Development of e-learning resources
- A good practice guide
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Executive summary

The need to improve the quality of engineering education to meet the needs of industry and the expectations of students is well established. In this context, there is a strong case for exploiting the opportunities made available by e-learning to enhance the learning experience of engineering students. But despite the potential benefits, many students and teaching staff would argue that developing or accessing suitable engineering e-learning resources can be challenging.

This guide addresses these challenges by providing people developing e-learning resources with useful information and practical support. Taking a project process view of e-learning resource development, we have structured the content in this guide around three phases in the development process: commissioning, production and operation.

The first section of this guide presents an analysis of the current state of play in the development of e-learning resources, identifying the challenges faced by commissioners, developers and users. The second section of the report provides suggestions and guidance to commissioners, designers and users for overcoming these challenges.

While this guide can be read cover-to-cover, it is really intended to be a quick reference for commissioners, developers and users of e-learning resources, all of whom can look up the appropriate section to find the information they need.
Introduction

The Royal Academy of Engineering has produced several reports over the past few years, all of which point to the need to improve the quality of engineering education if we are to meet the demands of students and employers for industry-relevant skills. The recent report *Skills for the Nation – engineering undergraduates in the UK* pointed out that, “continuation rates in engineering are lower than average for higher education as a whole by up to two percentage points.” As that report points out, the reasons for this are not known, but we could speculate that a continuing reliance on traditional lecture-style teaching in today’s world of high-tech communication might be a contributing factor.

The publication *An Avalanche is coming* alerts universities of the need to seize the opportunities open to them through technology to provide deeper and more exciting education. In this context, there is arguably a strong case to be made for exploiting the opportunities that e-learning technologies provide to enhance the learning experience.

In the experience of the authors, many teaching staff still prefer the traditional lecture format to disseminate information. While this can be an effective way for disseminating information in the appropriate circumstances, the reality is that students are likely to have access to a wealth of related information online from static webpages, video services such as YouTube and through social media channels such as Facebook and Twitter. The odds are that the content of the lecture, or something broadly similar, is already available (or soon will be) through platforms such as CORE-Materials, Coursera, FutureLearn, Jorum, and MIT OpenCourseWare.

However, the quality of the resources available online is sometimes questionable. Some resources are simply traditional face-to-face lectures that have been uploaded to the internet. While some of these examples will have value, they often fail to take account of the needs of students in the online world – for example, the need for social interaction and engagement. The result: students will always be able to find something, even if it is wrong.

It is important to bear in mind that our students are, according to American writer and speaker on education Marc Prensky, ‘digital natives’: “Our students today are all ‘native speakers’ of the digital language of computers, video games and the Internet”.

In comparison, the majority of people commissioning and producing e-learning resources are “digital immigrants... who speak an outdated language”. Prensky goes on to say, “It’s very serious, because the single biggest problem facing education today is that our digital immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language.”
Nevertheless, the multiple benefits of e-learning have been widely acknowledged. For example, Jisc, an organisation that champions digital technologies for use in education and research in the UK, gathered evidence of the tangible benefits of e-learning and a sample of the benefits identified are listed below:

› enabling universities to support additional students and improve personalisation and mentoring – thus reducing isolation
› employability and employer engagement as features of many of the e-learning developments
› increased opportunities for formative assessment – contributing to enhanced motivation and learning of students.

More specifically in relation to engineering, the Royal Academy of Engineering published, in 2008, a presentation on the adoption of a blended learning approach on a first year engineering degree module. A sample of the benefits of the changes introduced is identified below:

› the use of active learning techniques
› prompt feedback to students
› improved performance of students led to improved retention which in turn led to increased income
› encouraging cooperation among students
› encouraging contact between students and staff.

We can see that e-learning presents potentially huge opportunities to enhance both the effectiveness and the efficiency of engineering education. There may now be few who would argue that e-learning has no relevance in the education of engineers, but there are many students and staff who would argue that developing or accessing suitable resources can be challenging.

“The most fundamental point to come out of all of the case studies is that the appropriate use of technology is leading to significant improvements in learning and teaching across the sector and this is translating into improved satisfaction, retention and achievement. E-learning is facilitating the expansion of the sector without necessitating corresponding increases in the footprint of the physical estate and it is allowing broadly the same numbers of staff to educate a larger and more diverse student body. The kind of high quality, diverse, accessible, expanding higher education system desired by government and funders is no longer possible without e-learning.”

This guide sets out to:
› present an analysis of the current situation in relation to e-learning resources
› offer best practice suggestions to industry, university engineering departments, professional bodies, government and non-governmental funding bodies for the commissioning, production and operation of e-learning resources.

While many of the issues and opportunities discussed in this report could apply to the general use of e-learning resources in teaching, we have focused on those factors that are most relevant to the teaching of engineering in higher education.

This guide is primarily intended to be a helpful reference for people involved in the commissioning, production and operation of engineering e-learning resources. Both the analysis and the suggestions sections are broken down into small chunks to enable users to find content that is most relevant to them. An attempt has been made to provide clear definitions of technical terms used when they first appear in the guide; however, for the benefit of users dipping in and out of the document, a glossary of key terms and acronyms is included at the back.

Many 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.

This guide can be read cover-to-cover, although read in this way some of the content may feel repetitive as the salient points have been repeated in the places where readers are likely to dip in and out. The authors estimate that to read the report from end to end would taken an interested reader around two hours.

Fluid dynamics simulator
The image above is a screenshot of a computational fluid dynamics simulator developed by Gennaro Sensatore of Expedition Engineering and UCL. Gennaro's work illustrates the huge advances in simulation technology that now make it possible to demonstrate complex engineering principles through a web browser on a mobile phone or desktop computer.

“Electronic-learning (e-learning) presents a solution to address engineering’ requirements by providing a learning environment that can be self-directed and also guided, individual and also collaborative, global and also local, and standard and also customised.”

Extract from A framework to facilitate effective e-Learning in Engineering Development Environments - Yvette James-Gordon, 2007

“Combine technology-enhanced options with the best of established practice and the practitioner has greater capacity to create meaningful and transformative learning experiences.”

Effective Practice in a Digital Age - JISC - 2009
Analysis of the current state of play in the use of e-learning resources in engineering education
What is e-Learning?
Based on the definitions offered by the Chartered Institute of Professional Development and Jisc, the authors offer the following definition: e-learning (or electronic learning) is learning that is delivered, enabled or mediated through the use of information and communications technology.

Method
To structure this analysis, three phases were defined to characterise the deployment of e-learning resources as illustrated below.

› Commissioning – this phase is the start of the process, where e-learning resources are conceived, commissioned and funded. It is the stage in which briefs are developed and initial concepts discussed.
› Production – this is the design and production phase. Here our analysis covers both how existing e-learning resources have been produced, and the production of new ones.
› Operation – this phase is concerned with the publication and use of e-learning resources, as well gathering feedback.

The analysis method was to interview leading commissioners and designers of e-learning resources from academia and digital consultants from industry; conduct a desk study of relevant literature; and to draw on the authors’ own experience of commissioning, producing and operating engineering e-learning resources.

1. Commissioning
In this phase, the following observations were made:

› Commissioners and creators of e-learning resources are often not ‘digital natives’ and so often lack awareness of:
  » the pedagogical models that e-learning supports, for example active learning
  » the computational power and hence possibilities of the technology available to students
  » the opportunities for using social media in learning
  » how learners use the web
  » learners’ expectations of online resources.

The consequence is the brief for new materials can be inadequate, or that funding is not made available for the most appropriate resources.

› Not enough thought is given to how resources will be disseminated or used in virtual learning environments (VLEs) and massive open online courses (MOOCs).

› More consideration needs to be given to funding not just the creation but also the long-term maintenance of the resources.

› There is a growing expectation that e-learning resources should be made freely available to all; commissioners can no longer expect to recover the cost of development at the point of use. Development costs therefore need to be met at the point of commissioning, otherwise quality is likely to be compromised.

› Many people conceive, create and publish their own resources. This phenomenon supports innovation and volume development but has the disadvantage that quality is highly variable. As well as commissioning new resources, there is an opportunity for professional engineering institutions (PEIs) to play a role in syndicating and rating resources.

› While some PEIs, such as the Institution of Engineering and Technology, have invested heavily in the development of e-learning resources, many have not.

Also there appears to be a focus on school-age learning with very little material yet targeted at Further education or Higher education. That said, several of the PEIs have begun to explore how e-learning resources can form part of their strategies to attract and retain talent in engineering.

› Engagement within industry is somewhat patchy with some organisations and sectors using e-learning resources for their in-house development programmes. A few are involved in developing educational resources for HE and fewer still in producing e-learning resources. Notable participants in this arena are Siemens and Expedition Engineering.

› Funding bodies, such as the Ove Arup Foundation, the Institution of Structural Engineers’ Educational Trust and the Institution of Civil Engineers R&D fund are becoming interested in the emerging possibilities for e-learning.
2. Production
Reflecting first on the design of existing e-learning:

- Universities have produced a significant quantity of e-learning materials, especially in conjunction with bodies such as the former Engineering Subject Centre and CORE-Materials. Some of this material is very good, but many of the resources are of poor quality.
  - Many e-learning resources are simply lectures captured and posted online.
  - It is not uncommon for poor classroom pedagogy to have been simply transferred online.
  - Many e-learning resources are not optimised for viewing on the web through the various screen sizes that students use.
  - Few e-learning resources make use of the massive computational power now available in students’ hands.
  - Few take advantage of the collaborative learning opportunities offered by social media.
  - There is little evidence that online resources take much account of how students use the web and what students’ expectations are of their experience online.
  - There is little evidence that online resources make the most of the emergent pedagogies such as active learning that online learning could facilitate.

- MOOCs have been identified by many as a major disruptor in the provision of education generally and consequently in the education of engineers. Clearly e-learning resources are intrinsic to MOOCs, but a brief survey of some of these courses revealed that some universities have taken a traditional course of lectures and handouts and transferred these online, giving rise to the same issues raised in the previous bullet.

- The low cost barrier to creating and posting e-learning resources allows many practitioners to create their own resources, resulting in the creation of a vast amount of material of hugely varying quality.

- The first wave of e-learning resources was arguably the videos and television programmes created for the Open University. The next wave was the production of educational CD-ROMs. Many of these resources are now out of date and need updating; however the original source material is often lost, making the process more difficult.

Reflecting now on the process of designing and making new e-learning resources:

- There are a range of factors that have made it easier for individuals and organisations to create their own resources:
  - Tools for designing and publishing e-learning resources are now freely and widely available – including tools for creating and publishing websites, podcasts, videocasts, and blog sites and tools for creating online forums - opening up the possibility of creating e-learning resources to more people than ever before.
  - Platforms such as YouTube and TedEd have made it easy for educators to remix existing materials to create new resources for a new purpose.
  - Creative Commons licencing encourages individuals to share and get credit for the work they produce, encouraging more practitioners to do so.
  - Increasingly, universities are employing learning technologists to support teaching staff in the development of e-learning resources.

- However despite these positive technological factors, there still remains a significant skills gap, particularly with regard to:
  - interface design
  - graphic design
  - web coding
  - video production
  - search engine optimisation.
3. Operation
In this phase, the following observations were made:

› Use of e-learning resources is often restricted to the students of the university that created them, either because lecturers have a preference for resources that they or a colleague have produced, or because access to other universities’ resources is restricted.

› Many academics point to difficulties finding material that they would choose to use. It could be argued that when universities and other organisations decide to share their learning material on the internet they do so without understanding the need to ensure that others can find the material.

› In recent years, search engine ranking algorithms have made it easier to find certain resources based on ‘social proof’ – in other words, how many high-quality sites link to a particular page and how many people share that page on social networks. The higher a resource is rated according to these factors, the higher it will appear in search results. In addition, a number of platforms exist which specifically syndicate or search for engineering e-learning resources, such as CORE Materials and Kritikos. The combination of these factors will help make well-written resources easier to find in future.

› The use of VLEs such as MOODLE in universities has been growing; however, the authors’ research suggests it is very common for VLEs to be used purely as a repository for storing content. There seems to us to be a need to use VLEs to enable learners to engage with interesting, exciting and interactive material.

› Because of the nature of searching, students will always find poor quality content if good content is not available - this effectively amounts to misinformation filling the voids.

› Many students may have developed lazy habits when using e-learning resources, for example, not questioning the origin of the material they use, or simply using the first answer they find when they search a question on Google.

› Though tech-savvy, many students may not fully appreciate the opportunities available to them, especially if they have never been exposed to using these learning technologies in a teaching environment.

› While e-learning resources enable distance learning, this approach comes with its own challenges, for example, how to build a sense of community among learners, and how to effectively manage multiple streams of asynchronous learning.

› Once e-learning resources are developed, there remain tech and interface challenges. As students use software and hardware to access the materials, there is always the risk that the materials are not compatible. There is also the risk that, as students may be using these resources at any time of day or night, the teacher may not always be available to help solve any problems - creating a potential barrier to students’ learning.

Conclusion
From the above analysis it can be concluded that there is significant room for improvement in the commissioning, production and operation phases of e-learning resource deployment. The following section sets out practical suggestions to support the commissioners, designers and users active in each of these phases.
Best practice guidance for designing, commissioning and operating e-learning resources

In the previous section, we described three stages in the development and use of e-learning resources. This section begins with overarching recommendations that apply to the whole process of developing e-learning resources and then goes on to offer practical guidance in relation to each of the development phases.
This section gives high-level advice directed at organisations such as PEs, large-scale industrial bodies and companies and university development programmes that have the power to influence all three stages in the development and deployment of e-learning resources for engineering.

**Overarching recommendations**

- **Build capability** – there is a clear need to build capability at organisational level to commission, design and operate e-learning resources. In the commissioning phase, organisations need a much clearer understanding of the possibilities that technology offers and both the expectation and behaviour of students. In the production phase, organisations need support in providing higher quality and more appropriate learning resources that support the deployment of modern teaching pedagogies. And in the operational phase, teaching staff need support in finding appropriate resources and successfully integrating them into the curriculum.

  Capability is built through commitment at management level to developing skills and understanding of the development and use of e-learning resources. A wealth of training for staff at all organisational levels is available to help develop skills in this regard – much of which can be accessed through e-learning modules.

- **Adopt loose-fit, low-risk responses** – innovation in e-learning resources tends to be led from the bottom up. Don’t stifle innovation by creating too many restrictive top-down initiatives: rather, provide tools and training to support bottom-up development.

- **Bench test, pilot, scale** – the e-learning domain abounds with examples of expensive investments that have not delivered, most likely because of a lack of concept testing at small scale before ramping up. We recommend a three-stage business model for any large-scale investment in e-learning resources.

  1. **Bench test** – thoroughly develop the core aspects of the concept and test the pedagogy at small scale.
  2. **Pilot** – test at a larger scale, seeking to identify and address in particular operational issues.
  3. **Scale** – move to large-scale operation of the scheme.

- **Leverage funds effectively** – we recommend the most effective use of large-scale funds in the development of e-learning resources would be to:
  
  » support the vast number of enthusiastic individuals who develop their own resources by providing training and guidance to enhance the quality of what they produce
  
  » collaborate across industry to fund the high-impact expensive resources related to key topics that individuals wouldn’t be able to afford to develop themselves
  
  » develop comparison sites that identify and rank the best resources that are freely available.

> It is clear that our senior managers need to be knowledgeable and competent in relation to digital technologies; we can’t just leave this stuff to small groups of specialists anymore.”

Nick Baveystock
- Director General, Institution of Civil Engineers
Commissioning

This section is for people producing e-learning resources and contains key considerations, dos and don’ts and references to support that creative process. The information is organised under headings that each relate to a different part of the design process from initial concept development to considerations for publication. In this section:

1. Keep your finger on the pulse
2. What are people looking for?
3. Find out what students use
4. Pretend to be a student
5. Fund pilots
6. Fund high impact resources
7. Support comparison portals
8. Don’t duplicate: collaborate
9. Focus on practice-orientated content
10. Commission students
11. Creative brainstorm
12. Put e-learning in accreditation
Make A Scape is a structural mechanics-based game app that the authors have recently been involved with developing, the commissioning phases of which can be used to illustrate a number of key points from this section. The app development was funded through organisations such as the Ove Arup Foundation, the Institution of Structural Engineers and the Useful Simple Trust, none of which expected any financial return on their investment, understanding that their funding was enabling a high-impact project that no one institution was likely to be able to do alone. Communication designers were core to the development team, ensuring that key messaging about structural engineering are consistent throughout the user experience.

The app is designed to be free at the point of use, recognising the expectations of today’s students. The design team worked with students to develop a teacher guide for the app that reflected how they enjoyed playing the game.
1. Keep your finger on the pulse

Those who self-identify as ‘digital immigrants’ can make more informed decisions during the commissioning phase by keeping up to date with the latest developments in e-learning. Digital natives would do well to do the same, as in this quickly moving field it is easy to fall behind. An easy way to do this is to follow some educational blogs. Here are a few recommended reads:

› Onlinelearninginsights - focuses mainly on e-learning for schools. Follow the author Debbie Morrison on Twitter @onlinelearning

› Edutopia is another school-focused blog but it has interesting articles that relate to e-learning in universities.

› Elearningcoach comes at e-learning from a design perspective. Follow the author on twitter @elearningcoach

› Cathy Moore’s blog comes at the subject from more of a business perspective. Follow the author on Twitter @CatMoore

2. What are people looking for?

Data on popularity of search terms provide information about the topics on which students are looking for help, and should influence which new resources are commissioned. Tailoring resources to search term results helps both to ensure the resources are found and that they are meeting a need.

For example, using this technique, the authors established that each month 50,000 people around the world type the question ‘what is soil mechanics’ into Google. On this basis, the Ove Arup Foundation commissioned The Bare Essentials of Soil Mechanics, a set of high-quality online videos in which world leading geotechnical engineering Professor John Burland answers related questions. Within one month of its publication, this material is already top of the YouTube search rankings and rapidly working its way to the top of the Google rankings for the search term ‘what is soil mechanics’.

Keyword research is a quite a specialised discipline, that usually involves using the keywords planner tool that is part of the Google Adwords package. The tool allows content authors to see how many people search for a given search term on a monthly basis. It also offers suggestions for related keywords. Domain experts can use the tool to successfully tailor their content to match the words people use when they search the internet – improving discoverability.

Another way to find out what students are looking for is to search technical fora, such as Eng-Tips Forums and the IET’s Technical Discussion Forum, in which students are increasingly participating in discussion threads to help them find the answers they are looking for.

3. Find out what students use

When commissioning new e-learning resources, it is important to understand the students’ study habits and preferences. E-learning resources have caused a paradigm shift that means that students’ method of working may be completely unrecognisable to those commissioning resources. This information can be either gained by directly by surveying students, or indirectly by using analytics data to identify what types of devices students are using, or how long they are spending using a particular page.

4. Pretend to be a student

This is another suggestion designed to bridge the gap between digital immigrants and natives. Build on the results of the previous suggestion about surveying student behaviour, and use the approaches that students use to find information out about a
certain topic. Doing so will get you into the mindset of the student and will help to make sure that the resources you are commissioning meet their needs. Searching for resources from the perspective of a student may also help to identify gaps in the provision of e-learning resources which may not have otherwise been apparent.

5. Fund pilots

The trend for high-quality e-learning resources to be free at the point of use means that more upfront funding is needed for their development. Funding small-scale pilots can help to attract additional industry funding for scaling up and can help ensure the money is well spent. Typically, institutional investors and industrial organisations are unwilling to invest large sums of money in experimental concepts, which e-learning resources often either are or appear to be. Pilot initiatives can be used to prove the concept on a practical and pedagogical level, and for those developing the concepts, provide an opportunity to test and develop before large-scale investment is needed.

For example, many of the novel e-learning resources on the Expedition Workshed website, including Push Me Pull Me, Catastrophe, and the Virtual Materials Laboratory were all started with a pilot costing £5,000 - £10,000 each. Those pilots were able to demonstrate the value of the concepts and possible improvements, and have led to significant subsequent investment.

Key things to think about when developing or commissioning a pilot:
› Ask teaching staff to evaluate the tool in use – this carries great weight with funding bodies. Quotes from users will also support the case.
› Support feedback with analytics data about use around the web, including backlinks from other sites. Evidence of international use is likely to appeal to corporate sponsors.
› Look for unintended uses – practitioners may be using the test resources in ways never imagined and these uses could inform future development.
› Publish evidence of your pilot.

6. Fund high impact resources

Funding bodies and industrial organisations should focus on funding high-impact resources that are usually prohibitively expensive and difficult for individuals or universities to produce, and leave the development of the lower-cost time-intensive resources to the latter. Examples of such resources are listed below:
› Video teaching resources - Despite the reduced cost of working with modern professional digital recording equipment, it is still great compared to the cost of capturing a burst of video on a smartphone and uploading it straight to the web. Given the large numbers of people using online videos for learning, industry should invest a modest sum in creating definitive high-quality teaching videos, which should quickly become recognised as the best material available.
› Laboratory tests - Invest in definitive video footage of laboratory tests on specialist equipment, either in specialist departments or from industry, that students would not otherwise have the opportunity to see. Doing so allows a far greater pool of learners to benefit.
› Simulators and games - creating high-quality simulators and games that meet the expectations of today’s students requires budgets and expertise that are usually beyond the reach of individual universities. If industry is able to cover the cost of the development of the core platforms, the design of the individual lesson activities which use these resources can be taken on by teaching staff who are much better placed to do so.
› Personalities – industrial organisations are in a good position to invite leading experts in their field to contribute to learning resources whose insights have the potential make a great impact on learners.
7. Support comparison portals

One way to embrace the self-starter approach to the creation of e-learning resources is for PEIs to develop and operate portals in which practitioners rate e-learning resources. The benefits of this approach are:

› good resources are easier to find
› users can have more confidence in the quality of the resources that they find
› motivation of individuals to create better quality resources
› sharing good practice
› it is a good way for PEIs to influence content and raise quality without having to produce the resources themselves.

Key issues to consider when setting up a review and rating portal are:

› Level of control - PEIs operating such a portal may wish to have a high level of control over the upload and rating process. The benefit of this level of quality control comes with increased cost and is counter to the spirit of the social web in which people are free to express their own opinions.

› Moderation and operation - Even the most open of platforms require regular administration and occasionally stimulation to encourage new resources to be added.

Two good examples of rating portals are the Times Educational Supplement's Teaching Resource Bank and Merlot II (Multimedia educational resource for learning and online teaching).

8. Don’t duplicate: collaborate

There is already a bewildering array of teaching resources available online of varying quality, which is potentially confusing to learners. This situation is made worse when various organisations in the same sector duplicate teaching materials. Professional institutions and trade associations have a role to play in identifying key topics that are not well taught. They may even go further and invite industrial partners to fund the development of specific resources where there is the need.

Clearly large corporations take great pride in producing high quality resources of their own, and so may not sign up to a joint scheme to create resources; even so, a centrally-organised regular review of what is available and where the gaps are should help to avoid unintended duplication by individual organisations.

9. Focus on practice-orientated content

Authentic learning materials from industry are a potentially motivating factor for students because these materials reinforce the links between the learning and application in practice. Thus industry should focus on giving access to authentic resources from industry that universities are less able to supply. Good examples are technical drawings, technical data, images and documents.

In a similar way, resources that help students develop skills for industry are potentially motivating for students because they also reinforce the link between learning and work. Organisations that practice these skills are probably more likely to be to advise on the content of these resources than universities. A good example of this in practice is the Drawing Gym, a collaboration between UCL and Drawing at Work.
10. Commission students

One way to bridge the gap between digital natives and digital immigrants is to get students involved in the commissioning and design of e-learning resources.

An example in practice is described in Working in Partnership with Students: The Summer School at Cambridge. The paper describes an initiative at the Department of Metallurgy and Material Sciences at Cambridge, in which students and lecturers collaborate to create Teaching and Learning Packages (TLPs), flexible web-based resources suitable for use by students or academic staff. The pairing ensures typical learning difficulties commonly encountered by students are addressed at the same time as guaranteeing academic rigour. Staff at the Department of Metallurgy and Material Sciences at Cambridge see the TLPs as a way of enhancing the student experience by creating alternative resources, which promote interaction and which capture course content through visual representation. The resources created have received international recognition for their quality and educational value. This approach is now being adopted by UCL’s engineering department.

11. Creative brainstorm

Invite input from communications designers at the briefing stage for new e-learning resources. While representatives from the engineering sector are likely to be subject-matter experts, they are not usually trained in communication design or interface design. Communication designers are often looking for a context to which they can apply their skill. There is at least the potential for an interesting conversation for both parties.

12. Put e-learning in accreditation

We suggest that the PEIs involved in accreditation consider the effective use of e-learning resources to support and enhance the educational experience of the student as part of the accreditation process. Experience suggests that by making this a subject for explicit consideration in the accreditation process, universities will focus on it and improve. Some PEIs adopt this approach with respect to the use of laboratory teaching, field trips, the provision of adequate library resources and so on. We suggest that e-learning resources are added to this list. We also suggest that PEIs capture and disseminate best practice across universities in relation to e-learning resources and practice.
Production

This section is for people producing e-learning resources and contains key considerations, dos and don’ts and references to support that creative process. The information is organised under headings that each relate to a different part of the design process from initial concept development to considerations for publication. In this section:

1. Explore the pedagogical models
2. Design with dissemination in mind
3. Design with accessibility in mind
4. Design for how people use the internet
5. Gamification
6. Creating online quizzes
7. Creating simulators
8. Working with virtual learning environments
9. Working with MOOCs
10. Creating online videos
11. Creating online presentations
12. Publishing documents online
13. Using meta tags
14. Use authorship
15. Working with blogs in the classroom
16. Working with wikis in the classroom
17. Using Facebook and other social media
Engineering Mastermind, an online multiple choice quiz, is another project that the authors have recently been involved with producing, and which can be used to illustrate a number of the key points from this section. The starting point was establishing a pedagogical model, which related the simple declarative knowledge to higher-order thinking required for design, and which then turned the process of acquiring declarative knowledge into a game. The dissemination mechanism was built into the game from the outset: a leader board, which shows the relative performance of universities on the game, and which encourages universities to get their students playing. Dissemination by social media is encouraged by awarding students digital badges upon successfully completing a quiz, which can then be shared on Facebook.

The game play was tested at small group scale, and then through online beta testing in order establish the right balance between learning and challenge.
Early e-learning technologies primarily supported one-way transmission of information and so were ideally suited to supporting more didactic forms of teaching. But the emergence of social media and the second generation of the internet (so-called ‘Web 2.0’) represents a paradigm shift in the way information is exchanged online and the pedagogical models that e-learning can support. User-generated content, networking, customisation and participation in online communities lend themselves well to supporting constructivist approaches, which require the learner’s active involvement in knowledge construction and the learning process.

This guide will not attempt to summarise the vast body of literature on the ways in which e-learning can support the manifold approaches to teaching, and will instead just focus on one approach. The Royal Academy of Engineering’s report *Experience-led learning for engineers – a good practice guide* identifies the Vanderbilt Northwestern Texas Harvard (VaNTH) learning model as one which is very appropriate for delivering experience-led learning for engineers. How e-learning can support the four strands of this teaching approach is described below.

- **Knowledge-centred learning (you need some facts)** - Never before have students had access to so much rich information to support their learning. E-learning can encourage students to make the most of this massive knowledge base.

- **Student-centred (it has to start from where the students are)** - Even early web-based technologies allowed student-led learning, in so far as students can search for and use resources that suit them. Web 2.0 technologies, such as social media, blogs and wikis allow users to create their own content, express themselves, and participate on their own terms in the process of learning. What’s more, their whole learning experience can be more or less customised to suit their needs.

- **Assessment-centred (everyone needs feedback on how they are progressing)** - E-learning supports formative assessment through tools such as quiz software and online multiple-choice tests. Many of these functions are built into VLEs. Social media platforms enable students to participate in peer-to-peer feedback.

- **Community-centred (students should feel they are part of a community of learners and practitioners)** - Online collaborative learning tools, such as wikis, games, blogs, forums and collaborative documents support students working in a community of learners. Through social media, students can participate in wider professional and special-interest communities that provide a context for their learning. Social media platforms even allow those less confident to observe until they feel confident enough to actively participate.
Designing with dissemination in mind is about making sure that users can find resources. Since most resources are found using search engines such as Google, Yahoo! and Bing, good dissemination is about search engine optimisation (SEO), the process of tuning resources so that they are correctly listed by search engines and easily found by users.

Search engines are basically robots that read every website on the internet, creating an index based on what they read. When a user searches for a term, the search engine goes through the index that it created when it last crawled the web and then displays the search results that it thinks are most relevant for the user based primarily on the search terms they used. The sites at the top of the results list are the sites that are most likely to be clicked on by users.

Designers of e-learning resources can use SEO to influence the ranking of their resources in search listings. The recommendations in this report are based on the information that Google, the most popular search engine, makes available on search engine optimisation. SEO is not cheating the system; rather it recognises that Google’s advertising-linked business model depends on the search engine listing the pages that the user is looking for: a win-win situation for the search engine and the user. It is likely that other search engines work on similar principles.

SEO involves careful crafting of content so that it is easily accessible by both human users and search engines. Here are some content crafting suggestions:

› As content must be indexed by search engines it must be readable by search engines. HTML sites are easily read and Flash sites are not.
› Content should be original and useful for users.
› Content should have good backlinks, links from other authoritative sites linking back to the content. Content authors should therefore attempt to connect and engage with related sites in a natural and unforced manner. Note, search engines may penalise sites that engage in ‘dishonest’ link building strategies such as the practice of buying links. Content should have good social proof - content is shared on social media, and site authors are individually verified.
› Content should be presented on a website that is uncluttered, free from malicious code, free from misleading adverts and is World Wide Web Consortium (W3C) compliant.
› Crosslinking within a website can improve visibility for a target page.
› Including appropriate frequently searched keywords in content and metadata (title tags and meta-description).
› Updating content regularly.
Designing with accessibility in mind is about making sure that e-learning resources are accessible to all, including those with common disabilities and special learner needs.

Designing with accessibility in mind is a vital part of e-learning design. The Equality Act 2010 makes it a legal requirement for websites to be usable regardless of disability. But in addition to avoiding discrimination, designing for accessibility increases general usability, addresses differences between web browsers and improves the ability of search engines to index the page content correctly - improving search engine ranking.

Some key considerations for accessible e-learning design are:
› Structure, layout and positioning
› Navigation
› Colour
› Images
› Multimedia
› Text (acronyms, abbreviation, font type, font size, language).

The box on the adjacent page provides a list of considerations for designing e-learning resources to support specific types of disability. The following are useful references:
› The World Wide Web Consortium (W3C) has published an online checklist of the checkpoints from the Web Content Accessibility Guidelines 1.0 for Web content developers.
› The British Standard BS 8878:2010, Web accessibility code of practice is the first British standard to outline a framework for web accessibility when designing or commissioning web products. It applies to all products delivered via a web browser, including websites, web services and web-based applications, and is designed as an introduction to digital accessibility for non-technical professionals.
E-learning design: supporting specific types of disability

**Colour blindness**
- Ensure text is well-contrasted against the background.
- Avoid distracting background images.
- Avoid colour-dependent navigation, e.g., “Click on the green button.”
- Avoid using colour alone to convey meaning. If colour is used, consider adding a textual cue as well. For example, it is common practice to highlight quotes in a different colour for online discussion forums. Adding speech marks and/or the quoted person’s name in brackets provides additional textual clues.

**Motor impairment**
- Provide tests or quizzes in alternative format if limited dexterity would affect a student’s ability to answer, for example, drag and drop questions in Hot Potatoes.
- Allow students ample time for completion of activities, e.g., quizzes.
- Avoid making link names too short. Short names make smaller links which may be difficult for someone with limited fine muscle control to click on them.
- Use online announcements in the news forum to let students know in advance of changes to face-to-face schedules, in case they have to make special adjustments to their transport plans.

**Visual impairment**
- Provide quick and easy navigation to activities and resources. For the benefit of screen-reader users, it may help to place the activities block near the top left of the screen where it can be accessed quickly.
- Always provide alternate text for images.
- Provide tests in alternative format if questions rely on image recognition. Use alternate text if this can convey the sense of the image without giving away the answer.
- Ensure that any documents you upload are accessible (see section on Creating accessible documents below for further information).

**Hearing impairment**
- Provide a linked transcript as an alternative to any audio used.
- Consider providing synchronised captions or a transcript for video. People who are deaf need this if the video does not make sense when the sound is turned off. This can be done relatively easily with applications such as Camtasia.

**Dyslexia**
- Place salient points first.
- Use clear, concise and simple language. In discussion forums, for example, use meaningful and clear subject headings for discussion threads.
- Break content down into bite-sized chunks eg by using bulleted or numbered lists.
- Choose an appropriate font. Jisc TechDis, a leading UK advisory service on technologies for inclusion, recommend the use of sans serif fonts such as Arial, Helvetica, Verdana and Tahoma.
- Allow ample white space on the page.
- Avoid using text justified to both margins.

Source: UCL, Making e-learning more accessible.
It is important to consider how users read information on a screen, how they navigate their way around a web page and how they respond to the design of a web page.

E-learning resources will not help learners meet the intended learning objective if the learners are put off by the content or design of the page. Research shows that users take on average 50ms to form an impression of a website. Given the ease with which learners can go back to their search results and opt for a different resource, users may leave your resource prematurely if it is not what they like.

Here are some tips for content and site design:

› Text content should be presented in a web-friendly way, with fairly short, staccato-style paragraphs that are well spaced.

› Sentences should be relatively short and readable. As users tend to scan web pages, short paragraphs and bullet point lists help to keep users on the page and can help to draw them in to explore the site further. Images should be used to break up blocks of text.

› Considering good user orientation has a number of consequences for site design:

  » First impressions count – Research carried out by Google suggests that users typically value sites which are simple and designed with a familiar layout. If the visual complexity of a website is high, users perceive it as less beautiful, even if the design is familiar. If the design is unfamiliar, users judge it as more ugly, even if the site is simple. Users love sites with simple and familiar designs.

  » Meet expectations - The site should match the user’s expectations, which will have been generated from the referring site (or a personal recommendation). The site should clearly demonstrate its purpose at a glance, without requiring the user to scroll down. The site mission might be included in tagline format with the header logo. All pages of the site should communicate the purpose of the site, and this should be supported with a well-crafted ‘About Us’ page.

  » Be beautiful - Bad navigation and information architecture (the way content is structured) can cause users to leave a site prematurely. Research suggests that when websites have a familiar layout (ie with horizontal navigation at the top of page, logo at top left etc), users typically view them as “more beautiful”.

› Site navigation should be simple, intuitive and standard. Certain terms like ‘About Us’ have become normalised and site owners should resist the temptation to use non-standard descriptions.
5. Gamification

Gamification is the application of gaming metaphors in non game contexts to influence behaviour, improve motivation and enhance engagement\(^\text{13}\).

Using games to facilitate learning aligns well with several aspects of engineering education: it can support collaboration and teamwork; it can simulate a context in which to carry out problem-solving activities; and it can reinforce the benefit of iterating and continuous improvement.

Proponents of the use of games in education point to a number of more general advantages of the approach, including:

- boosting motivation to learn
- using fun to support a self-sustaining learning environment
- providing continuous feedback and rewards, such as points and badges, that can act as an extrinsic motivator for learning\(^\text{14}\).

However, gamification has its critics who voice among their concerns:

- Gamification can only provide a benefit for students who are motivated by being better than their peers, and that this may leave struggling students behind.
- Current popular strategies for gamification are not fun, having an artificial sense of achievement, and that gamification can encourage unintended behaviours.
- There is no evidence that extrinsic reward (like earning badges) is a strong motivator in games. People play video games because they involve mastery and promote a sense of self-efficacy - not because they earn points or badges.

Generally speaking, gamification in engineering education is emergent, and the jury is still out on best practice for implementation. Teachers interested in using this approach should review the literature to form their own view of this methodology. Below we list a number of broad considerations to bear in mind.

In general, good online learning games have:

- good educational content
- good gameplay - providing motivation to continue playing
- integrated learning tasks, rather than being entertainment with quizzes ‘bolted-on’
- engaging challenges that are well-calibrated - they should be neither too difficult nor too easy.

Productive failure is an important part of successful gaming in online education. The willingness to fail and keep trying helps prepare students to deal with real-life challenges and encourages resilience\(^\text{15}\).

Games and game-based strategies can probably contribute to online learning - but they should be more than simple educational content with added badges if they are to be optimally effective.

Taking an invalid educational idea and turning it into a game is not likely to be effective online learning tool.

Games are not fun because they are games - but because they are well-designed\(^\text{16}\).
6. Creating online quizzes

An online quiz is simply a quiz hosted on a webpage. Quizzes can include multimedia content. Many online quizzes allow players to create an account and save their scores. Tools for creating online quizzes are embedded in many virtual learning environments.

The principal benefit of using online quizzes in engineering education is to support formative assessment, an important aspect of the pedagogy we advocated for the reasons described at the start of this section on producing e-learning resources. Quizzes allow students to quickly check their progress, and though they may be time-consuming to set up, are easy for teachers to use over and over again. Of course quizzes can also be used for summative assessment or as part revision for summative assessment. Here are some important considerations for good quiz design:

› Consider the format of the quiz questions. Options include:
  » multiple choice questions (MCQs) which allow the learner to choose one answer from a list
  » multiple response questions (MRQs) which involve the selection of more than one answer from a list
  » special types of multiple choice questions such as True/False and Yes/No questions
  » text/numerical questions which involve entering text or numbers.
› Keep the questions short and unambiguous.
› Test one concept per question, which is related to a course goal.
› Ensure there is a definite correct answer.
› If using a multiple-choice question, make sure that each wrong answer represents a common misconception (this helps diagnose student thinking and eliminate easy guessing).
› Write questions that require your students to think at different levels; include some recall questions, some comprehension questions and some application and analysis questions. This will help you determine where students are having problems in their thinking.
› Avoid unnecessary jargon, metaphors, and slang.
› If time limits are going to be used, make sure they allow all students to finish the test and do not penalise second-language learners or those with vision or reading problems.
› The key to successful quiz design is to ensure students get feedback which explains why their answer is correct or incorrect. Successful learning involves understanding not just memorising.

Finally, make sure use is made of the quiz data. Quizzes provide information about the aspects of a subject that students do or don’t understand, enabling teachers to adapt their teaching accordingly.

The Moodle ‘Quiz module’ allows teachers to design and build quizzes consisting of a large variety of question types, including multiple choice, true-false, and short answer questions. Moodle has also developed a useful webpage on effective quiz practices which includes creative quiz uses, and guidance on avoiding cheating.
A simulator is a model of a system or a process that involves a time dimension. A simulator can be as complicated as the recreation of an aircraft flight deck, or as simple an interactive model of a beam. Much of engineering involves systems and complex time-variant processes. Therefore, in engineering education, it is helpful to develop the skills necessary to operate in those environments. Simulators have long been commonplace in the aviation, petrochemical and nuclear industries delivered using specialist facilities, but recent advances in computing power have meant that it is now possible to deliver powerful simulators through web portals.

An example of the powerful simulators that can be delivered through a web portal is the Push Me Pull Me 3D platform, led by Gennaro Senatore at Expedition Engineering, which uses a real-time physics engine to show how structures respond to being pushed and pulled in different directions. What is so notable about this example is that, until recently, this sort of simulation would only have been possible using a powerful desktop computer: now this simulation is being delivered through a browser on a mobile phone. The creators of Push Me Pull Me are now looking at how this real-time physics engine can be used to simulate the entire construction process of a building from site clearance to topping out.

Like gamification, use of simulators in engineering education is an emergent field and it is too early to talk about best practice. The experience, however, of developing Push Me Pull Me reveals to two important factors to consider when creating a simulator for use in the classroom:

› Don’t let the interface be a barrier - Creating an easy-to-use interface is as important, if not more important than making sure that the simulator is accurate. If users are not able to operate the simulator then they will not be able to achieve the learning outcomes for which it was intended.

› Balance realism with an achievable learning journey - Realistic simulations often require many variables to be set; however, presenting a learner with too many options at the start can be overwhelming. Start the learning journey with a simple simulation that may not be realistic, but may at least be easy to understand, and then build realism (and complexity) from there.

› Be clear about what the model does and does not do - Part of learning with simulators is understanding the limits of the model. Provide learners with the information that will allow them to do so.

› Remember that the modern student has typically high expectations of software interfaces and will be turned off by confusing or clunky interfaces - See the observations above about how to lay out an interface.
A virtual learning environment (VLE) is an online platform offering various functions to support teaching, including: storage for e-learning resources; a notice board for class announcements; hosting for class websites, blogs and wikis, an electronic post box for online submission of course work; and a system for logging and transmitting grades and feedback.

The box below provides more detailed information about what a VLE does. Given the many useful functions a VLE can fulfil, it is not surprising that the use of VLEs is increasing. They are particularly useful for enabling institutions to teach not only traditional full-time students, but also those who cannot regularly visit the campus due to geographic or time restrictions, for example students on distance learning courses or studying part-time. Despite their popularity, however, not enough thought is given to the effective design and use of VLEs, and it is very common for them to be used purely as a repository for storing content.

Whichever VLE platform is used, here are some good practice principles:

› Those who have never used a VLE should consider enrolling on a course that uses a VLE to see what the experience is like.

› Much of the pedagogy which underlies successful e-learning can also be applied to VLE use.

› Take the time to carefully plan the structure and content of a VLE to maximise its usefulness to students and provide a high quality educational experience, eg divide course materials into clearly defined sections and include introductory and explanatory information.

› VLEs are much more than a document storage system; use VLEs to enable learners to engage with interesting, exciting and interactive material (eg quizzes, videos, games).

› Encourage interaction and collaboration through the use of teacher-student discussion forums, instant messaging, wikis and blogs.

› Technology and software for VLEs are continually developing. Try to keep up to date with developments, review content annually and make any necessary adjustments and improvements made before the next course cycle.

› VLEs should be accessible through mobile devices.

**Different types of VLE**

There are different types of VLE, which all work slightly differently but ultimately perform the same function and can deliver the same learning materials. A higher education institution is likely to have a licence for a VLE that fits into one of the following three categories:

› Off-the-shelf, such as WebCT (Web Course Tools) or Blackboard.

› Open source (often free to use and adapt, but support is charged for), such as Moodle. Moodle can be customised in any way and tailored to individual needs and is currently the world’s most widely used learning platform. It delivers a powerful set of learner-centric tools and collaborative learning environments that empower both teaching and learning.

› Bespoke (developed by institutions for their own individual needs).
MOOC stands for massive open online course. MOOCs are a relatively new form of online learning and have been created to support unlimited participation and open access via the web. Courses offered through MOOCs are generally free of charge, open to everyone, have no entry requirements and are based on traditional academic courses combined with quizzes to assess progress.

MOOCs are significant because they have opened up quality education to a huge number of people. For example in 2014, Alison, a popular MOOC platform, recorded 3 million registered users; however one of the major criticisms of MOOCs is their reliance on self-directed learning, and drop-out rates can be high. Sign-up numbers therefore can be misleading and are no guarantee that users have successfully completed a course.

MOOCs are another example of an e-learning technology that is relatively new and for which best practice is yet to be broadly agreed upon. The advice therefore provided for creators of courses on MOOCs is limited and boils down to applying the same general principles described in this guide for the production of effective e-learning resources, particularly in relation to: creating video, publishing presentations online, gamification, use of simulators, use of online quizzes, publishing documents online, design for accessibility, use of blogs, use of wikis, and use of social media.

Current popular MOOCs

- Coursera
- Khan Academy
- Alison
- EdX
- FutureLearn
10. Creating online videos

Video is a very popular way for people to view content on the Internet. Educational videos come in lots of forms: videos of lectures; presentations, sometimes with voiceovers; short movie clips - sometimes very informal; and, animations. Some are made with high quality production values; others are quick clips recorded with a handheld device. Some are hour-long lectures, some are no more than 30 seconds long.

Given its popularity with users, there is no doubt that video has become a popular e-learning tool. Video offers many potential benefits for engineering education:

› It is ideal for showing how something works or how to carry out a specific task.
› Video appeals to visual and aural learners and caters for people who may have difficulty reading.
› Used as part of a blended learning approach, video can help to keep learners engaged for longer.
› It can add a human dynamic, which may be particularly needed in distance learning courses.

The integration of the movie camera into the smart phone has meant made it very easy to create and post videos online. Here are some tips for helping to make sure this content is effective, based on research carried out using the edX MOOC platform (using data from 6.9 million video watching sessions)17:

› Videos should be short and specifically designed for the online format.
› The instructor’s talking head should be interspersed with presentation slides.
› Khan Academy-style tablet drawing tutorials are more engaging than presentation slides or code screencasts.
› Videos where instructors speak fairly fast and with high enthusiasm are more engaging - students can always pause and/or repeat the video.
› Students engage with video lectures differently from how they engage with video tutorials - lectures should focus more on the first-time watching experience, whereas tutorials should add more support for re-watching and skimming.
› Videos should certainly be no more than three minutes long - allowing users to control how they consume the content.
› Avoid all distractions - people, signs or objects in the background.
› Add interactive elements to video - ask questions or try to provoke a response from your audience.
› Online video should consider visually impaired learners. Topics might be covered fully in the spoken presentation, and visual information might be described by the presenter.
› Including a timed video transcript can improve accessibility - this can help students whose first language is not English. Learners who are comfortable with text can easily scan through the transcript to find information that they need.
It is commonplace for teachers to publish presentations online to facilitate distance learning, asynchronous learning or simply for revision. Online presentations come in many forms: as PowerPoint files available for download; as slide shows posted to a slide-sharing site; or as videos with recorded voiceovers.

Compared with creating an online simulator, creating an online presentation is relatively simple. Nevertheless, there is a lot to think about, and since so much e-learning involves online presentations it is important to get them right. Best practice in using online presentations involves first creating a good presentation, and second, disseminating it in a useful way. For the latter, see the next section on publishing resources online.

Here are some tips for improving the writing of presentations:

› First, ask if a presentation is the most effective technique to enable the desired learning outcomes.

› Determine what students should learn from the presentation - what is the story to tell and why. Map out the story, the structure and main content before turning on PowerPoint.

› Include one key idea per slide. Breaking the message up into smaller pieces, supported by clear visual aids, dramatically increases the chances that the audience will digest, understand and retain the information. Use the minimum of text; optimise the use of images and pictures.

› Bullet points are not always helpful to the learner and are often used more as notes for the lecturer. If you need to use them, use no more than seven words per bullet point and six lines per slide.

› Keep it clear and simple. Colour palette, font choice and size, visual grid and the appropriate use of image are all critical to legibility and impression. Avoid irrelevant graphics and logos.

› Ensure that slides have relevant titles.

› Presentations are increasingly being used on handheld devices – ensure the content works in that format.

› Consider the use of an audio track with the presentation.

› Use the PowerPoint Accessibility checker to ensure your presentation is maximised for use by anyone with a disability > click File > info > check for issues > accessibility.

› Embed video clips from YouTube, TV, movies, or student projects into slides or stream in clips for powerful, memorable learning experiences; edit clips to get to the specific point.

› Remember a presentation presented enthusiastically in person does not necessarily translate to a good online presentation.
12. Publishing documents online

Documents published online are typically accessible to users via a web page where they can click on a link that gives them access to that file. But in order to make sure your resource is used, provide users with information that will help them find it and then decide if it is appropriate. And for the benefit of those who do decide to use your resource, there are a number of steps to take to make your resources easier to download. Here are some best practice tips:

› Give some guidance on how to use the resource and record this in the description of the resource.
› Decide who is the target audience for the resource and put this in the description.
› The resource description should make it crystal clear what the user will learn from using the resource or how the resource might be integrated into a learning activity or course module.
› If uploading a PowerPoint presentation, take out any animations on the slides and compress the images. This will reduce the file size.
› Converting files to PDF will help ensure the document looks exactly the way it was planned with no distortions, and can help protect the content.
› Name the file clearly, to assist students once downloaded.
› State the file format and file size in brackets, e.g. (PDF, 66 kB).
Title tags and meta-descriptions are short bits of text that provide information about a webpage. The titles and meta descriptions are displayed on search engine results pages and so they are often the first experience that users have of online content.

Adding the correct meta tags for a resource is an important way to help users find content. Since they are one of the things that are listed on a search results listing, they provide an extra piece of information that may help a user choose specific content. Meta tags are also a way of helping search engines understand the content of images (search engines can't read images, so they must rely on the information provided that describes the image).

Here are some practical tips for effective use of meta tags:

› The title tag for a web page should be no longer than 70 characters long. If it exceeds this length, search engines will truncate them.

› Write a carefully crafted and descriptive title tag that appeals to human users – this will increase the likelihood that someone will click on that link.

› Meta descriptions for a website should include relevant keywords, and be easily understood by human users. Titles should be no longer than 150 characters. Again, if they exceed these values, search engines will truncate them. If a meta description for a page is not given, search engines will usually generate one automatically - and this is likely to be a sub-optimal description of the content.

› Both title tags and meta descriptions should ideally contain keywords or key phrases designed to attract relevant search engine traffic. Title tags and meta descriptions should provide prospective users with a clear and accurate picture of the content on the page.

› Image filenames and meta data (title attributes and alt-text tags) should contain the keywords that describe the image in the context of the page content. This helps search engines to index the content appropriately, as well as providing an essential service to visually impaired users.
14. Use authorship

Authorship is a protocol that Google uses to link content with authors and is intended to enable author legitimacy be a factor that influences search results.

Authorship is one way to help users of e-learning resources decide which resources they should trust. And since Google ranks pages in which the authorship has been verified more highly, it is more likely that a particular page will be seen by other users if it has been associated with an author.

If an individual has lots of online content attributed to them, it is likely that the Google search engine will consider that individual as an authority and rank their entries higher on a search results page for a search term related to their domain of expertise.

To be effectively indexed and ranked highly by search engines:

› Content should have assigned authors, and these should be individuals rather than institutions.
› Content authors should set up a personal Google+ profile (less than 5 minutes work).
› Google+ profiles should have a profile photo with a recognisable headshot.
› A byline containing the author name should appear on each page of the content (for example, “By Jane Smith”).
› The author byline name should match the name on the author’s Google+ profile.
› Verify that the author has an email address (such as jane@educational.org) on the same domain as the content.
› Authorship can be set up for multiple sites. This is probably a good thing since Google is likely to recognise individuals as an authority if they author content on different high quality sites.
Blog, short for ‘web log’, is a word used to describe a personalised webpage or website on which users write short posts that can include opinions, a diary and links to other sites.

Blogs are primarily written from an individual’s perspective. They are therefore a powerful tool for supporting constructivist education in the classroom. They are also a very flexible tool that can be deployed to achieve a range of educational goals. Popular educational uses for a blog are:

› Giving students the opportunity to explore a topic and chart their journey.
› Encouraging students to express and develop their opinions.
› Private reflection on personal development.
› Use as a learning scrapbook.
› Peer-to-peer assessment through the comment feature of blog posts.
› Formative assessment of students’ thinking as they develop their own ideas.

Blogs when used as an educational tool are commonly set up in one of three formats:

› A class blog - one in which teachers can regularly post assignments, relevant information and reflections on class activity.
› A shared class blog - one in which teachers and students make posts and comments on subject matter.
› Individual blogs - in which students create their own content, and invite others to comment on their work.

Here are some tips for using blogs in the classroom:

› Students often need encouragement to engage with the process of blogging. Ideally blog posts should be self-directed, but it is a good idea to help students develop confidence by guiding them through the creation of their first couple of posts.
› Give students guidance on writing style. They may not be clear on who the intended audience is and this may be a barrier to writing.
› Give prompt feedback using the comments section on a blog. Blogging becomes a rich experience when multiple readers comment on an individual’s post.

The most popular free blogging site is WordPress, but many other platforms exist. Most VLEs also include a blogging functionality. Blogging doesn’t just have to be text-based. Students can use platforms such as Flickr and Pinterest to create photo blogs. Twitter can be used as a microblog, involving much shorter posts and ideas around a particular topic or theme.
16. Working with wikis in the classroom

A wiki is a type of website that allows users to easily create their own pages, edit existing content, or even delete pages. The most famous example of a wiki is Wikipedia, the scale of which is vast compared to the sorts of wikis that might be developed by a class of students.

Wikis are a potentially valuable teaching tool because they encourage organic, collaborative writing - ideal for facilitating a group of people working together to create their own shared understanding of a topic. The user-centric nature of wikis means that, like blogs, they lend themselves well to constructivist and collaborative learning pedagogies. See the box below for how an illustration of how a wiki could be used in the classroom.

Here are some practical tips for using wikis in class:

› Before getting started online, it is a good idea for students to map out the rough structure of their wiki. This allows identification of key topic areas and allows individuals to be assigned initial responsibility for developing certain content areas.

› Agree some house rules. The philosophy of wikis is that everyone can edit each other’s work. One consequence is that contributors can get involved in a game of editing table tennis where one party changes an entry, and another changes it back again. Should this situation arise, encourage contributors to use this as an opportunity to have an open debate about the topic.

› Wikis are an asynchronous learning tool, so to help keep track, set up automatic alerts for when changes are being made.

› Many free-to-use wiki platforms exist and many VLEs include a wiki module that can be used in class.

An illustration of how to use a wiki in the classroom

The following is an illustration of how a wiki could be used in practice. A teacher who is interested in encouraging his or her class could set up a dedicated wiki for a topic to build their class’s shared understanding of a topic. As a way of introducing the topic, the students could be instructed to set up a wiki based on what they already know about that topic.

This initial task requires students to think about the key parts of a topic and how they interrelate. This exercise immediately enables teachers and students to identify misconceptions, disagreements and gaps in knowledge. As new material is covered in class, students can add this information to the wiki. Where the new material is inconsistent with what is already included in the wiki, students will have to restructure their wiki - a visual proxy for the reshaping of their understanding that is the process of learning. At the end of the class topic, the wiki is a record of what they have learned and can be referred back to. An interesting feature of this approach is that each class will produce their own unique wiki for a particular topic, reflecting the differences in group understanding between different cohorts.
Facebook is an example of a social media platform, an online environment in which users can create a personal profile, upload images, video and text, create status updates and use these tools to maintain a social network.

Many of the benefits of blogging apply equally well to use of social media networks such as Facebook. In many ways, Facebook could be considered as a virtual learning environment with much of the same functionality, albeit one that is more public and in which teaching staff have a lot less control. As such, they can be used to support both personal and collaborative projects.

Some of the additional benefits of social media platforms are:

› These environments are often very familiar to students - in many cases students will already have an account. This means that access and ability to use the tool are less of a barrier to learning.
› Social media platforms are designed to appeal to the target audience.
› They are a rich environment for supporting distance learning.
› Social media platforms are very useful for reaching outside an institution, for example, supporting an inter-university or international project.
› Given the popularity of social media platforms, the chances are that there is a platform that are already special interest groups associated with a particular topic that students can join.

Despite the benefits, a number of important factors need to taken into consideration before embarking on using social media in the classroom:

› The risk of cyber-bullying - staff should be aware of the risks and students should be trained in how to protect themselves.
› Student privacy of personal data - again, staff should be aware of the risks and students should receive appropriate training to protect themselves.
› Teacher privacy - teaching staff should be cautious about protecting their own privacy. One technique is to set up a ‘professional’ persona on social media networks that is used only for the teaching context.
› The public nature of posts - users of social media platforms need to understand that anything they post online may be accessible in public for ever.

While these are important considerations, social media is already an important part of how students interact with one another, and how they will communicate professionally. It would seem odd not to include these channels as part of their learning experience.

Megan Poore’s book *Using Social Media in the Classroom*, published by Sage, is the best practical reference on this topic the authors have found for practitioners in universities.
Operation

This section is for people using and operating e-learning resources and contains key considerations. The information is organised under headings that each relate to a different part of the operational phase from making sure students have the right skills to access the resources to reviewing the performance of these resources to inform future design.

The information in this section is gathered under the following headings:
1. Train students in using e-learning resources
2. Be prepared to overcome interface problems
3. Use synchronous online learning to overcome distance problems
4. Promote material through sharing platforms and social media
5. Capture data about effectiveness and evaluate to inform future design
The Bare Essentials of Engineering is a series of educational videos that can be used to illustrate some of the key points from this section on Operation. The authors led the development and dissemination of this series of films across engineering departments in the UK. Key to that dissemination strategy has been getting the videos uploaded to two sharing platforms, Go Construct and Expedition Workshed. They have also used Facebook, Twitter and LinkedIn to raise awareness about the resources, and use analytics to assess the impact of these different online campaigns. The commissioning, production and operation of the Bare Essentials series is a cyclical process: at the end of each development cycle, usage data is used to inform decisions about what content to develop next and what meta data to use to promote the next round of materials.
1. Train students in using e-learning resources

While many ‘digital natives’ will be confident in using the internet, using new online learning platforms for the first time can be daunting for many people. Others may already have developed lazy habits such as not checking the origin of materials that they have found online.

Given the potential impact that e-learning resources could have on the learner’s experience if used correctly, it is worth investing time early on in a course of study to ensure that students have the necessary skills to make the most of e-learning resources. Guidance and training for students in the use of e-learning resources and virtual learning environments could be given through face-to-face classes at the beginning of a course, guided tutorials, explanatory videos or clear written guidance.

2. Be prepared to overcome interface problems

A potential barrier to effective use of e-learning is when students or teachers are faced with interface problems that prevent them from accessing the desired resources. The following tips will help to avoid this sort of frustrating scenario:

› When selecting resources, think about whether the resources are going to be accessible by students in the learning context. For example, if the resource is a Flash-based website, is it an issue that some learners will not be able to access the resource from their mobile devices?

› If using the e-learning resource in a classroom, check that it loads using the computer in that context. If you are expecting students to access the site using their own devices in the classroom, check that the resource is accessible, and not, say, blocked because it is on a restricted site.

› Train students to be proactive in ensuring that they can access learning resources with their computer devices. As long as students are not expected to use resources accessible on only the newest devices, it is reasonable to expect that students keep the software on their computers up-to-date in order to access class resources. Also emphasise the importance of making sure they have the right network access to enable them to access learning materials.

› Advise students in advance of any specialist software or plug-ins required, and provide a download link.

3. Use synchronous online learning to overcome distance problems

Increasingly e-learning is being used to enable larger numbers of students to learn at distance. Historically, most e-learning has taken place asynchronously: educational material being posted and consumed at a different points in time. One of the problems of this approach is that it can make learners feel isolated and give teachers little knowledge about how learners are progressing through tasks – so called ‘transactional distance’.

But now technology has developed to allow synchronous e-learning environments. There are currently a range of robust and effective tools that facilitate synchronous online learning - ranging from simple video links or instant messaging services to fully featured webinar platforms. It is now perfectly possible for a teacher to watch a student type an essay - character by character if necessary - and provide real-time feedback.

The obvious benefit of a synchronous approach is that it connects learners with each other and with the teacher, reducing a feeling of isolation and improving the quality of the interaction.
Another synchronous learning tool is online video conferencing, whereby a group of learners and a teacher can interact. Instructors could run online lab sessions or demonstrations, or simple tutorial sessions. Two easy-to-use free services are:

- **Appear In**: Allows up to eight participants free - very simple to set up and use.
- **Google Hangouts**: video conferencing - Up to 10 participants.

A webinar is a web-based interactive conference or workshop. They can involve multiple participants and can involve live audio, slideshows, live (streaming) video, instant text messaging, quizzes, instant polling, and shared screens. Webinars provide a means for synchronous online education - they can usually also be recorded for reference purposes. Webinar software packages include:

- **Big Blue Button**: free, open source [http://bigbluebutton.org/](http://bigbluebutton.org/)
- **Meeting Burner**: free, web-based [https://www.meetingburner.com/](https://www.meetingburner.com/)
- **Any Meeting**: free (up to 200 participants), ad supported, web-based [http://www.anymeeting.com/](http://www.anymeeting.com/)

4. **Promote material through sharing platforms and social media**

One of the problems identified in the first part of this report is that it is often hard to find good quality learning resources. The suggestions on search engine optimisation presented in the ‘production’ section of this report will help resources be more easily found using search engines.

Another step is to upload content to content sharing platforms such as [Core Materials](http://www.corematerials.org/) and [Jorum](http://www.jorum.ac.uk/), which will require metadata to be added that will help other users find the resources. Many content sharing platforms host communities of users, serving to encourage and disseminate best practice.

Social media networks are another powerful way to disseminate and share e-learning resources. Since search engines consider social media ratings (such as Google +1s and YouTube ‘likes’), a greater social media presence for a particular learning resource is likely to increase its chances of being found. When using social media to promote educational resources, the following are useful considerations:

- Identification of the particular target market.
- Determining which social media channels are needed.
- Growing your social media presence - increasing the number of engaged users.
- Posting content on social media for maximum user engagement.
- An appropriate blend of informative and promotional material.
- Responding to users and dealing with complaints.
- Using social media to further the objectives of the educational content provider.

Because social media are still developing, the way in which an educational provider interacts with social media should be evaluated on a regular basis. Engagement with social media requires an ongoing commitment – resources should be properly allocated to the maintenance of social media channels.

As far as possible, the return on investment in social media should be measured. This can be achieved by proper configuration of Google Analytics to track goals, where a goal might be successful completion of sign-up to a course landing page from a social media link.
5. Capture data about effectiveness and evaluate to inform future design

This guide has used a project process diagram to describe the development and implementation of e-learning resources. The final stage and most important stage in this process is to evaluate effectiveness of resources in order to inform future design. Traditional ways of evaluating the effectiveness of teaching resources and approaches still apply to e-learning resources, for example, conducting student surveys, focus groups or comparing test results. However, web analytics tools give educators access to a great deal of data about how their tools are being used, which can inform future design.

Include in online resources a discussion forum or feedback form that explicitly asks users to evaluate your resources. If resources are published in a place that gathers comments (for example, on YouTube), gather feedback from the comment feeds. And from a bulk behaviour perspective, analytics data will show:

› how users found the resources
› what devices and browsers they used to access your resources
› how long they spent on each page
› what their journey was through the set of resources, and at what point people left the site.

Analytics data can even be used to test different versions of a resource to see which version creates the desired behaviour.


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

5. Fidler, K. *The R.A. of E. Skills for the nation: engineering undergraduates in the UK*


7. Prensky, M. *Digital Natives, Digital Immigrants*


10. Taylor, I. & Mannis, A. *Working in partnership with students: the summer school at Cambridge*


15. Wilkens, K. *Gamification of Education*


18. Craver, T. *Eric Schmidt: Google Will Give Higher Rankings to Content Tied to Verified Profiles* Search Engine Watch (#SEW)


21. Kansas State University. *Synchronous Course Delivery - E-Learning Faculty Modules*.
## Table of resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Website</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Meeting</td>
<td><a href="http://www.anymeeting.com">www.anymeeting.com</a></td>
<td>Ad-supported platform that offers a free webinar service for up to 200 users.</td>
</tr>
<tr>
<td>Bare Essentials of Engineering</td>
<td>thinkup.org/innovation/bare-essentials/</td>
<td>The Bare Essentials of Engineering is a suite of educational videos that were commissioned on the basis of Google search term data. The series includes the Bare Essentials of Soil Mechanics, the Bare Essentials of Concrete, the Bare Essentials of Reinforced Concrete and the Bare Essentials of Pre-stressed Concrete.</td>
</tr>
<tr>
<td>Big Blue Button</td>
<td>bigbluebutton.org</td>
<td>Big Blue Button is an online learning platform that enables universities to offer distance-learning services.</td>
</tr>
<tr>
<td>British Standard web accessibility code of practice</td>
<td>shop.bsigroup.com/en/ProductDetail/?pid=000000000030180388</td>
<td>An outline framework for web accessibility when designing or commissioning web products.</td>
</tr>
<tr>
<td>Catastrophe</td>
<td>expeditionworkshed.org/workshed/catastrophe/</td>
<td>Structural modelling tool that allows students to assemble simple pin-joined structures and test them in real-time.</td>
</tr>
<tr>
<td>Cathy Moore's blog</td>
<td>blog.cathy-moore.com</td>
<td>A blog on training and e-learning written from a business perspective.</td>
</tr>
<tr>
<td>CORE Materials</td>
<td>core.materials.ac.uk</td>
<td>The CORE-Materials repository contains 1662 open educational resources in Materials Science and Engineering, freely available under a range of Creative Commons licenses.</td>
</tr>
<tr>
<td>Coursera</td>
<td><a href="http://www.coursera.org">www.coursera.org</a></td>
<td>Coursera is a MOOC platform that partners with top universities and organisations worldwide, to offer courses online for anyone to take, for free.</td>
</tr>
<tr>
<td>Creative Commons</td>
<td>creativecommons.org</td>
<td>Creative Commons develops, supports, and stewards legal and technical infrastructure that maximizes digital creativity, sharing, and innovation. Its site offers guidance on how to integrate Creative Commons licences into e-learning resources.</td>
</tr>
<tr>
<td>Drawing Gym</td>
<td><a href="http://www.ucl.ac.uk/drawing-gym">www.ucl.ac.uk/drawing-gym</a></td>
<td>The UCL Drawing Gym is an exercise programme to help engineers improve their sketching and visualisation skills. Starting with simple sketches to develop spatial literacy, the exercises will boost your ability to draw ideas.</td>
</tr>
<tr>
<td>e-Learning Coach</td>
<td>theelearningcoach.com</td>
<td>A blog about e-learning written from a design perspective.</td>
</tr>
<tr>
<td>Edutopia</td>
<td><a href="http://www.edutopia.org">www.edutopia.org</a></td>
<td>A school-focused blog on e-learning with some interesting articles applicable to the HE sector.</td>
</tr>
<tr>
<td>Engineering Mastermind</td>
<td>engineeringmastermind.org</td>
<td>Engineering Mastermind is an online multiple choice quiz. Students answer questions about Engineering to win prizes.</td>
</tr>
<tr>
<td>Expedition Workshed</td>
<td>expeditionworkshed.org</td>
<td>Expedition Workshed is a collection of high-impact free-to-use e-learning resources supporting learning about construction and the built environment.</td>
</tr>
<tr>
<td>FutureLearn</td>
<td><a href="http://www.futurelearn.com">www.futurelearn.com</a></td>
<td>FutureLearn is a MOOC platform run in collaboration with 20 universities, led by the Open University.</td>
</tr>
<tr>
<td>Go Construct</td>
<td><a href="http://www.gocodeconstruct.org">www.gocodeconstruct.org</a></td>
<td>Go construct is a website with careers information and education tools for the construction industry.</td>
</tr>
<tr>
<td>Google Adwords</td>
<td><a href="http://www.google.com/adwords">www.google.com/adwords</a></td>
<td>Google Adwords includes a keyword search tool that allows content authors to see how many people search for a given search term on a monthly basis.</td>
</tr>
<tr>
<td>Google Drive</td>
<td>drive.google.com</td>
<td>Google Drive is a cloud-based service that allows users to store up to 15GB of documents online. These documents can be worked on simultaneously by multiple authors, facilitating synchronous online learning.</td>
</tr>
<tr>
<td>Jorum</td>
<td><a href="http://www.jorum.ac.uk">www.jorum.ac.uk</a></td>
<td>Jorum is a portal for free open education resources for the UK FE and HE communities.</td>
</tr>
<tr>
<td>Description</td>
<td>Website/description</td>
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<tr>
<td>Kritikos</td>
<td>kritikos.liv.ac.uk Kritikos is a customised search engine for visual media relevant to higher education, aimed at reducing the time required to find useful resources for study and for teaching.</td>
<td></td>
</tr>
<tr>
<td>Make A Scape</td>
<td>thinkup.org/innovation/makeascapespanning Make A Scape is a structural mechanics-based game app. It allows students to build structures under the effects gravity in real time.</td>
<td></td>
</tr>
<tr>
<td>Meeting Burner</td>
<td><a href="http://www.meetingburner.com">www.meetingburner.com</a> A webinar platform that allows users to create a free webinar for up to ten participants.</td>
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</tr>
<tr>
<td>Merlot II</td>
<td><a href="http://www.merlot.org/merlot/index.htm">www.merlot.org/merlot/index.htm</a> Merlot II stands for Multimedia educational resource for learning and online teaching, and is a portal of engineering education teaching resources that includes peer-rated and editor-rated material.</td>
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<tr>
<td>MIT OpenCourseware</td>
<td>ocw.mit.edu MIT OpenCourseWare is a web-based publication of virtually all MIT course content. OCW is open and available to the world and is a permanent MIT activity.</td>
<td></td>
</tr>
<tr>
<td>Moodle Quiz Module and quiz guidance</td>
<td>docs.moodle.org/26/en/Quiz_module docs.moodle.org/26/en/Effective_quiz_practices Moodle quiz module allows teachers to design and build quizzes consisting of a large variety of question types, including multiple choice, true-false, and short answer questions. The second link is to a document on effective quiz practices including creative quiz uses and guidance on avoiding cheating.</td>
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<tr>
<td>Online Learning Insights</td>
<td>onlinelearninginsights.wordpress.com Education blog that focuses mainly on e-learning for schools.</td>
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<tr>
<td>Open Meetings</td>
<td>openmeetings.apache.org Free video conferencing, instant messaging, white board and collaborative document editing.</td>
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<tr>
<td>Push Me Pull Me</td>
<td>expeditionworkshed.org/workshed/push-me-pull-me Interactive structural models that allow students to learn about how structures behave by pushing and pulling responsive models.</td>
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</tr>
<tr>
<td>Push Me Pull Me 3D</td>
<td>expeditionworkshed.org/workshed/push-me-pull-me-3d The Push Me Pull Me 3D platform allows you to build, push and pull your own structures in 3D. It is powered by a real-time physics engine.</td>
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</tr>
<tr>
<td>Siemens Education Resources</td>
<td><a href="http://www.siemens.co.uk/education/en">www.siemens.co.uk/education/en</a> Siemens Education provides a rich set of resources for teachers and students related to science, technology, engineering and maths. Resources include simulators, interactive games and an image bank.</td>
<td></td>
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<tr>
<td>TED Ed</td>
<td>ed.ted.com A video platform that allows teachers to build lessons by editing together videos from the TED site.</td>
<td></td>
</tr>
<tr>
<td>TES Teaching Resources</td>
<td><a href="http://www.tes.co.uk/teaching-resources">www.tes.co.uk/teaching-resources</a> TES Teaching Resources is an example of a teaching resource repository in which teachers rate other people’s resources. The site contains over 700,000 lesson plans, classroom resources, revision guides and curriculum worksheets.</td>
<td></td>
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<tr>
<td>The World Wide Web Consortium accessibility guidelines</td>
<td><a href="http://www.w3.org/TR/WAI-WEBCONTENT/full-checklist.html">www.w3.org/TR/WAI-WEBCONTENT/full-checklist.html</a> This document provides a list of all checkpoints from the Web Content Accessibility Guidelines 1.0, organised by concept, as a checklist for Web content developers.</td>
<td></td>
</tr>
<tr>
<td>Virtual Materials Lab</td>
<td>expeditionworkshed.org/materials The Virtual Materials Laboratory is an area of the Expedition Workshed website that hosts high-quality videos of common material tests.</td>
<td></td>
</tr>
<tr>
<td>YouTube</td>
<td><a href="http://www.youtube.com">www.youtube.com</a> The world’s most popular video sharing site.</td>
<td></td>
</tr>
</tbody>
</table>
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorship</td>
<td>This is a protocol that Google uses to link content with authors and is intended to enable author legitimacy to be a factor that influences search results.</td>
</tr>
<tr>
<td>Backlink</td>
<td>A link from another website back to your website.</td>
</tr>
<tr>
<td>Blog</td>
<td>Short for web log, a blog describes a personalised webpage or website on which users write short posts that can include opinions, a diary and links to other sites.</td>
</tr>
<tr>
<td>FE</td>
<td>Further education</td>
</tr>
<tr>
<td>Gamification</td>
<td>The use of game mechanics and dynamics like badges, leaderboards and actions to improve motivation and learning in informal and formal settings.</td>
</tr>
<tr>
<td>HE</td>
<td>Higher education</td>
</tr>
<tr>
<td>JISC</td>
<td>Formerly Joint Information Systems Committee, this organisation now operates as a business and is simply referred to as Jisc.</td>
</tr>
<tr>
<td>MOOCs</td>
<td>Massive open online courses.</td>
</tr>
<tr>
<td>MOODLE</td>
<td>Modular object-oriented dynamic learning environment.</td>
</tr>
<tr>
<td>OERs</td>
<td>Open educational resources.</td>
</tr>
<tr>
<td>PEIs</td>
<td>Professional engineering institutions.</td>
</tr>
<tr>
<td>Podcast</td>
<td>A digital audio file made available on the internet for downloading to a computer or portable media player, typically available as a series, new instalments of which can be received by subscribers automatically.</td>
</tr>
<tr>
<td>SEO</td>
<td>The process of tuning web resources so that they are correctly listed by search engines and found by users.</td>
</tr>
<tr>
<td>Videocast</td>
<td>A digital video file made available on the internet for downloading to a computer or portable media player, typically available as a series, new instalments of which can be received by subscribers automatically.</td>
</tr>
<tr>
<td>VLEs</td>
<td>Virtual learning environments.</td>
</tr>
<tr>
<td>Webinar</td>
<td>A contraction of web + seminar, a webinar is a seminar delivered over the web.</td>
</tr>
<tr>
<td>Wiki</td>
<td>A type of website that allows users to easily create their own pages, edit existing content, or even delete pages.</td>
</tr>
<tr>
<td>W3C</td>
<td>The World Wide Web Consortium (W3C) is an international community where member organisations, a full-time staff and the public work together to develop Web standards.</td>
</tr>
</tbody>
</table>
Royal Academy of Engineering
As the UK’s national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering.

**We have four strategic challenges:**

**Make the UK the leading nation for engineering innovation**
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.