FISITA

Promoting excellence in mobility engineering

Mobility Engineer 2030
FISITA White Paper

www.fisita.com

/FISITA.official

@FISITAhq

/company/FISITA

Table of Contents


Foreword

Mobility Engineer 2030 is a collaborative initiative, led by FISITA, utilising the organisation's unique, international status and relationships between its key industry and academic stakeholders to consider how mobility engineers of the future can be best educated and prepared to deliver the skills-sets that the fast-evolving 'mobility services' industry will require.

This year-long initiative, which has drawn contributions from FISITA Corporate Members, the FISITA Technical and Education Committees and the Academic Advisory Board, is a detailed consideration of a complex challenge at a time when the industry landscape is changing fast, and forever.

This period will undoubtedly be recognised in history as the most significant in technological terms since the industry transformed transportation needs over one-hundred years ago with the introduction of the mass production automobile.

The pace at which this change is gathering momentum dictates what consideration is given to the key engineering disciplines of future mobility. These will continue to enable the engineers of tomorrow to develop and deliver enhanced product innovation over the long-term.

With connectivity, autonomy, propulsion, safety and security now as important to the next phase of our industry development as the traditional mechanical and electrical engineering disciplines have been to previous generations, it is clear that how industry and academia engage is critical to the process of creating and sustaining sufficiently capable and 'workplace ready' engineers.

Mobility Engineer 2030 has been created as a mechanism of establishing an initial perspective and outlook over this important and evolving landscape, to stimulate discussion and the continued process of positive engagement between our industry's technical leaders, academia and other stakeholders, in order to create solutions to the benefit of the international engineering community, industry and society.

In its first iteration, the Mobility Engineer 2030 initiative has gathered opinion from industry and academic leaders within the international FISITA community and begun the process of establishing an on-going dialogue that will support a continued collaborative approach to evolving academic and industry approaches in this critical area.

As this report becomes widely available, FISITA welcomes the engagement of other contributors as this initiative is intended to become an on-going collaborative, international study of engineering capability and expectation.

Engineers create solutions, FISITA continues to support them to do so.

Chris Mason
Chief Executive
FISITA

Dr.-Ing Karl Siebertz
Head of External Alliances Europe
Ford Research & Advanced Engineering
Chair Mobility Engineer 2030 Working Group


1. Introduction

The Mobility Engineer 2030 initiative aims to identify the skills that mobility engineers will require in 2030 as a first step in a long-term process of engagement, evaluation and feedback. FISITA holds a unique, international position which connects engineering societies, industry and academia in a global network and each of these stakeholders have a clear, vested interest in how future mobility engineers are educated to deliver against the future industry needs:

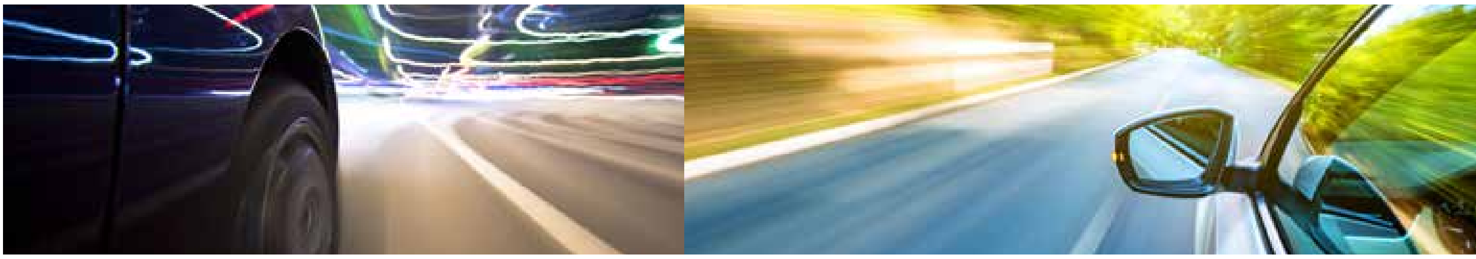
- Engineering societies within the international FISITA community represent the interests of 200,000 engineers working in the traditional automotive and emerging mobility arena.
- Industry has a direct need to continually recruit new engineers and plan to succeed current employees with appropriately skilled engineers.
- Academia develops talent, feeds the employment market and provides significant research capability and support.

As no single stakeholder would be able to consider all aspects and requirements, the Mobility Engineer 2030 initiative sourced input and feedback from all three groups.

This paper outlines how the automotive sector is changing, before considering the evolving needs of industry, drawing on input from Corporate Members of FISITA and engineering society members through the FISITA Industry Committee and Technical Committee.

The paper then explores how the role of education can adapt, outlining the views of the FISITA Academic Advisory Board (AAB) and Education Committee, both of which consist of leading academics and scientists from world-class universities, extending a reach across three continents. The input of the AAB and FISITA Education Committee provides an excellent insight into current education models, best practice and future considerations.

The report then proposes a concept for the future by combining input from the multiple stakeholders aligned through FISITA; the inaugural Mobility Engineer 2030 White Paper aims to support further progressive discussions, considerations and thought leadership as industry and academia prepares the environment for the next generation of our industry's technologists; the 'mobility engineers'.



2. How Automotive is Changing

Current developments in mobility engineering are increasingly volatile. Many things happen simultaneously and it is crucial to maintain the overview. In this section we would like to offer three independent inputs that might be able to provide some insight. There is no aim to provide a complete picture, however, a discussion about future education of engineers does require a vision about the future technology demand.

Four Disruptions[1]

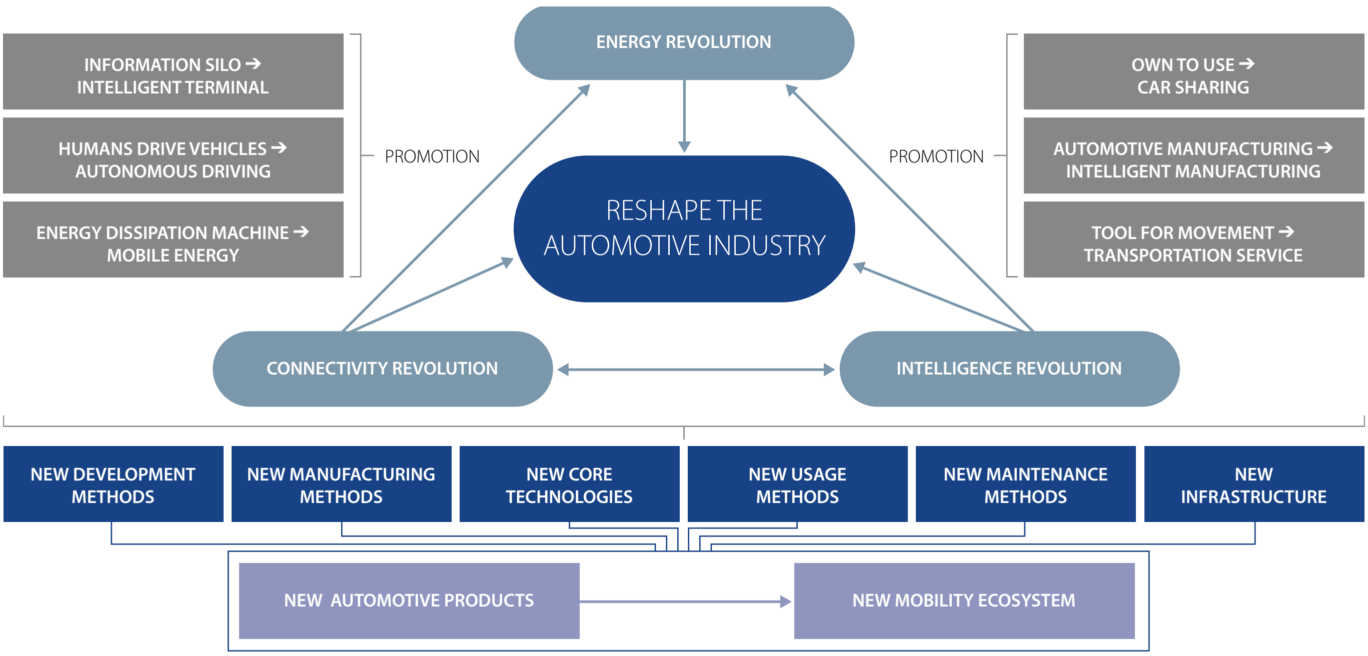
1. Electric traction: eco-system including non-automotive infrastructure. This includes renewable energies and smart grids.

2. Automated driving: robotisation with high level of safety/security. This includes artificial intelligence, machine learning and formal methods to provide the required level of safety.

3. Connected cars: eco-system with telco technologies and business model. This includes standardisation of protocols, bandwidth, cybersecurity, etc.

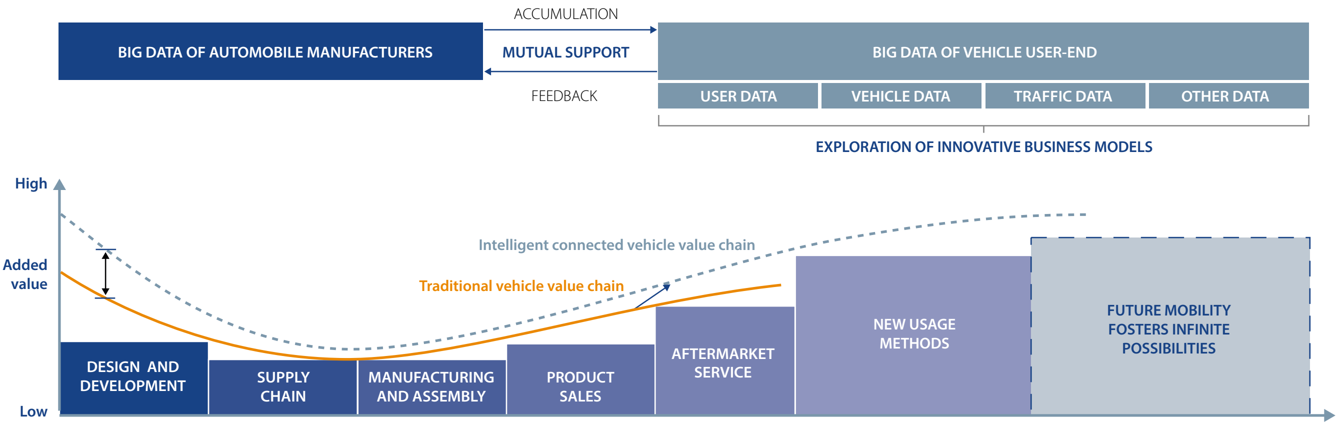
4. Mobility on demand: new services with partnership with public authorities (city, etc…). Access versus ownership, new business models, diverse partnerships.

Redefinition of automobiles[2]



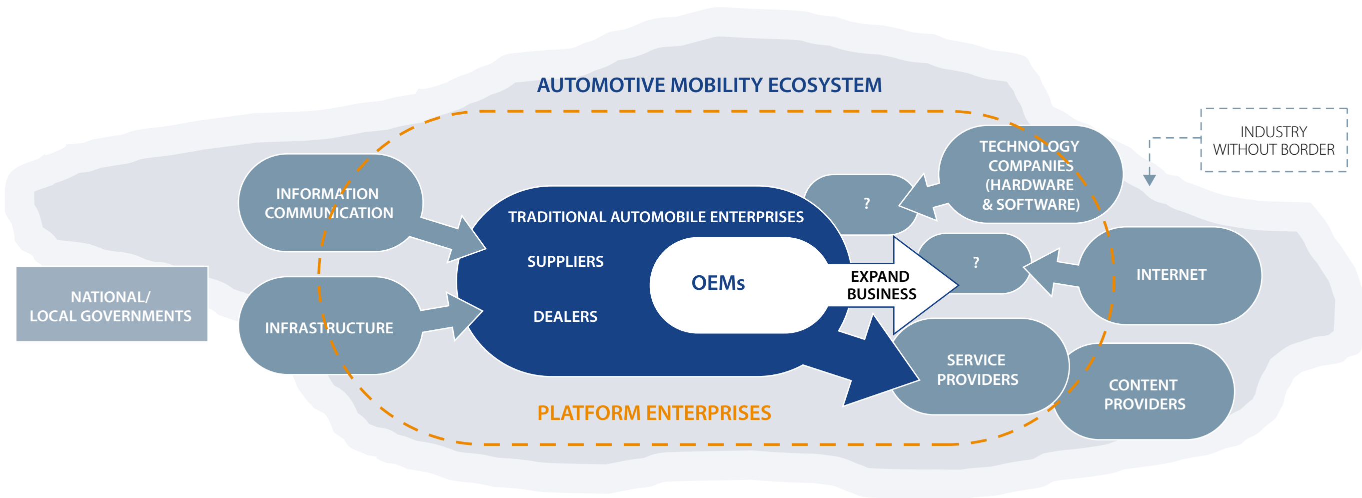
Three revolutions have brought six revolutionary changes to the automotive industry. Automobiles will transform into mobile and connected terminals from simple tools for movement.

1. Renault
2. Tsinghua Automotive Strategy Research Institute, TASRI



The whole automotive industrial chain has undergone substantial changes due to connectivity and big data.

Core: focus on the opening of big data of the whole automotive industrial chain and value excavation.
Support: cloud platform + big data + artificial intelligence.



Automotive Industrial Pattern in the Future: Multipartite Participation and Cooperative Competition. In case of such changes, the automotive industry has transformed from the original vertical industrial chain composed of OEMs, suppliers and dealers into an ecosystem without border with multipartite participation, bringing huge opportunities.

Attributes of a Modern Mobility Device[3]

Mechanics: Highly optimised construction, weight and cost-effective. Complexity management to cover various demands, e.g. powertrain, body style or level of equipment. Mix of high- and low-volume manufacturing techniques, including personalisation. Industry 4.0.

Electrics and Electronics (including automated driving): Increasing proportion in the value chain. Short development cycles and x-industry innovations. Increasing number of interfaces and industrial standards. New players entering the automotive domain.

Software (including v2x and automated driving): Increasing proportion in the value chain. Many interfaces and strategic alliances. Sophisticated algorithms, e.g. AI, machine learning, sensor fusion, model-based controls. Substantial effort on quality engineering.

Device and Environment (including business models): Mixed modal transportation. Access vs. ownership. Total customer experience vs. vehicle performance. Smart vehicles for a smart world.

3. Ford

3. The Demands of Industry

In view of the fundamental changes in the automotive industry driven by digitalisation, electrification and societal trends, the Mobility Engineer 2030 initiative asked FISITA's Corporate Members two fundamental questions:

1. What type of engineers will your organisation need in the future?

2. What are the future industry requirements in terms of engineering expertise, skills and abilities?

Their collated response can be summarised as:

1. The engineering landscape in the automotive industry will broaden in scope – in addition to mechanical engineers, companies will be in significantly greater need of engineers from IT and associated 'new technology' disciplines.

2. Besides specialists, the industry will require generalists with capability across different engineering disciplines that link the various engineering fields, and engineering collaboration across multiple disciplines will become critical success factors for engineering in the future.

3. In parallel, the skillset of engineers will expand from predominantly technical requirements to more process-related skills, such as agile project management, communication skills, operating in virtual environments, and flexible organisations will become important competencies in the engineering role profile.

Technical and Interdisciplinary Skill Requirements

Feedback from FISITA Corporate Members shows that traditional science, technology, engineering and mathematics (STEM) skills will remain an important part of the skills mix. Respondents unanimously confirmed that the 'classical' automotive engineer with profound knowledge in mechanical engineering, mechatronics and materials will still be necessary.

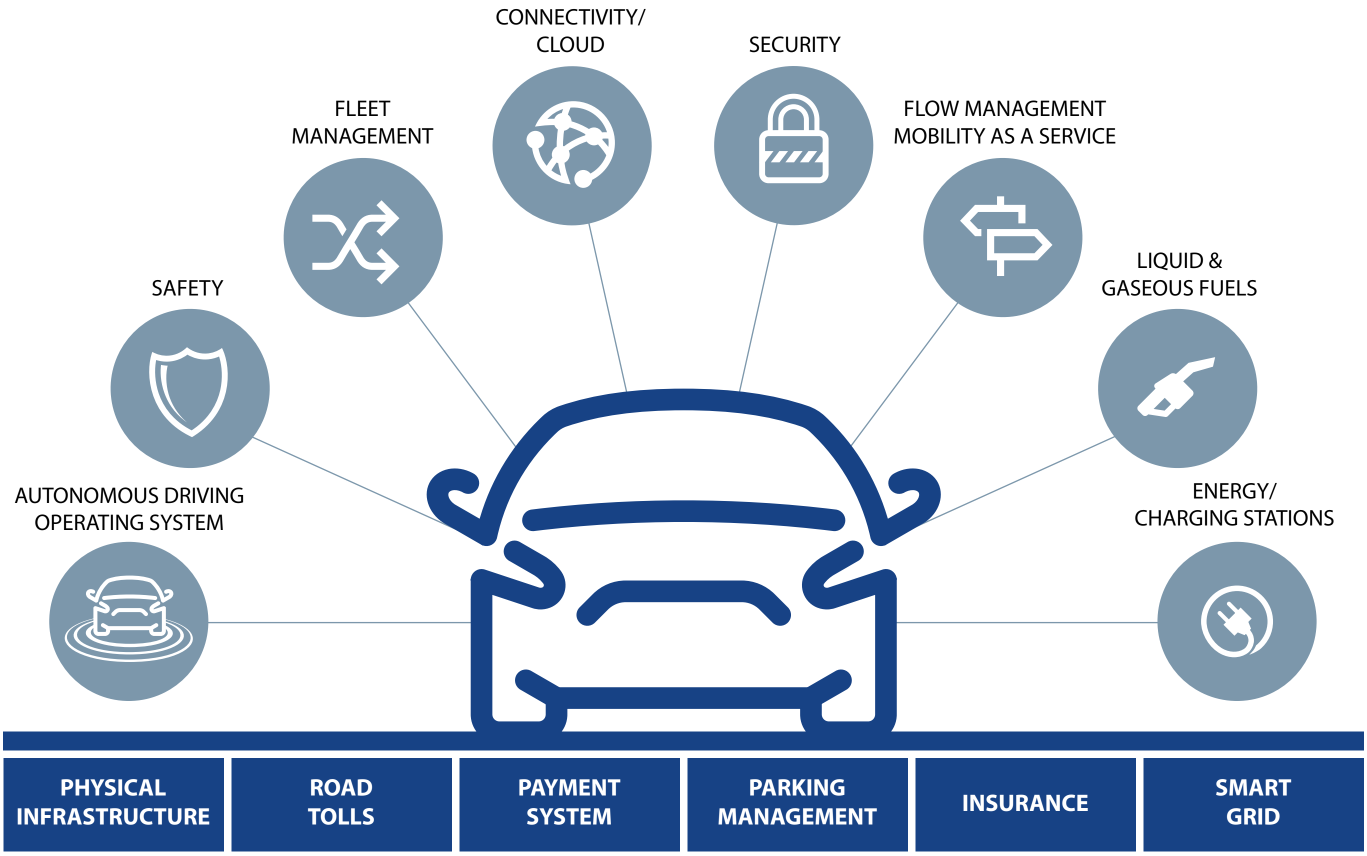
However, in the context of electrified, connected, autonomous and shared mobility, the qualification profile of a 'universal' engineer with a deeper understanding of other engineering disciplines will gain increasing importance.

In general terms, companies anticipate a shift in requirement from a pure mechanical engineer profile towards a mixture of mechanical and electronics or mechanical and software engineer profile.

Respondents noted, for example, that a mechanical engineer must have a robust knowledge of electrical/electronical systems to lead detailed discussions with their counterparts in cross-functional teams. They also highlighted a growing need for engineering specialists in the fields of data networks, electrical engineering, software engineering, software architecture and systems, digital signal processing, and in the increasingly important technology areas of cybersecurity, artificial intelligence, and robotics.

Several respondents prioritised systems engineering and the increasing complexity of vehicles as crucial in engineering discipline terms, and already becoming a significantly important area. Industry experts see simulation, virtual testing, virtual prototyping and virtual reality as areas with disruptive potential in the automotive engineering process. A rapid increase in model-based development, hand-in-hand with the ability to transfer simulation results into reality, is seen as essential to developing advanced products rapidly.

Figure 1: The surrounding environment of the future automotive/mobility industry



The evolution of Industry 4.0 (automation and data exchange in manufacturing technologies) and the growing availability of big data, enabling the development of predictive models, are challenging the automotive engineering community to establish competencies in gathering, analysing and working with the large volumes of data being generated by machines and processes. Engineers who understand and think in process-terms, rather than silo specialists, are required to meet this challenge.

It is therefore suggested that a new engineering species of 'data scientists' who are experts in analysing complex data, will collaborate with process experts to quickly make reliable predictions.

In view of the increasing role of simulation and the trend towards remote engineering, industry contributors also highlight a growing need for expertise in 'manufacturability'. The ability to recognise key factors that impact the manufacturing process very early in the design process is and will continue to be an important asset for engineers, as development cycles get shorter and products become increasingly complex. In this context, detailed knowledge of the appropriate manufacturing processes, techniques and tools will be crucial.

Project, Process Management and Soft Skills Requirements

As the car evolves and incorporates more consumer electronics devices with a development emphasis on in-car experiences, traditional engineers must now also deliver other 'non-engineering' capabilities, such as knowledge in market and societal trends, in user experience and human factors. With technology evolving faster and faster, companies stress the need for visionary thinking and an out-of-the-box attitude to find innovative and creative solutions quickly.

In the evermore connected global environment, work-sharing within worldwide R&D networks is required, with companies expecting engineers to have strong project management skills and the flexibility to work in different locations on different projects.

In this context, communication skills are considered an increasingly important requirement. For example, engineers require presentation skills in virtual environments for collaborative team-working, project reviews, reporting and other virtual and actual team-based activities. Engineers also require an increasing capability of co-designing in virtual team environments, while collaborating with colleagues in remote locations. Soft skills, such as social/cultural competences, an appreciation of diversity, and language skills, will all support a successful engineer of the future.

In the future, engineers will work in even more agile and cross-functional environments than today, meaning companies will increasingly value open-mindedness and a curiosity for new ways of collaborating in new organisational structures and new team-based working models. Working in so-called 'swarm organisations' is likely to become part of the daily routine, a new style of work discipline which is considered to be an important and progressive management skill.

Broader, interdisciplinary knowhow and flexibility are seen as key ingredients of the future engineers' skill set. The 'ideal' engineer will be able to adopt new knowledge and understand new technologies quickly and be able to develop non-standard solutions.

In the context of fast changes in technology, legal and regulatory requirements, emission laws, differing customers and needs, combined with international social trends and complexities, engineers need to be capable of collaborating with multiple groups of colleagues of differing engineering disciplines, and working in cross-functional teams, while applying virtual tools across different working locations.

New Paradigms

Mobility engineering, more than many other professions, exists in a state of flux between traditional and understood forms of engineering and those that are yet to be fully established in a changing environment. Specialist versus generalist, mechanics versus electronics, hardware versus software, disruption versus refinement, complexity versus simplicity, exclusivity versus mass production, manual versus automated, to reference just a few factors.

As a result, potential students could experience a complex and challenging environment. This is understandable and therefore short-term delivery of clarity and an achievable and attractive curriculum is important. However, the academic community should consider two paradigm shifts to prepare students for a career in mobility engineering:

- **Paradigm 1:** It becomes questionable whether it is achievable to attempt to teach the most important subjects associated with 'mobility' in a single curriculum.

  While there may be opportunity to educate a generalist with shallow knowledge in the relevant areas, it would be challenging to reach the levels of knowledge required for competitive R&D experts in mechanical, electrical and software engineering in one single education, as experts will be needed to operate to high standards of competency in many different disciplines.

- **Paradigm 2:** The concept of university education preparing engineers for many years of success in their profession is becoming challenged. Engineers who were educated in the 1980s and 1990s will not have the knowledgebase to deliver against future mobility engineering requirements, without some form of further personal development. Therefore, the same will be true of today's engineers in 2030 and beyond.

There is no reason to believe that any education can last long enough to carry someone through their entire professional life, continued professional development is key to the continued technical relevance of a career-long engineer. An investment in 'career learning' would be a positive approach for all engineering foundations that need to be laid at university. Close cooperation between academia and industry in the on-going educational support of engineers throughout their career journey can become a success factor for all in continuous personal and industrial development, and not just applicable to research.

4. Examples of Current Best Practice

Our 2020 Engineers are already in the current education system. It is therefore interesting to compare current education systems and potentially learn from good examples. This section contains insight and feedback contributed by academics from Aachen University, University of Bath, Deakin University, University of Pitesti, University of Michigan and Tsinghua University – all are academic stakeholders with FISITA.

RWTH Aachen University, Germany

A solid technical education in mechanical engineering continues to be the backbone of RWTH Aachen. The University used to only offer the Dipl. -Ing. degree in engineering sciences, which is comparable to an MSc. While only a few students stop at BSc level, approximately 10-15% continue beyond MSc and progress with a PhD. There is a huge selection of around eighty elective courses in mechanical engineering but currently fewer options in electrical engineering and computer science, which still provide substantial variety for an individual curriculum.

Industrial internships are mandatory with a 20-week requirement and a stringent curriculum, requiring students to work in different areas, which is typically achieved by working in different companies. Students need to organise the internship themselves, which then takes place at different phases of the course. A basic internship is required prior to the first semester, while the last internship is completed in the middle or even close to the final BSc exams.

Most of the University's institutes offer positions as student assistants, which is a wonderful opportunity for any science-oriented student as they become part of a research team, led by a PhD student. Real research helps to understand the world of science and some of the teams are mixed, with researchers from different disciplines. Final projects, in which substantial research work is conducted, are mandatory for BSc and MSc.

RWTHAACHEN UNIVERSITY

Aachen University has very good relationships with industry, resulting in substantial research funding and a significant network of connections. Students can profit from this network and prepare their transition to industry while working on their MSc or PhD theses. Strong technical education, internships and application-oriented research have been in place since the 1980s at Aachen University. Since this time, interdisciplinary profile areas have been established, which is an important structural change to overcome rigid separation of faculties and institutes.

For example, mobility and transport engineering combines relevant institutes from mechanical engineering, electrical engineering, information technology, civil engineering, natural science, economy and humanities. In addition, interdisciplinary curricula have been introduced. The faculty of civil engineering, for example, offers a MSc in transport engineering and mobility, providing a unique package of interdisciplinary lectures, including electives in humanities, to explain the mobility of people in the context of public transportation.

University of Bath, United Kingdom

By working with industrial collaborators, the University of Bath exposes young engineers to the commercial environment at a point in their career where it can profoundly contribute to their development. The young engineers enter the industry as MEng and MSc and PhD graduates and all need to have a strong understanding of the technical and commercial requirements of the modern automotive industry. As such they are ideally placed to have the maximum impact on the industry.

The nature of the relationship with industry is shaped by the level at which the students are working. For undergraduates the main interaction with industry is through a year-long industrial placement that the majority of students undertake. This is a demonstrable, transformative experience as it is easy to see which year three and four students have been out on placement by their application, attitude and professionalism. This is in addition to their rapidly advanced understanding of how the industry and the products work.

The University of Bath is also seeking to encourage more cross-functional and cross-disciplinary working in the belief that the biggest challenge in improving the training of future mobility sector graduates is the way large companies traditionally work. Large companies commonly have a discipline-specific separation of the engineering teams in the design, simulation, manufacturing, calibration and validation steps, with these teams often based on different continents. To be more holistic, these functions need to be connected. For example, the re-use and improvement of the initial physical models throughout the vehicle development and validation process would enable more complete optimisation, but, in today's fractured environment, this is impossible.

With an increasing drive to narrow the subject expertise of modern engineers to achieve progress in specialised areas of technology, the system-level problem is too often neglected. The system-level problem is itself a critical specialism and engineers need to be trained specifically to operate within this environment. Once engineering graduates are employed, it can be too late to learn the wider aspects of the way the vehicle (and industry) work.

The University of Bath aims to ensure that students are able to understand the complex system-level relationships for an engineering product, such as a modern powertrain, and are involved in collaborative projects throughout their training to ensure they are comfortable within a business setting. Such engineers will have the right mix of capabilities to rise rapidly to positions of leadership in the industry.

UNIVERSITY OF BATH

Only with high-quality technical leadership can the commercial requirements of the manufacturer, legislative requirements of the market, customer aspiration and engineering rigour be understood and used to shape products that truly deliver the affordable, sustainable, efficient and clean final product required.

The way that engineers learn, and the situations to which they are exposed, are equally important and, perhaps, more important than the precise mix of topics in the curriculum. Therefore, industry and universities need to focus on closer and progressive working relationships from the earliest possible point in order to create the correct learning environment. For example, the thin-sandwich degree scheme run in the UK until the early 1990s was an excellent way to get universities, students and companies working together from the time that the undergraduate started at the university. The student was placed in the university for half of each year and at the sponsoring company for the remaining time. By the time they graduated, the student had benefitted from placements in a wide range of departments around the company and was already prepared to be doing a real job from day one as a full-time employee.

Professional associations play an important role in accrediting the quality of education and training provided, to give some quality assurance to the industry. The Institution of Mechanical Engineers (IMechE) run a Monitored Professional Development Scheme which helps to structure the early career development of professional engineers, putting into place the aspects that are often lacking in a university degree and that can only be provided by an industrial party.

The University of Bath aims to set up a 21st Century equivalent to the thin-sandwich undergraduate scheme in an initiative titled the Doctoral Training Centre, that provides training in these wider aspects in the early part of the PhD study, combined with a placement period during the PhD in a related industrial partner. This will educate to PhD level in a specific topic, but also give students a working knowledge of associated technical fields and the broader industrial experience and knowledge that only partnership with industry can provide.


Deakin University, Australia

Deakin University has overhauled its curriculum over the past four years in order to introduce a new style of teaching called Project-Orientated Design Based Learning, or PODBL. PODBL is a teaching and learning approach that is based on engineering design activities that are driven by a project that has a defined deliverable that is presented to them by industry partners or academic staff. PODBL encourages independent learning and a deep approach to learning. It also supports the development of information literacy and design thinking in the field of tertiary education - two of the key learning outcomes in modern provision engineering.

The PODBL model integrates on-line and on-campus learning, which has a positive effect on student content knowledge and the development of skills such as collaboration, critical thinking, creativity, innovation, and problem solving which increases their motivation and engagement. This has been influenced by the modern flipped classroom pedagogy (Long, 2016), which has enabled a greater amount of interaction between the disciplines, as projects need to have multi-skilled teams to devise solutions.

Each semester, throughout the engineering degree programme, students take part in project-oriented design-based work linked to their curriculum. Much of this project-based work is cross-discipline in nature. A considerable amount of first year engineering is common across all disciplines at Deakin. This allows each discipline stream to understand the basics of the other disciplines. At the conceptual level, there are core competencies that are the same across the disciplines. For example, solid mechanics is the same across civil, mechanical, and robotics. In the second year and beyond, the students specialise, but work with other disciplines.

The second-year mechanical/electrical design unit, for example, brings together mechanical, robotics, and electronics students to study discipline-specific design knowledge and apply it to a project. The project is a cross-discipline problem, often involving robotics, mobility, mechanical loads, and electrical power. The teams are made up of students from each discipline, where they are asked to scope, create, design, separate and distribute work on the project. Conducted each semester, these projects have led Deakin students to have a greater appreciation for other disciplines. For this approach to work, it is critical to find appropriate-level projects that can involve each of the disciplines at the correct level.

In the future, this teaching approach may allow outside disciplines to be involved in the projects with students of the appropriate level. Industrial designers and marketing may become involved in engineering product design, which would bring a realistic and new dynamic to mechanical/automotive engineering students who would gain first hand exposure to the tension between styling and functionality.

This new PODBL approach is supported at Deakin by the construction of purpose-built classrooms to provide standard discipline hands-on technical knowledge, break out spaces for team-based learning, maker and assembly spaces, open gathering spaces, and some spaces for individual students to work on detail in relative peace.

PODBL enables industry partners to be involved in the education of students through the projects that occur in each semester. Industry partners are encouraged to provide meaningful projects and allocate time to help guide the class through the project. The students gain from having an industry perspective on a project, learning both deep discipline-specific knowledge and the transfer of industrial experience from the industry mentor.

Traditionally, a PhD has been an entry point into academia. However, many PhD graduates are now finding employment outside of academia, particularly in Europe. Recognising the change in employment outcomes, Deakin University has introduced PhD-XTRA, which includes additional courses that each PhD student is required to take throughout their candidature to provide both hard and soft skills. Soft skills include presentation skills, clarity in writing and budgeting projects. Hard skills include technical courses on generic discipline knowledge, statistical skills, and experimental design knowledge. As a result, Deakin PhD graduates should be able to find employment outside of academia as technical leaders, with deep discipline knowledge and complementary soft skills.

University of Michigan, USA

The College of Engineering at the University of Michigan – Ann Arbor continues to develop new pedagogical methods and advanced tools for engineering education. They empower their students with the critical skills and beyond-the-degree experiences required of the engineers who will invent our future. This also includes professional and continuing engineering education with global impact.

The College of Engineering offers a range of four-year Bachelor of Science degrees in core disciplines that allow flexible student choices to emphasise particular topics, such as Automotive Engineering. Specialised courses with an automotive focus are available to students of a broad range of Majors. Notable examples are the courses in control and automation of vehicles cross-listed across the Mechanical, Electrical and Aerospace engineering departments. In addition, automotive focus is available through Minors (Multi-disciplinary Design Minor, International Minor for Engineers, and many others), student team experiences, (Solar Car, Formula SAE, UM::Autonomy, many others), and entrepreneurial programmes.

Masters and PhD programmes are designed with a similar philosophy with the exception of two dedicated automotive programmes. The Master of Engineering in Automotive Engineering and the Master of Engineering in Global Automotive and Manufacturing Engineering are offered through the Integrative Systems & Design Division.

Michigan's automotive engineering education programmes benefit from work done at its Robotics Institute, the University of Michigan Transportation Research Institute, the University of Michigan Energy Institute, Mcity (our Center for Connected and Automated Vehicles) and the Automotive Research Center. Their students have access to world renowned facilities at the Automotive Laboratory and numerous other experimental and computational facilities.

A summary of underlying educational frame work is provided here. A University of Michigan undergraduate engineering graduate will be prepared to generate value for society through a lifetime of technical and professional creativity. Their graduates will display reasoning skills and proficiency in problem definition, problem solving and quantitative expertise, a respect for measurement and data and the wisdom of experience. They will use these skills to achieve the following objectives within a few years of graduation:

- Contribute to technical engineering practice
- Pursue graduate education in engineering or science, either following a path towards a professional master's degree and practice, or a doctoral degree
- Pursue careers in law, medicine, education or other fields, bringing engineering problem solving skills — honed through practice in problem definition and quantitative problem solving — to bear in those disciplines.

Michigan graduates must understand that solutions, especially for society's most critical needs, are not just technical in scope but depend on many disciplines working together and that as engineers their core contribution will include bringing data-driven, quantitative problem-solving skills to the table. Graduates will embrace teamwork and have gained global competency to appreciate and address the international dimensions of many societal problems.

The university also understands that their students have many varied aspirations and that its primary duty is to provide them with a foundational education that they can carry forward into any of the career paths they may follow over the decades of their careers. Many of the College's undergraduate degree programmes are accredited by the Accreditation Board for Engineering Education and Technology (ABET). Each such programme has statements of educational objectives and outcomes that are based on the College's mission and on the needs of its constituents. Those constituents include alumni, students, employers of students and the graduate schools at which many of their students later study.

In addition to the Ann Arbor campus, there is a strong Automotive Programme at the University of Michigan-Dearborn (UM-Dearborn) that was established in 1959 as a partnership between the University of Michigan and Ford Motor Company to prepare engineers and managers for Ford's growth needs. Since then, UM-Dearborn has maintained a symbiotic relationship with the automotive industry through active research collaborations between its faculty and practising automotive researchers. This has directly translated into the creation of undergraduate and graduate educational programmes that are responsive to the needs of the automotive industry; such as programmes in automotive systems engineering, in human-centred design and engineering, and in robotics engineering.

The UM-Dearborn College of Engineering and Computer Science offers graduate automotive systems engineering education at the master and the doctoral levels. Classes are offered in the evening to meet the needs of local practising engineers, and online (asynchronously) to offer accessibility to practitioners around the globe. The programmes are taught by both full-time faculty members who are active in automotive related research and by part-time faculty who work for automotive OEMs and suppliers. This allows for the delivery of educational programmes that connect engineering theory with practice.


At the Undergraduate level, UM-Dearborn offers a signature experiential honours programme. Through this programme, students earn recognition for experiential learning activities; such as, mentored cooperative education assignments with industry and mentored research and/or design activities with faculty.

To support its curricular and co-curricular programmes, UM-Dearborn maintains modern engineering laboratories and fabrication facilities that allow students to engage in the 'design-build-test-learn' process. These facilities are utilised by the student competition teams, the largest of which have an automotive focus, namely: the SAE Formula Combustion team, the SAE Formula Electric team, and teams that build autonomous ground and aerial vehicles through the Intelligent Systems Club.

In addition to their technical preparation, UM-Dearborn engineers are educated to think logically, critically, and creatively; to act ethically and professionally; to value safety; to communicate effectively and collaborate successfully; and to continue to grow and lead. At the undergraduate level, this education is delivered through programmes accredited by the Engineering Accreditation Commission of ABET.

University of Piteşti, Romania

The University of Pitesti takes the position that industry and academia can become much more closely aligned as industry employs the graduates trained by academia and therefore a greater benefit can be developed through improved communication and feedback in this system.

If industry is further involved in shaping the curriculum content of the engineering programmes, they can then be tailored towards the industry group that ultimately employs graduates from the programme and support/advise on setting and even creating the curriculum.

The optimisation of the current educational system's operation is difficult as the effects generated by every modification in the system can only be fully analysed some years after one full cycle of study. This process takes a long time to be realised as it could be five years before students who experience a change made in their first year of study make their way to employment, therefore changes to curriculum content are made in an informed and conservative manner.

A presentation from TechClarity, entitled 'Close the Engineering Skills Gap: Prepare New Graduates to Be Real-World Ready', calls on companies to "get involved in the engineering curriculum to help schools close the skills gap".

This is a message to companies to provide continuous feedback, it also notes that "while industry involvement in the engineering curriculum is an investment of time, it is also an investment in the future with a strong return."

Using a bachelor's degree from higher or tertiary education as an example, the assessment of the added value of an implemented modification can only be performed long after the completion of the studies, which usually takes three or four years. Then, another modification can be issued according to the result of the analysis, and so on.

Tsinghua University, China

According to the China Auto Industry Yearbook of 2017, the auto manufacturing industry in China amounts to 4.83 million professionals, among which technical personnel cover 13.4% and R&D 9.1%.

With the rapid development of the Chinese auto-industry, this number of engineers is not sufficient for the demand being generated by the current development of the auto industry.

New technology areas related to vehicle engineering are increasingly expanding with the development of connected vehicles and automated vehicles, electronics, computer science, information technology and AI entering the scope of vehicle engineering. This means new engineering talent is required in areas such as materials, electric motors, electric engineering, computer science, communication, network information and traffic transportation.

Therefore, the current curriculum and talent cultivation system for the vehicle engineers, which is mainly based on mechanical engineering, cannot fully meet the demand required for auto engineering talent in the new era and, due to this, the cultivation of engineers in the future needs to be re-reviewed and re-planned.

In the context of the above situation regarding the development of the auto industry, and in order to understand the current challenges of engineers in the new era, universities need to study, adjust and review the curriculum system of mechanical engineering majors, as industry needs to adjust the strategy of talent cultivation so as to adapt itself to meet the requirement of talent and quality in the new period. This drive shall play a strategic role in terms of promoting the development of universities and enterprises and further the cooperation between industry and academia.

In the past, engineers who majored in mechanical engineering, in addition to the basic knowledge of mathematics and physics, usually held sufficient knowledge of mechanical design and manufacturing, as well as automotive theory, construction, and design. With the realisation of more vehicle functions through the integration of mechanics and electronics, materials, chemistry, power, information and networks, engineers will also need to master new disciplines of engineering. Therefore, updating the knowledge structure of automotive engineers is a priority to enable them to manage new materials, electronic information, data mining, and artificial intelligence.

With the scope of knowledge structure expanding and the characteristics of all-round talent requirement evolving, engineers in the future also need to strengthen comprehensive knowledge in the field of industry and systems 'know-how' such as commercial practice, supply chain, production management and quality management. Engineers of the future need to develop their knowledgebase before they enter and work in the industry to ensure a comprehensive knowledge structure can meet the requirements of their future work.

As far as we know, the current auto industry is facing a new-technology revolution and business models are evolving, innovating and upgrading quickly. This will present new requirements regarding practical capabilities and professionalism. In terms of talent cultivation, the problem of the split between talent cultivation and market demand needs to be solved especially in the field of automated and connected vehicles.

The philosophy, means and practical methodology shall be updated with the times, however, the system of continuing education for engineers needs to be improved. As in the innovation of vehicle engineering education, especially cooperation between industry and academia, we need to explore new, alternative methods and improve the education and training of engineers of the future.

A scientific and sound talent cultivation system, which is guided by the auto industry, needs to be created. In terms of structuring a new concept of discipline development, faculty building, teaching materials and best practice, the companies, universities and training institutions could realise a sharing and deeper cooperation and full support towards the career growth of engineers in different stages and offer the certainty through contribution towards their continuous development and life-long study.

According to a recent survey of several big auto groups in China, we can see, with the development of new energy, automated and connected vehicles, the competition for talent acquisition is significant within the auto industry.

This is a result of the imbalance between talent supply and the rapid development and technical need of the auto industry in China. To solve the problem of sufficient workplace-ready engineers in China, industry and academia need to establish a coordinated mechanism and make full use of all available resources to realise a reasonable allocation of human resources into the industry and invest in the future development in the supply and cultivation of future engineers.

In 2017, the Ministry of Education in China started an initiative titled 'Construction of a New Engineering Discipline' and it aims to explore engineering education with Chinese characteristics, which shall be a great help towards vehicle engineering education in China.

In conclusion the universities, companies and R&D institutions in the auto industry can work together to develop a massive open online course (MOOC) and jointly establish an incremental talent cultivation system for future industry development so that internal transfer of employees from auto companies or other aspiring engineers can commence and sustain their careers.

5. A New Educational Concept

To support the development of engineers the industry will require in 2030, this paper proposes a new concept in education consisting of three layers: expertise, integration and growth (see Fig 2).

1. Expertise will always be required and builds the foundation of learning. Mechanical engineering is the current starting point, as delivery of mobility requires physical movement of people and goods. Electrical components and electronics now comprise a substantial proportion of the value chain, while computer science has joined these disciplines in recent times and is the key which enables future mobility to evolve from traditional transportation.

2. Integration will take place in many different areas, through many different routes: between systems in the first instance, then via disciplines in order to deliver this, and finally through companies, industries, and within engineering teams, which is of course essential.

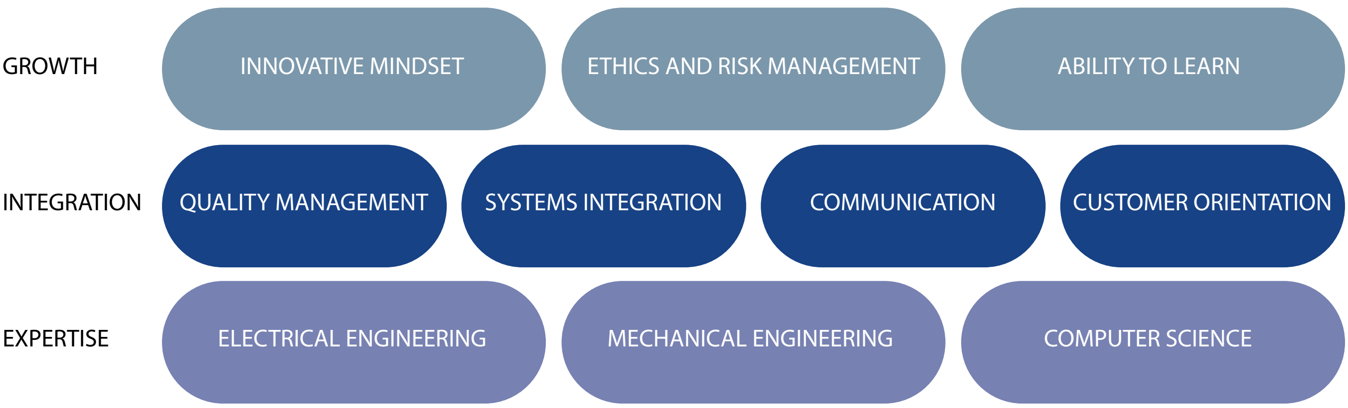
   Therefore, successful integration includes leadership skills, and an appreciation of emotional intelligence, both of which are examples of non-engineering skills which can be influenced through an engineer's continuous, professional development. The further integration of industry and academia in support of this consideration is therefore relevant.

3. Growth that is sustainable requires a managed preparation for change. The rapid evolution of other sectors such as telecoms have demonstrated how large companies can fail, if their leaders do not create a growth culture, or equally their products do not gain (or lose) acceptance from consumers.

An innovative mindset is a precondition for successful growth, applicable to individuals and companies, and with the increasing complexity being delivered through the evolution of mobility a greater need for quality management is being created.

As growth is driven through new technologies, ethics come into consideration regarding automated driving, bio-fuels, safety, cyber security and other related topics.

Figure 2: A three-layer approach to visualise the required skill sets. Future-proof education will consist of expertise, integration skills and the ability to grow. Depending on the individual role, there will be different weights of the skills needed. We need to think in skills profiles, as opposed to engineering disciplines



Designing the Individual Curriculum
How do we fit all three layers in an education with a reasonable duration?

It would clearly be unfair to stretch the duration of engineering education beyond the expectation of an education of this type. Therefore, a blend between university education and postgraduate education in industry could solve this issue, underpinned by new cooperation models between industry and academia.

The core competencies of engineering should always be delivered through university education with multiple access points (mechanical engineering, electrical engineering, computer science) to engage engineers with different backgrounds, skills and aspirations.

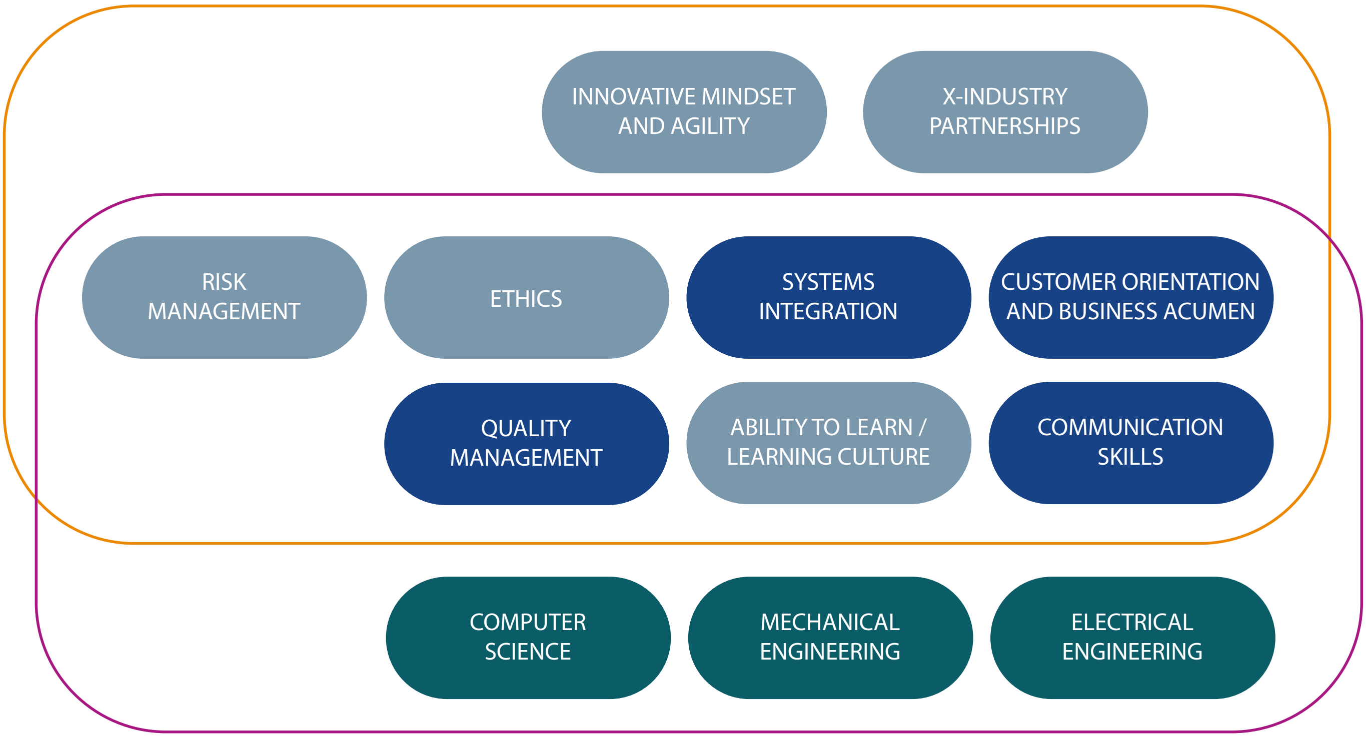
It is reasonable to assume that there might be an overlap between the three technical domains mentioned above, but all three cannot realistically be combined into a single curriculum.

However, the area of overlap can be large: many subjects could be taught at university or in industry, depending on the individual development paths (see Fig 3). The paradigm shift here might be to offer industry-style courses on campus and university-style education modules for engineers in their professional life. The boundaries will blur and education will become more a matter of personal development.

Some elements of education could fit extremely well within the work environment as they require the relevant context to be fully understood. Without this context, students might find a course irrelevant, not realising how important it might become later in their own career journey.

Other subjects require refreshment after a period of time, in order to revitalise the spirit of innovation or help experienced engineers to improve their learning against newly created skills, technologies or challenges.

Figure 3: Combined education, taking place prior and in the working life. The black circle indicates education which should take place on campus. The orange circle indicates education which could take place in industry. There is a large overlap and development plans will be very individual



University Education

Examples of best practice can be found within this paper from contributors of different regions, within the FISITA Academic Advisory Board and Education Committee. These are intended to stimulate thought leadership within the academic community regarding how the local adaptation of best practice could add value, or indeed lead to some augmentation of these proposals.

Students should also take a proactive approach, which can be pursued through adopting some of these practices on a voluntary basis, even if the university does not require it. Internships, for instance, are an excellent mechanism for personal development, while cross-sectional project work develops communication skills and non-technical courses widen the scope of a student's education.

The analysis in this report provides insight and opinion regarding a need for change, enhancement and even which specific subjects could be added or strengthened within the existing framework.

Some universities are able to eliminate the boundaries between engineering disciplines, while others might create a matrix organisation, using interdisciplinary profile areas. In any event, it should be possible for 'non-mechanical engineers' to specialise in mobility via the active selection of courses.

Education and Training on the Job

Industry could consider an opportunity to deliver education in different ways, as one of the key corporate values of the future mobility industry. The workforce is the industry's biggest asset and it will need to invest in continuous learning and personal development, which will require a sustained, long-term commitment to education programmes from industry.

Employees will need individual training plans with focused content relating to the new engineering and associated disciplines future mobility will bring. It is also important to consider how the execution of these plans could be protected as delivery of corporate educational programmes by universities needs to be cost effective and customer oriented, otherwise companies may not sustain their support.

To encourage employee development, companies should offer dedicated 'self-learn' time and accessible reading spaces to complement traditional and new methods of education. As it is true that while technology evolves, engineers will still need the ability to digest complex information in a suitable environment.

Conferences and congresses are vibrant places for networking. Beyond the gathering of information, participation enables a dialogue among peers, the development of international personal networks, and deep dives into new subjects in a pre-competitive environment.

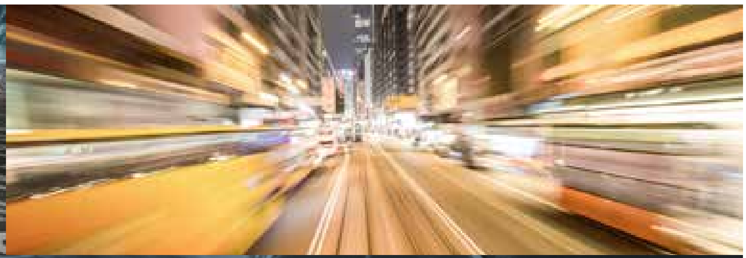
Classroom-based learning always benefits from the dialogue between participants, their knowledge exchange and ultimate networking opportunity. New technology is enabling new educational formats to be considered, such as the 'flip classroom' concept or moderated webinar, which can be extremely useful. In both formats, a 'teacher' only appears in person for the Q&A, as the standard lecture or provision of information can be live-streamed or retrieved on demand.

The same tools can be used for the training of new recruits and experienced employees, allowing technical skills to be taught and also upgraded to fill 'knowledge gaps' and to reflect the technological changes of the industry.

Maximised Learning and Virtual Education Delivery

It is suggested in studies (by Allen, 2005 and Anderson, 1998) that the deep technical knowledge that engineering graduates learn during their degree programme is generally forgotten within five years if that knowledge is not used or reinforced. Given the limits on knowledge retention, universities could consider what and when to teach students in order to enhance their lifelong learning.

Research also suggests (Davis, 2017) that universities could be disrupted through the online delivery of courses. New entrants into the education market, with low research costs, will provide cheap programmes for digital-savvy students. Existing in the 'Facebook and YouTube' era, future students are post-Millennials who have an increasingly unlimited access to the internet. These students will undoubtedly source information from the net, but the challenge for academia is how to engage with this new type of student and how to operate in this type of environment.




6. Conclusion

Engineering capability is fundamental to the sustained success of the mobility industry and individual companies. In a global environment, which is seeing unprecedented technological advancement within a condensed timeframe, this trend is set to continue and potentially accelerate.

Therefore, it becomes questionable whether it is achievable to teach the most important subjects associated with 'mobility' in a single curriculum.

The engineering landscape in the automotive industry will broaden in scope – in addition to mechanical engineers, companies will be in significantly greater need of engineers from electrical engineering, IT and associated 'new technology' disciplines. Besides specialists, the industry will require generalists with capability across different engineering disciplines that link the various engineering fields. Engineering collaborations across multiple disciplines will become critical success factors for engineering in the future. In parallel, the skillset of engineers will expand from predominantly technical requirements to demand more process-related skills. Agile project management, communication skills, and operating in virtual environments and flexible organisations will become important competencies in the engineering role profile.

The suggested education concept consists of three layers:

- **Expertise**
- **Integration**
- **Growth**

Expertise will always be needed and builds the foundation. Mechanical engineering is the starting point. Knowledge in electrical engineering and computer science is becoming increasingly important and methods are more universal than specific applications and should therefore be prioritised.

System integration, communication skills, customer orientation and quality management build the Integration layer.

Finally, growth means a preparation for change. It requires an innovative mindset and the ability to learn, but also understand ethics and risk management.

The concept of university education preparing engineers for many years of success in their profession continues to be challenged.

Future engineers will require a continuous path of education, as technology is set to continue to evolve rapidly. A pre-mobility engineer cannot always be sustained by the education gained at the start of a career. Academia needs to adapt to the changing skill set required by industry, and industry needs to further engage with academia to develop the programmes to create the right personnel profile for the future. Continuous education should be delivered in different ways and include soft-skills to ensure the engineers of the future are 'workplace ready'. To deliver this new concept there needs to be open and continuous cooperation between industry, academia and the international engineering community. Future engineers will benefit significantly from being a proactive member of a peer group network, which will support them to contribute to the community, learn new skills, participate in open dialogue and identify opportunities.

FISITA is a unique global platform to connect engineering societies, industry and academia. Based on this Engineer 2030 study, FISITA will continue to support the discussion around the future of mobility engineering education.

Closing Thoughts from the FISITA Presidents

This 'helicopter-view' of required skills of the future will change in time, with new engineering disciplines entering the traditional industry and new engineering disciplines being created as the mobility evolution pushes the boundaries of technology and engineering.

Therefore, understanding the many topics and questions raised within this initial discussion paper is fundamental as a starting position, and that's what the FISITA community thinks is important at this time in order to deliver against the future demands – whatever they may be.

It is also challenging to consider how much computer-aided delivery will be found in mechanical and electronics as time progresses. As these technologies augment and supersede existing approaches, current and future techniques which will become redundant as capability develops in artificial intelligence and deep learning.

Many aspects of the Mobility Engineer 2030 initiative will need to be continually assessed, based upon emerging technologies, consumer expectations and industry trends.

The fundamentals of an engineer's education and experience should not only include the foundational engineering skills, but also include several other new skill sets including finance and business, engineering ethics, and project management. The ability to learn and retrain are also important attributes for any professional for today and the future.

Industry needs to provide the direction that will influence and shape the university education programmes that equip a mobility engineer of 2030 with the appropriate skill sets and encourage a continuous learning environment that is required to meet the demands of the evolving mobility systems sector.

Academia needs to construct the education programmes that provide the modular opportunities for the development of the future mobility systems engineers. By working closely with the mobility systems developers, the education programmes should be tailored and built upon through a continuous learning structure.

A team creation approach ensures that the specialised skills required for future mobility systems development are met and that opportunity for continuous workplace learning creates mobility systems leaders of the future.

Dan Nicholson
FISITA President
2016–2018

Dr. Frank Zhao
FISITA President
2018–2020

7. Contributors and Acknowledgements

References

Allen, K., Kwon, O-N. and Rasmussen, C., Students' retention of mathematical knowledge and skills in differential equations. School Sci. Math., 2005, 105, 227.

Anderson, J., Austin, K., Barnard, T. and Jagger, J., Do third-year mathematics undergraduates know what they are supposed to know? Int. J. Math. Edu. Sci. Technol., 1998, 29, 401–420.

Chandrasekaran, S., Littlefair, G., Stojcevski, A., Project-oriented design-based learning in engineering education., Reflections on problem-based learning, 2015, 16, 16-21, Republic Polytechnic.

Davis, G, The Australian idea of a University, 2017, Melbourne University Press.

Long, J.M., Chandrasekaran, S. and Orwa, J.O. Engineering fundamentals in a new undergraduate curriculum, in AAEE 2016 : The changing role of the engineering educator for developing the future engineer : Proceedings of the 27th Australasian Association for Engineering

Education Conference, Australasian Association for Engineering Education, 2016, pp. 1-11.


Contributors

Adient Ltd. & Co. KG	**Dr. Detlef Jürss** **Gabriele Studener**
Akebono Brake Industry Co., LTD.	**Takashi Kudo**
Ansys	**Arwel Davies**
BAIC	**Dr. Jiuda Guo** **Xinyu Cui**
BorgWarner	**Chris Thomas**
Continental	**Jeff Klei** **Frank Steinmeier**
Daimler AG	**Dr. Dieter Zetsche**
Deakin University	**Prof. Bernard Rolfe**
Denso	**Takao Nojiri**
FEV Group GmbH	**Dr. Ing. Stephan Pischinger**
FISITA	**Chris Mason** **Paul Mascarenas** **Hayley Millar** **Robert Sydee**
Ford	**Dr. -Ing Karl Siebertz**
Ford Aus-und Weiterbildung e. V.	**Michelle Hilbert**
General Motors	**Dan Nicholson**
Groupe Renault	**Remi Bastien**
H&A Watson Consulting	**Harry Watson**
HORIBA MIRA Ltd	**Dr. Anthony Baxendale** **Dr. Geoff Davis**
Koito manufacturing Co., Ltd, (Japan)	**Noriyki Nakamura**
Opel Automobile GmbH	**Dr. Thomas Johnen**
Robert Bosch GmbH	**Dr. Mattias Klauda** **Dr. Falk Terry**
RWTH Aachen University	**Prof. Dr.-Ing. Lutz Eckstein** **Dr.-Ing. Peter Urban** **Prof. Dr.-Ing. Stefan Kowalewski** **Prof. Dr. phil. Martina Ziefle**
TATA Motors	**John O'Connor**
TE	**Yasuyki Ueno**
TMD Friction Holdings GmbH	**Cristina Petito**
Toyota Motor Corporation	**Hiroaki Okuchi** **Akhito Tanke**
Tsinghua University	**Dr. Frank Zhao** **Prof. Diange Yang** **Prof. Minggao Ouyang**
Tyco Electronics G.K. (Japan)	**Akiko Ishikawa**
University of Bath	**Prof. Chris Brace**
University of Michigan	**Prof. Volker Sick**
University of Piteşti, Romania	**Prof. Adrian Clenci**
University of West Bohemia	**Luděk Hynčík**
YAZAKI EUROPE LIMITED	**Herbert Rixen**

8. About FISITA

Vision

Mission

In promoting knowledge-sharing among its stakeholders, FISITA contributes to the development of safe, sustainable and affordable mobility solutions, guiding the future direction of global mobility engineering professionals. Uniquely placed as an international membership organisation with open and pre-competitive dialogue platforms, FISITA supports its members in promoting excellence in mobility engineering. Collaboration among FISITA Corporate Members, its Academic Advisory Board, Technical, Education and Industry Committees, via this White Paper, provides the combined perspective of how industry and academia will collaborate to produce the mobility engineers of 2030.

FISITA
FISITA (UK) Limited,
29 M11 Business Link,
Stansted,
Essex CM24 8GF,
United Kingdom