

An Academic's Journey of Life Long Learning



K.P. Madhavan

As I reflect on various phases in my personal and professional life, I have come to realize how I have benefitted from diverse learning opportunities that came my way from time to time. My early life in a village in Kanjani, Trichur (Kerala) was an exciting learning experience of the unstructured kind. I learnt how villagers without access to modern tools could innovate and carry out their farming activities many of which are now done by machines. Watching village craftsmen at work, we learned to make our own toys and sports goods like nets, balls etc. I had my first lesson in Physics watching my eldest brother construct an automatic water dispensing system for the poultry he was rearing. Perhaps one of the most exciting learning experience was the unintentional demonstration of principle of applied mechanics by a team of coconut climbers in bringing down the heavy top of a coconut tree, which was hovering ominously over our house, along a safe trajectory away from the house. These early experiences underscored the importance of learning through such unstructured events and making judicious use of available resources to achieve desired goals

Though my early school education was in Government Schools near Kanjany, for higher secondary education I had to move to the mining town of Kolar Gold Fields (KGF) and get enrolled as a student in St. Mary's High School. Moving from the secure joint family in Kanjany and settling down to an urban life in Kolar required a good amount of learning and adaptation. I had to overcome the immediate challenge of acquiring proficiency in Tamil within a year. I could also develop progressively reasonable command of English under the tutelage of our Principal, Father Rajappa. Access to quality reading material in English comprising of newspapers, magazines and tabloids had also helped in this effort. St. Mary's School had a well-structured academic programme, which did provide the base for us to go ahead in our academic career.

I was singularly lucky to get a chance to pursue my college education at the prestigious St. Joseph's College, Bangalore. True to its reputation, the college had an array of excellent teachers in Mathematics and Chemistry and good lab infrastructure. Learning was an exciting experience at this hallowed institution. On the personal side, this was the beginning of my hostel life. Despite the disciplinary constraints prevalent in such institutions, hostel life was a lesson in living harmoniously among a cosmopolitan student group.

I developed some fascination for Electronics as three of my brothers had chosen Electronics as their specialized area of profession. After completing my intermediate (12th) at St. Joseph's, my attempt to enter Government Engineering College in Bangalore proved abortive. This did not bother me, as pursuing BSc at St. Joseph's Bangalore was always a good option.

Post BSc there was a dilemma as to what could be the road ahead as the job prospects for BSc graduates were not very bright at that time. As my yearning to pursue Engineering did persist, I went on an application spree targeting all possible entry avenues to Engineering. Persistence did ultimately pay when I got admission to the Chemical Engineering programme of AC Tech, Madras under the quota reserved for Kerala students. The irony of the situation was that I had no idea of what Chemical Engineering stood for. Since it was an engineering programme at the prestigious AC Tech, I decided to plunge into the area trusting my erstwhile learning and scholastic capability to help me embrace this unknown discipline. Since it was a two year post BSc programme there was imperative need to

absorb the essentials of Chemical Engineering within the limited span of two years. We had the advantage of learning from Prof. G.S. Laddha (Director) who was one of the leading academics in Chemical Engineering of that era. Prof. A.P. Madhavan Nair and Prof. Murugamanickam were the other two faculty members whose lectures were very informative. Prof. Murugamanickam had also marveled us with the display of a remote controlled car that he built in his garage. We found laboratory experiments in Engineering very interesting. Doing a B.Tech. project on Design of Multicomponent Reactive distillation for production of Butyl Acetate was one of the toughest assignments we had to handle. In 1958 when the only computational aid was the ubiquitous sliding rule, the plate to plate calculations we had to do were very arduous and time consuming. This initial tryst with distillation was the forerunner for many of other investigative work I could do on the topic in later years.

The first exposure to working in an industrial setting came when I had to do a three month compulsory training as a part of the curricular requirement for the BSc Tech degree. My training stint was with Travancore Cochin Chemicals, Alwaye (Kerala) making Caustic Soda, Chlorine and Hydrochloric Acid as its primary products. It was with lot of excitement and anticipation that I went for the training. After languishing for a few weeks with no definite assignment to work on, I was asked to take on a project of extracting mercury from the electrolytic cell mud waste. I started work on the project with a good bit of enthusiasm and had started getting some good results. The project had to be terminated abruptly due to safety concerns of working with mercury without proper fume hoods. This was an early lesson about the paramount importance of safety in the plant and in the laboratory.

With no immediate prospects of a job after graduation, I took advantage of the Practical Training Scheme offered by Government of India and joined Travancore Titanium Products Ltd, Trivandrum for a one year training stint. This stint was a rich learning experience from an industrial perspective. The plant had a good amount of unit operations like crushing, grinding, size separation, sequence of reactors, precipitators, rotary drum filters, calciners, dryers and powder mills. The most interesting among these were the huge RCC reactors, in which the Ilmenite digestion with Sulfuric acid was being carried out. The intensity of this exothermic reaction would make the reactor go into a sustained vibration mode, which propagated to the supporting structures also. There was much to be learnt by studying the operation of each of the unit operations in the plant. As I was a paid trainee I was given various tasks. The first task was development of material and energy balance for the Titanium Dioxide plant, a task more demanding than the simple material and energy balance problems we solved in the classroom. I had to learn the art of extracting reliable information from myriad sources, which included plant operating personnel, laboratory technicians and plant records. Closely on the heels of this was the knowledge I gained by associating myself with the team involved in installation of a Sulfuric Acid plant and its commissioning .The startup sequence used in commissioning the plant was an interesting eye opener as such practical issues were seldom discussed in the class rooms. I was also impressed by the excellent quality and completeness of technical documentation provided by the German licensor of the Sulfuric Acid plant.

While the industrial training did bring knowledge about the practical aspects of chemical industry, the urge to continue my higher studies persisted in my mind. During the industrial training, the area, which caught my fancy, was Instrumentation and control, as I saw a large number of instruments being deployed in the plant with only a few of them being operational on a continual basis. I had the good fortune to get admission to IIT Bombay for pursuing Master's Degree programme in Chemical Engineering with specialization in Automation in Chemical Industries. I felt that postgraduate education at IITB would indeed be a turning point in my career. As I was among the first batch of students admitted to this specialization, there was considerable amount of self-learning to be done as there were no peers to reach out to. Most challenging was setting up the experimental system for my Master's Degree project on a pH control problem. After graduation, the limited job offers that came in the area of Instrumentation and Control were not attractive. The enriching academic environment and the social life at IIT campus did entice me to continue for my PhD. During the early phase of my

research I had the good fortune to receive guidance from the Russian expert, Prof. Ivanov. He encouraged adoption of a research methodology, which required us to plan our own research independently. For researchers, there were several constraints with respect to the infrastructure, facilities and resources. Here again, the earlier lesson about judicious use of the available resources came into play. A typical instance of this was the development of a simpler Q meter equivalent to the Marconi Ecko Q meter for my PhD work using the available Russian metering instruments and signal generators. Completing PhD under these conditions was truly a lesson in endurance, optimism and self-belief to stay the course.

The academic ambience of IIT Bombay did provide a strong incentive for me to take up academic career as my best option. Since IITB itself was in its growth phase, this could provide an opportunity for me to be part of its development programmes. As a faculty joining the Chemical Engineering department in 1964, I was lucky to have Prof. Kamath as its astute Head who could play the role of a mentor, philosopher and guide. Besides his stature as a leading academic, he was also known for his prowess as an inspiring teacher with a mastery of the subject and excellent communication skills. These became the guiding factors for many of us privileged to work with him. While planning my own approach to teaching, I chose the option of reading as many of the books as I could on the subject and develop a course plan culled out of the material from these sources. This, I thought, would provide a richer source of information and also make me better prepared to approach the class with a fair degree of confidence. Implied in this approach was also the need for continuous learning and preparation rather than the discrete approach of preparing learning material lecture to lecture. The first two subjects I got to teach were Instrumentation and Process Control. As things turned out, Process Control became the flagship course, which I could teach with relish to four generations of undergraduate students. The material for the course was very analytical. The challenge was to develop easy to understand interpretation of the theory of some of the topics like stability and dynamics related controllability issues. These exercises became useful when control had to be taught to professionals later in some of the continuing education programmes for the industry. Optimization was another course I enjoyed teaching at the Postgraduate level. In the initial years this course had attracted a good number of students from other departments also. The course material had to be carefully designed to give equal attention to theory and applications. A broad range of problems drawn from various domains had to be drawn up to meet the learning needs of the diverse student groups in the class. I had also diversified my teaching to take up courses like Process Dynamics, Chemical Plant Simulation and Advanced Process control. Towards the fag end of my academic career, I was requested to take a new course on Artificial Intelligence in Process Engineering. Though I had some familiarity with the subject, I had to do lot of reading on the topic to negotiate the course successfully. The AI techniques I learnt in this process could help me later when I had to handle certain problems from the industry. This lesson I learnt from this is “never lose an opportunity to learn new skills and knowledge even if it takes you out of your comfort zone “. Besides teaching, I was also deeply involved in most of the exercises undertaken by the department in curriculum revision of existing programmes and curriculum formulation for a Five Year Master’s degree programme with specialization in Process Systems Engineering. Converging on the final curriculum, in the face of divergent views, was often a delicate exercise needing patience and persuasive skills.

The development of teaching and research labs was a challenging task especially in a department in its growth phase. While the Russian aid had left the department with an impressive array of equipment and instruments and the Russian Technician had set up a functional Instrumentation and Controls lab, complete utilization of all these was hampered by inadequate documentation in English. In addition, much work had to be done to adapt them to teaching. Using a working knowledge of Russian to study the original Russian manuals and resorting to theoretical analysis, it was possible to get many of the instruments working which included controllers, a wide range of measuring systems and an Analog Computer. Having acquired total familiarity with a wide range of Russian instruments, it was possible to modify the features of some of these to devise some new innovative experiments. A few examples were the use of the 1:1 relay module of a stack diaphragm controller as a low flow control valve,

adapting a position balance controller for sampled data control and converting an Analog computer to simulate sampled data control. The laboratories needed to be continuously updated to cope up with the transition pathway from pneumatic, analog, digital to microprocessor based systems. With the assistance of my PhD student, Dr. Sachin Patwardhan (who later joined the department as a faculty) I was able to set up a versatile PC based pressure control system using the resources available in the lab. This was augmented with additional electronic and microprocessor based control systems procured from MHRD modernization grants. There was much learning to be done to transcend from the analog to the digital world

While the initial phase of my academic career was devoted to teaching, in subsequent years research became another equally engaging activity. The choice of modeling, simulation, optimization and control as the broad area of research did help in getting motivated MTech and PhD students to work with me. Guiding research is always a learning experience especially when one has bright students who have the spirit of enquiry working under you. I had PhD students from various backgrounds. This included IIT research scholars, teachers under QIP programme and scholars sponsored by R&D Organizations. I realized that besides providing guidance on technical issues, I needed to play the role of a mentor and a motivator rather than assuming the role of a relentless taskmaster. This approach of building of capability in them to do independent work seemed to work well with the assorted collection of students who had worked with me. It was necessary to acknowledge that each student would come to you with specific talents and certain weaknesses. Recognizing these and shaping their career had been an enriching experience. My research topics for PhD covered modeling and control issues of batch, azeotropic, divided wall distillation columns, exothermic semi-batch and laser photochemical reactors, hydrodynamics of jet type contactors, developing an integrated approach to design and control of chemical processes, model based control of nonlinear systems and heterogeneous and reconfigurable control structures. Two PhD projects which had great industrial significance in the Heavy Water manufacturing practice, related to Modeling of Heavy Water Cascade and Analysis of Jet loop reactors.

A new learning opportunity opened up for me when I got involved with setting up of a CAD Centre as part of an UNDP-DOE initiative for promoting computer applications in Chemical and Metallurgical industries. CAD Centre provided a good platform for me to engage in teaching and research in the emerging area of Computer Aided Process Systems Engineering. Another dimension to the learning was to develop the Centre to act as a window to the industry with a mandate different from that of the academic departments. With proper planning and proactive activities of those associated with the CAD Centre, it could emerge as a unique model of a self supporting Centre in the campus. Process Systems Engineering has also emerged as a dominant research area of the Chemical Engineering department

A change in working environment can provide abundant opportunities for learning and understanding the professional world outside your habitual work place. My first opportunity to interact with my peers in academic universities in USA and UK came in 1985 when I had had spent time with leading research groups working in the area of Computer Aided Process Systems Engineering at universities of Purdue, Washington, Wisconsin, Carnegie Mellon and Imperial College, London. This visit as an UNDP fellow was an excellent experience for me. I could get to know the state of art and the software tools available in the academic and professional domain to engage in teaching and research in the area of Process Systems Engineering. During my second visit to Purdue as a visiting faculty in 1987, I could get to play a more active role in the academic activities of the department which included running a hands-on course on Computer Process Control for the undergraduate students of the department using the real time IBM ACS control software and supervising laboratory courses. The material for the Computer Process Control course was subsequently modified by me to include advance control topics like multivariable control, process identification and self-tuning control. I could also do some developmental work, which included developing an integrated platform for fault diagnosis using IBM ACS with an IBM Expert system and developing computer based experimental

systems for three units in the lab namely a distillation column, absorption column and a CSTR using the Camille Control System donated by DOW Chemicals to the department. My third visit to USA in 1993 was to Mobil's Research Centre at Princeton, New Jersey, to work on developing interface packages for integrating Mobil's Custom process packages with SIMSCI's Pro II simulation software. The work had to conform to the software structure standards and protocols prescribed by Mobil for all their future software development activities. Through this association, I could get a first hand experience of the working style and professionalism of a global R&D organization.

As a faculty I felt that interaction with industry would provide an opportunity for me to work on real life problems. As the focus of industry consultancy and sponsored research assignments was on deliverables, I had soon learnt to chalk out a distinctive line of research which would explore not only intellectually stimulating ideas but would also meet the project expectations. I found by experience that successful industry targeted projects were those where there had been close interaction between the academia and industry. One such illustrative case was the long term R&D programme which IITB CAD Centre had with Honeywell Technology Solutions Ltd, Bangalore (HTSL). The collaborative project with HTSL had a high degree of complexity and an artful decomposition of the large scale problem was required to generate a tractable solution strategy. The close involvement of the industry ensured that the solution developed could be readily incorporated into its industrial practice. Another project, which had considerable success, was the development of a simulator for a Sulfuric Acid plant undertaken by the CAD Centre for a leading Sulfuric Acid manufacturer near Mumbai. Here again, the active involvement of the CAD Centre team with the industry team at every phase of the development had led to the development of a simulator which could be relate to the actual operating scenario of the plant. Another challenging industry sponsored project, where there was close industry involvement, was the development of integrated software environment for control system development for a process plant using the resources of a dynamic process simulator, control system design software and an Expert systems package. A unique learning experience opened up for me when I had the opportunity to sit on the Boards of Heavy Water (BARC) and Jopasana Software, Pune. The first organization functioned in a strategic area with assigned targets and growth plans while the second one operated in a competitive business environment. I could get to understand the subtle differences in the way the respective boards looked at operational performance and future plans.

While the prime activity of a faculty is teaching and research, opportunities often come by faculty's way to participate in institutional developmental programmes. Though pursuit of these activities may take time away from research, I found that there were some administrative positions in the institute which could enrich your background and vision. One such was the Dean R&D role where I could get a closer look at the spectrum of research done in various disciplines but also understand fully the ethos of academia –industry interaction. My experience as Dean R &D did help me to tackle a number of institutional developmental programmes that I was entrusted with. The first was to work on a plan to start a Management School with focus on Technology and Manufacturing Management. Since this area was not the prime focus of many of the existing management schools, the first challenge was to put up a curriculum, which will embed these focus areas without compromising the essential facets of a general management education. The second was to mobilize funding from sources other than the Government for setting up the school. Prof. Nag, the then Director and Dr. D.V. Kapoor, Chairman of the Board in position at that time , were the driving forces behind starting of the Management School. Dr. Mashelkar, who was on the Board of Governors of IITB and Prof. A.P. Kudchadkar (in his position as Deputy Director, IITB) had also lent their active support to the cause. They were able to evince the interest of Mr. Nagul, Chairman of ICICI at that time, in the unique character of the IITB Management School in the pipeline. I was entrusted with the onerous task of preparing a credible proposal for financial support to be placed before the ICICI Board. With active co-operation of all concerned persons I was able to prepare of a comprehensive document which was not only academically sound but had also realistic estimates of infrastructural and funding requirements. I found this task a little more intimidating than writing up of a research proposal. The

report got acceptance by the ICICI Board and IITB was able to get a sizeable financial assistance from ICICI for its Management School. This exercise was a unique learning experience for me as I could get an idea about the manner in which financial institutions addressed appraisal of developmental proposals. A few years after this exercise, I was again called upon by the institute to explore options of integrating the Biotech and Biomedical academic divisions of the institute into a larger Bioschool, which could have a broader canvass for research. This required extensive efforts to bridge the engineering and science dichotomy and come up with a School which could provide a synergetic growth of the two disciplines. The concept of such a school could only be evolved after protracted discussions with all the stakeholders. The lesson I had learnt from this exercise was that with frank and open discussions one could come up with a solution that could enable people with divergent views to work together in a harmonious manner. Another interesting assignment that I had to undertake for IITB was to co-ordinate the research of a multidisciplinary team working on the Mission Mode project on Integrated Design for Competitive Manufacturing. This required tactical handling of various research groups in the team and adopting a rational approach to resource allocation.

I consider myself lucky to have worked in an institution like IIT Bombay, which provided me opportunities and freedom to pursue my professional interests in an unfettered manner. Chemical Engineering department provided me a warm and friendly atmosphere with my faculty colleagues and departmental staff supporting me in all the ventures I had undertaken. I am happy to see the emergence of the department as one of the leading departments in the country. It has been a privilege to work in such a dynamic department. While being at IIT Bombay, I had also the good fortune to come under the influence of many who have helped shape my professional career. Prof. Kamath was the ideal mentor who inculcated in me many qualities, which helped me to counter the highs and lows in my career. Prof. Kudchadkar pushed me to undertake assignments, which helped me, broaden my spectrum of activities beyond the narrow confines of teaching and academic research. I had the good fortune to work closely with a succession of Directors holding the reins at IITB. Prof. De has been a great source of support to me both during his tenure as Director and thereafter. Prof. Nag gave me freedom to function as the Dean R&D. He had also entrusted me with some important institutional developmental activities. Prof. Sukhatme and Prof. Ashok Misra had also some interesting assignments for me to work on. I have learnt a lot interacting with them and these experiences have helped me become a more mature and complete professional. As resident of the Campus, I had realized the important position that students occupy at such a place. In my several roles of interaction with the students as faculty, supervisor, Head of the department and Chairman of Sports, I had always found excellent support and endorsement from the student community. I would cherish this as the greatest reward that I can get in my academic career.

After having worked for a long period in academic environment, a time had come for me to retire from the active service of the institute in 2002. Fortunately this did not signal premature retirement from professional activity for me. The professional engagements that came my way post retirement were as exciting as my earlier assignments. I could work with the R&D of some of the leading industrial organizations on a range of problems drawn from various domains. This called for extensive learning effort to understand the domain and develop solutions appropriate for the problems from the respective domain. A greater satisfaction that came out of these engagements was the mentor role I could play in nurturing the talents of the young engineers and scientists working on these projects.

As I conclude this narrative, I have come realize how the life of an academic can be an exciting journey of expedition with freedom to explore chartered and unchartered pathways providing abundant learning opportunities and professional challenges.