Introduction to Research

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Research in Mechanical Engineering

Prof. Prathap Haridoss: Welcome to Prof. Babu Viswanath, who is professor in the Department of Mechanical Engineering here at IIT, Madras. He has a very rich background of various things that he has done before. He has a PhD from Ohaio State University in the United States; he has worked with Ford, so he has very good industry experience with one of the leading automobile manufacturing companies in the world. Here in IIT, Madras, he is also been our placement adviser so, again a lot of industry interaction. He does a lot of active research in the areas of high performance computing and caustics and propulsion.

Prof. Babu Viswanath: Propulsion.

Prof. Prathap Haridoss: So, these are all areas that he works on. So, he has a very good experience with both industry and research and so we are very glad that he could join us today and to discuss research in the area of Mechanical Engineering and various aspects that researchers might encounter through their stay here, at in their research carrier. So, Prof. Viswanath, we do have you know Mechanical Engineering is a field that is been around for a long time and in fact, I mean I think whenever we talk of Engineering colleges that's the first thing that immediately comes to mind, Mechanical Engineering is there, it is one of the core areas that is there. So, what you think?

Prof. Babu Viswanath: Mechanical, Civil.

Prof. Prathap Haridoss: Sure, sure.

Prof. Babu Viswanath: And Electrical are 3 oldest branches around in the Engineering.

Prof. Prathap Haridoss: 3 holders branches around. So, what do you think what people would think as traditional areas of research in Mechanical Engineering?

Prof. Babu Viswanath: Yeah traditionally, Mechanical Engineering department faculties can be divided into 3 verticals. One is the so called Terminal Engineering and the other one is the so called Design of components and other things, and the third one is the Manufacturing. So, these are the 3 verticals that you can divide Mechanical Engineering research into. The first one deals with Thermodynamic aspects of design and things like that energy conversion, energy conservation and so on.

The second vertical namely Design, works on the material aspects of equipment and devices so, once you have a design on paper that has been let's say, you are talking about an internal combustion engine or jet engine or comprehensive for a refrigerator, once the thermodynamic aspects are being looked at and the requirements have been sized, then comes the task of designing the equipment which actually will achieve those goals. If you let's say, you want to achieve a pressure, certain temperature and so on, we need to select materials which will be used to fabricate the equipment which can deliver these kinds of requirements. So, that is the design aspect of Mechanical Engineering.

The manufacturing aspect logically comes last because, having frozen the design both the thermodynamic aspect as well as the materials aspect. Now, it is necessary for us to figure out, how to actually manufacture this component? So far all these designs are on paper, you know, you say, you select such and such material to make the piston rods or piston itself and so on. But, how do you actually manufacture them? So, that requires that may require special tools, special fixtures, special machines, special machining processors and so on. So, that is the third vertical in Mechanical Engineering. So, if you look at all of 3 of them as a whole, it is end to end design. So, you start from conceptualization, theoretical analysis, energy waste analysis and so on, followed by materials and followed by actual manufacturing details of the components.

Prof. Prathap Haridoss: Okay so, of course, these as you mentioned are, may be what immediately come up as a traditional areas.

Prof. Babu Viswanath: Correct.

Prof. Prathap Haridoss: So, may be even in association with this or independent of these, are there certain areas that are considered modern areas of research which have come up maybe in let say, the last 10 years which are associated with Mechanical Engineering that you think?

Prof. Babu Viswanath: Mechanical Engineering over the years, what has happened is 2 things have happened. One is the even within the 3 verticals that I mentioned earlier. Things have become very, very special. So if, for example, you look at an application like internal combustion engine let say, Diesel engines. The emphasis today as you know is on reducing emissions and pollution and this goal is being pursued in many different funds. One is of course, to look at alternative fuels which are better than hydrocarbon fuels in some sense so, people are looking at fundamental aspects of combustion of alternative fuels. There are also researchers, who are looking at chemical kinetic aspects of combustion of such fuels with the view to reducing the emissions so, these are new areas.

Now, further more there are also researchers who are now, who now have the capability with lasers and high speed cameras and other devices and we now have the capability to actually take real time pictures of what is going on in an engine, then analyzing them to see whether something about the spray or other aspects combustion aspects can be optimized to mere to reduce a emission. So, we now have technology which can take real time images of actual engines. So, these are, within each vertical there have been lots of advancements.

And, the other change that has taken place is many things have become interdisciplinary. Again, if you go back to internal combustion engine example, if you look at an automobile today, everything is electronically controlled. Most of the things are electronically controlled which means, you are working with embedded systems. So, people with backgrounds in Electrical Engineering are coming into Mechanical Engineering and vice versa. So, these 2 things are happening just say, this is becoming more interdisciplinary and there are also developments within the traditional areas of

research itself, things like Mechatronics, things like Nanotechnology which is now being used in Thermal Engineering as well as in Manufacturing also, to get desired finishes, desired quality of machining and things like that. So, these are new things which have come into Mechanical Engineering.

Prof. Prathap Haridoss: Very interesting to know. So, when students come in to the Department of a Mechanical Engineering for PhD or an MS program, they do come there with you know, background from a variety of different places that they have been at for their undergraduate Engineering, which could be small towns, big cities I mean well equipped colleges, may be some are new colleges and so on. What do you see are issues that they tend to face during their initial say initial years here or even through their PhD program is more specifically with respect to your department? Are there any specific things that they initially find that they are you know unprepared for the need to get up to speed on and so on?

Prof. Babu Viswanath: The several problems that students from other colleges face, typically over the years that is what I have seen the biggest problem that they have face probably is the regress academic processes that we follow. Unlike, other institutions where for many different reasons, things will not run in the sequence in the rigid sequence that we follow. Where we have test evaluations the exam papers are discussed in class and some marking schemes are given to students. So, the process runs you know, runs in such a control fashion that students who are coming in for the first time into the IIT classroom, kind of they are surprised by the when the semester suddenly you face in semester exam and the semester is over. So, you take some of while to get adjusted to the academic process that IIT, where things are very well organized and structures and we have very robust academic processes in place.

Now, this is particularly true of a Department like Mechanical Engineering because, it is a probably the biggest department on campus. So, we have about any given time, the department probably has about 1800 students on roll, our department alone. So, it is almost like a mini college.

Prof. Prathap Haridoss: Mini College.

Prof. Babu Viswanath: It's not a college.

Prof. Prathap Haridoss: Not a college.

Prof. Babu Viswanath: So, this actually can also be intermediating to the students who are coming in, because the department is very big and at IIT, Madras particularly the officers of faculty and labs are scattered all over the campus. So, the department office is in one place, other things are in other places. So, it takes a while for students who kind of get used to this geographic diversity of their department.

And, the other thing as I said is the academic process. Being a big department, we actually have, we need to have and we do indeed have very robust academic processes because, that is the only way we can deal with such large numbers. Emphasized processes will lead to lot of confusion, complaints and unfair in acquisitions of unfair treatment and so on. So, we have very, very well structured syllabi, very well structured time lines, number of lectures for each and so on. And, we also in the department as a department we go through a periodic reviews of our curriculum as well as our syllabus to take into account new things that have taken place and also to see whether in a based on a experiences, difficulties that students have, whether some bridge courses are required to make the transition easy for such student. So, we do that also.

Prof. Prathap Haridoss, But, in terms of say let's say preparation for research. Is there something that students you know may not necessarily be even just coming to an IIT, but just their general preparation to face research or to pickup research in an academic setting in the area of Mechanical Engineering. Are there certain things that they are, they feel less prepared for when they come in and when they have to you know learn some thing new in addition to just you know specific course work?

Prof. Babu Viswanath: Yeah, I mean many of the students who come they actually are not very clear about the areas that they want to work in so, that is one major problem for them. So, they come here and then they are exposed to the regress aspects of the area that they have chosen and that might perhaps be little bit unsettling for them because, they thought it was something else and this is actually something else. So, that is one thing

and in that case we try to work with the students to see whether, something can be more interdisciplinary the research topic, can be made more interdisciplinary or whether they can take courses in certain other topics also and what can areas which are suited more to their liking.

So, those are all done on an individual case to case basis between the guide and the student and it is very much possible to pursue interdisciplinary research also. So, we try to take that into account. Understandably, undergraduate students who come here for research many of them, kind of have likes and dislikes but, they are not really sure whether this is something that they want to proceed.

Prof. Prathap Haridoss: To do research on.

Prof. Babu Viswanath: To do research on. So, they find out whether they are actually prepared academically to do research in this topic, is something that they find out, only after they come here so. But, that is understandable as under graduate students.

Prof. Prathap Haridoss: Sure, sure.

Prof. Babu Viswanath: You cannot really expect them to know everything.

Prof. Prathap Haridoss: Absolutely correct.

Prof. Babu Viswanath: So, we are prepared to what with the students. So on is the student is open-minded and willing to make some changes and adjustments and so on, the department is always you know to try to dispatch being so big. The department always has actually accommodated the individual student needs and requirements and you know matured that they have a good experience while they are here.

Prof. Prathap Haridoss: Okay so, maybe since we were talking of processes and procedures and systems in place to for students to have a good experience here. I have bit of mundane question. So, some students join's here for or join's your group for PhD.

What is your, what is your opinion on you know how often a student should you know meet their advisers? Spend time with their adviser? That's an interaction that that's always there inherent in this kind of a setting. What do you think are your views on you know how frequent it should be? How intense it should be and so on?

Prof. Babu Viswanath: This is actually pretty much dependent upon the guide and you know the likes and dislikes of the guide. But, as a general rule what I have tried to do is of course, you know emulate what my PhD adviser did in our research group. What I try to do is, I usually would like to meet with my research scholars on a daily basis.

Prof. Prathap Haridoss: Ok.

Prof. Babu Viswanath: This is not; this does not mean that I expect them to make progress every day. Research is something as someone said, research is something which where you have long periods of frustration, interspersed with brief periods of elation.

Prof. Prathap Haridoss: Ok.

Prof. Babu Viswanath: So, the role of the guide is to prepare the student mentally for those long periods of frustration and teach some that this is a mindset, you know you should not get frustrated. What is more important is the effort that you put in everyday, day in and day out rather than progress or lack they are of. So, that is what research is all about. So, I meet with the students' everyday and most of the days the students will tell me; Sir, I tried that you know it did not work and we have discussions like that. So, I tell them yeah, do not worry about it, why did not you try this or keep trying?

So, in my mind you know this gives students the feeling that the guide is actually sympathetic and understands that you know the progress, the lack of progress is not due to a lack of effort, but because the problem is simply difficult. And, it takes a while you know to figure out it, so otherwise it would not be research that is the difference between a researcher doing research and doing project work. Project work you have the problem, how to solve the problem, there only the details have to be filled in, you do it you get the answer. Whereas, with research many times the problem itself is not well defined and

you don't know how to actually solve the problem, you have handful of options hopefully, that you can try and perhaps one of them will work out. But, until that one works out you have to go through periods of disappointment.

So, many people say frustration, I don't like that word, I prefer to use the word disappointment you try something it doesn't work out you are disappointed, you want to try something else. So, that would be a better way to look at research. How do you handle long periods of these kinds of trials and failures that is the mindset that you need to develop? So, I meet with the students on a daily basis only for that reason that you know.

Prof. Prathap Haridoss: Ok.

Prof. Babu Viswanath: We have an interaction the students feel happy that you know, they have someone to talk to and they can come to me they should not feel that they can come to only to report successes, they should feel comfortable coming to me.

Prof. Prathap Haridoss: And reporting.

Prof. Babu Viswanath: Reporting lack of progress.

Prof. Prathap Haridoss: Lack of progress.

Prof. Babu Viswanath: They would not call it failure. But, I will tell lack of progress

Prof. Prathap Haridoss: Ok.

Prof. Babu Viswanath: They should be, they should feel comfortable to come and say, No, it didn't work. Now, some students are very cryptic, they will say, No, it didn't work. Otherwise, would elaborate a little bit more, but whatever the students feel comfortable with, I would like do that on our daily basis.

Prof. Prathap Haridoss: Very nice, very nice. So, see when we talk of MS and PhD kind of degrees people tend to think that you know these are specializations and in fact, that's the general perception that it is a specialized degree and it is a specialized in a specific problem associated with that general area of Engineering or Science. And, then you come out with the degree. So, what sort of positions in your view that you have seen? What sorts of positions do these people who have done an MS or a PhD in Mechanical Engineering? What sort of positions do they tend to get when once they graduate from the

Prof. Babu Viswanath: See, first of all if you look at the kind of skills you are expected to acquire, I still remember attending a research meeting when I was first year graduate student at United State and an executive from GM, I was talking about, how they make the decision to recruit either an Undergraduate student or a Master student or a PhD student? And, he said something very nice. He said, when we recruit a B. Tech student, we tell the student do this; when we recruit a Master student we tell the student, would you like do this? When we recruit a PhD student we tell them, what should we do?

Prof. Prathap Haridoss: What should we do, ok, very nice.

Prof. Babu Viswanath: So, these are the.

Prof. Prathap Haridoss: These are the way to distinguish the.

Prof. Babu Viswanath: These are the skills that the student should acquire. They should be able to answer these questions you know. So, with PhD or MS which are both degrees based on research you have 2 carrier options, one is to go into research and development in the Indian industry or any other place or R and D is definitely a very good option for them. And, for students with both MS and PhD, these days there is a tremendous requirement for teachers in India today because, the number of colleges being so high, number of students studying Engineering being so high, there is a tremendous requirement. And, many universities and colleges from around the country do come to IIT, Madras, to recruit our students for such positions. So, they can also look to a carrier in teaching and you know they I think at the end of the program here, they should be,

they should equip themselves well to go into one of these 2 carrier options, either carrier in Research and Development or a carrier in Teaching.

Prof. Prathap Haridoss: Okay So Okay so, we now have some students, who are probably considering, you know joining Mechanical Engineering for a higher degree and so on. So, what is your, what are your words of advice for an aspiring student in for higher education in Mechanical Engineering?

Prof. Babu Viswanath: My word of advice to such students would be the following. You look at the options that you have, many of the students actually will probably not be clear whether they want to do higher studies or whether they want to go for a job, may be they have a job offer you know. So, my advice is you know if you trying to decide between the 2. In today's world I would almost always tell you that, if you are able to secure an admission at IIT Madras, for an MS or a PhD you should definitely take it up because it is a very enriching program you have probably the best teachers in the world, and if you look at the rankings of the individual departments in our institute in IIT, Madras, you will see that in QS ranking, they have ranked among the top 100 departments in the world. So, these actually are very, is a very good place to study. And, whatever you did not learn in your undergraduate education for whatever reason, you can probably compensate for that by pursuing a Master's program here.

And, as the you know as the former placement adviser, I can also say that the employment opportunities that you would get at the end of your masters, probably of the best that you get in this country. Best companies come here for selecting, for example, companies like TVS motors, Robot Bosch, General electric, Rolls Royce, Nvidia, Texas instruments, Eaton all these companies come and recruit our Masters, MS students from here. So, you will have your short add, the best possible companies in the country.

Now, so you take this decision that you are grappling with now, whether you want to go for a job or a higher studies, you take that decision. You are not really in a good position to take the decision now okay. Whereas, after you get an MS from IIT, Madras you will be in a much better position to take that decision, you have a very good job that you have at your hand in one of the best companies in the country and now you can decide

whether you want to continue with that or pursue even higher studies like PhD and so on and then go from there. So, my position is you will be in a much better frame of mind both academically as well as personally as well as professionally to take that decision at the end of a Master's program from IIT, Madras. So, my advice is, if you have an admission for MS in IIT Madras, don't even think twice; take it.

Prof. Prathap Haridoss: Great. With those words of advice, thank you very much.

Prof. Babu Viswanath: Thank you.

Prof. Prathap Haridoss: For joining us.

Prof. Babu Viswanath: Thank you Prathap for this opportunity.

Prof. Prathap Haridoss: And, it is very valuable for all the students.

Prof. Babu Viswanath: Thank you for this opportunity.

Prof. Prathap Haridoss: Thank you.

Prof. Babu Viswanath: Thank you.