**ENGINEERING EDUCATION, SKILLS AND INDUSTRY ALIGNMENT – COMPARATIVE ANALYSIS OF THE UK AND USA**

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**Abstract**

There is an ongoing debate on engineering education, future skills development and alignment of universities with industry. This debate includes discussion on whether graduating engineers have the required skills and competencies to make a positive impact in industry and the wider workplace. Academia is focused on maintaining the technical standard of engineering education, while industry seeks to recruit engineering graduates that not only have a solid grounding in the engineering fundamentals but also have effective professional skills, such as communication, team working and project management skills. Additionally, there is a need to consider how engineers can harness innovation and creativity as well as leveraging the emerging opportunities associated from digitization. In this regard there have been a series of reports that have investigated this area and many such reports tend to be issued at the national level. Therefore, this paper reports on a comparative analysis of studies and reports from the UK and USA that have focused on engineering education, skills development and industry alignment.  This analysis has identified various insights and keys areas to be developed in the context of the Engineering Management Body of Knowledge. The paper concludes with recommendations on how the field of engineering management can be positioned to address the challenges and opportunities that have been identified.

**Keywords**

Engineering Education, Skills & Knowledge, Industry Alignment, Engineering Management.

# Introduction

Engineers need to have a full grasp of the technical competencies across traditional engineering science areas, including numerical and engineering design skills as well as the ability to be effective in knowledge-driven organizations through, for example, working as part of teams and on engineering projects. But will this be enough for the engineer of the future? Indeed, in 2016 the World Economic Forum (WEF) estimated that by 2021, around one-third of skills (35%) that are considered important in today’s workforce will have changed. We are also potentially on the cusp of a new industrial revolution and engineers continue to be presented with challenges and opportunities associated with adopting new technologies, for example, those associated with Industry 4.0 (Liao et al., 2017). Although do today’s graduating engineers have the knowledge and skills to capitalize on such technological developments? Moreover, are existing pedagogic models in universities adequate to support the development of graduate engineers so they can harness these technologies, or do we need new approaches to teaching practices?

 In regard to engineering education, academia faces a number of challenges, including the need to ensure professional and design skills can be adequately integrated with discipline-specific content in order to meet the demands of both graduates and their employers (Mitchell et al., 2019). There is of course a need to ensure strong coverage of the engineering fundamentals, provision of more real-world engineering design and operational areas, such as quality engineering; in addition to more frontier oriented engineering areas as well as providing opportunities for students to gain improved communication, team-working, critical and creative thinking and problem-solving skills (Felder et al., 2000). Moreover, many authors point to a mismatch between skills possessed by graduates and those required in the workplace. Nair et al. (2009) identified the shortfall in skills required by industry, including improved communication, decision-making, problem-solving, leadership, emotional intelligence as well as ethical related skills.

 Froyd et al. (2013) provide an interesting historical perspective on engineering education over the last 100 years through identifying five major shifts. Firstly, there was a shift from hands-on and practical orientation to engineering science and analytical aspects. Secondly, there was a shift to outcomes-based education and the accompanying accreditation. Thirdly, there was a shift to focusing on engineering design. Fourthly, there was a shift to applying education, learning and behavioral sciences research. Finally, there was a shift to integration of information, computational, and communications technology in education. They suggest that the first two shifts have already occurred but the latter three are still in progress and have a continuing influence on engineering education.

There are studies (Radcliffe, 2005) that advocate placing the development of innovation and entrepreneurship related competencies more centrally in the engineering curriculum, with such a focus providing benefits for graduates in terms of enhanced employability as well as more macro-economic oriented benefits through helping to generate wealth and job creation. The challenges for engineering education extend to the need to accommodate the rising complexity of technology systems in conjunction with the need for engineering programs to foster creativity and develop creative related skills in students so they can handle such complexity in industry (Zhou, 2012). Although this challenge is not new. Indeed, in one of the earliest ‘modern’ books focusing on engineering management by Amos and Sarchet (1981), they noted: “*Engineers who have completed four years of a traditional engineering curriculum frequently learn from interviewers that their education is deficient in an important area, i.e., the area of management*”.

In this context, there have been a series of reports that have investigated the area and many such reports tend to be issued at the national level and by engineering professional societies and related bodies. Therefore, this paper provides a comparative analysis of studies and reports from the UK and USA that have focused on engineering education, skills development and industry alignment.  This analysis identifies trends and key areas to be developed in the context of the Engineering Management Body of Knowledge (ASEM, 2015). The paper concludes with recommendations on how the field of engineering management can address the challenges and opportunities.

**Methodology**

The methodology employed in the research study is summarized in Exhibit 1. The first stage of the project involved setting the objectives and background studies. This included scoping out the study in terms of engineering education, skills and industry alignment as well as formulating the approach of gathering information from the UK and USA. The second stage involved analysis of the literature, which included identification of relevant reports and documents issued by professional societies and related organizations in the UK and USA, followed by review of the material to capture key findings. The third stage involved summarizing key findings from the literature identified from each country. This was followed by formulation of recommendations in the context of the field of engineering management.

## Exhibit 1. Methodology employed in research study.



**Analysis of Reports from the UK and USA**

Exhibits 2 and 3 provide the results from the analysis of reports and relevant documentation from the UK and USA respectively, which is related to engineering education, skills development and industrial alignment.

## Exhibit 2. Analysis of reports and relevant documentation from the UK.

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| **Report details** | **Relevant findings** |
| Royal Academy of Engineering (2007) | * Engineering focused companies require graduate engineers with the abilities and attributes associated with two broad areas, namely a sound technical understanding and the requisite enabling skills.
* The first of these areas is composed of a comprehensive understanding of the engineering disciplinary fundamentals, combined with a strong grasp of mathematics, creativity and innovation as well as the ability to apply theory in practice.
* The second area is associated with the set of abilities to allow engineers to work effectively in a business environment and this includes communication and team-working as well as commercial awareness of the implications of engineering decisions.
* The role that engineers play in the business world can be articulated in regard to three inter-related elements: A technical specialist with expert knowledge; an integrator operating across boundaries and in complex situations; and a change agent acting with creativity, innovation and leadership attributes in order to tackle new challenges.
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| Royal Academy of Engineering (2012a) | * Although the UK historically produced many ground breaking inventions (such as the television, jet engine and penicillin), the commercial benefits of such inventions are not always realized in the marketplace. This has resulted from an excessive focus on incremental innovation focusing on small improvements to existing practice as well as engineering education being delivered within distinct disciplines.
* In order to remedy this situation, there is a need to focus on more radical innovation and for a greater emphasis for such approaches to be embedded as part of engineering education. It is proposed that engineering education is realigned from a focus on downstream improvements in productivity and efficiency gains to an upstream emphasis on creativity and transformation.
* Although engineering students need to be taught the principles of radical innovation, they should be gaining such knowledge and related skills from experiential learning through working on real-life projects.
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| Royal Academy of Engineering (2012b) | * There is econometric evidence that the demand for graduate engineers exceeds the level of supply from higher education institutions.
* In order to support balanced economic growth, there should be a key focus on the development of the engineering skills base.
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| Institution of Mechanical Engineers (2013) | * The UK faces particular challenges in regard to educating an adequate number of engineers to meet the needs of the industrial strategy. A number of measures are proposed to help address this situation.
* This includes improved tracking of the destination and progression of former students of schools and colleges. Enhanced career information, advice and guidance for those interested in a career in engineering. Also, improved work-related learning provision, including work placements as well as apprenticeships schemes.
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| Royal Academy of Engineering (2014) | * The report suggests that “*engineers make ‘things’ that work or make ‘things’ work better*” as part of a core engineering mind. This core is described as part of the engineering habits of the mind framework.
* The framework includes six engineering habits of the mind, which as are as follows: systems thinking, adapting, problem-finding, creative problem-solving, visualising, and improving. The framework also includes seven learning habits of the mind, which are as follows: open-mindedness, resilience, resourcefulness, collaboration, reflection, ethical consideration, and curiosity.
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| Royal Academy of Engineering (2015) | * Strategic business-university research collaborations offer a number of benefits to the parties that are involved in the collaboration as well as wider stakeholders.
* Government organizations have a role to play in brokering effective collaborations and this can include public and private co-funding investment vehicles.
* University-based technology transfer offices need to consider prioritizing knowledge exchange with industry over more short-term income generation, and further work is required to improve commercial approaches to contracts and IP agreements.
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| Institution of Engineering and Technology (2017) | * The rapid advances in digitization and automation will have a significant impact on engineering and IT businesses over the next 5 years. This will result in the need to recruit people with new skills as well as up-skill existing staff so they can support companies to undertake an increasing level of process digitization.
* Employers that were surveyed have concerns over skills supply with 46% reporting difficulties in skills supply when recruiting from the external market, contrasted with there being a 25% reported skills gap or limitations for existing staff within engineering businesses.
* A majority of companies surveyed (84%) believe that companies should accept responsibility for helping with the transition from education and training to the workplace in order to ensure new recruits have the required skills and knowledge. However, only a fifth (21%) of companies would like to become more involved in actions to improve the supply of engineers with the required skills.
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| Institution of Engineering and Technology and Engineering Professors Council (2017) | * The annual IET survey of industrial employers continues to highlight a discrepancy between the numbers of engineering graduates from higher education institutions and what industry expects and needs from the graduates.
* The IET and EPC have called for a platform of change for engineering education across six key areas, which are as follows: Incorporating creativity into engineering; broadening the diversity of students; providing a strong emphasis on project work; working with industry to secure engagement in program design and delivery; providing experience of the workplace for students; and ensuring greater inter-disciplinarity to address modern engineering challenges and the global issues.
* Also, three key challenges have been identified to enable a successful engineering skills pipeline. The key challenges are as follows: How can universities work in an improved way with industry to ensure that the present and future requirements of engineering are delivered? How do we need to redesign engineering education to meet the modern requirements of diversity, inclusivity and flexibility of engineers? How can we improve the integration of work-related learning into engineering education?
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| Royal Academy of Engineering (2017) | * Undergraduate and postgraduate engineering students need to be exposed to industrial experience and receive basic skills related to business management and entrepreneurial activity. Furthermore, a specific focus on entrepreneurship education is needed to support the commercialization of intellectual property from the research base.
* There should be a continued focus on upskilling and professional development of the existing engineering workforce so that companies can remain competitive and leverage arising opportunities associated with digitization.
* Skills development should include a focus on multiple levels, including technicians, engineering professionals and related occupations as well as the various educational routes including traditional university courses, apprenticeships and other modes.
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| Royal Academy of Engineering (2018a) | * Engineering UK has estimated that the UK needs over 1.2 million more engineers and technicians between the years 2014 and 2024, with a potential shortfall of 37,000 and 59,000 engineering graduates and technicians required to fill core engineering roles.
* Diversity and inclusion is required across engineering employment as there can be several positive impacts, including enhanced performance of engineers and companies as well as supporting innovation and creativity.
* There can be barriers to the employment of diverse engineering graduates and steps need to be taken to address this situation.
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| Royal Academy of Engineering (2018b) | * The Internet of Things (IoT) technology has potential application in many areas of industry and society, offering new and improved services and promising increased resource efficiencies as well as greater social wellbeing.
* The necessary digital skills are required at all stages of the educational pipeline in order to deliver IoT strategic opportunities and harness the economic value.
* In addition to technical skills and knowledge across computing areas, other important skills required by graduate engineers related to IoT applications include design, strategic planning, leadership and change management skills.
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## Exhibit 3. Analysis of reports and relevant documentation from the USA.

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| **Report details** | **Relevant findings** |
| American Institute of Chemical Engineers (2015) | * Joint project by AIChE and the National Science Foundation (NSF).
* The ChE undergraduate core-topic structure (balances, thermodynamics, transport, separations, kinetics, and design) has endured not because it is frozen but because it has adapted dynamically to new ideas, emphases, challenges and opportunities.
* Terminal master’s degrees can add valuable depth, but the individual must weigh the benefits versus the cost of the program.
* PhDs usually transition smoothly into industrial positions when their doctoral research and first job are closely related, but their career development requires breadth.
* Faculty members all bear responsibility to have a sound, sufficiently deep perspective on the core curriculum.
* Industry is a key partner in preparing students to be effective employees by providing co-ops/summer jobs, collaborating in research, hosting grad-student internships, and seeking/hiring faculty for summers and sabbaticals.
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| American Society for Engineering Education (2013) | * First report of four on a project to transform engineering education that meets the needs of industry in the 21st century.
* Identified core competencies that remain key, but added an array of skills and professional qualities that help students succeed in a dynamic, rapidly changing field.
* T-shaped engineering graduates bring broad knowledge across domains and ability to collaborate within a diverse workforce and deep expertise within a single domain.
* Industry still values a solid foundation in math and science, although the relative importance of math may diminish slightly in the years ahead.
* That foundation, however, should incorporate programming, systems thinking and ability to use relevant tools. Less well-defined but necessary, in the view of many participants, are good communication skills, persistence, curious learning capability, drive and motivation, economics and business acumen, high ethical standards, critical thinking, and willingness to take calculated risks.
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| American Society for Engineering Education (2017a) | * The second part of the ASEE study focused on student input. Students assessed the value of 36 characteristics of engineering graduates most sought by industry, referred to as KSAs (knowledge, skills, and abilities).
* Students concluded that their institutions were paying insufficient attention to multiple KSAs needed to produce the desired T-shaped professional — one who possesses deep expertise within a single domain, broad knowledge across domains, and the ability to collaborate with others in a diverse working environment.
* They did not fault the subjects emphasized in their education (particularly the rigorous grounding in math, science, and engineering fundamentals that are a priority of engineering programs), but criticized how these and other courses were taught.
* Urged a greater emphasis on instructor training, students suggested that pedagogy be part of the basis for securing tenure and salary increases.
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| American Society for Engineering Education (2017b) | * The third part of the ASEE project perceived gender diversity as a significant element of transforming engineering education, but did not explain why this is important.
* Report proposed the main elements of a comprehensive strategic action plan to fulfill a key aspect of the transformation of undergraduate engineering education: reducing the gender gap in engineering. This action plan includes key components, such as accountability standards, measurement and evaluation of results, incentivizing measures, and encouraging engagement of everyone in reducing the gender gap.
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| American Society for Engineering Education (2018) | * This final part of the ASEE study examined the factors of faculty views and professional societies.
* Drawing on the knowledge, skills, and attitudes (KSAs) identified during TUEE Phases I (Synthesizing and Integrating Industry Perspectives) and II (Insights from Tomorrow’s Engineers), participants distilled a list of essential KSAs. The list was further refined in small group discussions once the meeting began, opening the way for an examination of how students could acquire the needed competencies.
* Examples of proposed improvements to curricula included: A “curriculum map” with a body of knowledge for each KSA; enlisting societies as “brokers” among industry, faculty, and students; creating dynamic repositories for curricular materials or, similarly, a faculty resource portal with guides to training, best practices, mentoring, case studies, webinars; and online learning on ethics, leadership, and communications.
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| McMasters (2004) | * This paper provides an example of an input to education from the aerospace industry.
* It discusses steps that the broader technical community (industry, government and academe) can and should take to assure an adequate future supply of well-prepared engineering graduates for the full range of employers who have need for such talent.
* While presented from an aerospace industry perspective, the issues to be addressed have far wider relevance. Airplane design, in common with most modern engineering practice, should be fundamentally viewed as a social activity wherein technology, processes and are treated as a unified whole from a true `systems perspective'.
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| National Academies of Sciences, Engineering, and Medicine (2018) | * The first goal of the workshop was to increase stakeholders’ understanding of both the importance of workforce adaptability and the definition and characteristics of adaptability. The second goal was to provide an opportunity to share best practices for fostering adaptability and to identify needs for future study and development
* Adaptability is related to sustainability and durability, in both educational and workforce settings. An emphasis on mindsets in addition to skill-sets has the potential to be transformative in education. Companies and educational institutions must keep communication lines open about existing and anticipated company needs, especially in non-technical skills. Community colleges can create excitement through competition, challenges, and partnerships. Workers can be educated to move up a career later rather than headed into dead-end positions. A healthy innovation ecosystem requires diverse inputs, and flexibility and adaptability are one way of achieving diversity.
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| National Academy of Engineering (2015) | * This study addressed technological developments, reengineered operations, and economic forces are changing the way products and services are conceived, designed, made, distributed, and supported.
* Manufacturing or “making things” can no longer be considered separate from the value chain, the system of research and development, product design, software development and integration, and lifecycle service activities performed to deliver a valuable product or service to market.
* Businesses are focusing on this entire system to ensure that they are “making value” for customers and are less likely to be disrupted by competitors or new technologies.
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| National Academy of Engineering (2017a) | * The primary goal of this report is to provide a perspective on the engagement of engineering professional societies with the engineering education community. This was accomplished by examining websites for indicators of engagement.
* This review found that engineering societies work to impact engineering education both indirectly and directly. In an effort to prepare the future engineering workforce, 93% (114) of the 122 societies reviewed directly engage students: they offer student memberships, have student chapters on campus, or provide some type of financial support to student members. Over a quarter of the societies (28%; 34) have foundations that provide funding for students.
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| National Academy of Engineering (2017b)  | * This summary is based on a search for articles on engineering society involvement in undergraduate engineering education and 61 papers published between 1991 & 2015.
* Although many of the engineering societies engage in activities related to undergraduate education, the literature is limited and documentation of the work is often informal. Much of the literature is from non-peer reviewed sources.
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| National Academy of Engineering (2018) | * This report contains the proceedings of a workshop to explore the role of engineering societies in enhancing understanding of faculty impact on the engineering profession as part of the reappointment, promotion, and tenure (RPT) process.
* Recommendations included recognition of faculty, promoting a focus on students, promotion of models and best practices and similar items.
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| National Academy of Engineering (2019a) | * This National Science Foundation-funded project takes an in-depth look at the extent and nature of professional engineering societies’ contributions to improving the quality and effectiveness of US undergraduate engineering education.
* One of the key results was a survey of professional societies and this identified that societies are engaged in a range of education related activities, a major focus of this is membership. Barriers included curriculum changes, and communication with the larger education community. Unfortunately, funds available for this investment have been shrinking as budgets have been tight.
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| National Academy of Engineering (2019b) | * This workshop convened senior managers from industry, engineering colleges, and professional engineering societies to assess the gap of industry needs and academic preparation of new engineers.
* Societies provided a ‘lightning round’ of presentations on their efforts to provide professional skills’ development opportunities to student and professional members.
* Recommendations included providing training in industry for faculty, increasing experiential learning for students, developing more opportunities for industry to work with universities and pre-K-12 education, and establishing an Engineering Societies’ Education Directors’ Council.
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**Summary of Findings**

The reports and documents reviewed from the UK identified that engineering education faces a number of challenges but these exist alongside many opportunities (RAE, 2012a & 2012b; IET and EPC, 2017). It is recognized that engineering education should be grounded in a solid technical foundation (i.e. numerical skills, engineering design and discipline specific knowledge, such as from chemical, civil, or aeronautical engineering). However, there continues to be a recognition that universities need to pay greater attention to engendering suitable ‘enabling skills’ (RAE, 2007). These professional type skills relate to the often cited areas, such as communication, team working and project management areas, but they also include complementary competencies, such as systems thinking, an ability to act and work creatively as well as flexibility and adaptability. Alongside professional related skills there is a need for engineering graduates to have a basic understanding of enterprise skills and corresponding knowledge (RAE, 2017); this includes an ability to understand the innovation process (including idea generation and new product development) as well as entrepreneurship (relating to startup formation as well as intrapreneurial working within large companies).

In terms of the demand for engineering graduates, it has been estimated that the UK will need over 1.2 million more engineers and technicians from 2014 to 2024 (RAE, 2018a). This underscores the importance of engineering education to meet this need and for the corresponding requirement to highlight at school level the merits of an engineering education and the potential professions and careers available to graduate engineers. Additionally, there continues to be a need to ensure appropriate levels of diversity and inclusion both in engineering educational and employment fields. A number of reports highlighted the rapid developments associated with digitization and how this can potentially impact the engineering and IT professions (IET, 2017). In this context and as companies adopt increasing levels of process digitization and automation, there is an even greater need to ensure the engineering curriculum remain up-to-date and aligned with emerging industrial paradigms, such as those associated with the Internet of Things (RAE, 2018b) and more broadly Industry 4.0.

 The university-industry relationship in the UK is an important dimension identified in the reports (RAE, 2015). This includes the need for academic degree programs to have the necessary industrial relevance and where possible the active involvement of industry in the design and delivery of programs, e.g. through guest lectures delivered by industry representatives. Universities are also increasingly required to operate in a commercial manner through knowledge exchange and enterprise engagement with industry. In this context there is a need for business model innovation to support greater levels of startup formation, licensing and technology transfer with industry. Commercial skills development has a part to play in this context – this extends to the provision of enterprise skills to researchers interested in being entrepreneurial as well as ensuring professional service teams at universities have the required competencies. Additionally, it was identified that there should be a stronger focus on more radical innovation and for such approaches to be embedded as part of engineering education (RAE, 2012a).

Similar to the UK, industry input to engineering education in the US emphasized the importance of solid technical ability, coupled with professional skills needed to succeed in the workplace. Similarly, issues with the willingness to update pedagogy and faculty reward systems appear to be significant potential impediments to change. However, here were several different areas of focus in the US. One involved the understanding of the emerging technical workplace and the issues of what manufacturing means and is comprised of in a developed economy (NAE, 2015). The impact of these factors on engineering education is still evolving. Another area is the focus on technical professional societies as the leaders for influencing engineering education (NAE, 2017a). A significant issue is that it is not clear how this will work and be effective since current indicators are not promising.

One area that was not examined or addressed in the US literature involves the input of program advisory boards. ABET (Accreditation Board for Engineering and Technology) accredits engineering, engineering technology, computing, and applied science programs around the world and requires programs to identify ‘constituencies’ and to assure involvement into the program educational objectives, defined as what graduates are expected to be capable of several years into their careers. Programs must identify industry or employers as constituents and so advisory boards generally have several employer representatives at the table. No studies were found on the effectiveness or degree of input from these groups.

ABET (2019) requires that programs assure that, by the time of graduation, engineering students achieve learning outcomes that address working in teams, communicating effectively, and designing solutions that meet societal and other constraints, among others. While the university programs do assess student abilities and implement continuous improvement to strengthen the attainment of the outcomes, it appears that the gap of student abilities and industry expectations has not closed. It should be noted that professional societies provide the input to program criteria for ABET and furnish the program evaluators for accreditation visits. On this matter, it has been the observation of one of the authors, who has served on a number of accreditation visits that the large majority of program evaluators appear to come from academia rather than industry.

**Conclusions, Recommendations and Future Work**

This research study has provided the results of an analysis of engineering education, skills and industry alignment from both the UK and USA. This analysis has been undertaken through a comprehensive review of relevant reports and documents issued by professional engineering societies from the two countries. The findings have been summarized in order to identify the key issues from each country.

As can be elucidated from the analysis reported in this study, there are many challenges and issues facing those involved in engineering education in both the UK and USA. We can consider that the challenges relate to four overall requirements. (a). There is a requirement for engineering programs to deliver graduating students that have the necessary skills and knowledge that meets the needs of industry – this relates to both technological and engineering systems knowledge as well as the wider set of enabling skills (including creativity, professional and enterprise related skills). (b). There is a requirement to ensure teaching content on engineering programs has adequate coverage of emerging technologies and up-to-date engineering applications that are relevant and inspiring for students. (c). There is a requirement for engineering programs to be able to leverage modern teaching practices, while ensuring learning outcomes are effectively delivered. (d). Finally, there is a requirement for engineering programs to be delivered efficiently through adopting modern ICT systems and related processes.

The skills requirement in both the UK and USA is accompanied by a need for continued development and refinement of pedagogic models at universities. The question arises – What are the optimal teaching models to support the delivery of the enabling or professional skills alongside the traditional core engineering components? Moreover, how can new teaching methods (such as experiential learning, peer-to-peer learning, blended learning as well as online learning) be adopted in this context. Universities and academic teaching staff need to be cognizant of both the challenges and opportunities but development in this area will also be contingent on their ability to accept the necessary changes required to meet the expectations of engineering students as well as employers. Remuneration and incentives for faculty members will be a factor in this regard.

It can be observed that many of the enabling skills that are requested by industry are included in *A Guide to the Engineering Management Body of Knowledge (EMBoK)* (4th edition, 2015). Project management, teamwork, leadership, communication, systems thinking, financial management, strategic management, and innovation are all included in the EMBoK, among other domains. While not the answer to all of the challenges, the EMBoK can certainly serve as a resource for entry-level and new engineers. Indeed, the field of engineering management (EM) is ideally suited to provide the enabling skills and knowledge for engineers – engineering management can be considered as a component of T-shaped skills for engineers, where the broad EM discipline is the horizontal part of the T, and the vertical part of the T is the narrow engineering discipline, such as chemical, mechanical, or civil engineering.

The reports from both the UK and USA clearly highlight the need for enabling skills and if they can be properly articulated as being a core component of EM, there would be appear to be significant scope for EM to be further integrated into engineering education at both the undergraduate and graduate levels. It is further recommended that in order for the appeal and utility of the EM discipline to be promoted that there is a greater connection made to applications involving the very latest technological developments (such as IoT and Industry 4.0) in order to maintain the relevance of the EMBoK. Moreover, a strong focus on the application of EM to different industrial sectors (such as aerospace and defense, oil & gas, pharmaceutical, and the built environment) needs to be maintained and where possible enhanced in the EMBoK, again so that the utility and relevance of EM is clear and readily understood.

In regard to future work, it is proposed that more detailed studies are carried in order to develop an overall framework that incorporates engineering education, skills and industry alignment. This can be achieved through building on the insights from this research through development of a conceptual model that is subsequently evaluated through a suitable case study investigation – focusing on how engineering education and skills development is integrated with the needs of industry and wider society.

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