Digital teaching and learning during the coronavirus pandemic: Call for evidence

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Organisation
Engineering Professors' Council

About you

Which category best describes you?
Higher education sector body

About you

What type of provider(s) are your part of, or do you represent?
Other (please specify): Engineering provision within multi-faculty providers

Context

How did the move to remote teaching and learning affect you (or your university or college, subject, students, or business)? Please explain the operational approaches used to meet the new demands, in the first few months of the lockdown period.

During the period May to August 2020 - in work that involved over 250 academic contributors, 23 case studies of practice and 34 student perspectives - we captured the challenges, adaptations and opportunities facing engineering education as practitioners were adapting to remote delivery and assessment. These are recorded in our publication 'Emerging Stronger: Lasting Impact From Crisis Innovation' (available for pdf download at http://epc.ac.uk/wp-content/uploads/2020/08/Gibbs-Wood-eds-2020-Emerging-Stronger.pdf) which we submit as evidence.

Part of the impact of the 2020 move to remote instruction is a function of the constitution of our student cohorts. There are c.165,000 engineering students in UK, around 30% of whom are international students. The contribution of non-EU students is important across programme types including undergraduate (25%), postgraduate taught (57%) and postgraduate research (50%) (Engineering UK 2020 research data). A majority of our international students are from China and the Asia Pacific region. In a sector where international students contribute in excess of £20bn to the UK economy, engineering and technology is the subject area that has the second-highest number of international students, second only to business and management (Universities UK International, Facts and Figures 2019).

The move to remote learning and teaching happened very quickly (for many, over the course of a weekend) against a backdrop of rapidly collapsing international mobility and it did not draw on any consolidated sector-level scenario planning. This caused significant anxiety for students who were juggling a desire to return to their home countries and ambiguous statements from HEIs who did not know whether students would be required to return to campus later in the semester. Needless to say, a number of these students had pre-existing health conditions and were concerned for their family and friends both here in the UK and in their home countries. When they did return to their home countries, they found themselves in quarantine, in a different time zone, with extremely poor bandwidth and sometimes in domestic settings without discrete study space.

At the aggregate level, the closure of university buildings happened very quickly, meaning that engineering students no longer had access to lecture theatres, collaboration space, high-performance computers, specialist software, laboratories and manufacturing facilities. Broadly speaking, there were no exceptions made to this. Academics prepared video materials in a short turnaround, rewrote assessments and reconceptualised learning outcomes so, for example, students could explain and interpret modelling data rather than use modelling software themselves.

Digital poverty has been an issue for home students too. Some students have been without their own laptops, many without a study space and some without reliable bandwidth or internet access. A limited amount of hardware was reallocated, although there was significant supply chain pressure at the time. In many instances, because of PSRB (1) requirements, engineering faculties had to navigate their own path through alternative delivery and assessment, with less specific institutional guidance.

This was recognised in the introduction of safety nets around the awarding of student marks and, for final year students, degree classification. The introduction of a safety net carries with it an acknowledgement that our ability to assess learning outcomes has been compromised. Therefore the sector needs to grapple with the fact that – at least in the first half of 2020 – the disruption was compensated for in terms of assessment, rather than addressed through the confident upskilling of staff and students to enable delivery in a digital environment.

(1) Accredited engineering courses in the UK meet the requirements of the Engineering Council, administered through Professional Engineering Institutes. This accreditation provides a quality assurance function for employers and a mutual recognition scheme for international mobility,

Challenges of remote delivery

What were the immediate challenges (in the first few months of the lockdown period) of the move to remote teaching and learning?Please give examples and explain the challenges you have, and have not yet, been able to overcome.

Of immediate priority for engineering faculties was the need to provide for alternative assessments. All accredited engineering courses have significant quantitative elements and this, compared to often large cohorts and historical traditions, means that unseen invigilated examinations are a large part of assessment profiles in engineering courses.

Most assessments had been written and had undergone QA processes by the time campuses closed, so conceiving, designing and communicating new assessment forms added a great deal of workload to academics who were already having to prepare new materials for remote delivery (Emerging Stronger, Chapter 1). Alternative formats included: take-home exams, video presentations and time-limited exams with controlled upload/download times administered through a VLE. This might be a 3-hour exam administered in a 4-hour window, giving time for students to take mobile phone images of their handwritten responses and collated in a pdf; this was challenging and stressful for students and difficult to mark. Particular challenges for students included lack of access to specialist software on which they were completing assignments (such as simulation software), halted access to high-performance campus computers for specialist tasks, halted access to manufacturing facilities for students completing design and build projects (in particular, in dissertation work) and lack of familiarity with alternative assessment formats. Even though guidance was offered, students did not have the opportunity to rehearse or build their skills in this regard.

A second challenge that faced engineering education was the innate importance of practical learning in laboratory experiments, manufacturing processes, and design and build work. As well as being an important and rewarding part of engineering curricula, these types of practical skills are PSRB requirements. This normally involves specialist equipment on campus. In the rapid transition to remote delivery, students were unable to complete planned modules and dissertation projects because they were unable to come into university buildings. The sector innovated rapidly to provide a range of alternative modes of meeting associated learning outcomes (see ‘Emerging Stronger’, chapter 3), with notable thought leadership from Dr Andrew Garrard at the University of Sheffield who codified alternative strategies as including: digital artefacts, simulated practicals, synchronous remote participation, asynchronous remote participation by proxy, and procedures in alternative environments (2).

A third factor with particular relevance for engineering students is the necessity for collaboration and team work – another innate part of engineering education, also a PSRB requirement. The dispersion of student teams mid-semester caused immediate challenges, and at the time, a snapshot indicated that only around a quarter of educators were confident that collaboration skills could be delivered in an online world (see ‘Emerging Stronger’p19). Since then, we have developed our skills, and those of our students, in video communication and online collaboration. Some educators have recognised that this shift presents an opportunity for enhancing the professional skills of students, by using modern workplace communication technologies and supporting students in global teams. On the other hand, by the Spring many teams were already established, so we have yet to test our ability to support the large-scale establishment of new student teams (in particular the ‘storming and norming’ phases)(3) in largely remote modes.

While engineering educators have found many innovative ways of scaffolding the learning experience, some challenges remain. Sustained workload pressure on academics since March 2020 means that there has never been headroom to create reliably high-quality learning materials that support independent learning. This was true in the Spring and, although improving, remains the case now. A further sustained challenge is on off-site software licensing that equips students to complete tasks of drafting, analysis and computational modelling. While the supply chain has innovated in expanding cloud-based licences, this works to increase pressure on students experiencing digital poverty. Finally, the benefits of using specialist manufacturing equipment cannot be overcome without bringing students on site. Innovations have included students contracting out local manufacture (and there are some skills benefits for communication and costing), but it still reduces the amount of time engineering students spend developing hands-on skills.

(2) Garrard, A., Bates, J., Beck, S., & Funnell, A. Codifying an Approach to Remote Practicals. Preprints 2020, 2020060182 (doi: 10.20944/ preprints202006.0182.v1)
(3) Tuckman, B.W. & Jensen, M.A.C. (1977) Stages of small group development revisited. Group and Organizational Studies, 2(4), 419-427.

Have any planned aspects of teaching and learning not been delivered or been significantly changed, delayed, postponed or of compromised quality because of remote delivery? Please give examples and explain why.

These have been partly introduced in the answer to Question 6, but in summary:

Viva voce examinations were removed as a requirement in some institutions because of concerns about digital capabilities of students (in reliable connections, bandwidth, study space).

Collaboration in teams is implicit in an engineering degree and a PSRB requirement. While there has been much scaffolding and support, there have also been so many allowances made that we do not actually know whether it is working.

Modelling and simulation: while different programmes in different institutions have different emphases, engineering educators will not be able to be confident in these learning outcomes in remote contexts until questions of digital poverty are resolved.

Manufacturing, fabrication and prototyping could not be completed as planned because specialist equipment is required that resides on campus, often requiring Health & Safety oversight.

Many work placements and internships have been cancelled, as industrial companies close their buildings and reduce their scope of activity. This is to the detriment of individual students and the quality of engineering graduates as a whole. Coupled with this are extra-curricular activities (such as various engineering initiatives where students apply their skills to competitive or 'real-life' projects) were curtailed as students could not meet on campus and could not access their project prototypes. Many engineering students perceive that their employability is significantly enhanced in these kinds of activities and were deeply concerned that their long-term prospects were being damaged on top of the short-term disruption (Emerging Stronger, chapter 4).

Has the move to remote delivery presented new barriers for student and staff engagement with teaching and learning? Please explain any specific impacts caused by the change in delivery.

We consider engagement through a number of lenses. At its most fundamental, engagement requires that students participate in their own learning. During the pandemic this was largely sustained, although some student groups had particular vulnerability, which often related to questions of digital poverty described in Section 5. Some international students returned to their home countries in different time zones and with poor connectivity (especially when in quarantine) and some UK students returned home to rural areas that were not supported by broadband coverage. In contrast, many educators have noted that different students are heard in an online classroom – students who are often quiet in classrooms become more vocal and confident in digital formats. In Part 2 of our report 'Emerging Stronger', engineering student voices describe how their shyness was lower in remote formats or how other barriers to engagement (such as commuting) were lowered.

In terms of students becoming meaningfully engaged in the redesign of their programmes, there seemed to be little of this being reported in the Spring, despite the opportunities offered for meaningful collaboration on this front. Our view is that this has actually been happening on quite a wide scale informally, but it has not been labelled as engagement. The rapid changes brought about by COVID-19 meant that a great deal of innovation happened very quickly. This represented a fundamental shift in staff-student relations, as we worked together to find formats, processes and interactions that worked. However, because of the enormous workload that was happening and concerns that student expectations should be managed, this flux has not yet led to a transformation in 'students-as-partners' approaches.

Successes in digital delivery

How has digital technology supported the move to remote delivery? Please give examples of the digital technologies used and explain how they supported your success.Please also provide information about any external networks or sources of support that contribute to your success.

VLEs have become staples of communication with students and to facilitate peer interaction within students. These have not been without a variety of challenges, including, for example, the number of breakout rooms in any one class, lack of captioning etc. Largely speaking, they have been a reliable online location to continue teaching and learning remotely. Tutorials have shifted to online video meeting platforms such as Microsoft Teams or Google Meet. Expansion and careful management of VPNs has been important in maintaining contact with students in China for institutions with disallowed products (such as the Google suite).

Digital twinning or simulation of experiments has been supported in the short-term by commercial providers such as Quanser, Labster, Learning Science, NI Multisim, TinkerCAD although some have been developed within the sector such as 'Racing Academy 2'. (4) Commercially, laboratory equipment providers have spotted an opportunity to expand their virtual offering and this has seen significant growth in recent months.

(4) Racing Academy 2 is a game where students learn about engineering dynamics by competing against an AI opponent. It was developed and is made available by Dr. Jos Darling, University of Bath

What are the advantages of delivering teaching and learning digitally? Please give examples of how teaching and learning has been improved or enhanced by digital delivery.

Many educators who shifted to online formats this year noted that there was often greater engagement from different groups of students compared with face-to-face teaching. In particular, shyness is overcome.

How do you envisage teaching and learning delivery will change in the next three years? Please give examples.

First, we note the genuine contribution engineers have made to the pandemic crisis and expect engineers and engineering skills to be key contributors and features of economic recovery plans. McKinsey forecast 'STEM professionals' as the occupational category with greatest potential net job growth in Europe, at 25% (2018-2030)(5). In this, we expect demand for engineers with tertiary education to be maintained or increase. On the applicant side, we expect to see continued interest and growth in general or integrated engineering offers, as young people take the opportunity to explore engineering in its fullest sense, and take the opportunity to understand the subject in the context of its contribution to society.

A second area to watch is what might constitute a nascent tension in the introduction of PSRB requirements through the Engineering Council's 4th edition of Accreditation of Higher Education Programmes Guidance (AHEP4). In response to persistent calls to action from employers that engineering graduates lack work-ready skills, AHEP requires graduates to apply knowledge, rather than simply recall it, and to think holistically. This directly challenges educators to move away from didactic, segregated delivery to modes that facilitate application and integration; this requires more constructivist approaches and is comparatively challenging in remote formats.

We expect to see a spectrum of responses amongst providers. We can foresee a group of trailblazing HEIs with senior management teams who have the appetite to support all of their staff in upskilling, rethinking their practice and seizing the opportunities that this shift has highlighted – such as opportunities for graduates with work-ready skills, 21st century collaboration and teamworking approaches, and opportunities in ensuring all face-to-face contact time is of high quality. In contrast, there will also be HEIs whose focus is so much on survival that they will struggle to innovate at a level that gives critical mass. Without senior commitment to (and resourcing for) staff development, minimum standards and a reversion to historical practice can be expected. In between will be institutions with pockets of good practice or with change that is sustained by a few key enthusiasts rather than being truly embedded. Also some institutions – perhaps with a strong track record in traditional forms of teaching and learning – may be resistant to changes that might undermine their previous successes.

(5) McKinsey, The Future of Work in Europe: Discussion Paper, 10 June 2020
https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-in-Europe

Successes in digital delivery

How will the lessons from this experience shape your approach to digital teaching and learning and inform you organisational culture in the medium to longer-term?Please give examples.

Our observation is that if transformation is to happen, it needs to be reflected, supported and resourced at an institutional level. The EPC provides a platform to magnify the work of many impressive innovators in engineering education and we aim to bring focus to the need for sustainable impact. However, many metrics across the sector discourage faculties from making significant changes. We welcome OfS' reflection on the National Student Survey and would like to see this pause allow for more large-scale innovation based on inequalities, shortfalls and opportunities highlighted this year. How many HEIs will be prepared to do the thinking, planning, implementation and training required to differentiate themselves through their degree of blending remains to be seen.

This is relevant to engineering as HEIs struggle to offer meaningful practical experience. Those that use this year's disruption as a springboard towards a more modern range of learning technologies, with a renewed range of industrial partners, opening up a more ambitious range of contexts and insights, will see rewards. Equally, those that challenge themselves to use staff-student time together on campus for the best quality learning opportunity will have a more coherent story and more value to offer students and applicants.

Digital poverty

To what extent does digital poverty among students and staff have an impact on the delivery of high-quality digital teaching and learning? Please explain any approaches used to address digital poverty among students and staff since the start of the pandemic.

Some students did not own their own laptop (or had an unreliable laptop) or were borrowing (for example) a parent's who then had to use it for their own work. In this context students were attempting to watch video material or finish assignments or dissertations without basic hardware for basic tasks.

Some students were using specialist software such as Simulink, Ansys, Solidworks for engineering drawing or analysis and would have been using applications on university-owned computers, with such licences not being available for student laptops. Here, students had to stop working on their modelling analysis and meet their learning outcomes by, for example, explaining what they would have expected to find, how they would have analysed their results and how they would have assessed the validity of any results generated.

Some students live in rural areas without reliable internet access, adequate broadband capacity to stream video nor the ability to participate in video discussion synchronously. (We note that, while the consultation is aimed at English providers, many students join us from Wales who, on returning home, can have more challenges in this regard). Here, educators had to download video materials to memory sticks and post them to students. This is not a scalable process, and may have to be repeated more than once to maintain student progress when materials are being prepared on a week-by-week basis. With reasonable mobile service, a student can voice-dial into a session or meeting, but this presents its own challenges in unequal experience and cost implications for the students.

When leaving campus accommodation, some students did not have a suitable study space. Some were sharing with parents also working from home. Some were at kitchen tables with younger offspring at home. Some were in mixed accommodation in family environments with, for example, crying babies. Given the national context, no ameliorating actions were available, beyond accepting that a student will have not been able to perform at their best and offering a safety net at an institutional level. Some assessments were reformulated to more open-book/take-home formats, with 24-hour window for completion or to offer flexibility of 'start time' so students could settle themselves as best they could within a 24-hour window before, for example, a 2-hour exam clock started ticking.

Under these types of conditions, some students were still expected to take time-limited examinations. As the sector considers whether they can provide laptops or licensing, this still does not resolve challenges associated with internet coverage and broadband capacity.

Digital poverty

We propose that: A student is in digital poverty if they are without access to one of the core items of digital infrastructure, which are: appropriate hardware appropriate software reliable access to the internet technical support and repair when required a trained teacher or instructor an appropriate study space. Do you agree that these items of digital infrastructure underpin digital poverty? Please explain if and how you currently, or could in the future, use mechanisms to measure students' access to these items.

Yes, the Engineering Professors' Council would support this definition of digital poverty and we have seen cases of all of these aspects posing difficulties for students this year. Because digital technologies are relatively intensive in engineering courses (for the reasons explained previously in this document), the EPC would be interested in establishing threshold requirements and options to meet them – in the engineering education context – that providers should aim for in order to support students in their studies. We would also add that access to a reliable source of power is integral to digital wellbeing.

Secondly, we would promote the use of resilient online teaching and learning strategies and agreed definitions of what resilience means in this context. In the light of the preceding definition of digital poverty, one hallmark of resilience that lies very close to the surface would be minimised expectations of synchronous interactions and multiple routes to student-educator and student-student engagement. Again, the EPC would be keen to engage in this work in the context of engineering education.

Looking ahead

What new digital and blended teaching and learning approaches have been gained from the shift to remote delivery that will be retained?

We see digital and blended teaching and learning as occupying a spectrum – rather than binary changes to practice. We anticipate a general shift in what the 'mainstream' is. Examples include:

More 'flipping' of classroom time, where students learn principles independently, then come together to test, apply and explore. It has sometimes been difficult to coax students into learning in this way, especially in isolated islands of innovation. Flipped formats have expanded rapidly and students see the value in this approach.

Digital pastoral tutorials, which are probably here to stay. They allow students to call from their accommodation, them to be seen more quickly, without waiting, and are representative of a useful workplace skill.

Some change to assessment practice seems to be emerging, given the amount of innovation that occurred in this area. In certain HEIs this may be a permanent step away from invigilated exams, drawing on lessons learned in open-book and take-home exam formats.

Remote experiments have been debated at length and their benefits identified. So much learning has been done by academics that we would not expect them to disappear completely, even if campuses re-opened completely. Not least, they provide a route to greater scalability which will continue to be a demand in engineering education. For more outward-looking providers, remote strategies also provide opportunity for equipment-sharing between different HEIs.

What are the challenges still to be overcome to enable high-quality digital teaching and learning in the future?

As previously mentioned, there is a training issue and a mindset issue. Some educators are still trying to deliver the lecture/examination class they always have, only remotely. This is a lost opportunity, and inconsistent with our PSRBs' direction of travel to more application, integration and contextualisation. This is a significant challenge of mindset, that is probably hindered by digital modes of delivery rather than supported.

A related challenge is that educators still need to see the added value of high-quality digital teaching and learning. While the avalanche of work that took place in the Spring/Summer 2020 was commendable and critical, few colleagues would claim that they produced resources of the highest quality. There was limited time, limited access to specialist hardware and software, and support was spread extremely thinly and often deployed to more strategic work. As we look forward, we face the challenge that colleagues do not know what is 'high quality', or what 'high quality' looks like. We need a continued supply of excellent examples so that their value can be appreciated, allowing them to act as stimuli for innovation and benchmarks.

As more assessment moves online, we can foresee more sophisticated responses from predatory actors such as essay mills or other facilitators of academic fraud. If this does prove to be the case, PSRBs might begin to be more stringent in, for example, time allowances or remote proctoring requirements. This would work against the interests, wellbeing and attainment of the large majority of students.

The final challenge is a philosophical one: how do we engender an engineering mindset when delivering a significant part of the course virtually? This is a genuine challenge. It is difficult to support digitally the development of engineering approaches and habits of mind, such as the early stages of team formation that precede productive collaboration and support constructive failure. Even more so, bridging the introduction of engineering as a vocational discipline – that is so much more than physics or maths and is a subject that few students will have studied at school – from their prior learning requires some careful thought and will remain a challenge as we move forward.

What are the cost vs quality implications of digital teaching and learning delivery in the medium to longer-term?

We maintain that there will always be a need for engineering students to get hands-on experience during their studies – as well as engendering specific practical abilities, this kind of work develops one of the most elusive engineering traits – judgment. This may fundamentally challenge existing estates strategies, in a sector that is investing heavily in new buildings. Less didactic teaching, more facilitated learning and rescheduled practical activity is likely to disrupt existing utilisation plans and negatively impact cost.

Scale remains an issue that engineering faculties have to grapple with. We have mentioned here that engineering and technology are the part of the occupational sector forecast to have the highest growth in Europe in the coming 10 years. Digital delivery could realise this additional growth at reasonable cost. Furthermore, resolving some of the remaining challenges in (for example) supporting teamwork and finding the right balance of virtual and physical practical work could provide some genuine scalability. However, the need for high-quality learning resources and digitally skilled educators remains and it is not clear that HEIs are able or prepared to make this facilitating investment.

What are the strategic opportunities arising from the shift in delivery mode for the medium to longer-term?

Digital delivery provides genuine opportunity for intercultural, global collaboration. This is inspiring, as well as being realistic preparation for a career which may well operate on a global stage. Students groups can be connected across time zones and countries, learning to work together in virtual formats to solve a wide range of problems.

Digital delivery also provides opportunity to refresh widened participation agendas by reaching further and decreasing the total cost of the university experience by allowing learners to (largely) remain at home. This sits in direct tension with the need for learners to have effective equipment and support and the full range of factors to be considered when identifying digital poverty. It also potentially undermines the wide range of co-curricular and non-curricular benefits of the in-person student experience, which have been shown to develop students' wellbeing, employability and social responsibility.

Finally, engineering faculties can struggle to be truly distinctive. In an accredited environment, there is reduced opportunity to differentiate through course content and outcomes and digital learning presents some opportunity for differentiation through mode of learning. We appeal to HEIs to articulate and examine their mission and values as they have been impacted by this year's challenges and changes and adapt in authentic ways. If strategic opportunities are identified in this new landscape, they should be pursued along with the requisite investment in staff to ensure delivery mode is serving the vision – the reverse is unlikely to be long-lasting or strategic.

What is the main way government, higher education provider leaders, teachers, or students could improve digital teaching and learning across the higher education sector?

Government needs to enhance subsidy and incentives for digital infrastructure, to ensure that even students in rural areas can have a good quality online education, should circumstances require that. HEIs need to resource the types of upskilling in educators described. Free resources are proliferating, and many people continue to share innovation and good practice. At the same time, universities have reduced resources in order to anticipate reduced student income – this makes it even more difficult for educators to find the time to develop her skills, and often reduces the availability of local champions who can transform practice. Students are at the heart of any educational enterprise, and they deserve to have the very best opportunity within the physical constraints in place at any one time.

Thought also needs to be given to what opportunities may be lost through digital learning. Even if the curriculum can be taught as effectively – or even more effectively – will student outcomes be compromised by the lack of social and cultural interaction with peers (on their course and beyond)? Will students have the same opportunities to develop life skills and 'graduateness' that employers value so highly? These questions need to be considered and, if lost opportunities are identified, compensatory measures need to be taken to ensure we do not undermine the effectiveness and esteem of UK higher education.

Additional evidence

Is there anything else you would like to add, to be considered as part of the digital teaching and learning review?
During the first half of 2020, the Engineering Council clarified its position on the demonstration of learning outcomes in times of disruption. This was interpreted slightly differently by different PEIs, which does raise the question of how providers practically ensure they meet the requirements of accrediting bodies when circumstances have moved beyond their control.