IChemE

Making a difference with chemical engineering research

Personal career journeys

November 2023

Foreword

The personal journey of researchers in the continuously evolving landscape of chemical engineering research, particularly at the early stage of their careers, is a captivating narrative of passion, perseverance, and innovation. This collection of stories within the pages of *Making a difference in chemical engineering research – Personal career journeys*, showcase the dynamic minds shaping the future of their field. Chemical engineering research is even more relevant with the current state of the world and its major problems to solve.

This booklet, a collaborative effort put together by the dedicated members of IChemE's Research and Innovation Community of Practice of the Institution of Chemical Engineers (IChemE), demonstrates the diverse paths these researchers have taken, the challenges they've conquered and continue to face, and the transformative impact they aspire to achieve. The interviews serve as direct insights into the experiences, aspirations, and personal philosophies that help enable chemical engineering progress. I sincerely wish that this booklet had existed 20-something years ago when I started my own academic career as a young PhD graduate.

From new discoveries to innovative methodologies, the journey of these early career researchers not only inspires but also provides invaluable insights for those following in their footsteps. I hope this booklet can be a source of motivation for aspiring researchers everywhere who continue tirelessly to propel our world forward.

Cordelia Selomulya FTSE CEng FIChemE

Professor, School of Chemical Engineering
UNSW Sydney, NSW 2052, Australia

Contents

Introduction

Understanding the perceptions and drivers for early career individuals and students in engaging with chemical engineering research is a focus topic for the Research and Innovation Community of Practice. In 2021, the Institution of Chemical Engineers (IChemE) conducted a short survey to understand the perceptions around chemical engineering research. The initial findings suggested that the purpose and possibilities in this area were not always clear to early-career individuals, and there was a need for a holistic insight into the field.

In this booklet, we present a collection of nine interviews from individuals working (or having worked) in chemical engineering research. We have representatives from both academia and industry, working across a range of sectors, including specialty chemicals, (bio)pharmaceuticals, food, nuclear technology, software, and consultancy services. In these interviews the individuals were asked not only about their career goals and journey to date, but also how their perceptions of chemical engineering research have changed over time. We have aimed to capture an end-to-end view from both the individual's own career experiences and their views on the chemical engineering research field overall.

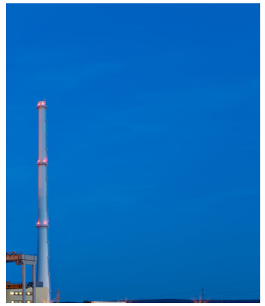
Within the chemical engineering community, industrial and academic research is a critical enabler to growing, and sustainably maintaining the impact of our profession in solving global grand challenges in the long term. As such, we must continue to support and encourage the development of future generations in this vital area. Our profession also provides great opportunities to bridge interdisciplinary gaps with other subjects, leading to novel ways to solve challenges of the day and building the career options of those involved. Indeed, many conducting chemical engineering research did not necessarily begin their career as chemical engineers!

The interviews presented in this booklet provide a unique glimpse into the experiences and careers of early career chemical engineering researchers. They offer a variety of perspectives on the field, from the challenges and opportunities to the rewards and satisfaction, as well as advice to those considering such a career and to IChemE about the support these researchers need. We hope that these interviews will inspire and inform early career individuals who are considering a career in chemical engineering research.

Alex Lockwood

Deputy Lead – Particles with Fluids Centre of Expertise

Sellafield Ltd, UK



What degree qualifications do you hold?

BEng (Hons), Chemical and Nuclear Engineering (with industrial placement), 2016

PGDip, Next Generation Nuclear – Nuclear Fission, 2017

PhD, Chemical Engineering (Next Generation Nuclear Centre for Doctoral Training), 2021

University of Leeds, School of Chemical and Process Engineering

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

Registered Scientist (RSci)

Briefly outline your role and the research sector you work in:

As part of an internal pseudo-consultancy group, I provide expertise in particle technology and colloid science support to nuclear decommissioning projects. I provide support where research is contracted to the supply chain and academia. I coordinate research between academia and industry to align and support the Sellafield Ltd scientific plan. I supervise PhD and master's degree students completing relevant industrial research and conceptualise new research portfolios for joint industry-academia investigations. Where appropriate, I deliver research directly as a Visiting Researcher at the University of Leeds. I also provide technical training to Sellafield staff and guest lectures at the University of Leeds and publish in research journals.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

I wished to lead a research group to push the frontiers of chemical engineering knowledge and to contribute to real change in the understanding of particle and fluid science while working in research and development in an environmental field. I hope to become an Industrial Professor and/or Fellow of Chemical Engineering.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

My perception was that chemical engineering was focused on consumable goods, including oil and gas. Now I know that real environmental change is going to be driven by chemical engineers scaling up lab-scale breakthroughs into deployable economic technologies.

Illustrate your journey from graduation to your current role:

I undertook my undergraduate degree in chemical and nuclear engineering; after my third year, I was successful in achieving an industrial placement year at Sellafield Ltd. In my role in the Strategy and Technical Division, I interacted with research programmes regularly. I noticed that most people completing the fundamental and technical work held PhDs, so I contacted my university and found some projects that were funded by Sellafield Ltd and found out I could bypass my MEng year and jump straight onto the programme. After completing my placement year, I then worked for Jacobs on a Sellafield Ltd-contracted project for three months as a design engineer before beginning my PhD. During my PhD I worked closely with the nuclear industry, published several journal articles, and attended international conferences, winning a number of international awards. Upon completing my PhD, I joined the Sellafield team (Sludge Centre of Expertise) that supported my PhD project. I have also been seconded to the National Nuclear Laboratory to work on full-scale rig trials in support of Sellafield's mission.

Describe the research environment you work in:

My day-to-day experience with research is incredibly varied. I can either conduct research directly at the University of Leeds (UL) as a Visiting Researcher, including publishing journal articles, or I can act as technical support for subcontracted research. I supervise PhD and master's projects in support of Sellafield at the School of Chemical and Process Engineering, UL. Additionally, I sit on technical committees to help maintain Sellafield's high technical standards and I peer-review research outcomes internally and from the supply chain.

What is the greatest challenge in your current role?

Balancing the needs of various stakeholders during projects, ie the needs of research and project milestones. More technical problems involve scrutinising project assumptions, which are challenging to underpin on the scales of Sellafield's mission to decommission legacy nuclear facilities, where even increases in atmospheric carbon dioxide levels could affect nuclear waste chemistry.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry or academia and how did you overcome it?

It would have been valuable to have had more opportunities to develop technical and critical report-writing skills during my undergraduate studies. Strong written communication skills were developed during my PhD due to the one-to-one nature of the supervisor-researcher relationship. Understanding how to make assumptions is an important skill for researchers, leading to a risk of idealistic models and correlations being used, where these do not adequately represent reality.

In your opinion, what is the biggest difference in the way of working between academia and industry?

Balancing the priorities of conflicting stakeholders. Academia is generally focused on a single task of delivering cutting edge research, whereas research in an industrial environment has to be balanced with project milestones and budget priorities.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

With regards to an undergraduate education, more focus on report writing and critical analysis skills. The importance of comparing your research to literature and understanding the fundamental differences between works at a technical level. Reporting experimental procedures in sufficient detail to improve repeatability of one's work.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Achieving net zero as soon as is practical.

What exciting developments in chemical engineering research is your company or institution working on right now?

Improving nuclear decommissioning safety and efficiency, reducing the burden to future generations. Translatable developments to water treatment and minerals engineering in the form of improved sludge dewatering and species separation.

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Pushing the frontiers of human knowledge, developing techniques and procedures that currently don't exist to improve the living standards of all species on earth.

What is your top tip for anyone considering a career in chemical engineering research?

Consider carefully your choice of supervisor. One who is capable of empathy and who prioritises pastoral care will be able to provide very valuable support during your challenging PhD journey.

What can IChemE do to be more relevant to chemical engineers working in research?

Provide researchers with more information and support related to Chartered status, both CSci and CEng qualifications, and the routes offered by the Engineering Council and the Science Council for these qualifications.

Ben Luqmani

Research Engineer

Cranfield University, UK

What degree qualifications do you hold?

MEng in Chemical Engineering, University of Bath, UK, 2012
Currently completing an Engineering Doctorate (EngD), Cranfield University, UK

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

Chartered Chemical Engineer (MIChemE, CEng)

Briefly outline your role and the research sector you work in:

I am a Research Engineer at Cranfield University, studying towards an Engineering Doctorate (EngD). My research is sponsored by industrial partners in the UK water sector (Anglian, Severn Trent and Northumbrian Water) and the Engineering and Physical Sciences Research Council (EPSRC). I'm developing novel processes for the efficient utilisation of bioresources in wastewater to support a circular and net-zero water sector. Specifically, I'm focused on the production of biomethane using hollow fibre membrane contactors, and on the recovery of ammonia from wastewater by vacuum stripping for utilisation as a zero-carbon fuel.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

I had an industrial placement built into my degree, in which I spent one year working in the process engineering team at a manufacturing plant. This helped to shape my early ambitions, as I gained a breadth of experience and exposure to the different roles and opportunities that existed for chemical engineers in the manufacturing sector. Upon graduation, I entered the manufacturing sector with aspirations to develop as a process engineer, gain experience in leadership positions, and attain Chartered membership with IChemE in my early career. I didn't have a long-term plan beyond the first five to seven years.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

As an undergraduate, I perceived chemical engineering research to be dry and abstract. Much of the research that I was exposed to as a student was highly theoretical and related to fundamental science. Since I transitioned into academic research, I have been involved in applied research into technology development and solving immediate challenges in the water sector. Personally, I find applied research fascinating and it is rewarding to see clear applications and impacts of my research.

Illustrate your journey from graduation to your current role:

Upon graduation, I started as a process improvement engineer in a soluble coffee manufacturing plant (I was offered a role there following a one-year industrial placement during my degree). After a few years, I progressed to operational and leadership roles including 18-months as a process shift lead and then was promoted as the process improvement lead to manage the team that I started in as a graduate. I was mentored and supported by several chemical engineers within the company, including an assigned IChemE mentor who met me regularly to discuss and reflect on my experience and personal development. This helped me to successfully become Chartered with IChemE. Shortly after becoming Chartered, I wanted to transition my career towards roles in sustainability and combating climate change. I decided to pursue an industrially-sponsored engineering doctorate in the water sector focused on energy and nutrient recovery from wastewater to develop expertise in sustainability, technology innovation, and to gain a broad perspective of the opportunities and challenges in this area.

Describe the research environment you work in:

I am based at Cranfield University. My research project is industrially sponsored by partners in the water sector, and so I have also had the opportunity to visit wastewater sites to help contextualise my research. The project is experimentally focused, as I am designing and exploring the application of new technologies, and so the majority of my work is done within a lab environment. My doctorate is part of the STREAM Industrial Doctorate Centre, and so I am part of a wider community of researchers across several UK universities and the water sector who meet regularly at conferences and training events. I am also part of

Communities of Practice in the areas of Membrane Technology and Wastewater Treatment at Cranfield University, which help me to understand the wider implications of my research.

What is the greatest challenge in your current role?

As a doctoral researcher, the greatest challenge is in continuously learning new skills whilst balancing the different aspects required to deliver a doctoral thesis – experimental design, data collection and analysis, learning to communicate complex technical research effectively, synthesis of literature data, and effective technical writing for scientific publications.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

Personally, I found it was a natural transition from my undergraduate into industry – aided by the experience gained during my industrial placement year. After an intense final year of studying, I was very happy to leave academia and to be challenged in a different way in a hands-on engineering role. However, several years later I re-entered academia as a doctoral researcher and this transition was challenging. I had to adapt from a dynamic and fast-paced team environment to one that required a much greater focus on detail and understanding and that was almost totally autonomous. I was able to translate many of the skills that I had developed in industry, particularly organisational skills, self-discipline and personal resilience to help me manage this transition.

In your opinion, what is the biggest difference in the way of working between academia and industry?

I can only compare based on my own experience, but there are many stark differences between process engineering roles in the manufacturing sector and doctoral research at university. The industrial roles were strongly team based, fast-paced and your responsibilities shifted dynamically as you developed. This is excellent for developing many chemical engineering skills, but the challenge is that all your focus can be drawn troubleshooting and fire-fighting daily issues, away from longer term project work and innovation. In contrast, as a doctoral researcher you are working almost autonomously and at a much greater depth of detail. There is a greater opportunity to think through problems and to develop and test new ideas, and interaction with industry and other researchers at conferences can give you a broad perspective of your sector. Personally, I think a blend of both worlds – exciting and dynamic teamwork and space to innovate – would be ideal in a role.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

I think that the curriculum is already heavy on research and light on industrially relevant skills. As an undergraduate, research into chemical engineering can feel very dry and abstract. I think it would be greatly beneficial if more academics could effectively communicate the impact of their research to students in an understandable way, and to share their enthusiasm and passion for their subject. For me, the few lecturers who achieved this were a great inspiration to pursue a career in research.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Chemical engineering researchers will play a key role in the transition towards a net-zero society, particularly in the areas of green energy and CO2 capture. For example, I have encountered cleantech start-ups who need researchers with a chemical engineering skillset to lead process scale-up and commercialisation for new CO2 capture technologies.

What exciting developments in chemical engineering research is your company or institution working on right now?

We are developing innovative technologies to maximise resource and energy recovery from wastewater – re-imagining waste streams as circular economy opportunities and supporting societal decarbonisation. For example, in my research I am developing technology for the recovery and transformation of ammonia in wastewater into a zero-carbon energy source.

In your opinion, what differentiates research from the rest of the chemical engineering field?

My answer would be the same as for the question 'In your opinion, what is the biggest difference in the way of working between academia and industry?'.

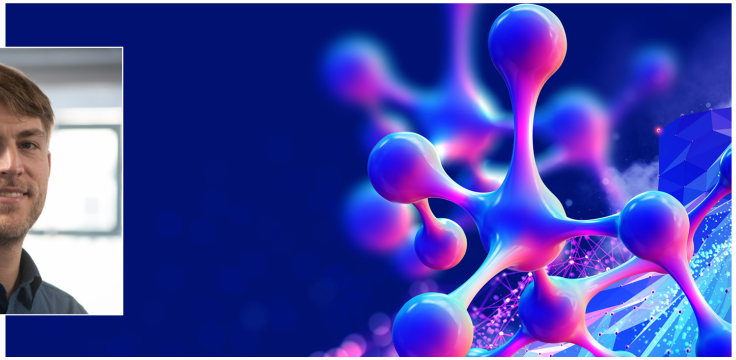
What is your top tip for anyone considering a career in chemical engineering research?

Gaining experience in an industrial role before entering research can be invaluable. An industrial perspective can help you to stand out in an academic environment and deliver impactful research. An alternative would be to seek out research opportunities within industrial doctorate centres which combine research and industrial elements to give you a well-rounded experience.

What can IChemE do to be more relevant to chemical engineers working in research?

I'm not sure what more should be done here. Personally, I'd like to engage more with IChemE and attend/speak at IChemE mini-conferences on specific research areas – water, sustainability, etc.

Jonathan Wagner



Senior Lecturer

Loughborough University, UK

What degree qualifications do you hold?

MEng in Chemical Engineering, University of Bath, 2008
MRes in Sustainable Chemical Technologies, University of Bath, 2013
PhD in Chemical Engineering, University of Bath, 2017

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

Fellow of the Higher Education Academy, 2022
Associate Member of IChemE

Briefly outline your role and the research sector you work in:

I am a Senior Lecturer in Chemical Engineering at Loughborough University. My research looks at integrating complementary thermochemical, biological, and catalytic technologies to develop efficient and commercially viable processes to convert bulk biomass and wastes into sustainable chemicals and fuels. I am the programme lead for the Centre for Circular Chemical Economy and co-investigator of Loughborough's SlowCat MiniCDT (Centre for Doctoral Training), which aims to develop new types of catalysts for converting dilute and oxygen-rich biomolecules into useful chemicals.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

I have always had an interest in (renewable) energy and sustainability and completed a research project on hydrogen storage during my third year. However, I then applied for and accepted an industrial placement with BP, as they were one of the highest paying and competitive companies at the time. After my placement I was offered a permanent graduate position and hence I didn't really think about other alternatives during my final year and certainly didn't consider a research career during my undergraduate degree.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

When I started my career, I mainly saw chemical engineering as the bulk processing of chemicals and fuels, focused on industrial design and technology scale-up. The most important considerations were cost and safety, with less focus on other impacts. Since then, it has become clear that whole system evaluation and life cycle analysis are integral to all chemical engineering research. As a result, chemical engineering research has become even more multi-disciplinary, combining fundamental sciences and engineering with digitalisation, business, policy, and social sciences. At its heart remains the desire to develop and implement solutions to real-world problems, ranging from climate change, food security, water and health.

Illustrate your journey from graduation to your current role:

After graduation, I joined the BP upstream graduate scheme, working for Schiehallion floating production, storage and offloading (FPSO) and central area transmission system (CATS) gas terminal. This experience gave me a deep understanding of process operation and safety management and continues to inform my research and teaching career. However, I realised I wanted to work on something I really believe in and hence started a doctorate in the Centre for Sustainable Chemical Technologies at Bath. During the first year, I had the opportunity to complete two different projects in chemical engineering and chemistry, helping me to choose my PhD project on hydrothermal liquefaction of algae. As well as developing my own research skills, my time in Bath taught me about the importance of public engagement, industry collaborations and interdisciplinary working.

I subsequently joined Imperial College as PDRA, working on the Horizon 2020 'Photofuel' project. Besides broadening my research background, I learned about project reporting and international collaboration to achieve overall project goals. I then joined Loughborough as Lecturer in 2018, promoted to senior lecturer in 2022.

Throughout my career, I have been fortunate to work with highly supportive and inspiring supervisors and colleagues. In particular, my PhD supervisors were very motivating and inspiring through their clear research visions and gave me the freedom to pursue my own ideas. At Loughborough I have been mentored by a senior colleague who has encouraged and helped me to push my research to the next level.

Describe the research environment you work in:

My group is based in the department of chemical engineering, but I frequently collaborate with colleagues in chemistry, materials engineering and civil engineering through shared research projects and PhD studentships. We are lucky to be based in a fully refurbished department, offering us clean and modern research laboratories, office spaces and access to shared analytical facilities. Most of my research is laboratory based, using a range of high-pressure batch and continuous flow reactors to convert biomass and municipal wastes into solid, liquid and gas-phase products. After this initial reaction, we use different approaches to upgrade these intermediates into valuable products, ranging from physical separations to anaerobic digestion, algae cultivation, or catalysis. A key priority of our research is to study the whole system, from biomass/waste to desired product, rather than individual processing stages to optimise and assess the overall potential of the process. Our experimental work is combined with process simulation and life cycle analysis to simulate carbon flows, energy requirements and compare different process options. Over the last couple of years, we are increasingly collaborating with other disciplines to address non-technical challenges and impacts, ranging from policy engagement, supply chain analysis, finance, and social impacts.

What is the greatest challenge in your current role?

The greatest challenge is probably finding enough time for research, amongst my many other teaching and administrative commitments. As a result, it can be difficult to stay on top of recent developments and explore new topics and ideas outside my own area of expertise.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

One of the biggest challenges of starting in industry was how to effectively communicate with non-engineers, particularly site operators, to get them on board with new ideas and changes to operation. At the beginning I saw my assigned projects mainly out of my own perspective and expected everyone else to share the same priorities. Only after being asked to move into the control room, when I started to spend more time with the operators, did I learn the importance of building personal relationships, understanding others' priorities, and explaining the importance or relevance of changes. Listening to the operators and learning from their experience was essential to delivering practical solutions to improve the operation of the plant. As a result, operators started to actively contact me with problems and include me in their discussions. These skills continue to be critical in my everyday research, be it through interaction with colleagues, students, technicians, or administrators.

In your opinion, what is the biggest difference in the way of working between academia and industry?

One of the key differences between academia and industry is the motivation behind what we do. In most industries, the main priority is to be profitable while working within existing frameworks, whereas in academia we can consider other priorities such as the environment, long-term sustainability, and social impacts. As a result, academia offers more flexibility to explore high-risk high-impact solutions, while industry mostly relies on well-proven technologies which are guaranteed to deliver results.

On a more personal level, academia offers more freedom in pursuing my own interests, choosing my own projects, and managing my time. There is no one to directly report to or tell me what to do. On the flipside, this means that it can be difficult to know if I am doing the right thing or doing enough. It can take months and years to apply for funding and complete research before we know if we have been successful, and we must be prepared that most of the things we try won't work. Despite this, it is incredibly rewarding to be able to work and shape an area you are passionate about, learn new ideas and work with students and researchers.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

For me, one of the key challenges in starting my research was my lack of fundamental science background. The current chemical engineering curriculums are mainly based in preparing students for jobs in industry, whereas most of chemical engineering research is relatively small scale and relies on a large number of analytical techniques, such as nuclear magnetic resonance, x-ray diffraction, infrared, gas chromatography, etc. which are not, or only superficially, covered by the chemical engineering degree. There probably could be better integration of the chemistry and biology modules in the first two years of the course with other engineering modules, to clearly demonstrate the progression of research from lab- all the way to industry-scale.

Secondly, I feel that students are increasingly focused on single solutions to a particular problem and struggle to think outside the box to address multi-component problems. They also find it increasingly difficult to independently look for information. Particularly for research, it is critical to look beyond the boundaries of the existing area to explore potential solutions. To address this, more open-ended tasks and assignments could be used which allow students to develop their creativity and research skills, without reducing the importance of the final solution. They should also be challenged to investigate and explain unexpected behaviours, rather than following model solutions.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

I believe chemical engineering plays a key role in addressing many of our most pressing challenges, from energy security, clean water, modern healthcare, and food. However, it will be most crucial for tackling climate change by developing whole-system circular processes to recycle and recover carbon for material synthesis and use as energy vector.

What exciting developments in chemical engineering research is your company or institution working on right now?

Our department leads the Centre for Circular Chemical Economy, focused on developing and implementing new technologies to recover olefins and other fundamental chemicals from end-of-life wastes through technology development, system analysis and tackling the non-technical barriers. We also lead several exciting projects on digitalisation and artificial intelligence, as well as regenerative medicine and bio-manufacturing.

In your opinion, what differentiates research from the rest of the chemical engineering field?

Academic chemical engineering research is mostly concerned with the initial technology development from technology readiness levels (TRLs) of two to four or five, prior to industrial scale-up and commercialisation. It connects fundamental scientific understanding at molecular level with process development across multiple scales, to develop simplified correlations to facilitate industrial application.

What is your top tip for anyone considering a career in chemical engineering research?

Find out what you are really interested in and passionate about, eg by attending research seminars and speaking to different researchers to find out about their day-to-day work and understand your motivations for wanting to do research. A PhD can be incredibly rewarding, but only if you are interested in what you do.

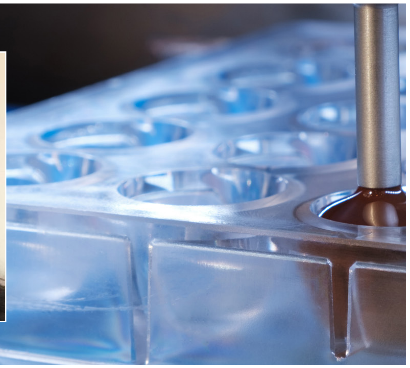
What can IChemE do to be more relevant to chemical engineers working in research?

IChemE is very well placed to facilitate more industrial-academic dialogue, to help us address real industrial needs and identify potential project partners. It can also play an important role to inspire more engineering graduates to consider a research career by highlighting its importance and achievements. Finally, IChemE could consider more targeted research funding and scholarships, eg for research internships, exchanges and conference attendance, particularly to undergraduate and PhD students.

Laura Malhi

Associate Principal Engineer

Mondelez, UK



What degree qualifications do you hold?
MEng Chemical Engineering, University of Birmingham, 2010
PhD Formulation Engineering, University of Birmingham, 2014

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?
Chartered Chemical Engineer (MIChemE, CEng)

Briefly outline your role and the research sector you work in:
I am a senior engineer working on new technologies for the chocolate brands in the business to deliver against a consumer need. Within the food business there are many different research opportunities with three main drivers, all of which I have worked on in the past few years: productivity, quality, or new products/technologies. Productivity or quality improvements can be made if the manufacturing process is well understood as this can identify where changes can be made to save money or control the product output.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?
From the start of my degree, I was drawn to the fast-moving consumer goods industries, food, cosmetics, personal care etc. These products are often complex to manufacture on a large scale. For example, it is necessary to temper chocolate, which requires carefully crystallising several tonnes per hour to target the correct in-mouth melting that is loved by all.

During my undergraduate degree I did a summer placement with PepsiCo working in a breakthrough technologies area – new equipment to produce exciting novel products. I enjoyed this and made the decision to do a PhD to better equip me to work in technically demanding areas.

What was your perception of chemical engineering research at the start of your career and how has it changed since?
At the start of my career, I perceived chemical engineering research to be always on a manufacturing scale. This is only half of it: understanding the product transformation through the process is necessary (bench work) to support the understanding of how to manufacture. This work is often done in a team with a chemist and a chemical engineer.

Illustrate your journey from graduation to your current role:
I loved my undergraduate degree placement. I had joined a team that did nothing normal! They had taken the existing crisp frying process, thoroughly understood its impact on the crisp, and then looked at very novel ways to achieve this. I loved the forward thinking and depth of understanding – it was fascinating! I unofficially and unintentionally adopted a career-long mentor from this company who supported me through my PhD so I had the necessary skills to complete long term research for years in the future.

Though it is not necessary to have a PhD in long term research, it certainly helps, and I landed a manager's level job in Unilever straight after my postgraduate studies where I had a team and more radical game-changing projects to work on and lead.

Describe the research environment you work in:
I have worked in many different research environments. Currently my team looks to deliver personalised products to win market share. Not surprisingly the products are very new to the business. My main role is to work with suppliers to build bespoke equipment or adjust existing equipment to suit our requirements. Once the technology is developed the team tests the popularity with consumers via small launches.

Most of the development work is done within the project team, however, when the engineering and product development work needs deeper research understanding, complex laboratory analytical work is done offsite by analytical experts. For example, microscopy work to understand the product microstructure is carried out by microscopy specialists. Any simple analytical tests can be done in the manufacturing location.

What is the greatest challenge in your current role?

Understanding the consumer product need. We can engineer and manufacture lots of cool, novel products but there's no point if no one will buy them! This lack of understanding is our greatest challenge.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

During my degree I did several product design and research projects that set me up well for the bigger picture understanding that is required in a research environment. I was unaware of how teams are supported within the business and the stakeholder network. I worked closely with several colleagues who understood stakeholder management and did an exercise to formally map those involved in the project and how to regularly update them. This map included technical experts and considered how to use their expertise.

In your opinion, what is the biggest difference in the way of working between academia and industry?

Academic output is based on novelty and fundamental understanding. Industrial output is measured by monetary value to the business. Academics use model systems to identify the role of each ingredient in the product behaviour from a bottom-up approach. Industry will use the product that is sold to consumers and tweak ingredients, delivering quick wins. Also, academics intend to make their research relevant to many companies or products. For industry there is always a delivery route for the research to ensure that the company benefits from having done the work.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

I think an understanding of how research funding is set up, for example bodies that support research and academic-industrial bridging, would be a sensible addition to the curriculum. Such bridging is needed – in my experience, many engineers go into industry without knowing how to influence academic researchers to increase the usefulness of their output.

Though difficult, it is important include teaching on current environmental, social and governance (ESG) pressures, since these lead to a need for research.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

The world needs large step changes to achieve net zero. One of the step changes is to achieve a high intensity of heat release to allow gas-fired unit operations to be replaced. This is a large challenge where engineers can have a big impact.

What exciting developments in chemical engineering research is your company or institution working on right now?

I am excited to see the progress all companies are making in their bid to be net zero. My company is working on this, supported by computational modelling and model predictive control.

In your opinion, what differentiates research from the rest of the chemical engineering field?

Research is the future of the chemical engineering field. It uses all the same principles but is five to ten years ahead of when manufacturing needs the knowledge.

What is your top tip for anyone considering a career in chemical engineering research?

Do it! It is a fascinating career choice and always stretching. My tip is to be patient if you are doing research in industry as you will likely have less promotions initially than your peers. This is because delivering in research and development (R&D) requires a thorough knowledge of the product and experience in research and this must be built up through time. It is worth it in the long run as R&D have more senior roles available.

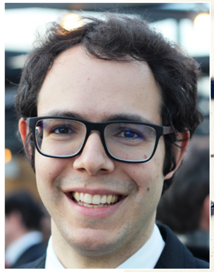
What can IChemE do to be more relevant to chemical engineers working in research?

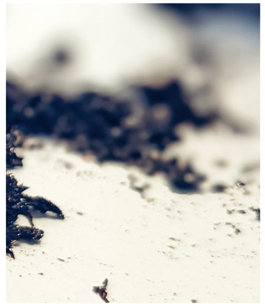
Support research mapping projects across key themes and have these as a resource to members. Ask special interest groups for input to these with leadership from the Learned Society Committee or Research and Innovation Community of Practice. Support academic-industrial bridging work.

Mauro Luberti

Lecturer

University of Manchester, UK





What degree qualifications do you hold?

BEng in Chemical Engineering, University of L'Aquila, Italy, 2009
MEng in Chemical Engineering, University of Rome 'La Sapienza', Italy, 2011
PhD in Chemical Engineering, University of Edinburgh, UK, 2016

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

Chartered Chemical Engineer (MIChemE, CEng)
EUR ING, Engineers Europe/FEANI
Fellow of the Higher Education Academy, UK

Briefly outline your role and the research sector you work in:

I am a lecturer in chemical engineering at the University of Manchester. I teach several modules across the MEng and MSc degree programmes, and I am the study abroad coordinator in the department. My research focuses on gas separation using adsorption technologies, hydrothermal carbonisation of biomass, and use of waste heat in low temperature-driven processes.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

Since the early years of my degree in chemical engineering I have always been fascinated by teaching and research, so I knew I wanted to continue to work and operate in academia. Thus, the choice of pursuing a PhD after my master's degree was straightforward. At the same time, I was lucky enough to take a break from academia and work in an engineering company for more than four years.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

At the start of my career, my perception of chemical engineering was intrinsically linked to process engineering as my degree was traditionally oil and gas focused. However, through my PhD and subsequent experience in industry I learned about many more relevant sectors where chemical engineers work, including food and beverage, fuel cells and more sustainable processes.

Illustrate your journey from graduation to your current role:

In my bachelor's degree, my thesis focused on the modelling and simulation of industrial processes to produce biodiesel from micro-organisms. In my master's thesis I carried out an internship at a waste-to-energy power plant in southern Italy. Since I really enjoyed the academic environment, I decided to continue my career with a PhD in adsorption and carbon capture. I subsequently joined Process Systems Enterprise Ltd (PSE, now part of Siemens group) in London as a consultant engineer. During my time with PSE, I worked in the process safety sector within the Oil and Gas business unit for one year and then moved to the energy and chemicals business unit where I was promoted to senior consultant engineer. I offered consultancy services to major chemical and petrochemical companies. After more than four years in industry, a renewed enthusiasm to pursue an academic career brought me back to the University of Edinburgh where I joined the chemical engineering discipline as a university teacher. I taught several modules and carried out research activities in areas including adsorption, hydrothermal carbonisation of biomass and use of waste heat in low temperature-driven processes. I joined the department of chemical engineering at the University of Manchester as a lecturer in 2022. Several people strongly influenced and helped me in this journey including my dissertation supervisors, my PhD advisors and the managing director of PSE company, who also supported me with my CEng application.

Describe the research environment you work in:

I carry out my research mainly with the help of PhD students and MEng students, where I supervise their research projects. I also collaborate with colleagues in other institutions in the UK and abroad, including Imperial College London, NTNU Trondheim and the University of Rome. The collaborations are usually built on a common research topic, a proposal work package and/or co-supervision of students. Thanks to my ties with industry, I also supervise the dissertation projects of students on industrial placements or studying abroad. I hope to start collaborations at the University of Manchester.

What is the greatest challenge in your current role?

In my current role, the greatest challenge is to find an optimal balance among teaching, research, and administration duties. This is particularly challenging for the teaching and administration load as the department of chemical engineering of the University of Manchester is one of the largest in the UK.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

My greatest hurdle was how to tackle and manage a real and complete research project in academia or a consultancy activity in industry. University degrees never really prepared me for such tasks, apart from (partially) the design project. The tools I used to overcome the challenges have been optimal time management, continuous discussion with supervisors and/or senior colleagues and clients, as well as a great patience to deal with mathematical modelling and master new software in general. At the end of the day, I have achieved a good level of efficiency being fast to cope with changes.

In your opinion, what is the biggest difference in the way of working between academia and industry?

As I have worked in both industry and academia, I am in a position to answer this question fairly well. First, I would say that the academic research is deeper as it is less constrained by time and/or clients. Greater freedom makes it possible to grasp the essence of the investigated topic and produce novelty in a field. However, the projects I have worked on in industry made me realise that some academic research is useless from an engineering perspective or has the potential for real-world applications only in the long run. Therefore, it would be better to focus on some topics that will have more immediate repercussions on human health, society and/or the environment. In the end, my decision to go back to academia was dictated by my vocation to shape and inspire the next generations of chemical engineers.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

First, I would encourage students to think more critically about what they are calculating and designing in their design projects through a thorough revision of the core subjects of chemical engineering, including chemical thermodynamics, transport phenomena, unit operations and chemical reactors. The knowledge of some rules of thumb in chemical engineering would be particularly useful in this regard. Secondly, I would strengthen the digital and programming skills from year one to year four through the constant use of programming languages (MATLAB, Python, C++) and commercial software (Aspen, UniSim, Pro-II) across the degree modules. Nowadays, more and more companies and universities are looking for young graduates with a minimal knowledge of big data processing, artificial intelligence, and machine learning.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

The key areas are energy and industries, both of which contribute to a wealthy and modern society. Thus, trying to make these sectors more efficient will have a positive and direct repercussion on the life of everyone. If chemical engineers were responsible for shaping the society as we know it today, we will have the same level of responsibility and competence to lay the foundations for the low-carbon and more sustainable society of the future.

What exciting developments in chemical engineering research is your company or institution working on right now?

The University of Manchester, birthplace of chemical engineering, has several research groups that are active at the heart of the net zero society, environmental sustainability, and advanced materials. The core topics currently investigated are bio-refineries, waste heat, low temperature-driven technologies, CO2 utilisation and the various applications of graphene, to cite the most relevant ones.

In your opinion, what differentiates research from the rest of the chemical engineering field?

The discovery of new technologies and materials and the possibility of making our processes more and more efficient, sustainable, and economical at the same time. Several processes are quite old and still polluting our planet; thus it is time to improve or even fully replace them with new concepts.

What is your top tip for anyone considering a career in chemical engineering research?

Anyone willing to carry out research in the field of chemical engineering should have a solid knowledge of the core subjects of chemical engineering and a strong set of mathematical modelling skills.

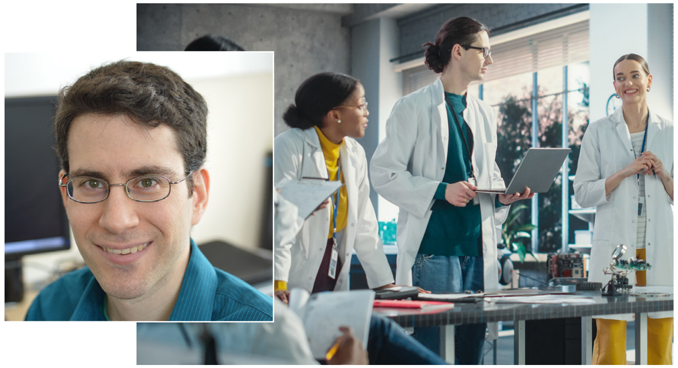
What can IChemE do to be more relevant to chemical engineers working in research?

IChemE could enhance series of webinars and/or events involving researchers in academic and research institutions as well as introduce some training specifically tailored to the research community. Examples of topics could be statistical analysis of experimental data, artificial intelligence, machine learning, digitalisation, etc.

Michail Stamatakis

Professor of Computational Inorganic Chemistry

University of Oxford, UK



What degree qualifications do you hold?

Chemical Engineering, National Technical University of Athens (NTUA), Greece, 2004
PhD in Chemical and Biomolecular Engineering, Rice University, Houston, TX, USA, 2009

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

Fellow of the Royal Society of Chemistry (FRSC)
Chartered Chemical Engineer (MIChemE, CEng)
Chartered Scientist (CSci)
Fellow of the Higher Education Academy (FHEA)

Briefly outline your role and the research sector you work in:

My role involves activities in education, research, knowledge transfer and administration. On the education side, I develop curriculum material and tutor undergraduate students and lecture on undergraduate and graduate level courses. Regarding research, I am responsible for drafting research funding bids and leading research projects, as well as supervising a team of researchers at all levels (master's and PhD students, as well as post-doctoral fellows), and potentially exploiting my lab's research outputs in partnership with the technology transfer office of my university. On the administrative side, I sit on various committees in the department of chemistry as well as my college, Lady Margaret Hall.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

Ever since I was an undergraduate student, I have known that I wanted to do research, and I have always enjoyed teaching and learning new things. An academic career path, therefore, seemed the natural choice for me and I steadily followed this career path.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

As the start of my (research) career, I will refer to the beginning of my PhD. Back then, I thought of research as a rather abstract activity focusing mostly on fundamentals without necessarily connecting the research questions or outcomes to practical application. However, as I have been performing research in chemical engineering over the years, I see that connecting one's research to practice is not only necessary (a researcher/scientist does not operate 'in vacuo', but they are also part of a society which needs to overcome certain challenges), but it also leads one to focus on the most interesting problems/questions!

Illustrate your journey from graduation to your current role:

I have been a chemical engineer all along, so at least this was a stable element in my career. However, as is probably always the case in real life, I had to deal with quite a bit of uncertainty and change in my PhD and beyond. For example, during the fourth year of my PhD my primary supervisor quit his position at Rice University, and left academia altogether, so, apart from the overall distress, he wasn't there to support me when applying for post-doctoral positions or academic jobs. Also, when I was a post-doctoral researcher, I switched my research focus from computational biology to catalysis, so I had to learn quite a lot of new things. Another radical transition was to leave the USA where I had done my PhD and post-doctoral research and start my lectureship in the UK. I can't say that I have followed a special strategy in overcoming the challenges of these transitions, I guess the things that helped me were perseverance, thinking of the opportunities of the future rather than the difficulties of the past, and finding good people to support me. For instance, my secondary PhD supervisor, my post-doc supervisor and certain collaborators have been my mentors and inspiring role models.

Describe the research environment you work in:

Academia is probably among the most traditional environments that one can find; however, the fact that my research activities really lie beyond traditional chemical engineering makes for an interesting case. I work on computational catalysis, developing simulation methodologies, which I then applied in constructing high-fidelity mechanistic and kinetic models that capture how catalytic materials work at the molecular and mesoscopic scales. These models explain experimental observations and guide the design of catalysts for processes of interest in the energy and sustainability fields, eg natural gas conversion to fuels, or biomass valorisation towards biofuels and chemical precursors. These activities are highly interdisciplinary, so I borrow knowledge from physics and chemistry for the fundamental principles, as well as computer science and mathematics for the development of computational approaches and software. Moreover, my research environment is highly dynamic: the practical problems can change rapidly, which requires a shift in the focus of applications-driven research activities, and the methodological approaches advance, so one needs to be up to speed with the latest developments.

What is the greatest challenge in your current role?

Access to funding and talent! Obtaining research funding is a well-known struggle in academia, so I expected it when I started as a lecturer. However, access to talent seems to be a bigger challenge, especially since a PhD is not viewed as an attractive option by many gifted students, who prefer to join the workforce rather than pursue advanced education.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

Probably the biggest challenge was a shift in mentality, from a being a PhD student and post-doctoral researcher to an academic research group leader (as a lecturer and now associate professor). As a researcher, the questions that you focus on are defined by someone else and your main role is to solve the technical problems. On the other hand, the role of the research group leader in academia is much more complex: they define the meaningful and impactful research questions, which requires thinking at both the high level (big picture) but also at the technical level (propose something feasible). They are also responsible for maintaining a competitive research group via attracting funding and talent, as well as disseminating their research broadly, and they have to balance all this with teaching and admin. Thus, effective management of time, people and resources is key.

In your opinion, what is the biggest difference in the way of working between academia and industry?

I haven't worked in industry, but I think the main differences are that, in industry, research conditions are even more dynamic compared to academia, and projects are shorter, as well as more practical (or well defined) in scope.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

I believe a more substantial research experience could help in better preparing people for research and making them more competitive in the job market. At present, a master's-level student in the UK typically spends up to 24 weeks on their research project. Such relatively short projects, which are performed concurrently with taking other modules, may not give students enough time to become immersed in the research environment. These graduates may then be at a disadvantage when competing with candidates from other educational backgrounds for PhD opportunities and when they begin working on their PhD research projects.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Developing novel chemical technologies or improving existing ones, to promote safety, as well as efficiency and sustainability, within the spirit of, for example, green chemical processes, net zero, and the circular economy.

What exciting developments in chemical engineering research is your company or institution working on right now?

Perhaps too many to list all of them, but as highlights I can mention: (i) next-generation catalytic materials that combine high activity, selectivity and long lifetimes in the reactor for challenging chemistries, such as those encountered in biomass reforming to chemicals and fuels, (ii) advanced propulsion approaches based on electrochemistry towards net-zero targets, and (iii) systems-level approaches for the optimisation of chemical processes taking into account uncertainty, promoting efficient and sustainable operations.

In your opinion, what differentiates research from the rest of the chemical engineering field?

I believe research must conduct itself at the 'frontier of knowledge' of the chemical engineering field, seeking ways to effect fundamental changes to the way chemical processes are designed and operated, in line with the requirements for safety, efficiency and sustainability. Thus, while such positive changes can happen in the rest of the chemical engineering field, the scope of research is expected to transcend traditional preconceptions or discipline-specific boundaries, and maybe even challenge fundamental assumptions or common practices.

What is your top tip for anyone considering a career in chemical engineering research?

Be bold and do not be afraid to venture into fields and knowledge domains that are not seen as traditional chemical engineering. Cross-pollination of research fields and knowledge domains can (and has been known to) deliver outstanding research outcomes.

What can IChemE do to be more relevant to chemical engineers working in research?

Perhaps providing scholarships for PhD students or fellowships for industry-academia secondments (enabling someone from industry to do a short placement in academia, or vice versa) would help in making IChemE more relevant to chemical engineers working in research. Another idea could be to facilitate the organisation of joint conferences that involve academic and industrial partners (certainly some of this is already done at a small scale, within the special interest groups, but could be broadened in scope).

Rebecca Gibson

Reaction Process Safety Engineer

Johnson Matthey, UK

What degree qualifications do you hold?

MEng in Chemical Engineering with Energy Engineering, Heriot Watt University, 2017
EngD in Formulation – Developing fundamental understanding of thermal processing of (catalyst) formulations, University of Birmingham, 2022

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

IChemE Associate Member
AIChE Young Professional

Briefly outline your role and the research sector you work in:

I currently work in corporate R&D within Johnson Matthey (JM), specialising in reaction hazards. Reaction hazards can come in many forms such as combustible dusts, exothermic reactions, the production of gases (both flammable and inert) and incompatible materials. Understanding potential reaction hazards within a process is essential to establishing a robust basis of safety. This role allows me to combine my expertise in reaction engineering with process safety principles. I specialise in modelling these reaction hazards, which includes kinetic modelling and consequence modelling using computational fluid dynamics as well as interpreting experimental results from reaction hazard testing.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

I have always wanted a challenging and varied career, and this was what attracted me to engineering in the first place. But I did not have a fixed idea of what my career would look like. I was very lucky to have the opportunity to conduct two summer placements within R&D at Johnson Matthey during my undergraduate degree. This was my first real taste of industrial R&D, and I quickly realised this work suited me. I've been hooked ever since!

What was your perception of chemical engineering research at the start of your career and how has it changed since?

As I had experienced two short summer placements during my undergraduate, I had been exposed to industrial R&D quite early. At first it appeared that industry and academia had very different types of projects, in terms of the technology readiness level, and I did not fully appreciate the overlap and collaborations that can be established between academia and industry. Industry does not work exclusively on short term projects; there is scope to investigate the more fundamental aspects. Within JM we usually conduct these fundamental projects in collaboration with universities, often in the form of master's or PhD projects.

Illustrate your journey from graduation to your current role:

Following my undergraduate degree, I completed my engineering doctorate with the University of Birmingham. The project was co-sponsored by Johnson Matthey and was based within the company. This meant a fairly unique mix of academia and industry during my doctorate. It had the benefit of allowing the fundamental research but also offering an experience of other aspects of industry. My interest in process safety was sparked during my EngD and led me to look for a position that combined my reaction engineering and modelling experience, with process safety.

Describe the research environment you work in:

JM is a global leader in sustainable technologies who operate in the automotive, chemicals and energy sectors. JM is an international company, with significant operations in more than 30 countries. Working in corporate R&D in a company with such varied products and services, means that R&D is often on the front edge, making products a commercial reality. These complex areas of research require a multidisciplinary team of researchers, including both chemists and engineers.

My role in JM is to support all sectors on their reaction hazards. This means discussing vastly different products and processes daily and communicating with colleagues across the globe. Whilst these conversations are often on short term problems, a benefit of working in R&D is the opportunity to investigate the fundamental, more longer-term problems, anticipating future problems that the business may face.

What is the greatest challenge in your current role?

In a multidisciplinary research environment, interdisciplinary communication is always a challenge. Ensuring essential information is exchanged effectively and early enough in process development is key to successful scale up, for example.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

Industry requires many short, concise documents outlining project proposals, research findings, etc. and frequent presentations to convey results. High quality technical writing is required along with clear and confident presentation skills. Neither of these skills were emphasised during my undergraduate degree. Practice is really the only way to improve these skills. However, feedback from colleagues can help to pinpoint areas for improvement. Techniques to overcome nerves are also useful, especially when delivering presentations to large audiences.

In your opinion, what is the biggest difference in the way of working between academia and industry?

Generally speaking, academia allows for longer term/more fundamental studies and usually works to a lower technology readiness level. While industry is usually focused on tackling problems which are having an impact now, or in the shorter term. Personally, I enjoy more of the real-world trouble shooting and varied work which comes with industrial R&D.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

The introduction of compulsory applied statistics, which would ideally include Design of Experiments (DoE), would allow for a more rigorous understanding of error, which is essential in any area of research. The inclusion of DoE would allow for more intelligent research, maximising information gained from experimentation. A focus on industry 4.0, increased automation techniques and coding would also enable forward-thinking researchers, with versatile skills which are applicable to many industry sectors.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Chemical engineers have many opportunities to impact the people and planet, specifically around the sustainability of products and processes. I believe clean energy routes such as hydrogen technologies provide the biggest opportunity to contribute to achieving net zero.

What exciting developments in chemical engineering research is your company or institution working on right now?

JM is putting its science and experience into developing many sustainable technologies which will used in sectors where emissions are difficult to abate, such as heavy-duty vehicles and domestic heating. These technologies include fuel cells, biorenewables and hydrogen technologies.

In your opinion, what differentiates research from the rest of the chemical engineering field?

Research allows longer-term problems to be tackled and enables step-change improvements to be made, rather than incremental improvements. This gives researchers exciting opportunities to think outside the box, to develop novel solutions.

What is your top tip for anyone considering a career in chemical engineering research?

Everyone has unique experiences and expertise. Your unique perspective could unlock progress in a well-researched area or provide novel ideas in a new space. Use all your experiences, even if this is outside R&D, to influence your research.

What can IChemE do to be more relevant to chemical engineers working in research?

Providing examples of R&D routes to Chartered Status and to have the assessment conducted by senior research engineers. Having more research engineers as IChemE assessors could help to facilitate this.

Silvia Di Lecce

Senior Consultant

Siemens Process Systems Engineering, UK

What degree qualifications do you hold?

BEng Clinical and Biomedical Engineering, Sapienza, University of Rome, Italy, 2010
MEng Nanotechnology Engineering, Sapienza, University of Rome, Italy, 2013
PhD Chemical Physics, Imperial College London, UK, 2017

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

When I worked as a postdoctoral researcher, I attended several training courses to improve my technical skills. I am currently a member of the Women's Engineering Society (WES).

Briefly outline your role and the research sector you work in:

I am a senior consultant at Siemens Process Systems Engineering Limited. In my role as lead developer in the technology group of formulated products, I apply knowledge of thermodynamics and coding skills to develop first-principles mathematical models for industrial problems presented by our clients. I am also involved in enhancing, maintaining, and testing the model libraries of our modelling platform.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

My career interests changed and developed throughout my education and roles. When studying towards my master's degree, I particularly enjoyed the modules on quantum mechanics and statistical mechanics. I knew that I wanted to learn more about these fields. I really enjoyed my PhD degree, as well as working as a postdoctoral researcher in academia. During these years I had the opportunity to attend many conferences and collaborate with several research teams, as well as industrial partners. Finally, I realised that I wanted to focus more on modelling systems relevant to industry and apply my knowledge to solve engineering challenges.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

At first, I thought chemical engineering research was very theoretical and far from industrial interests. I then realised that, even in an academic environment, research could focus on everyday challenges and the results could have a prompt impact on solving global problems.

Illustrate your journey from graduation to your current role:

During the final project of my master's degree, I was inspired to become a researcher. After my PhD, I worked as a post-doctoral researcher at the university, in different departments, including chemistry and chemical engineering. My research mainly focused on theoretical investigations of the phase behaviour, structural and dynamics properties of complex charged systems in bulk and in nanodevices, under equilibrium and non-equilibrium thermodynamics conditions. I then moved to my current role at Siemens Process Systems Engineering Limited.

Describe the research environment you work in:

The research environment I work in is multidisciplinary, since we interact with different clients on many projects related to formulate products and their manufacturing process. In my role, I collaborate with members of other teams with different background. It is critical to have a good understanding of unit operations, engineering skills, and thermodynamics. I also use my programming and computational skills and experience extensively.

What is the greatest challenge in your current role?

Some projects are new, long to complete and it is sometimes difficult to fully predict the outcome. Having a good planning strategy and regular interactions with more experienced members of the team help to overcome these challenges.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

Keeping motivated. As a researcher, you often try to answer questions which cannot be found online or in books. The results are not always what you expect, and things might not work the first time. It is vital to keep learning, finding new ideas and projects to work on. The environment can also be very competitive.

In your opinion, what is the biggest difference in the way of working between academia and industry?

In academic research, the results from your work are usually presented to the community through scientific publications or conference presentations. Your name will be in the authors list. It is essential to keep publishing in peer-reviewed journals to build your career and become an independent researcher. In industry, scientific publication are not always an important goal and the research you do is often part of a bigger project to develop a new product in the company.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

It would be good to provide a clear idea of the key challenges we face globally on energy, food, environment, health, and manufacturing. Students should learn how to break down complex problems as well as to be curious.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Chemical engineers play a key role in many research fields. Probably the biggest challenges to society where chemical engineers could make the difference are sustainability and energy.

What exciting developments in chemical engineering research is your company or institution working on right now?

The modelling platform is being used to develop zero-emission flights.

In your opinion, what differentiates research from the rest of the chemical engineering field?

When working as a researcher you face new challenges every day. Both your technical and soft skills are continuously used and improved. You need to keep learning new things, always being creative and passionate.

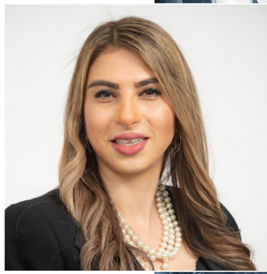
What is your top tip for anyone considering a career in chemical engineering research?

Always be curious. Gain as much experience as possible from every project. Keep learning.

What can IChemE do to be more relevant to chemical engineers working in research?

Organise additional conferences, symposiums, workshops, and webinars. IChemE could support the career development of early-stage researcher throughs funding and/or courses to help them plan their next steps.

Somaieh Mohammadi



Data Science and Analytics Manager

GSK, UK

What degree qualifications do you hold?

BSc Chemical Engineering, Iran University of Science and Technology, Iran, 2002
MSc Chemical Engineering, Iran University of Science and Technology, Iran, 2008
PhD in Chemical Engineering, University of Newcastle Upon Tyne, UK, 2014
MSc in Computer Science – Data Analytics, University of York, UK, 2021

Apart from your degree/further degree, have you taken any further qualifications, professional memberships, or professional registrations?

None

Briefly outline your role and the research sector you work in:

Until November 2022, I was a senior staff scientist in the global data science team at Fujifilm Diosynth biotechnologies, which is a global contract development and manufacturing organisation (CDMO) offering solutions in pharmaceutical manufacturing – from pre-clinical stage and process development to commercial 'current good manufacturing practice' production. I developed and applied computational tools and applications to support process characterisation and optimisation in early and late-stage development. My main interest was in the application of chemical engineering principles in development and manufacturing. I utilised various modelling and simulation tools and techniques related to fluid flows, such as computational fluid dynamics (CFD) to solve problems and develop new approaches to scaling.

Career goals and perceptions of chemical engineering research

What were your career aspirations during your degree, and did you know what you wanted to do?

I was not very certain about the type of industry in which I was willing to work but I had interests in the research and development area, while always being passionate about problem solving and creativity. I tried to be flexible enough to apply the skills developed during my degrees in different types of industries and didn't want to limit my choices. Generally, I preferred to get involved in process or equipment design, process modelling and process scale-up or scale-down.

What was your perception of chemical engineering research at the start of your career and how has it changed since?

My perception has shifted from valuing hard skills for applying knowledge and chemical engineering fundamentals, eg thermodynamics and transport phenomena, to softer skills. I believe that hard skills might suffice until you land in a job but what keeps you moving forward and progressing is soft skills. For example, how to work efficiently in a team, how to work under pressure, how to communicate effectively and how to put time and project management skills into practice. These are some key competencies that you need in the research environment to succeed.

Illustrate your journey from graduation to your current role:

After graduation from university, I was not sure if I wanted to continue my career in academia or industry. I chose to stay in academia, working for a year as a post-doctoral research associate in the department of chemical engineering at Newcastle University, UK, focusing on micromixing modelling. I then found myself ready to put the technical skills I had gained through research into practical use, and joined the process design team at Fujifilm Diosynth Biotechnologies, providing support to multiple projects at various phases of biopharmaceutical drug development and commercial manufacturing. I collaborated with scientists and engineers across the business to plan and design meaningful experimental studies, analyse and communicate results from these studies, and engage in effective decision-making. My main role was applying statistical knowledge in various aspects of the Quality by Design approach in biopharmaceutical drug development. My role as Senior Staff Scientist involved in-depth modelling and simulation, applying computational and statistical modelling, to support process characterisation and optimisation in early and late-stage drug development.

Describe the research environment you work in:

That work environment encouraged cooperation between groups and sharing of knowledge, and promoted and encouraged innovation and engagement. Our team supported the business across functions and provided expert scientific and engineering knowledge to clients and internal projects. We assisted in the development of solutions to technical problems by applying scientific understanding, assessing options, and applying innovative solutions to facilitate on-time, on-cost delivery of project milestones. We contributed to the initiation and management of scientific collaborations to support new or exploratory science and technology strategies. Core competencies were customer focus, relationships building, business standard and integrity and people development.

What is the greatest challenge in your current role?

As biopharmaceuticals is a fast-growing industry, one of the big challenges was to develop skills and to grow at the same pace, to adapt and apply the novel techniques in my job to support the team in order to achieve team and business objectives.

Chemical engineering curriculum and gaps for chemical engineering researchers building their careers

What was your greatest hurdle when transitioning from study to industry/academia and how did you overcome it?

One of the biggest hurdles when transitioning from study to industry or working in academia is the change of culture and mindset and the need to be able to adapt to a professional environment. One of the cultural differences I found was that I needed to build relationships not solely for fun, but more strategically in a professional environment. I had to build a robust network of colleagues who could help me prosper in my career. This relationship building can impact how you succeed and move up the ladder. You need to be willing to make the effort and spend some time to make the transition. For instance, for me it was identifying which soft skills I needed to develop and how to improve them, through training or asking for advice from more experienced friends or colleagues.

In your opinion, what is the biggest difference in the way of working between academia and industry?

The concept of research is similar in both academia and industry. The main goal in academia may be to gain a degree or publication, whereas industries' aims are based on market requirements. I believe in academia you can follow your passion more, while industry gives you less flexibility in that respect and you need to focus on a specific goal. In academia, you are more isolated in the lab or department where you are doing your research on one specific project; in industry you can work on multiple projects at the same time. You can find more collaboration among different departments, for example between upstream process, downstream, quality control, manufacturing and commercial teams, where all departments have the same goal – to achieve business objectives. I believe career progression has a faster pace in industry; for example, you can start as a research scientist and, based on your performance, can get promoted to senior, principal and leader positions in a few years.

What two changes to the chemical engineering curriculum would you make to prepare people for research?

I found communication skills, teamworking and problem-solving skills to be at least as important as technical skills. I would suggest that soft skills are given more focus within the curriculum. Encouraging researchers to engage with professional development and invest in their soft skills, as well as hard skills, is imperative, as those are the transferable skills that researchers can carry from academia to industry, or from one industry to another. Presentation skills are particularly important: even if you are a great researcher and very knowledgeable, if you cannot communicate, share and present your knowledge or analysis effectively, you don't have a chance of being recognised or promoted. I have also found data analysis skills to be very important – these skills will help you make better decisions, based on your data, and give you in-depth and unique insights, which will make you stand out, compared to others.

Making a difference in the future

In your opinion, what is the key area that chemical engineering researchers can make a difference to people and planet?

Research in chemical engineering has a high impact and provides very useful solutions to a wide range of environmental and life-changing problems. Chemical engineering advances have been extensively and comprehensively applied to problems such as biological treatments, biofiltration and wastewater treatment.

What exciting developments in chemical engineering research is your company or institution working on right now?

Some exciting research that I was working on was continuous biomanufacturing, to give our clients access to full end-to-end automation and integration of upstream and downstream processes. Continuous processing offers flexibility and agility to manufacture products, while awaiting a fully defined clinical and/or commercial forecast and makes things easier for customers' supply chains. Continuous processing can also increase robustness in manufacturing, by reducing the number of steps and holds, and utilises smaller equipment and facilities.

In your opinion, what differentiates research from the rest of the chemical engineering field?

To work in the research field, you need to be passionate and enthusiastic about advanced research, cutting across typical topic boundaries. You need the desire to go above and beyond to take on engineering challenges and solve complex problems. You need to keep up with your professional development; you need to read and digest many publications in the field. Finally, you will need more creativity and skills for innovation.

What is your top tip for anyone considering a career in chemical engineering research?

Chemical engineers work in many industries and sectors: choose one that excites and interests you to work in. Learn to use different software, such as Matlab and Ansys – this could make you stand out from other graduates.

What can IChemE do to be more relevant to chemical engineers working in research?

IChemE could organise events, webinars or training that highlight the skills and techniques that researchers need to acquire, develop or improve in order to be successful in whatever path they are taking – academia or industry – and help them get ready by giving some insight into what they are going to face and what is expected from them.

Outlook and conclusions

These nine interviews highlight how chemical engineering researchers can make a difference in the world, especially in the context of climate change and sustainable development. Researchers reported on their aspirations, the challenges they face or faced, and how their perceptions of research in chemical engineering evolved with time and experience. In their interviews, they share advice and encouragement for chemical engineers considering a career in research, based on their own hard-won experience. Their recommendations for how the chemical engineering curriculum could be changed to prepare chemical engineers for research-oriented careers are followed by suggestions of how IChemE can foster chemical engineering research and researchers.

The interviews illustrate that careers in chemical engineering research offer many exciting and highly diverse opportunities: there is no 'one size fits all' to chemical engineering research, particularly as the scope of the field is evolving rapidly. There is a strong message from the contributors that there are great opportunities for those who ask questions about the long-term future impact chemical engineering can have on society. The interviewees also encourage potential researchers to continue learning and develop people and networking skills in order to build their careers.

Chemical engineering researchers can make a difference

A very strong message is that chemical engineering researchers can contribute to a net zero future across a wide range of sectors, whether the research is carried out in academia or industry. They can make significant contributions to the development of clean energy technologies, including hydrogen, catalysts and catalytic technologies, batteries, fuel cells, zero-carbon liquid fuels, biofuels, provision of low-carbon high-temperature heat and safe decommissioning of nuclear energy facilities. Contributions to circular economies will also be important; examples include the development of recyclable or compostable packaging, recovery of clean water, resources and energy during wastewater treatment, and development of advanced recycling technologies. Modelling and optimisation, from molecular to circular-economy scales, will support the development, operation and control of efficient, safe and environmentally-benign technologies, processes and systems.

Aspirations, challenges and changing perceptions

In the early stages of their careers, some researchers aspired to contribute towards a sustainable future, especially in terms of energy needs and protecting the environment. Several researchers identified a desire to extend knowledge and understanding or to solve challenging problems, for example relating to product development, process technologies or modelling for a sustainable future. Few had fixed ideas about the sector in which they would work, but wanted the opportunity to work creatively, to be challenged and to innovate in a technical area.

Unsurprisingly, the development of technical skills in rapidly developing areas presents a challenge to researchers. Experience, skills and time are needed to stay abreast of and absorb new knowledge and to deepen knowledge, for example to scrutinise assumptions, to ensure that the right problem is being addressed. Effective working also requires development and application of new professional skills to enable effective teamwork, cross-disciplinary collaboration – ranging from science and data science to business, policy and social science – and communication in written reports and presentations and other modes. Industry-based researchers emphasised the complexity of the working environment, with multiple workstreams, stakeholders and objectives, together with uncertainties and changing targets, priorities and sometimes regulations, requiring a good deal of agility. Researchers need to ensure that the problem being addressed is well-defined and is being solved using a suitable approach, supported by appropriate and adequate information. For academics, the requirement to secure research funding and to engage suitable talent are additional challenges. Time constraints because of the multiple responsibilities that need to be balanced are a further challenge; for example, in academia, teaching and administration duties need to be managed, alongside research.

Several industry-based researchers commented on changes in their perceptions regarding the breadth of industrial sectors in which chemical engineering researchers work and the interdisciplinarity of the research. Their work reveals that researchers can and do work on solving problems and developing technologies that have important and relevant practical applications. Work is carried out at small scales – 'bench scale' and smaller – as well as at process scale and considering the life cycle of whole systems and with impacts that reach beyond technological to societal. While academia tends to focus on developments at lower technology-readiness levels (TRLs), some industry-based research or industry-academia research collaborations do too. Researchers also gained appreciation of the importance of professional ('soft') skills, including those for building relationships, often across discipline boundaries, and for managing projects or workstreams in the context of complexity, uncertainty and regulatory and other constraints.

Advice for chemical engineers considering a research-focused career

This booklet provides suggestions and guidance for students (and recent graduates) who might be interested in a research degree or research career. Students are encouraged to make the most of their research project which is a part of the undergraduate degree by equipping themselves with a solid technical skillset, being bold about working on a project in a non-traditional area and remaining curious. Those considering starting a research degree are encouraged to explore a range of research areas in order to identify one that seems exciting, and to seek empathetic research supervisors. Gaining some industrial experience before starting (or as part of) a research degree can help provide perspective and develop valuable professional skills. During the research degree, it is important to envisage the potential application or impact of the findings and shape the research focus or approach accordingly. Acquiring professional skills, for effective communication, collaboration, teamwork and time and workflow management, during the research degree is seen to be very important, as these will be needed in the next career step – where these skills will develop further. Once working as a researcher, there is a need to continue learning about the latest developments in the field, to continue building skills and to stay curious, enthusiastic and creative to make an impact and progress in one's career.

The chemical engineering curriculum

The interviewees suggested several ways in which the chemical engineering curriculum could change to better prepare graduates for careers in research and collaborations with researchers. In the opinion of the researchers we spoke to, courses could provide more:

- science-based knowledge and skills, including interdisciplinary knowledge such as chemistry and biology;
- skills for and experiences of creatively solving open-ended problems;
- skills for data analysis, statistical analysis, understanding of error;
- digital skills, including for modelling, simulation, coding, automation and machine learning;
- critical thinking skills, including critical analysis of previous work, analysis of assumptions and their implications and appreciation of the potential impact and application of research;
- professional skills, including report writing, effective communication, team working and collaboration, time management and agile working;
- broader and deeper experience of and exposure to research to showcase how chemical engineering research is making an impact; how research is funded; how industry-academic collaborations can foster research; how environmental, social and governance pressures can drive research and how research can translate into knowledge, social, policy and economic benefits.

IChemE support for chemical engineering researchers

The interviews asked respondents to suggest how IChemE could increase its relevance to chemical engineers working in research. This section summarises their responses. The text in italics outlines what opportunities and resources IChemE already offers researchers and identifies some areas where IChemE and its volunteers could provide further support.

Events

Interviewees' recommendations

The researchers noted that events such as webinars and conferences create valuable opportunities for presenting their work and interacting with other researchers working in related areas. They welcome opportunities to engage with those working in industry, to raise awareness of current research and to help researchers understand current industrial challenges and how their research can address these. Support is recommended for theme-specific mapping exercises that could provide a useful resource for members.

What IChemE offers its members

In the UK, the annual ChemEngDayUK conference, organised by the Heads of Chemical Engineering UK and supported by IChemE, provides opportunities for UK research students to present their work, network and more, while the Chemeca conference series provides a forum for researchers for researchers from Australia and New Zealand. IChemE's 19 special interest groups (SIGs) share knowledge in a wide range of technical areas, as do regional member groups. These groups' committees plan and deliver events and webinars providing these opportunities. There is scope for SIGs and member groups to strengthen their focus on research, R&D and pressing industrial problems, including by facilitating industrial-academic dialogue and by mapping industrial needs to active areas of research.

Resources, training and Chartered status

Interviewees' recommendations

The researchers recognise the benefit of resources provided by IChemE that highlight the importance and achievements of research. The researchers would value IChemE delivering training and holding events for researchers aiming to help them identify and build relevant skills to support their career development. They identified challenges related to progressing towards Chartered membership and professional registration (eg CEng and CSci) and a need for support from IChemE in this area, for example by providing further information and guidance, and by including researchers within their team of assessors.

What IChemE offers its members

The Chemical Engineer frequently includes news about research and development articles. IChemE's eight research journals showcase original, peer-reviewed experimental and theoretical research work, case studies and application of the research to solve problems. A recent Research and Innovation Community of Practice project collated case studies demonstrating the impact of chemical engineering research in Australia and New Zealand. Some SIG webinars focus on research and its application, including those by eminent researchers who have been awarded IChemE medals and prizes. The focus on research and its application could be expanded further in webinar programmes.

One Research and Innovation Community of Practice webinar (available as a recording) focused on translation of research from academia to application and industry-academia partnerships. IChemE could offer further resources to support career and skills development, with the help of volunteers. In terms of Chartered membership, IChemE could explore ways to increase its support for the researcher community, assisted by volunteers who are themselves researchers who are Chartered and willing to act as mentors or assessors.

Opportunities for Experience

Interviewees' recommendations

Researchers said they would value IChemE funding to support research and the research experience, for example through grants to enable more students to take up internships and attend conferences, and through fellowships for early-career researchers.

What IChemE offers its members

Currently, IChemE supports researchers in the area of catalysis by offering bursaries to attend a catalysis summer school, and through its Andrew Fellowship (due to be relaunched in 2024). Some of the SIGs also offer bursaries to support attendance at conferences and other events; provision in this area has potential to expand. The Ashok Kumar Fellowship also provides opportunities for policy-related research within the UK's Parliamentary Office of Science and Technology.

Expanding support and opportunities in the above ways depends critically on volunteers. IChemE encourages all members to find ways to participate in and contribute to its member groups, activities and initiatives that can, in turn, increase the relevance and value of the Institution to its members.

Contact us for further information

UK
+44 (0)1788 578214
membersupport@icheme.org

Australia
+61 (0)3 9642 4494
austmembers@icheme.org

Malaysia
malaysianmembers@icheme.org

New Zealand
+64 (0)4 473 4398
nzmembers@icheme.org

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