delight?

Machine and Material focus of traditional IE kept productivity and quality enhancement as our primary goals .As we stretch to include the services sector, we need to add fairness and preservation as two major criteria for optimization of systems that we deal with. We prefer to be given a fair and equal opportunity. Fairness is dealings, allocation; selection etc is a natural expectation of all human beings. The other three factors of production, machinery, materials and money have no such requirement. Further machinery upon usage can be depreciated; materials consumed and money spent and discounted but human beings look for preservation and even enrichment with experience. This is a significant differentiator

and it opens up a vast new arena of research for us. Selecting patients for clinical trials, prioritizing vaccine distribution in a limited availability scenario, selecting passengers for random search in an airport, allocation of staff to available projects in a software services firm etc are some examples for fairness criteria. Designing social security for all, health care insurance for the elderly, pension system etal call for longevity focus implying that the populace has to live healthy to live long.

Should we not exploit today's scientific advances in technologies such as machine learning, location awareness, dynamic status update and personal authentication by embedding them in our products and processes so that we remain relevant as the leaders of quality, productivity and value in an ever-changing world? Can we be left behind in judicious selection and use of appropriate developments wherever they could serve our primary purpose? I believe that whether it is agriculture, manufacturing or services we have the potential to make significant contribution to any sector of the economy. We however need to put our hearts to this and lay to rest our fears and misgivings.

I leave you with these thoughts and with best wishes for your continued learning and knowledge sharing. Thank you.