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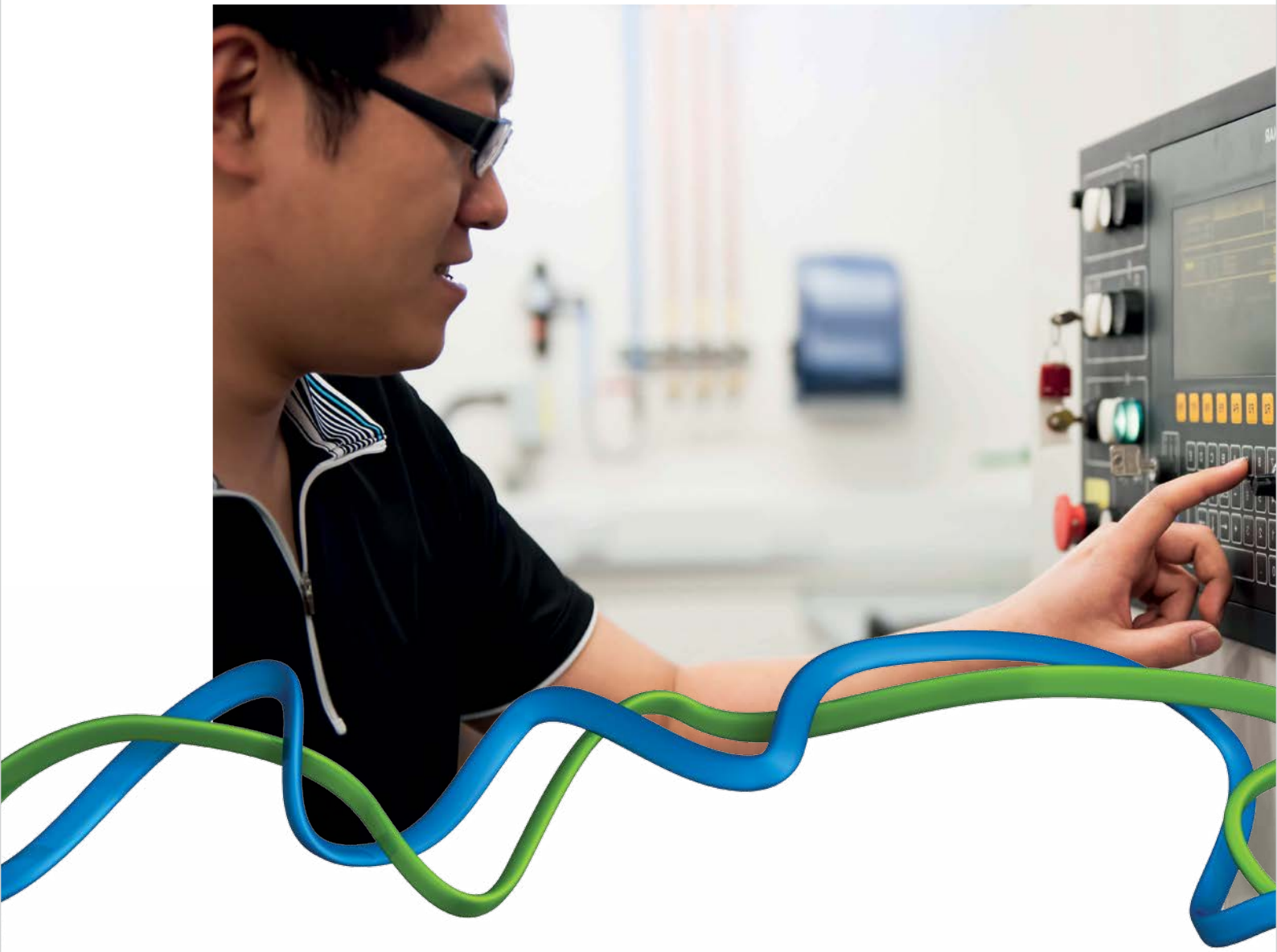

Effective industrial engagement in engineering education

– A good practice guide

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Contents

Executive summary

The Royal Academy of Engineering's report ***Engineering Graduates for Industry*** highlights the need for a radical increase in the involvement of industry at national and local levels in engineering education to ensure that undergraduate degrees are fit for the future, meeting the needs of industry and the expectations of students. The purpose of this guide is to supplement the strategic guidance and case studies provided in previous studies with practical, workable suggestions for universities, industry and professional engineering institutions to help them deliver and benefit from effective industrial engagement.

The guide begins with a brief description of current state of practice in industrial engagement in engineering education, and observes that quality and quantity of industrial engagement initiatives in engineering education is highly variable.

The authors attribute this variability to a wide range of challenges encountered by frontline staff: challenges to do with motivation and skill; the challenges of insufficient capacity or funds; and challenges of cultural and organisational difference.

To help frontline staff at universities, in industry and in professional institutions overcome these challenges the authors propose a series of principles to be applied in the development of industrial engagement initiatives.

The first three principles are written for professional engineering institutions, and say that they should foster relationships between industry and academia; they should coordinate industrial engagement activities; and that they should use their archives to support industrial engagement.

The next three principles say that industry, in turn, should develop staff motivation and skill for engagement in engineering education; should make real materials and resources freely available; and should invest in engagement activities.

The last two principles say that universities in turn should develop motivation and skill for industrial engagement in engineering education among their staff; and they should make strategic use of academics' and industrialists' time.

In the body of this guide, these principles are each explained in more depth and accompanied by practical suggestions for implementation.

Introduction

Four recent reports published by the Royal Academy of Engineering highlight the need to improve the quality and scope of engineering education if we are to meet the demands of students and employers for industry-relevant skills[1-4]. In its report *Engineering Graduates for Industry*, the Academy emphasised how important it is that engineering degrees should be "fit for the future" and highlighted the need for a radical increase in the involvement of industry at national and local levels in engineering education[2]. That report recognises that it is unrealistic to expect graduate engineers to have all the knowledge and skills that industry requires "but it is fundamental that graduates understand what other people do and how it all fits together".

The purpose of this guide is to supplement the strategic guidance and case studies provided in the previous studies with practical, workable suggestions for universities, industry and professional engineering institutions to help them deliver and benefit from effective industrial engagement.

The first part of this report gives a brief overview of the current state of industrial engagement in undergraduate engineering education and identifies the key challenges to the development of more effective relationships and engagement. The report then sets out key principles, broadly applicable to most industrial engagement initiatives, that can be adopted to overcome these challenges, and also provides specific suggestions for enhancing particular types of intervention.

Throughout the report key examples of common industrial engagement techniques are presented in boxes.

The arguments in this guide build on two previous Royal Academy of Engineering guides by the same authors, *Experience-led learning for engineers – a best practice guide*[5] and *The development of e-learning resources – a best practice guide*[6]. Together, these reports show how the use of experience-led learning and the use of e-learning technologies have a role to play in helping students develop industry-related skills, and underpinning both of these approaches is effective industrial engagement. To avoid repetition, this report makes references to many of the points made in these previous reports, and so the three should ideally be read in conjunction.

Professor John Perkins, in his *Review of Engineering Skills*, also highlighted the importance of effective employer engagement in higher education. We welcome the work of the National Council for Universities and Business (NCUB) to make employer engagement stronger across all subjects. NCUB will be hosting the advice and guidance specific to engineering, which has been developed as part of the Perkins Review[7].

References to online materials are provided in this guide. If the document is being read onscreen then the hyperlinks in the text can be clicked on directly; for readers with a printed version, web addresses are provided in the table of resources at the end.

Current practice in industrial engagement

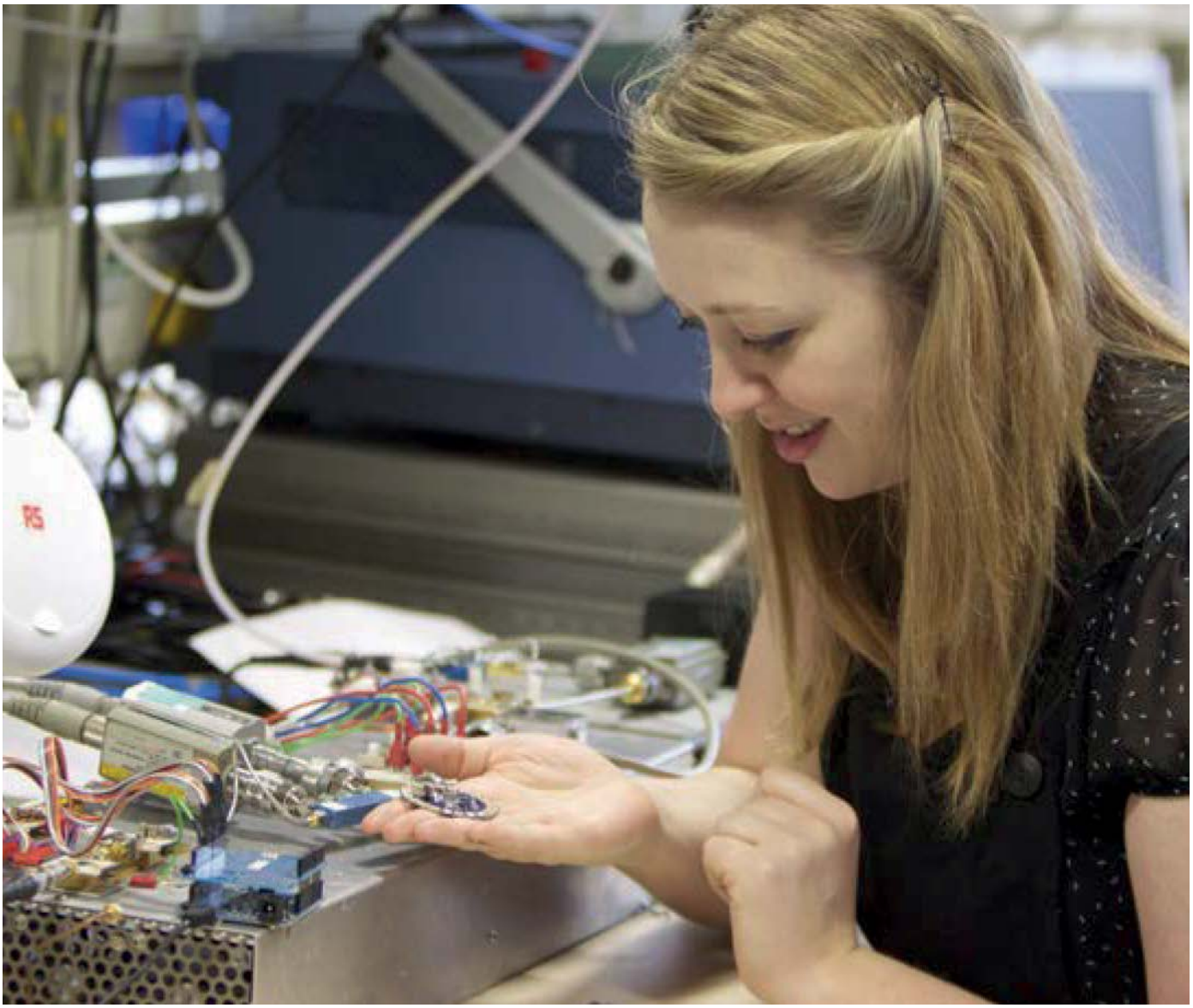

Image courtesy of BAE Systems

Accreditation of undergraduate engineering programmes is only possible where they provide progression to professional standards. The Accreditation of Higher Education Programmes (AHEP) guidelines focus on learning outcomes, yet little is said about how particular outcomes should be achieved or demonstrated[8]. There are, however, several places in the guidelines where it is suggested that industrial engagement is desirable, particularly in relation to project work and MEng programmes.

Professional engineering institutions (PEIs) responsible for the accreditation of programmes on behalf of the Engineering Council provide further guidance to universities with more detail to cover the discipline for which they are responsible[9-10]. Generally, the PEIs focus on specifying outcomes, although in some cases guidance is given about how the outcomes might be achieved.

On the whole it is left to the universities to decide on curriculum content and the educational techniques needed to achieve the required learning outcomes. Most universities involve industry in one way or another in the delivery of their engineering programmes. The common ways that industry is involved in undergraduate engineering education are listed in **Box 1** and key examples are described in more detail in **Boxes 2** to **13** found throughout the report.

At their best these initiatives are done well and highly effective; however, in the experience of the authors, the quality and quantity of industrial engagement initiatives remain highly variable. It is the opinion of the authors that this variability can be attributed to a series of challenges that staff in universities, industry and at PEIs encounter when developing such activities.

The challenges

01 – Appropriate motivation

- While academic staff may work closely with industry on research, there is less motivation to engage with industry in relation to education.
- Project-work-focused industrialists may have little motivation to engage with academia in relation to education.
- Accreditation requirements offer an extrinsic motivator for industrial engagement, but intrinsic motivators are less obvious.
- The desire to graduate from university and start paying off debts soon may discourage students from undertaking industrial placements as part of their degrees[2].

02 – Appropriate skills

- Industrialists in practice don't necessarily have the appropriate skills to make them good educators.
- Academics don't necessarily have the right networking and entrepreneurial skills necessary to develop high-impact industrial engagement initiatives.
- Academics, industrialists and PEI staff don't necessarily have the right skills to disseminate the teaching materials produced.

03 – Necessary capacity and funding

- Academic staff, who are often primarily judged on their performance as researchers, don't have the time to develop the relationships and resources beyond their existing teaching materials. Similarly they don't necessarily have the time to do the high levels of coordination that many industrial engagement initiatives require.
- Industrialists also have restrictions on their availability, especially during the working day – for example, for many it is difficult to dedicate half a day to an activity such as a design workshop.
- There is often insufficient money available to develop the sorts of initiatives that are likely to achieve the highest impact. Even when funding is available to establish a new initiative, long-term financial sustainability remains an issue.

04 – Cultural differences

- Academics and industrialists account for their time differently: industrialists typically account for their time on an hourly basis, whereas academics are usually more able to organise their time as they see fit as long as they meet their research and teaching objectives.
- Industrialists don't understand what university environments are like and are often surprised that teaching is not necessarily the primary focus of activity.

05 – Organisation

- Academic timetables are fixed, usually a long time in advance. This is a problem especially for senior industrialists as they don't know what they are going to be working on so far in advance.
- Industrialists often aren't aware of the learning programme and how it is organised.
- There are many industrial engagement initiatives, but not necessarily much coordination, either at a university level or at a national level.

Box 1 - Common ways that industry is involved in the delivery of engineering education in universities

- **Visiting professorships/visiting teaching fellowships** – these range from formal funded appointments, such as those through the Royal Academy of Engineering Visiting Professor Programme, to unfunded honorary appointments organised by some university departments.
- **Sponsored competitions** – such as the *Telegraph* UK STEM awards or the Airbus Fly Your Idea competition. See **Box 2** on page 14 for more information.
- **Deep-immersion role-plays delivered by academic-industry partnerships** – for example Nuclear Island Big Rig and Formula Student. See **Box 3** on page 14 for more information.
- **Ad-hoc lectures or participation in projects by industrialists** – these arrangements often arise from requests from academics through their personal networks. See **Box 4** on page 19 for more information.
- **Engineering societies in universities** – such as Imperial College London CivSoc. See **Box 5** on page 22 for more information.
- **Young Members' groups within professional engineering institution**. See **Box 6** on page 22 for more information.
- **Work placements** – both as a structured part of the programme or arranged on a more ad-hoc basis. See **Box 7** on page 23 for more information.
- **Industrial mentors** – these can be either long-term relationships that operate over several years, or short-term relationships set up in support of a particular module or design project. See **Box 8** on page 23 for more information.
- **Provision of free or discounted educational materials** – for example Siemens Education, or the educational resources made available through Expedition Workshed.
- **Provision of free or discounted engineering software or equipment** – for example, discounted access to the Solidworks software suite. See **Box 9** on page 25 for more information.
- **Sponsorship and bursaries.** See **Box 10** on page 27 for more information.
- **Provision of free or discounted memberships of professional institutions.**
- **Site visits** – for example to construction sites or factories. See **Box 11** on page 29 for more information.
- **Participation in department or faculty industrial advisory boards.** See **Box 12** on page 31 for more information.
- **Student prizes** – for example, in support of academic merit.
- **Careers fair and recruitment talks.**

Principles

In this section we identify a series of principles that stakeholders in the industrial engagement process can adopt when seeking to overcome the challenges identified above. The principles are grouped according to the stakeholder group to which they apply in the order: professional engineering institutions, industry and academia.

Professional engineering institutions

Principle one – Foster relationships between academia and industry

Principle two – Coordinate industrial engagement activities

Principle three – Open the archives

Industry

Principle four – Develop motivation for industrial engagement activities

Principle five – Make materials and resources freely available

Principle six – Invest

Academia

Principle seven – Develop motivation and skills for engagement

Principle eight – Make strategic use of academics' and industrialists' time

Professional engineering institutions – Principle one

Foster relationships between industry and academia

Professional engineering institutions (PEIs) are a natural meeting place between the academic and the industrial spheres, so these institutions have an important role to play in fostering positive relationships between the two. PEI staff are well-placed to identify and introduce potential collaborators. Their events and regional offices provide good opportunities for academics and industrialists to meet, and their extensive networks are ideal for promoting and celebrating liaison initiatives and the individuals who make them happen.

In practice

- **Promote networking** – Hold events designed to provide opportunities for academics and industrialists to meet. These events could be specifically focused on opportunities for educational collaboration, or they could have a more free-form agenda. Consider facilitating events that aim to link up staff at similar stages in their careers.
- **Build a campaign** – To help build momentum, staff motivation and funding, build a campaign to illustrate to industry the benefits of industrial engagement in education. Make celebrating the success stories part of that campaign. Use newsletters and social media channels to help raise awareness of new and existing initiatives. Offer regular prizes that recognise the contributions of individuals and organisations.
- **Make the most of student membership** – Student membership of PEIs in itself can play an important part in preparing students for industry because it can make students feel part of a community of practice and expose them to role models who may demonstrate the professional behaviour that industry wants them to aspire to. In addition, once students are involved with PEIs, they can play an important role in seeding new ideas and relationships that will grow over time.

  Most, if not all, PEIs already offer free or discounted student membership, but it is important to make sure that students sign up and make the most of the benefits. Make signing up the first thing students do when they arrive at university. Providing strong support for graduate and student groups and networks of academic liaison staff will also help to build and maintain active student membership. Also make the most of the archive material to support learning (see Principle three).
- **Enhance the network** – PEIs are often the hub of industrial engagement networks. These networks often consist of dozens of direct relationships between industrialists, academics and students brought together through the institution. In the experience of the authors, the coverage of these networks is patchy, with some parts of industry and academia being well-represented, and others absent.

  PEIs should take steps to learn about and tap into the vast potential that their networks offer. The first priority should be growing, training and motivating their networks of liaison officers, both in industry and academia. An important area of training should be in social media, where many of the new connections and networks are being formed and awareness of these networks is patchy, often relying on bilateral relationships. PEIs should take steps to learn about and harness the vast potential social capital that they have through their members. Pay attention to managing and keeping motivated networks of liaison officers in all universities and important employers, and harness more informal links through active use of social media.
- **Link industrial liaison to accreditation and qualification** – one way to encourage engagement between industry and universities that some PEIs already use is to recognise this sort of activity in qualifications for individuals (such as professional qualification or fellowship) and in accreditation for teaching institutions.
- **Link experience to chartership** – encourage student motivation to seek out work experience and work placements by highlighting to them the contribution it can make towards achieving professional registration.

Box 2 – Sponsored competitions

A popular and well-established approach to industrial engagement in engineering education is for companies to get involved in engineering-themed student competitions. Competitions can range in scale from high-profile initiatives run by third parties, such as the *Telegraph* UK STEM Awards or the Airbus Fly Your Idea competition, down to competitions run in the classroom by lecturers for which companies offer a prize. Whereas these high-profile initiatives offer impact, it is the view of the authors that smaller-scale initiatives developed in partnership with universities offer the opportunity for industry and academia to work together to shape the learning process.

Sponsored competitions have the potential to be very motivating, not just for the students but also for teaching staff and the sponsoring organisations. The following are some suggestions for activities that could be run as sponsored competitions and the role that industrial partners can take in shaping and facilitating the activities:

- **Design competition** – help set the brief and judge the winners; provide materials and tools for modeling.
- **Scenario-based role-play** – take on the roles of key stakeholders in a role-play scenario.
- **Paper-based competitions** – setting the topics; coaching the writers and judging the winners.
- **Debating competition** – hosting the event; providing source material for debate.
- **Research competition based on an industrial problem** – providing a context for the competition; offering site visits or interviews with staff to support research.

Some sponsored competitions are also deep-immersion role-plays – see **Box 3** for more info. See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Box 3 – Deep-immersion role-plays delivered by academic-industry partnerships

Constructionarium and Nuclear Big Rig are two examples of deep-immersion role-play initiatives delivered by academic–industry partnerships. By deep-immersion we mean an experience in which students are expected to take on a particular role for an extended period of time (usually the role of a practising engineer), where they are set a realistic brief that they must carry out using realistic processes in a realistic working environment.

Role-play scenarios such as these offer a rich set of opportunities for experience-led learning as they:

- Give students the opportunity to put theory into practice.
- Require students to use and develop a wide range of skills for industry, such as problem-solving, taking initiative, working in teams and understanding business and customer needs.
- Allow students to experience for themselves the role they will get to take on as engineers.
- Provide a chance for students to meet people from industry.
- Create workplace values in the classroom.
- Help students feel part of a community of practice.

Image courtesy of Royal Academy of Engineering

Packaging the Pi competition

In this competition the challenge is to design a system for packaging a Raspberry. The students' response was to use suction and an electronic control system to pick up a bag, move it to the end of the production line and open it, ready to receive a Raspberry Pi. Once the computer is in the bag, the package is released and the process repeated. Although the students' solution appears both elegant and simple, it was the culmination of several months' work that involved physical, virtual and mathematical modelling. The major challenge, which the students solved using mathematics, was to design a valve that would give their system the suction it needed. The design is now being used in the production process.

The success of these initiatives relies on the establishment of effective academic–industry partnerships to design, deliver and promote them. For example, the Nuclear Island Big Rig initiative was made possible by funding from Cogent, the sector skills council, which enabled a project board composed of representatives from industry and academia to come together to develop and pilot the concept, to attract users and to secure the funding to grow it.

There are then a number of key ingredients in the design of the events themselves:

- **Realistic learning environment** – Part of the reality of deep-immersion role-play events is the physical environment in which they take part. The Constructionarium takes place in a specially created landscape complete with river, gorge, lake and hills. The Big Rig:Nuclear new-build event takes place in a space designed to simulate a nuclear-licensed site, and in which all participants, including staff, are expected to demonstrate 'nuclear behaviours'. In the experience of the authors, the more real it looks, the more authentic the learning experience will be for the students.
- **Carefully tuned tasks** – The briefs that the students are set need to be carefully thought through: on the one hand they should be challenging in order to add a sense of excitement and jeopardy; on the other they should be achievable. One way to add an additional sense of jeopardy is by introducing a competition element as, for example, is the case in Formula Student.

  An alternative to setting a brief is to use a project-based learning approach (see Principle seven of the report *Experience-led learning for engineers* for more information on taking this approach).
- **Blended support resources** – Deep-immersion role-plays usually require a blend of different support resources. The trick is to provide students with the information they need using highly realistic means, for instance, using real technical drawings or online project reporting systems – here the ability of industry to supply real or realistic materials is very valuable.
- **Skilled facilitation** – All staff facilitating deep-immersion role-plays need to be carefully briefed by the coordinating team on the role they are taking on, otherwise the experience can be compromised. The facilitation team also needs to understand how to manage the mood of the participating students: how to increase the pressure or ease off as appropriate; how to hold back information or release it in order to help teams get the task finished.

The final crucial step in running any large-scale deep-immersion role-play, given the efforts and considerable expense of doing so, is to celebrate the initiative and recognise the participation of all who made it happen.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Image courtesy of Think Up

Nuclear Island Big Rig

The Nuclear Island Big Rig initiative brings industry and academia together to deliver transformative learning scenarios for engineering students.
At a Nuclear Island Big Rig event students are set the challenge of building a mock-up of a mechanical system under the simulated working constraints of a nuclear licenced site.

Image courtesy of Expedition

Constructionarium example

For over ten years, industry and academia have been collaborating to deliver the Constructionarium, a unique learning environment in which undergraduate civil engineers are set the challenge of building large-scale mock-ups of real engineering structures using real plant, materials and processes.

Professional engineering institutions – Principle two

Coordinate industrial engagement activities

Industrial engagement in engineering education tends to be based on linkages at a personal level rather than at an organisational or institutional level. Increasing the number of industrial engagement initiatives in engineering education will inevitably increase the number of direct linkages. In the authors' view we should not want or expect to be able to coordinate all this activity at the scale of individual initiatives but professional engineering institutions (PEIs) should provide more high-level coordination.

Were PEIs to set greater direction, it would help to make more effective use of academics' and industrialists' time and resources, it would help to raise the educational value of initiatives across the board, and it would help to overcome the organisational challenges previously identified. If, as part of their coordination activity, PEIs helped individuals to develop the necessary skills to support industrial engagement, the educational value of these engagement activities would be further raised.

In practice

- **Coordinate the activities of visiting professors** (VPs) – There are hundreds of visiting professors appointed from industry to academic institutions, either directly under bilateral arrangements or through schemes such as the Royal Academy of Engineering's VPs programme. Since VPs are usually senior personnel from industry, and they tend to liaise with senior members of teaching staff, VPs are perhaps the most obvious vector for influencing industrial engagement. To this end, PEIs should:
  - Identify VPs in their sector and what their activities are.
  - Identify appropriate themes for programmes of activity linked to availability of funding.
  - Establish new VPs programmes as necessary to address themes not currently covered.
  - Establish communities of practice in which best practice can be shared, perhaps involving an annual conference (see below). Consider running a VPs blog that syndicates activities of all the VPs in a given programme (blogging allows updates to be much more frequent than a printed publication allows).
- **Run an annual conference** – This conference would be exclusively dedicated to industrial engagement in education, helping to set the agenda, identifying key issues, promoting best practice, signposting resources and celebrating participation.
- **Offer training for engagement** – PEIs are ideally placed to design and deliver training to address key areas in which stakeholders in industrial engagement would benefit:
  - Appropriate pedagogy – making sure that industrial engagement initiatives are designed in such a way to support effective learning (for more information see Principle one of the report *Experience-led learning for engineers*)
  - Networking – industrial liaison depends on individuals making new connections outside of their usual networks. Networking like this is doesn't come naturally to all, so training in this area would support improved industrial engagement, helping in particular to overcome the challenge of cultural differences described above.
  - Design of e-learning resources – while e-learning is key to growing the impact of industrial engagement, according to the report *The Development of e-learning resources*, many of those involved in designing engagement initiatives are 'digital immigrants' rather than 'digital natives' and so need to raise their awareness and skills in this capacity.

Image courtesy of Birmingham University

- **Audit** – As part of their coordination role, PEIs could conduct an audit of industrial engagement initiatives to help identify best practice, opportunities for wider collaboration, and places where further support or funding is needed.
- **Signpost resources and activities** – One of the challenges to effective industrial engagement previously identified is not having the necessary capacity or funding. It is therefore essential that when an initiative has resulted in the development of resources that others can use, such as presentations, podcasts, and lesson plans, these are widely disseminated. Wider dissemination also raises the profile of these resources and so is likely to attract greater funding for such ventures in future. Possible channels for dissemination include websites, conferences, a blog dedicated to industrial engagement, industrial liaison networks and social media.
- **Coordinate development of e-learning resources** – In the view of the authors, e-learning resources are one of the most effective ways to achieve high impact in industrial engagement because of the experience-led learning outcomes that can be addressed and the high dissemination levels that can be achieved. The RAE report *The Development of e-learning resources – a best practice guide* contains a section on effective commissioning of resources, a section on design and a section on dissemination, all of which are critical to the process. The key points for PEIs seeking to coordinate the development of e-learning resources are below:
  - Encourage the development of appropriate resources by: focusing on what students are looking for and using; funding pilots, especially high-impact initiatives that individual organisations are unlikely to be able to afford themselves; supporting comparison portals that syndicate resources and rate the best ones; actively discouraging duplication; and focusing on practice-orientated content.
  - Encourage high-quality and appropriate design by: sharing best practice on accessibility; sharing research on how people use the internet; disseminating information on appropriate e-learning pedagogy.
  - Encourage dissemination by: making resources free and freely available through Creative Commons licencing; actively encouraging search engine optimisation and meta-tagging of resources; promoting 'authorship' of resources; recommending publication to portals such as Core Materials.
  - Encouraging continual improvement by using data to evaluate effectiveness and to inform future design.

Professional engineering institutions – Principle three

Open the archives

To support their function as learned bodies, most PEIs maintain a substantial archive of material going back decades, if not more than a century, and employ a team of expert staff dedicated to cataloguing and disseminating it. Indeed, by including the suggestions below in this guide, the authors are not trying to tell these experts how to do their jobs, rather to highlight to others involved in industrial engagement how to make the most of the opportunities that these archives offer.

Archive material has an important role to play in industrial engagement. Getting access to the material itself is potentially very motivating for students, particularly as university teaching staff often find it very difficult to give students access to real documents from engineering projects. Real material helps to put theory into context; it helps students understand what they might be producing and what role they might play. Archive material also has the potential to reinforce the sense of belonging to a community of practitioners, which is an important part of the experience-led learning that supports developing skills for industry[5].

It is therefore important that students have access to these materials, and equally that students develop the habit of using them. Beyond the value of the archive material in its own right, archive material could form the basis of new academic–industry relationships, as the following suggestions demonstrate.

In practice

- **Invite the students in** – Most PEIs already allow students to come and use their library and archive resources. But the difference between 'being able to' and 'actually doing' can often be large. Students often need plenty of encouragement so PEIs should consider running initiatives to actively encourage students to make use of their resources.
- **Attend IABs** – One way to make more use of archive materials in teaching is for archivists from PEIs to attend university industrial advisory boards to see how their materials can fit into the curriculum.
- **Talk to the accreditors** – Building on the previous point, archivists could also work with the staff from their organisations to identify ways in which the archives could support teaching of the engineering curriculum at universities.
- **Match-make** – There may be an opportunity for archivists to forge a link between a university and a company by identifying archive material that relates both to a specific company and to a topic in the engineering curriculum. The material could form the basis of a group project that representatives from that company could help to facilitate for example; or alternatively the material could form the basis of a student investigation into an aspect of that company's work.
- **People like people** – In the experience of the authors, one of the most appealing aspects of archives is the stories of the individuals who made things – who did things. Building on the previous point, the stories of engineers' activities may also provide the basis for a link between a university and a company, and provide a context for helping undergraduates understand what engineers do in practice.
- **Encourage student research** – PEI archive material could form part of the research for a student project or dissertation.
- **Digitise** – It is the author's opinion that the single most effective way to maximise the benefits that archives offer is to digitise the content and to make it freely available. Approaches for commissioning, designing and operating digitised archives are covered in detail in the report *The Development of e-learning resources – a best practice guide*[6].

Box 4 – Ad-hoc speakers from industry

Inviting people from industry to give a presentation to students is one of the commonest and most straightforward ways for industry to get involved with education. These speakers are in a great position to:

- Help students structure their knowledge by showing them what learning is relevant.
- Provide real examples from industry to inform students' studies.
- Relate the skills students are developing to real processes.
- Give students an insight into what they might be doing when they graduate.

Whether speakers become involved in an ad-hoc or a more formalised basis, the following are some suggestions for making the most of their involvement.

Visting lecturers:

- **Share content** - Create content/presentations that can be left behind. Tell universities what content can be shared so that it can be given the appropriate permissions.
- **Liaise with university** - Find out what students are learning about, so presentation content can provide a context for current topics in the curriculum.
- **Say what you will say** - The earlier universities are provided with content/context, the better staff will be able to promote lectures to students, or make connections within their own lectures.
- **Provide pre-reading** - Often the most valuable part of a one-off lecture from an industrialist is the Q&A. Try to send some content in advance, so that students come prepared with questions.
- **Provide real documents** - This is something that universities really struggle with.

Universities:

- **Promote** – In the experience of the authors there are few things more demotivating than talking to an empty auditorium. Use social media to raise awareness, and also to credit the industrial partner for mutual benefit. Take photos and share these after the event.
- **Go on the record** – Record presentations and integrate into pre-briefing materials for future lectures and workshops.
- **Learning outcomes** - Work with speakers to establish learning outcomes, and identify all the different courses to which the speaker's material is relevant. Linking content to other learning will help reinforce both.
- **Give staff contact** - Give staff the opportunity to talk to the speaker after the session to explore other areas of practice that can be integrated into the course.
- **Grow the relationship** - Use an ad-hoc lecture as the starting point for more involvement with the university. Regular involvement could lead to an honorary position at the university
- **Student crits** - Invite industrial representatives to critique student work. This is especially effective for helping undergraduates understand expectations in industry.
- **Share content** - Use technology to share content, such as video streaming or uploading content to knowledge-sharing portals such as Core Materials or Jorun with appropriate Creative Commons permissions.

Professional institutions:

- **Create a database of visiting lectures content** - This can help to grow a community of practice, grow coverage and avoid duplication.
- **Offer prizes**
- **Include speaking** - At universities and colleges as part of evidence required for professional registration.

Industry:

- **Celebrate the involvement of your staff.**
- **Allow staff to share content.**

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Institution of Civil Engineers - One Great George Street - Library. Image licence under CC BY-SA 3.0

ICE Library

The Institution of Civil Engineers (ICE) library collection is designated as being of outstanding national importance by the Museums, Libraries and Archives Council. With over 130,000 titles, the ICE Library is the largest resource in civil engineering in the world.

Principles for industry – Principle four

Develop motivation for industrial engagement activities

In the experience of the authors, many industrialists are motivated to get involved with some sort of industrial liaison activity, be that in a university setting or in a company setting. However, it is likely that the challenges outlined at the start of this report may go some way to eroding that motivation. Here are some practical suggestions that companies can adopt to help their staff overcome those challenges.

In practice

- **Be clear about the purpose** – Many staff will have a tacit understanding of some of the benefits to academic staff and students of industrialists getting involved with education but being clear about the full range of benefits might be a further motivator. For instance:
  - Professionals from industry have a potentially important role to play in motivating students to study, because they help to provide a sense of purpose for their studies, providing a real context for the sometimes theoretical activities that students work on. They also help students understand the community of practice to which they will belong.
  - There's an important part for industrialists to play in deep-immersion role-play activities, such as the Big Rig:Nuclear Decommissioning project where 'client' and 'safety inspector' roles are taken on by representatives from industry. Having industrialists take on these roles adds to the reality of the learning scenario, and potentially helps to increase its transformative impact.
  - Students worried about whether they are going to succeed at university or industry may find it motivational to hear real stories of success and overcoming failure from people already in industry.
- **Celebrate employees' involvement** – Celebrate your staff when they are invited to get involved with teaching at universities, both through internal and external news channels. Such activities are likely to require a considerable amount of a member of staff's own personal time, and so this should be recognised. Publically celebrating this sort of activity can contribute to building a culture of industrial engagement across industry.
- **Make it work for you** – University and industrial timetables don't always line up, but there are ways that this difference can be overcome, for example using Skype or e-conferencing software to form a remote link with students at a university. If synchronous working is not possible, staff should consider an asynchronous approach, for example by producing a podcast of the material to be delivered. See *The Development of e-learning resources* for recommendations on tools for video conferencing and producing podcasts.

  Similarly, there are tools available for helping staff overcome the challenges of looking after students who come into the workplace. For example, if a member of staff is being asked to manage a work experience student, but doesn't have time to do so, consider using a tool like Student Studio, a platform supported by the Academy designed to help take the burden out of supervising work experience.

- **Get the training** – In the authors' view there is a need for a short training package to prepare industrialists who are going to be involved in industrial engagement. Whoever offers this training (Principle two of this report suggests it should be the PEIs who do this), the authors believe it should cover the following points:
  - Awareness of different learning models – this topic is covered in much more depth in *Experience-led learning - a best practice guide*. An alternative very helpful resource is Felder's paper *Engineering Education: A tale of two paradigms*[12], which describes the difference between constructivist and positivist learning models as applied to engineering.
  - Motivating students – helping industrialists understand the role they can play in motivating students (see point above on being clear about the benefits).
  - Feedback techniques – staff will often be invited to critique students' work. There are appropriate techniques for doing so of which industrialists should be aware.
  - Understanding the curricula – industrialists need to be able to get a quick understanding of the overall curriculum to see how their contribution fits in. Greater awareness of the curriculum may help industrialists identify additional resources, case studies or experiences that they can bring to the classroom that they might not otherwise have done.
  - Understanding systems – most universities now use some sort of virtual learning environment for disseminating information and managing course work. These tools could help overcome challenges of availability by supporting asynchronous working, but many industrialists are likely to be unaware that these systems exist.
  - Find out student learner habits – study habits have changed radically, even in the last five years. Industrialists returning to the classroom after many years are likely to be quite surprised to see how different student learning habits now are compared to when they were in education. For instance, many students now work directly on a laptop, and in the experience of the authors, students' first port of call when faced with any sort of question is the internet, not a book. What is important is that people coming into universities are prepared for these different approaches.
  - How to disseminate – creating resources that can be widely disseminated is important for building long-term effective industrial engagement (see Principle six of this guide). This requires the use of various techniques, such as using Creative Commons attribution, in which staff would most likely benefit from training.
  - Support students in the workplace – as important as preparing industrialists going into universities is the need for training to support students who are on workplace-based learning schemes, such as work-experience placements or a sandwich course. The workplace is a very rich learning environment but students need guidance to help them make the most of these learning opportunities.
- **Create long-term relationships** – Forming the relationships that enable industrial engagement can take a lot of time and effort, which all needs to be repeated when the relationship comes to an end. Industrialists should consider ways to make their intervention last, recognising that they may not always be able to participate themselves. One way to do this is to train up other staff members to deliver in future what they are doing now. Another is to consider turning the intervention into an e-learning resource.
- **Don't duplicate** – This guide recommends that PEIs play a role in coordinating and signposting industrial engagement interventions to save effort for all involved. For their part, industrialists should consult with PEIs to see who else is doing what, and to see if there are materials or approaches that they can borrow and bulid on.

Box 5 - Student societies

Student-led engineering societies in universities offer a great opportunity for students to shape their own learning about engineering. They are also an important informal hub for the connections between universities and industry because through the annual flurry of activity, new connections are continually being formed. However, one of the challenges that face student societies is the turnover of volunteers that run them, which leads to organisational amnesia, and many of these connections being lost.

One way that departments can effectively support their student engineering societies is ensure that their activities are properly archived. This needs to be done in such a way as to not take away the initiative from the students, but rather to provide them with a resource that will avoid them making the same mistakes as predecessors. Part of that archiving process needs to include keeping track of lists of contacts, so that these can be maintained as part of the department's broader industrial engagement strategy. Another way to help overcome organisational amnesia and to grow participation is to set up a society newspaper. Not only are newspapers a good way to encourage widespread involvement, they also provide a lasting record of what has been done in the past.

Professional engineering institutions can support and encourage the creation of student engineering societies by providing them with model organisational structures and processes to help them get started, offering to host their meetings, and by providing a link to the young members' group in their area (see **Box 6** for more information on young members' groups). Industry can support engineering societies by putting up speakers for their events, by running site visits and offering sponsorship. Employers could consider establishing a longer-term relationship with student societies as part of a broader recruitment strategy.

Finally, one of the most effective ways that student societies can get support for themselves is to tap into recent graduate alumni networks - even better if those alumni were themselves members of the society. Graduates are often happy to return to their old universities to help support the sorts of initatives they were involved with themselves as students.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Image courtesy of Oliver Broadbent

CivSoc at Imperial College London

An example of a student-led engineering society is CivSoc, Imperial College London's civil engineering society. CivSoc's activities include arranging site visits, organising talks from industrialists, liaison with professional engineering institutions, publication of *Livic* (see below) and the organisation of an annual international trip, such as its visit to Paris, pictured.

Image courtesy of Oliver Broadbent

Livic at Imperial College

Livic is the civil engineering newspaper of CivSoc (see above). It was set up to give students the opportunity to write about developments in industry.

Box 6 – Young members' groups

Like student engineering societies, as described in Box 5, the young members' groups of professional engineering institutions provide students and graduates with an opportunity to shape their own learning and development, and to take a role in helping others do the same. Their activities typically include running lectures and seminars, networking events, competitions and training to help graduates prepare for their professional review.

These groups are often run by teams of enthusiasts who commit large amounts of time to making these activities happen. One of the ways that institutions can support their groups is to ensure that the administrative burden that these volunteers are subject to is kept to a minimum. Another is to provide these groups with access to meeting room space in their buildings free of charge.

One of the ways to achieve high levels of participation in their activities is for young members' panels to grow effective networks into universities and employers. In doing so, they are part of the glue that joins industry to academia. For their part, institutions should keep track of these connections as part of their broader work to coordinate industrial engagement activities, as described under Principle two of this report.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Box 7 – Work placements

For many students, work placements are the first chance they get to experience an engineering workplace. While a work placement might appear to be a good opportunity for students to put theory into practice, in reality, sometimes placements don't because the level at which university undergraduates can operate in the workplace is below what is required on projects. Nevertheless, what work placements can offer is the opportunity to observe how engineering projects work and to see what knowledge and skills engineers use in their every day practice. Students returning from work placements are likely to have a better sense of how the material they are covering in class can (or can't) be related to how an engineer does his or her job.

Despite the importance of work placements, this is one area of industrial engagement in engineering education around which there appears to be little coordination. In general students are left to find their own placements, and little is made of the learning opportunities that they present. Here are a few practical suggestions for how universities and companies could help students get the most out of these placements:

- **Before they go** – Ask students to think about what they want to get out of the placement. Are there particular professional skills students want to develop, or is there any particular topic that they could use the opportunity to investigate?
- **Keep a journal** – Encourage students to keep some sort of record of their experiences. Even a photo journal showing their workplace and the people they worked with can provide a memory aid for reflective learning later on.
- **Bring something back** – Invite students to make a presentation on their return to university about what they did on their placement. Better still, ask students if they can get permission to bring in real documents or examples that can be used to illustrate upcoming course material.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Box 8 – Industrial mentors

There are various roles that industrial mentors can play in engineering education. One common way is when industrialists are recruited by teaching staff to mentor individual groups in group design projects. A much less common approach, although one that has much higher potential impact, is for industrialists to act as a more general mentor for students in support of their broader development. In both scenarios, the mentor is broadening the student's horizons by providing the perspective of someone working in industry and helping them to understand what an industrialist would expect in a piece of work.

In the view of the authors, one of the most important roles that an industrial mentor can play is to help motivate students towards learning what is useful and what might make them a better engineer rather than just focusing on grades, which unfortunately in the university setting, is the preoccupation of many students.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Principles for industry – Principle five

Make real materials and resources freely available

A recurring theme in this guide has been the benefit to the learning process that access to real materials offers – be those materials documents, drawings, physical artefacts or images – and the difficulty that universities have in giving students access to these materials.

In practice

- **What to make available** – Material of all sizes, from expensive specialist equipment to a single photo, brought from industry into the classroom can be of benefit to the learning process. Here are some suggestions for materials that industrialists might consider bringing with them.
  - Photos and videos – images of machinery and processes help to provide context for theory. Images of people doing their jobs can bring engineering to life. Images of workplaces are potentially motivating for students.
  - Technical drawings and computer models – academics tell us that getting access to real drawings, and models is a big challenge. Where they can get access to real drawings they are not necessarily from a project that would best support teaching. Industrialists are likely to receive a warm welcome therefore if they ask academics what drawings or models would best support their teaching.
  - Process documents and software – project management tools are a part of daily engineering practice. Giving students access to these tools can be part of preparing students for the workplace, helping them to understand project management processes and the behaviours that are expected in industry. A component of the Nuclear Island Big Rig event described (see page 15) is requiring students to use real project management tools and processes from the industry as part of their activities as they help to reinforce the development of 'nuclear behaviours', which is one of the learning outcomes of the course.
  - Operational data – to set realistic problems in engineering education, academics benefit from access to real data from engineering projects – mechanical performance information, project budgets, quality testing data, etc.
  - Reports – technical report writing is an important skill for many industrialists. Giving students access to reports will help them learn about report writing and provide rich information about real engineering projects.
  - Templates – Even something as ubiquitous in an engineering office as a calculation pad can have the impact in the classroom of making students feel like they are part of a community of practice, thus supporting experience-led learning and preparing them for industry.
- **Disseminate resources freely online** – insofar as is possible within commercial and confidentiality constraints, industrialists should be prepared to make their materials freely available online. If all the case study information that industrialists had brought into the classroom in a single year were to be collated it would form an astounding and rich learning resource. Sharing also helps to avoid duplication and therefore wasted effort.

Image courtesy of Think Up

Box 9 - Free or discounted software

Some organisations offer students free or discounted versions to access professional software. For example Solidworks offers students discounted cut-down versions of its mechanical CAD package. The advantage to industry is that students familiar with a particular type of software are arguably more likely to stick with it given the choice; the advantage to universities is that software packages like these can help students develop their skills for industry at the same time as producing coursework submissions.

Despite these advantages, universities might not necessarily want to be seen to be endorsing one particular product over another, and some have pointed out to the authors that what they should be teaching students is the underlying principles of how the software packages work, and not the details of any one proprietary system. That said, if a particular software package can enable a student to more quickly illustrate and develop an idea, then that is a very valuable tool for supporting his or her learning.

- **Use Creative Commons licensing** – A cademics and students are rightly cautious about what right they have to use other people's material, especially given the tight plagiarism rules that most universities have put in place. It is not enough therefore for an industrialist to intend for material to be widely disseminated – she or he needs to declare to others that they have permission to do this. The easiest way to do this is using Creative Commons licensing, which uses a set of simple icons to show what permissions originators of a document give to users and how they want their original work to be attributed. The Creative Commons website has a handy tool that helps authors choose a licence for their work, and then generates the relevant Creative Commons licence mark for download and use in their document.
- **Help users search for materials** – It is important that students get to find the materials that industrialists have gone to the effort of making available. Adding the appropriate meta-data to online resources will help make materials more findable. Techniques such as 'authorship', a protocol that Google uses to link content with authors to enable author legitimacy to be a factor that influences search results, can also help to make content more findable. For more information on search engine optimisation, use of meta-tags and authorship, see *The Development of e-learning resources – a best practice guide*.
- **Disseminate high-quality resources** – Students are much more likely to choose high-quality resources, so if industrialists want their resources to go far, they need to take the time to make them high quality.
- **Bring materials back from work placements** – students who go into industry on work experience or longer-term placement, as well as part-time students, will all have access to real materials that could support learning in the classroom. Industrialists should help students to identify what materials they can take back into the classroom with them, and academic staff could ask students what materials they have seen during their placements that could support teaching.

Principles for industry – Principle six

Invest

As has previously been expressed in this guide, many industrial engagement initiatives are based on direct, often ad-hoc, relationships that exist between individuals. For engagement to be sustained these initiatives, far-reaching investment is needed to support training of the individuals involved, the creation of resources for wider dissemination, and the organisation and maintenance of more sophisticated programmes of activity.

The prime beneficiaries of enhanced industrial engagement in engineering education are the engineering employers who stand to gain a cohort of graduates who are more suited to their working environments. It stands to reason that it is industry that should invest. Of course, industry already does invest in industrial engagement in education, but to achieve higher quality and quantity of these initiatives, more investment is needed.

In practice

- **Invest in staff development** – Principle one of this guide recommends that professional engineering institutions coordinate staff training for industrial engagement; Principle five describes what that training should include. Investing in staff training for industrial engagement would not only benefit engineering education, it would benefit the companies as well as many of the skills needed for effective engagement in education are valuable in the workplace as well.
- **Invest in staff time** – Many staff give their own time for university engagement activities, but giving staff an allowance of time to work on these interventions would be fairer, given the benefits of engagement to the company concerned, including staff development, networking and opportunities to recruit.
- **Invest in the development of e-learning resources** – In today's online world internet users expect content to be free. The cost of developing e-learning resources, therefore, can't be met by usage revenue – industry needs to invest in content development. Though content development costs can be considerable given the high quality that users expect, the payoff can be greater impact in terms of both reach and educational value. One model for investing in e-learning resources that the authors have shown to be successful is annual sponsorship, which is being used to support the development and operational costs of the Engineering Mastermind, an online game designed to help engineers develop their general engineering knowledge.
- **Use industrial project boards** – An effective way for attracting and managing funding for large-scale industrial engagement initiatives is to set up a pan-industry project board made up of representatives from leading companies, professional engineering institutions, universities and sector skills councils. The role of such a board is typically to help shape content, apply industry's stamp of approval, and critically, to encourage participants to invest in in the initiative. In the experience of the authors, individual organisations are much more likely to invest in a particular programme if they can see that others are doing the same.
- **Sponsor visiting teaching posts** – Sponsoring visiting teaching roles in universities is a high-profile way for companies to demonstrate their commitment to engineering education. These positions also offer a significant way to influence teaching outcomes. Sponsored posts enable long-term relationships to form and for the quality of engagement initiatives to improve as participants learn from experience.

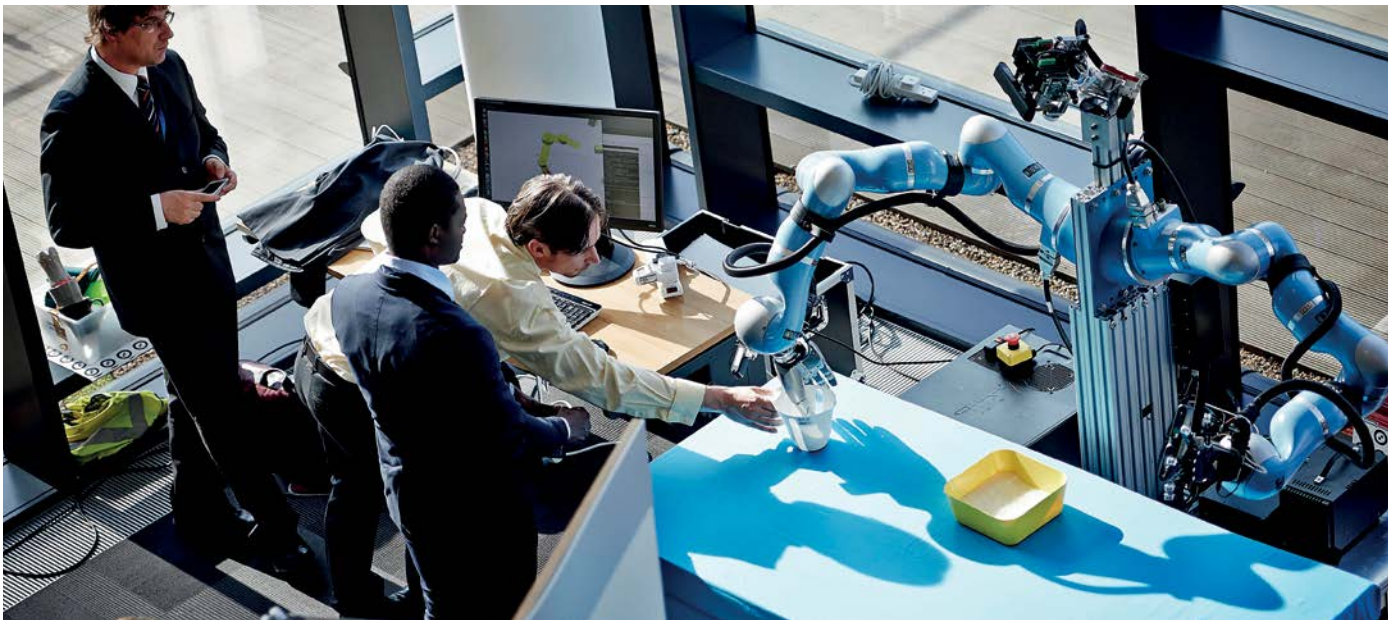

Image courtesy of Daniel Graves Photography 2014

University of Birmingham
'Boris' robotics exhibit from the University of Birmingham

Box 10 – Sponsorship and bursaries

Many companies, professional engineering institutions and charitable trusts offer industrial sponsorship or bursaries to support students through their undergraduate studies. Sponsorship and bursaries are often linked to work placements at the organisation providing the funds. For example, the National Instruments Scholarship programme is available to students studying engineering, computer science or physics and awards them funds to support students in their second year of study, an industrial mentor, access to National Instruments software and hardware, and a year-long paid internship.

The following are some suggestions to organisations offering sponsorship and bursaries to help all involved get the most of out of the initiative:

- Make sure students are assigned an industrial mentor who will keep in regular contact with the student. It is likely that during their studies, the student's perspectives will change, and so it is the mentor's role to make sure that the relationship with the sponsoring organisation evolves during this period of change.
- Help students understand how what they have learned in the classroom can be applied in the context of the sponsoring organisation. Similarly encourage students to look for opportunities to apply in the classroom what they have learnt during their placements.
- Allow sponsored students to organise site visits for their fellow students.
- Look for materials and examples that students can take back into the classroom to help enrich the learning experience for other students.
- Encourage students to keep a reflective log of their learning both in the classroom and during their work placements.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Principles for academia – Principle seven

Develop motivation and skills for engagement

Like for their counterparts in industry, it is the authors' experience that while many academics are in principle motivated to use industrial engagement in their teaching, for others, the challenges outlined at the start of this report often go some way to eroding their motivation. Here are some practical suggestions that universities can adopt to help their staff overcome those challenges.

In practice

- **Be clear about the benefits** – Many academics will have a tacit understanding of some of the benefits of engaging industry in delivering course content, but being clear about the full range of benefits might be a further motivator for greater engagement. Benefits to highlight include:
  - Industrialists may be able to help academics create the initiatives that they have been wanting to develop themselves but have lacked the resources or networks to do so on their own.
  - Industrialists are likely to be in a good position to help academic staff create activities that will develop students' industry-related skills. These skills (such as thinking critically, working across contexts, being innovative, self-management, team-working, and understanding business and customer needs) universities are under pressure from industry to develop in students, but according to the report *Experience-led learning for engineers,* many academic staff find them challenging to teach.
  - Industrialists can help students structure their knowledge by providing real contexts for application of theory, potentially increasing levels of understanding.
  - An industrialist in the classroom offers the opportunity for students to hear alternative perspectives, potentially increasing their engagement.
- **Celebrate activity** – Given the often considerable effort needed to set up effective industrial engagement activities, academic staff should be celebrated when they create a successful initiative. Celebrating success can encourage others to participate, raises awareness of activity (helping to avoid duplication) and helps to promote a culture of industrial engagement.
- **Get the training** – In the authors' view, there is a need for a short training package to prepare acadmics who are going to be involved in industrial engagement. Whoever offers this training (Principle two of this report suggests it should be the PEIs who do this), the authors believe it should cover the following points (note that some of these points are common to the training that should be offered to industrialists):
  - Awareness of different learning models – since industrialists are likely to be involved in helping students develop skills for industry, the academic staff they work with should make sure they are aware of the learning models that support experience-led learning. This topic is covered in much more depth in *Experience-led learning - a best practice guide*.
  - Techniques for deep-immersion role-play - while role-play is commonly used in engineering teaching, there are techniques, of which academics and industrialists should be aware, that can be used to help students get the most out from this approach.
  - Successful models – the training should include raising awareness of successful models for industrial engagement that have been employed elsewhere to avoid duplication of efforts and to raise the standard of activity across the board.

Box 11 – Site visits

Site visits, be they to a production line, an operational facility or a construction site, offer students the opportunity to see engineering in action. While site visits are a feature of many engineers' undergraduate experience, it is the feeling of the authors that more could be done to get the most out of the learning opportunities that site visits present.

- Before the visit, staff and students should think about what opportunities there might be to see theory being put into practice.
- Rather than a one-off visit, particularly in the case of construction sites, students would benefit from several visits over a sustained period in order to help them to see how the projects evolve.
- Where possible, students should go on local site visits. Visiting a local site, students are more likely to have a greater awareness of the surrounding area and the impact of the activity on the site.
- Students should be encouraged to record video of their site visit for the benefit of wider dissemination

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

  - How to disseminate – creating resources that can be widely disseminated online is important for extending the reach of industrial engagement initiatives (see Principle five of this guide). Widespread dissemination is also likely to raise the profile of the activity, potentially leading to the initiators getting more credit for their work.
  - How to manage their industrial partners – some industrial engagement initiatives (such as design projects in which engineers from industry act as mentors to student teams) require the involvement of a large number of industrialists, and so some academics may benefit from training in how to manage such large programmes.
  - How to train their industrial partners – while this guide recommends under Principle two that professional engineering institutions offer training to industrialists in appropriate teaching techniques, this job may be left to the academic staff they are working with. In which case academics would themselves benefit from training in how to train up their industrial partners.
- **Train students for work placements** – Students who go into industry as part of their degree, for instance on a work placement or as part of a sandwich course, would benefit from training in how to make the most of that learning opportunity.
  - Explain what industry-related skills are and what sort of workplace-based activities will help them develop these skills. See Principle four of *Experience-led learning for engineers* – a best practice guide for suggestions on activities for helping students develop tacit industry-related skills, which students could do as a precursor to going on their placement.
  - Help students develop their self-directed learning skills. There is no curriculum for learning in the workplace, so unless they are primed to do so, they are less likely to go looking for the learning opportunities that exist in industry.
  - Build student confidence in reflective learning by, for example, sending them on a one-day work-shadowing placement and getting them to reflect on the learning opportunities before then sending them off on a longer placement.
  - Encourage students to use their experiences from their work placements to help them shape their learning when they return to the university sphere, for example in their choice of elective subjects or in their choice of a research topic.

Principles for academia – Principle eight

Make strategic use of academics' and industrialists' time

Making strategic use of academics' and industrialists' time is important for overcoming several of the challenges identified at the start of this guide: staff availability; different approaches to accounting for time; limited funding; and the difficulty for industrialists to commit a long way in advance to timetabling requirements.

In practice

- **Appoint an administrator** – Universities should consider appointing an administrator whose role it is to manage and coordinate the activities of industrialists coming into the engineering department. Doing so takes the burden of coordination off academic staff and helps to ensure that all participants have the information that they need in a timely fashion. An administrator would be in a good position to promote activity, share good practice and keep lookout for opportunities for new collaborations.
- **Involve industrialists in curriculum design** – If senior academics' and senior industrialists' time is limited, then perhaps the most effective forum for their engagement is in curriculum setting, as this is where their input is likely to have the greatest impact.
- **Avoid detailed assessment** – Getting industrialists involved in detailed assessment of student work is not an effective use of their time, nor do they necessarily have the appropriate skills or experience of teaching to make them good assessors. Alternatives are to use automated tools for formative assesment, such as multiple-choice quizzes, and to use a simple traffic light system where summative assessment of project work is needed.
- **Support design projects and project-based learning** – Another place where industrialists can have a high level of impact is in the setting of briefs for design projects or setting the parameters in project-based learning. Even if industrialists are not able to be fully involved in the subsequent facilitation of these activities, their involvement at the start can help to make sure the activity is relevant and well-tuned to real practice.
- **Bridge the gap with technology** – When face-to-face contact is not possible, either because the industrialists are based too far away, or because timetables and calendars can't be aligned, use technologies such as Skype or webinars to bridge the gap. See Principle four for more information on this point.

Box 12 –Industrial advisory boards

An industrial advisory board (IAB) is a forum set up by a university department to give representatives from industry the opportunity to help shape and contribute to the delivery of their curriculum.

For many engineering departments, IABs are a major channel for industrial engagement. Here are some practical suggestions for getting the most out of an IAB.

- The chairperson should be from industry.
- The composition should be wide-ranging in age and discipline and reflect the balance of the engineering industry (contractors, consultants, agencies, institution representatives, etc), and the majority of the panel should be from industry.
- Some recent graduates should be on the panel.
- The IAB should be degree-course specific – ie the mechanical engineering IAB should be separate to the electrical engineering degree course.
- Length of service should be limited.
- The IAB meeting should take place quarterly if looking at arranging site visits, reviewers for student project work and guest lecturers but if they are covering strategic issues then twice a year would be sufficient.
- Guidance on the terms of reference should come from the professional engineering institutions and items to be considered at meetings should come from the industrial partners.
- The IAB should have a strategic role and sign off any revisions to the curriculum content. It can also provide advice to the senior management team at the university.

See **Box 1** on page 11 for a list of other common ways that industry is involved in the delivering of engineering education in universities.

Bibliography

1. Royal Academy of Engineering. Educating Engineers for the 21st Century. (The Royal Academy of Engineering, 2007)

2. Royal Academy of Engineering. Engineering graduates for industry. (The Royal Academy of Engineering, 2010)

3. Graham, R. Achieving excellence in engineering education : the ingredients of successful change. (Royal Academy of Engineering and MIT, 2012)

4. Grant, D. Educating engineers to drive the innovation economy. (2012)

5. Broadbent, O., McCann, E. & McCann, D. Experience-led learning for engineers – a best practice guide. (2014)

6. Broadbent, O., McCann, D. & McCann, E. The Development of E-learning Resources for Engineers - a best practice guide. (2014)

7. Perkins, J. Review of Engineering Skills. EPC Congr. (2013)

8. Engineering Council. The accreditation of higher education programmes. (2014)

9. Joint Board of Moderators. Guidelines for accredited MEng degree programmes leading to chartered engineer. (2009)

10. CIBSE. *Guidance notes on the submission of documentation for accrediation of academic programmes.*

11. Institution of Mechanical Engineers. The Institution of Mechanical Engineers Academic Accreditation Guidelines. (2010)

12. Felder, R. Engineering Education: A tale of two paradigms in Shaking Found. Geo-Engineering Educ. (eds. McCabe, B., Pantazidou, M. & Phillips, D.) 9–14 (CRC Press/Balkema, 2012)

Table of resources

Airbus Fly Your Ideas competition	www.airbus-fyi.com	A competition in which students propose ideas that correspond to six key challenges for aviation in the 21st century.
Constructionarium	www.constructionarium.co.uk	Constructionarium is an example of a deep-immersion role-play delivered by universities and industry working in partnership.
Expedition Workshed	expeditionworkshed.org	Expedition Workshed is a collection of free-to-use engineering teaching resources collated in collaboration between industry and academia.
Formula Student	http://events.imeche.org/formulastudent	Formula Student is a competition run by the Institution of Mechanical Engineers in which teams of students design, build and race single-seat racing cars.
National Instruments Scholarship Programme	uk.ni.com/careers/elp-scholarship	Available to undergraduate engineers, computer scientists and physicists, these scholars receive funding, an industrial mentor, access to software and hardware and a paid one-year internship.
Nuclear Island Big Rig	thinkup.org/innovation/the-big-rig	An example of a deep-immersion role-play, in this initiative, teams of students are set the challenge of assembling a piece of mechanical plant from the nuclear sector working under the simulated conditions of a nuclear-licenced site.
Royal Academy of Engineering Visiting Professor Programme	www.raeng.org.uk/grants-and-prizes/schemes-for-people-in-industry/visiting-professors-in-innovation	An example of a visiting professorship programme.
Solid Works	www.solidworks.co.uk	An example of a software company that offers students discounted licences for their products.
Siemens Education	www.siemens.co.uk/education/en/teachers/teachers-home.htm	An example of an organisation that makes extensive free-to-use teaching resources available online.
Telegraph UK STEM Awards	www.telegraph.co.uk/sponsored/education/uk-stem-awards/10675497/stem-awards-overview.html	A competition in which teams of students are invited to propose ideas for tackling major challenges from five sectors of industry.

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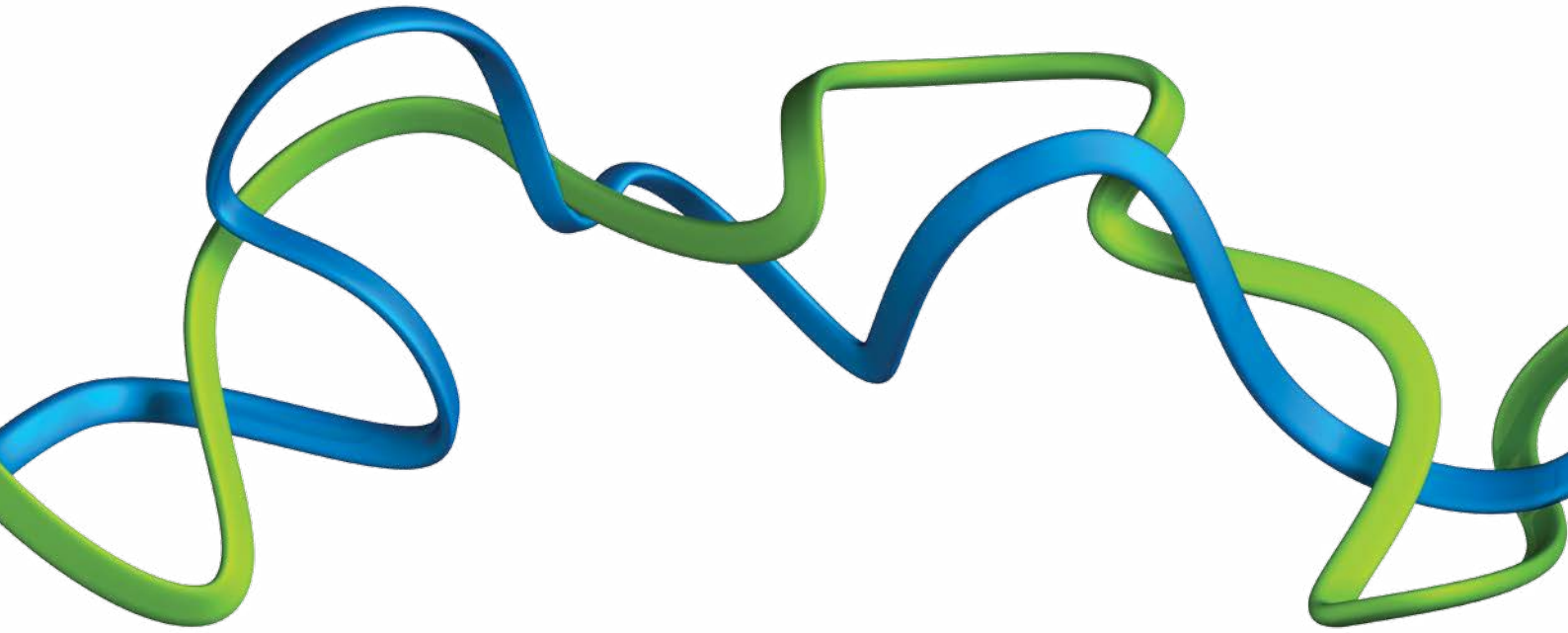
Supporting the development of successful engineering innovation and businesses in the UK in order to create wealth, employment and benefit for the nation.

Address the engineering skills crisis
Meeting the UK's needs by inspiring a generation of young people from all backgrounds and equipping them with the high quality skills they need for a rewarding career in engineering.

Position engineering at the heart of society
Improving public awareness and recognition of the crucial role of engineers everywhere.

Lead the profession
Harnessing the expertise, energy and capacity of the profession to provide strategic direction for engineering and collaborate on solutions to engineering grand challenges.



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