Technology as a driver and enabler of adult vocational teaching and learning

Briefing to the Commission on Adult Vocational Teaching and Learning

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Contents

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Introduction

This briefing paper addresses three of the Commission's terms of reference, to:

- review a range of pedagogical approaches;
- investigate the role of technology;
- develop a sector-owned framework to enhance the quality of adult vocational teaching and learning.

Technology is having a transformational impact on both vocational practice in the workplace and on teaching and assessment practice in FE. This paper focuses on how new technologies and blended pedagogies can support the vocational education sector in adapting to continual change in the workplace. After reviewing current research, development and practice the paper concludes with a contribution to the framework for enhancing the quality of vocational teaching and learning.

The Commission's work takes place in the wider strategic context of the Government's *Plan for Growth*, the inclusion of FE as a newly recognised industry sector in the 'Education Sector Industry Strategy' led by BIS, and the need to develop and sustain a highly skilled workforce. We know from work in other countries that a strong vocational education sector requires continuous work to maintain and improve it (Lingfield, 2012). Our solutions must recognise this.

We also know that there is a growing global demand for vocational education that cannot be met, except through exploiting the economies of scale that technology could offer. As we seek to strengthen UK vocational education through the use of technology, therefore, we may plan at the same time to contribute to meeting the demands from abroad. The recommended contribution to the sector-owned framework, attempts to address all these points.

The strategic context

The UK needs a highly skilled workforce, and government and FE sector policy is to create 'a more educated workforce that is the most flexible in Europe' (Plan for Growth, 2011). UK demand is growing fast, while attainment levels are very low for significant numbers of working age adults, as the Box summarises.

> In 2010-2020, we need to double the number of apprentices and recruits with qualifications like HNCs, foundation degrees or degrees, i.e. 1.86m (www.EngineeringUK.com)
>
> The UK needs to increase the number of graduates qualified in STEM subjects, e.g. to double the number of people with engineering qualifications and apprenticeships (Engineering UK 2013 Report).
>
> 15% Adults (5m) at or below Entry Level 3 (9-11 yr-old) for English; 24% Adults (8m) at or below Entry Level 2 (7-9 yr-old) for Numeracy; (93%) have access to a computer either at home or at work, up from 71% in 2003. (BIS, 2012).

The figures for attainment have changed little since 2003, while computer access is up from 71%. Clearly, we have not yet benefitted from the fact that online access could be assisting the much-needed improvements in attainment for millions of adults of working age.

As more people in work need to continually upgrade their skills, the demand for more flexible learning opportunities will increase to enable them to mix work with study, especially as the workplace demand for technical skills is also increasing (Hoyles, Kent, Bakker, & Noss, 2006). The FE sector is unlikely to be able to meet this demand for more people attaining a higher level of skill without the use of learning technologies, which can make the learning process more efficient, and can do this on the large scale, if managed effectively.

In the broader strategic context, the demand from overseas for UK higher and further education is increasing significantly, as the example in the Box illustrates.

> For example, there is a teacher-training problem in China: >2m engineering students need training every year. There are more than 1200 higher vocational colleges and more than 1000 engineering schools in universities so there are about 800,000 engineering teachers working in the education sector. Most of these teachers come from an engineering and technology background but lack necessary training on pedagogy [personal communication, Beijing Technical University].

Overseas demand is therefore at a level that could only begin to be met by courses run through online transnational education (TNE), which is why it is a major growth area worldwide. Given the level of involvement of UK FE and HE in TNE, there is the potential for significant growth in this form of educational export, especially for FE:

- UK FE income from overseas tuition fees is currently estimated at £140m per annum in total, and £2,400m for HE, (where the respective sizes of the two sectors are approximately 4.8m and 1.5m students respectively).
- UK FE income from Trans National Education is currently estimated at £27m per annum compared with £211m per annum for HE (Conlon, Litchfield, & Sadlier, 2011).

A new focus on FE as an export earner through a greater emphasis on TNE would fit well with the BIS 'education sector industry strategy' to encourage growth in overseas earnings by UK education. However, **the immediate target would be to increase the use of online technologies to improve the scale and effectiveness of teaching and learning in FE within the UK.** This fits well within the CAVTL context of improving professional collaboration in teaching and learning through the use of learning technology, and hence student improving attainment.

New expectations for learning and teaching

Achieving efficient teaching and learning methods (i.e. better results at the same or lower cost per capita) depends critically on building a model that uses digital technologies to provide 'highly personalised' learning, so that every learner is able to learn in the way that is most efficient for them.

The cost per learner in formal education is determined primarily by the cost of the teachers and the cost of the facilities provided. The learning benefit to the learner is determined primarily by the quality of the teaching-learning experience they encounter. Achieving greater efficiency through blended learning, therefore, means using digital technologies to deliver a better balance between per capita costs and learner benefits (Laurillard, 2011).

Why should digital technologies be able to do this? **The two main factors that make technology more productive for learning are personalisation and economies of scale.**

Personalised learning

The first critical factor is that digital technologies can personalise learning by

1. Allowing student *control over the pace* of presentation of concepts and the practice of skills
2. Automated testing of learner performance to *give feedback* on how well they understand the knowledge, and the extent to which they have mastered the skills
3. Using data on learner performance to *adapt the next task* accordingly
4. Providing simulation, gaming, and modelling environments that provide *intensive practice* on cognitive or skill-oriented challenges with *meaningful personalised feedback adapted* to learner input
5. Integrating *formal concept knowledge* with *authentic practices* in the workplace through technologies such as webcams, smart phones and digital videos linked to study environments
6. Using online discussion environments for teachers to provide *efficient feedback* to contributions from individuals and groups of learners, to help them develop skills such as *communication, collaborative team-work, problem-solving, learning to learn*
7. Extending individual learner support by supplementing limited teacher feedback with *extensive peer feedback*, while at the same time engaging each

learner in the high level cognitive exercise of *giving feedback,* based on given criteria

8. Providing user-generated design tools to enable learners to *produce and share representations* of their learning
9. Using virtual learning environments to enable the teacher to guide *independent learning* for individuals and groups of learners working together online
10. Using social media, personal planning tools and e-portfolios to enable learners to *learn from each other* about the feasible trajectories from study to work to promotion, and to assess and reward their developing skills and expertise (de Freitas et al., 2006).

To realise the potential pedagogical benefits of blended learning, the optimal model would maximise all these advantages by **making sure that teachers know how to select, design, develop and share these types of digital teaching-learning activities**.

Economies of scale

The second critical factor is that digital technologies can transfer some teaching-learning activities from variable (per student support) costs to fixed (capital and production) costs, and thereby achieve economies of scale, reducing per capita costs, while maintaining high quality learning. Figure 1 shows a typical analysis of how the teaching cost per student can be reduced by shifting from variable costs (e.g. a small group tutorial; a class-based lecture) to fixed costs (e.g. individual digital interactive tutorials; an online video). However, as long as there are still teaching activities related to each student, such as individual supervision, guidance, feedback, marking etc., these cannot achieve economies of scale unless we develop more sophisticated learning technologies to automate this kind of teaching.

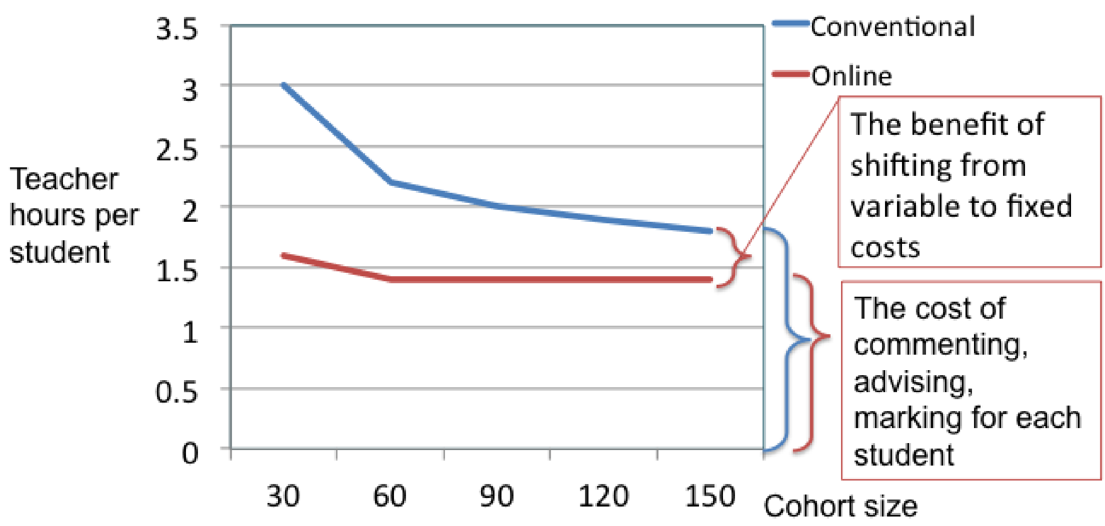


Figure 1: Technology cannot improve the per-student support costs through economies of scale unless these teaching activities are automated

The variable cost of per-student teaching activities can be reduced by using digital versions of existing ways of reducing teaching costs for large numbers, such as:

- Teaching assistants – usually graduate students who respond to student questions in online forums, and mark assignments according to a marking scheme; they are cheaper, but this method does not achieve economies of scale, as the cost per student remains the same, no matter how many students.
- Peer assessment – students exchange and mark each others' work according to a marking scheme; this method has the pedagogic value of enabling each student to reflect on their own work while judging another's; it also gives them feedback, but this is non-expert and may be inappropriate; the technique can provide formative (not summative) assessment; since the method does not require staff time to run, it can be scaled up to large numbers.
- Automated marking – multiple choice question (MCQ) formats have been used for many years in all education sectors, and have already been digitised; the method has to be used with care, because it invites students to think about wrong answers, and encourages guessing; it is another way of switching variable to fixed costs, and does achieve economies of scale.

A more pedagogically valuable form of automated testing than MCQ makes use of a simulation model of a task or system or situation. There were several examples of this type of program in the National Learning Network (NLN) materials (see Box).

> For example, one program represented a model of different ways of lighting a stage, where students could manipulate parameters such as colour, intensity, angle, etc. to gain an understanding of how to achieve specific effects. With such a model it is possible to automate either formative or summative assessment by setting a goal to achieve a certain effect – the program has all the information it needs to be able to judge how close the student's input is to the optimal set of parameter values, and therefore give helpful feedback and make a good summative assessment of their knowledge and skill.

Programs of this type are valuable because they provide automated personalised support, and may also assist learners in developing their self-assessment skills – the simulation model shows the result of their actions in relation to the goal or target performance, enabling them to judge their own performance. A good example is the use of a simulation that uses haptic technology to train dental students on drilling teeth (San Diego, Barrow, Cox, Newton, & Woolford, 2011). The same model can also be embedded in a gaming format as a way of motivating repeated practice.

The disadvantage of the simulation model is that it requires significant initial investment in the design, development and testing of the program. The NLN programme was a good example of investment in this form of pedagogy, but the investment needs to continue if the products are to keep pace with the range of curriculum needs, and with improvements in digital technologies. **The advantages of simulation models are that they provide a powerful interactive and adaptive**

pedagogy, and they do achieve economies of scale because they require no teacher time once developed.

Balancing good pedagogy and teaching costs

Learning technologies are important for the strategic ambitions of the FE sector because they have the potential to enhance the quality of the learning experience and thereby significantly improve student attainment. This will enable teachers to reduce the time learners spend in relatively passive whole class listening and watching, and increase the time they spend on active learning in groups, guided by the teacher or by a virtual learning environment (VLE), and in personalised, collaborative, and self-directed learning. Figure 2 illustrates one way of redistributing learners' time to reflect 21st C opportunities for improved learning experiences.

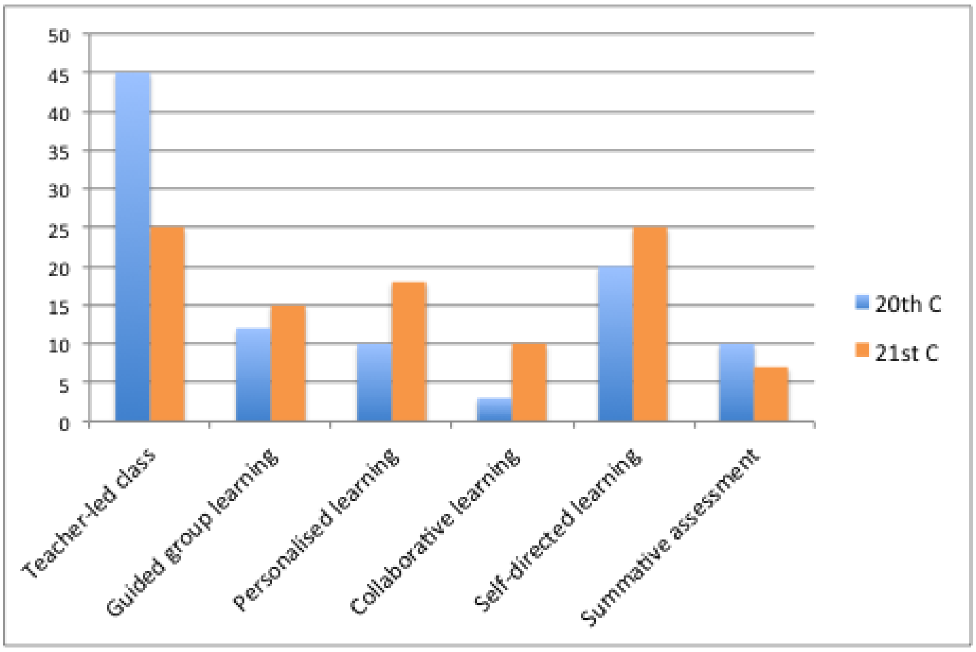


Figure 2: From 20th C learner to 21st C learner, showing the shift to more active learning supported by learning technologies

The change in how learners spend their time inevitably requires a significant shift in how teachers spend their time. The time and expertise needed for designing and testing digital learning activities is considerable and much greater than the time currently spent on class preparation. **Teachers are best placed to know what their learners need, and to innovate and test new ways of teaching with technology.** The sector will therefore need to harness every teacher's capacity for learning about how best to exploit new technologies. We have to plan for a different way of distributing teacher time, as Figure 3shows.

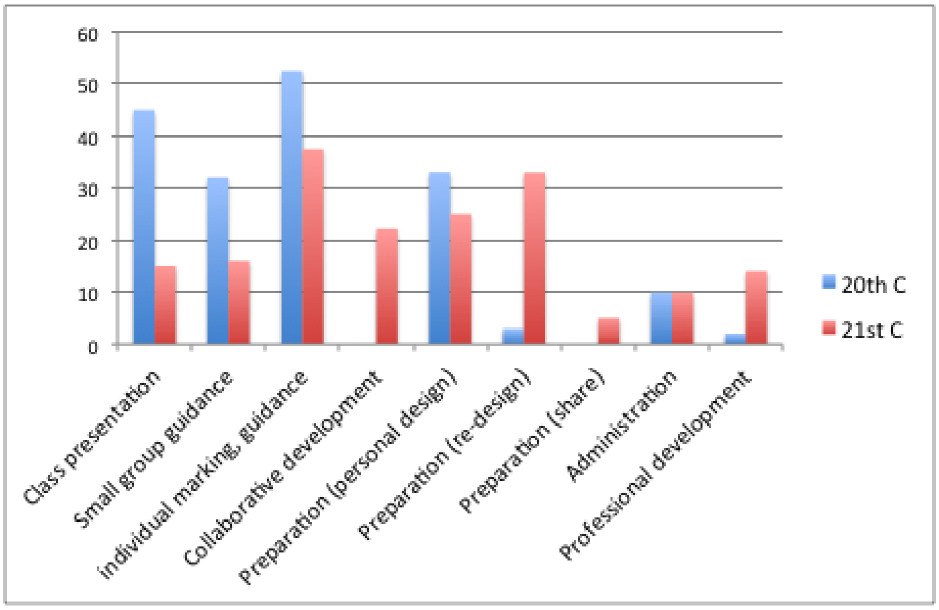


Figure 3: From 20th C teacher to 21st C teacher, showing the shift from class teaching to development, collaboration and student support

The new distribution of how teachers spend their time proposes reducing some of the per-student support and guidance activities by shifting this work to automatically assessed digital learning. This necessarily increases the time spent in contributing to collaborative development of those course materials, and the time needed for professional development to support the development of these skills. It also increases the time spent in redesigning the digital resources a teacher adopts from other teachers to adapt for their own courses.

There are design tools that enable teachers to develop their own MCQ marking and guidance activities. For the more sophisticated simulation modeling the development work would have to be supported by programmers, as in the NLN approach. This requires additional investment but should be reusable by sufficient student numbers across the sector that it can support a viable business model.

It is important to do this kind of modeling of how the teaching workforce will need to change its practice if we are to manage the shift to a new way of working. The cost-benefit model preserves the same overall workload, but would enable the teachers to support more students for less increase in time costs, as Figure 2 shows. Figure 3 offers one illustration of how teachers might work, which, averaged across the sector, could act as an overall plan for how we might re-professionalise the teaching workforce, and enable FE teachers to meet the demands and opportunities of 21st century teaching.

Supporting teachers as innovators in online learning

Research has been carried out recently on the feasibility of developing tools to deliver the optimal cost-benefit analysis of technology-based pedagogies, for individual teachers, teaching teams, and for their institutions. The 'Learning

Designer' is a suite of online tools developed as a prototype for HE and adapted for the FE sector through LSIS funding (report available on request).

The tools include a range of interactive features, summarized in the Box.

- A small collection of 'pedagogical patterns', some derived from designs contributed to the Excellence Gateway, organized according to the type of learning outcome they support; each pattern can be viewed as applied to three different topic areas, or as a generic pattern, or with the user's own topic features embedded;
- A 'designer' screen that enables the user to adapt an existing pattern, or design a new one, by using a menu to add types of learning activities, edit learner instructions, add links to online resources, etc.;
- Feedback on the nature of the learning experience they have designed;
- A sharing option, which enables the user to make their new design, or their improved design, available to other teachers;
- An analysis of teacher workload associated with the pattern they have designed;
- Context-related links to advice, guidance and information on learning technologies and pedagogic designs;
- Export to a Word template for sharing with colleagues and students
- Export to Moodle (under development) to run the learning pattern for students.

Digital design tools of this type are needed to help teachers and managers to focus their energies on the planning and development of new approaches to teaching and learning:

> *"college managers need to conceptualise learning as something that is central to the practices of their employees" (Lucas & Unwin, 2009), p432.*

We need investment not only in technology but also in teaching as a 'design science', i.e. teachers building on each other's best ideas, experimenting, innovating, testing, improving and exchanging the optimal ways of using learning technologies (Laurillard, 2012). Teachers must be able to engage in the "continuous enhancement of expertise" (Lingfield, 2012). **Like any professional, teachers need the tools of their trade to enable them to be more efficient and effective, and to be able to build and exchange their professional knowledge**:

> *"Much greater attention needs to be paid … by policymakers and the agencies responsible for teacher training to the way in which workplace practices and the organisation of teachers' roles and responsibilities might need to change in order to accommodate their professional development." (Lucas & Unwin, 2009), P431.*

The VLE is not sufficient to support FE teachers in achieving both individual and collective learning about how to innovate with learning technologies (James, Guile, & Unwin, 2011).

Modelling pedagogical patterns

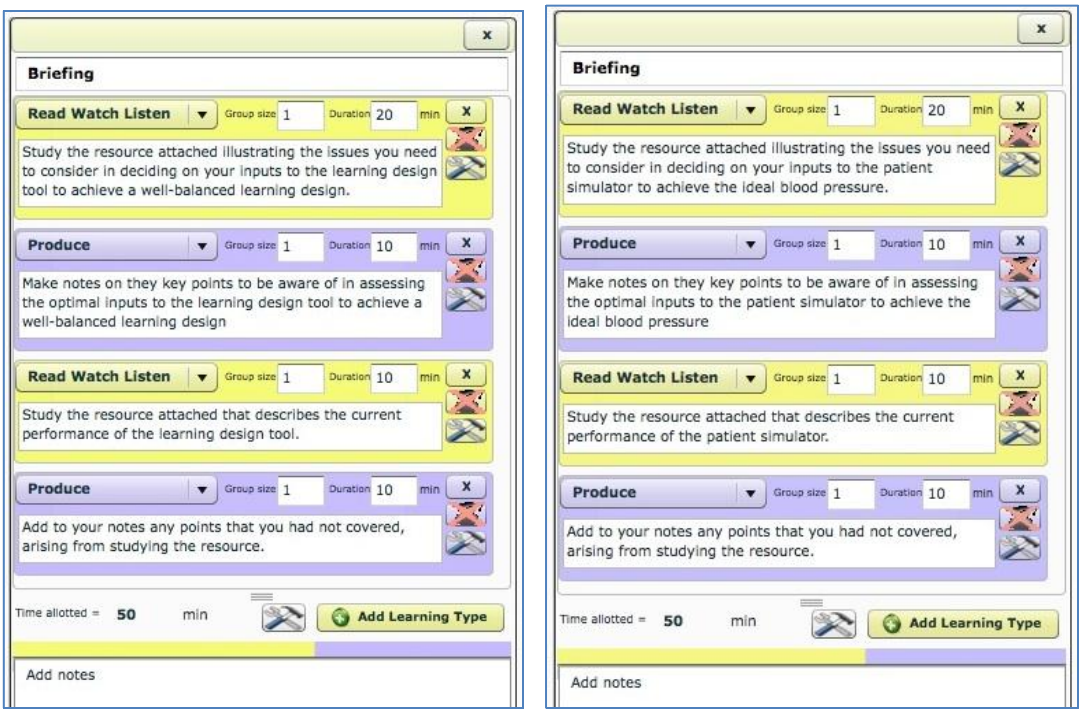
This section looks at ways of using recent work on 'pedagogical patterns' (teachers' own learning designs or lesson plans) as a way of enabling teachers to engage in the continuous enhancement of their expertise. A staff development workshop, or time made available for personal development is not sufficient. We need to build a collaborative professional community.

If they can learn together, collaborate, and build on the work of others, sharing and improving their pedagogical patterns for different outcomes and contexts, teachers can develop this community knowledge and innovate more effectively

Tools such as the Learning Designer and the Pedagogical Patterns Collector (PPC), now adapted to the Further Education sector provide the means for teacher-designers to collaborate to innovate effectively, summarized in the Box.

> The PPC website elicits the teacher's design in a similar way to a lesson template, but also requests explicit detail on
>
> the nature of each part of the activity, the time duration,
> the url for online digital resources needed, the group size,
> whether the teacher is present or not, and
> the advice and guidance given to the students.
>
> The software provides an analysis of the learning experience in the form of a pie chart showing the balance of types of learning activity.
>
> There is also space for teacher reflections and student feedback on each part of the design.

Once the design has been improved and honed in response to implementation with students, this detail gives other teachers an excellent starting point for their own technology-based design, which they can edit, test, and then re-publish to the community. The same pedagogic design can be adopted for a quite different topic area, as Figure 4 illustrates.



(a) (b)

Figure 4: (a) shows part of a pedagogical pattern for trainee teachers, based around a 'learning design tool'; (b) shows the same pattern adapted for medical students, based around a 'patient simulator', although the pedagogic form is the same.

Figure 4 shows how a pedagogical pattern for trainee teachers, which was built around a digital tool, has been adapted for medical students using a different digital tool. The second teacher was able to develop a tested and effective way of enhancing their own digital tool by adopting the first teacher's pedagogic pattern for a similar kind of learning outcome. The goal for the trainee teachers is to achieve 'a well-balanced learning design', as shown by the pie-chart feedback; the goal for the trainee medics is to achieve the ideal blood pressure, as shown by the reading given by the patient simulator. In each case, the learner is given personalised feedback on their practice with the digital tool, and their work is guided by the pedagogy built around it – bringing in collaboration and discussion activities in the later stages of the design. In this way, teachers are able to exchange and improve on each other's ideas, within and beyond their own subject areas, building the common pedagogical knowledge of the professional community.

The teaching-learning activities designed into the PPC can be implemented by exporting the design to a Word template, as for a normal lesson plan. However, if it is to be run in Moodle, each activity can be interpreted directly as a Moodle activity, such as Page, Forum, or Wiki, so that the PPC becomes a pedagogic design front-end to the Moodle environment. This mapping is currently under development. Figure 5 shows how the design in Figure 4b can be interpreted directly in Moodle (currently a non-automated process).

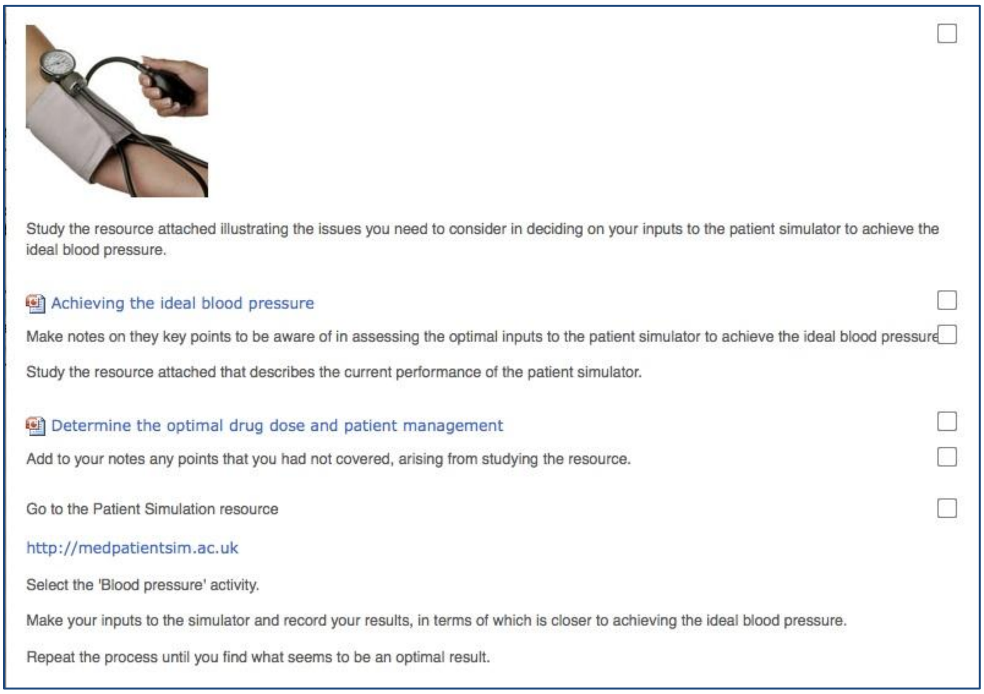


Figure 5: the medical pattern in Figure 4b has been exported to Moodle, where each designed activity has been interpreted as a Moodle activity.

Online CPD opportunities for teachers in the skills sector, built around these learning design tools, would scaffold and support the sector in improving professional collaboration in T&L, in the use of technology in learning, and hence in improving student attainment. There are plans for running webinars and a MOOC (massive open online course) to support the FE sector in this way, as part of an ESRC-funded Knowledge Exchange project. This would provide a test-bed for a new approach to teacher development. For example, the AoC or FE Guild could sponsor an *online professional academy* to integrate existing online resources and environments, and provide advice, guidance, support, and professional exchange as a way of orchestrating and leveraging the expertise already available in the sector. Figure 6 shows some of the existing tools and resources that could be integrated to build this kind of support for the sector.

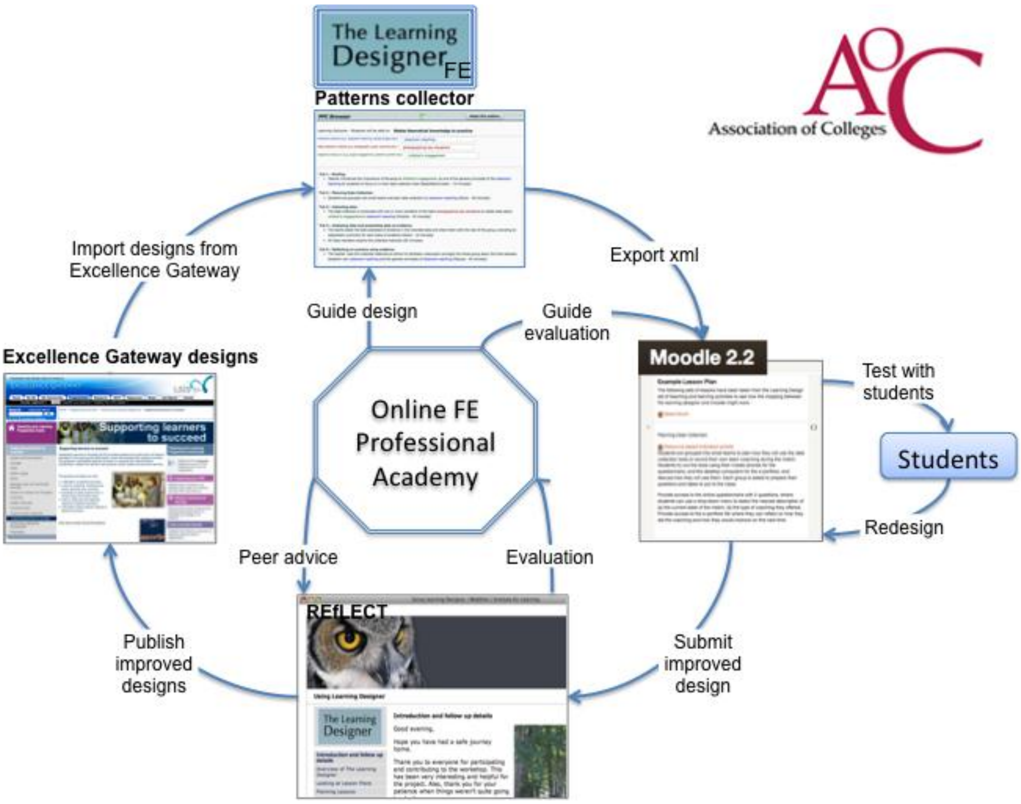


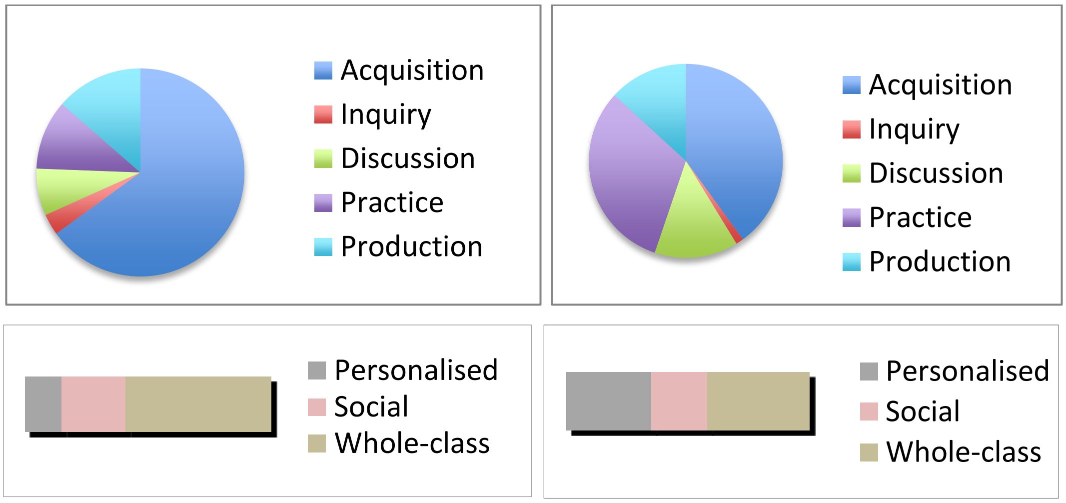
Figure 6: An Online Professional Academy integrating FE tools to build FE community knowledge and capability

Sustained investment for the continuing improvement of pedagogy will be necessary. It is ironic that at school level traditional teaching methods have attracted millions in funding to improve the quality and effectiveness in a range of curriculum areas, whereas innovation in the use of learning technologies is somehow expected to deliver measurable improvements with the simple introduction of the hardware. This means the potential of digital technologies is never realised, and this has been just as true for the FE sector. **With a different approach, that recognises the importance of investing in innovation in teaching and learning, we could enter a new phase of professionalised teaching.**

Modelling the costs and benefits of online learning

It is possible to use the digital learning design tools outlined above to estimate the pedagogic and workload effects of the decisions made in planning and designing a course. By specifying the detail of class-based activities as well as online and unsupervised work, the complete learning experience, as well as the teacher time needed to support it, can be represented in a way that allows us to compare conventional and online courses, and be sure that we are achieving all the benefits of efficiency and effectiveness that technology promises.

The teaching-learning cost-benefit model that drives the Learning Designer and the PPC, can generate output of the kind illustrated in Figure 7 for two versions of a 100-hour course. The significant increases in active learning and personalised learning made possible with new technology means that learners who struggle to reach the required standard of attainment will be able to spend more time at their own pace, supported in the extra work they need to reach those standards. Previously, the only remedy for poor student performance has been 'more teachers'. In the spirit of the CAVTL approach we now argue instead for better teachers equipped to deliver better learning experiences. That is what technology promises.



(a) Conventional course (b) Online course

Figure 7: Comparison of Conventional and Online course modelling in terms of their likely impact on the type of learning, where the Online model supports more active and personalised learning, having reduced the amount of learning through acquisition in whole-class activities, and increased the use of automated formative assessment practice.

Because the software also estimates the teacher time needed for preparation and student support, in this case for 30 students, it can also generate an estimate of the cost of the teaching. For this course it estimates the Conventional version as requiring twice the teaching time as the Online version. In addition to this there would also be administration and online hosting costs, etc. but the dominant cost is teacher time, so that is the focus of the modelling.

Such tools can therefore support teachers and managers in modelling the comparative pedagogical benefits, and the costs in terms of teachers' workload, of place-based and online learning. This makes it possible to estimate the investment needed against the expected fee return for varying student numbers over the long term for online or blended courses, as shown, for example, in Figure 1.

With an improving capacity to develop high quality online courses in vocational education with sustainable business models, FE will be able to offer more flexible and effective ways of meeting the national demand for lifelong vocational education.

With a strong national online provision in place, initially with those colleges that already have a strong online presence, it would be feasible to develop a growing international provision of vocational online courses for selected course topics.

The role of FE in the education industry

An improved national capability to deliver more flexible blended and online learning will mean that the skills sector can also contribute to significant growth in the UK's transnational education offer, as part of the BIS education sector industry strategy. This will be a valuable way of attracting significant investment into educational innovation for FE, particularly if a good business case can be made to the Technology Strategy Board.

This level of innovation requires significant and long-term investment across the sector, building on the excellence and experience already developed, but with a clear estimate of the expected return on investment. CAVTL is in an excellent position to recommend a way forward for the sector that would plan not only for incremental national provision and improvements in attainment, but also for developing an international capability to meet the growing demand.

Recommendations

There is likely to be very little investment in teaching innovation for national provision, so it is important to husband carefully every contribution to improving teaching and learning. Technology can assist teachers by providing design tools and online exchange of pedagogic innovations to orchestrate and leverage the small-scale local improvements achieved by individual lecturers into large-scale improvement of the sector as a whole.

It is possible that the FE sector could attract investment from the Technology Strategy Board by building on the online innovation already developed in the sector to build a forward plan that would include international export. This is worth exploring. Meanwhile, the focus must be to develop the sector for the increased efficiency and effectiveness needed to achieve improvements in national attainment levels.

For the sector to operate like a learning system, it could designate the most innovative and effective teachers, who are using learning technologies to address certain types of teaching and learning challenge, as 'Centres of Excellence'. They can lead and disseminate to the 'Leading Adopters', i.e. other teachers who are designated to develop these methods further, and so become Centres of Excellence in meeting new kinds of challenge, and pass on their expertise. A rolling programme of colleges adopting, adapting, testing, improving, and exchanging effective practice would eventually embrace the whole sector in learning from others and moving forward together. Figure 8 offers a timeline for a growing programme of innovation and change across the sector.

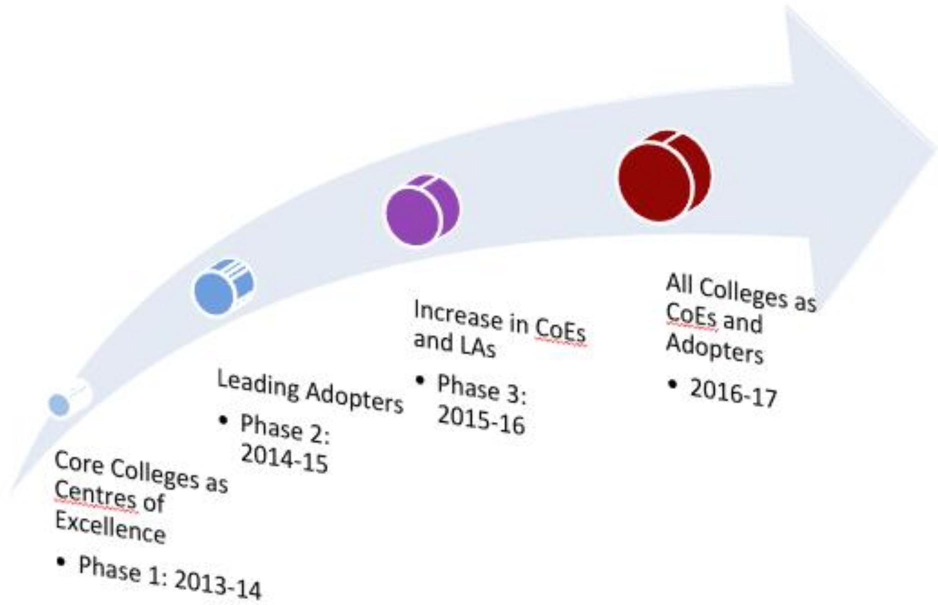


Figure 8: A rolling programme of innovation and change across the sector

Given the aims of the Commission the recommendations are drawn from the analysis and arguments throughout the paper, and propose a holistic set of interlinked actions:

1. Make a sector agency (such as the AoC or FE Guild) responsible for the development of an 'online learning business model' to assist Colleges in their local strategic investment in innovation with technology.
2. Set up a sector-wide Advisory group to (i) consolidate the requirements and link together the existing digital tools and resources generated by LSIS, JISC, RSCs and the other key agencies (ii) design a sustainable and technology-supported collaborative workflow, at sector and College level, for strategic innovation and professional development in teaching and learning.
3. Develop this as an *'online professional academy'* for continuing professional development of FE teachers to offer advice and guidance, support their exchange of ideas, and build their community pedagogic knowledge of the optimal use of learning technologies.
4. Select and support as Centres of Excellence the Colleges that have demonstrated leadership in the strategic development of innovative e-learning and online provision, including, for example those funded as JISC Advance projects.
5. Select and support other Colleges as 'leading adopters', to ensure the pull-through to other colleges of the effective innovations already established, and to enable their further development and extension to other areas.
6. Use these Colleges to begin building protected local libraries and open public repositories of designs, and the workflow for innovation, testing and implementation.
7. Plan sector engagement through (i) a series of webinars via sector agencies, such as the JISC Regional Support Centres, on institutional goals for online

learning, and the use of pedagogical design tools to take them forward; (ii) regional one-day conferences on innovation in teaching and learning, making use of the links already set up between, e.g. the Excellence Gateway, REfLECT, Moodle, and the Learning Designer tools.

8. Orchestrate the evaluation of changes in efficiency and effectiveness of the learning designs and resources shared through the public exchange of learning designs, within and across subject areas.
9. Develop a forward plan for the FE 'sector industry strategy' to build on national online course provision to develop an international product for export to contribute to meeting the growing international demand for vocational education.

Summary

CAVTL has identified the following specific needs, for which this paper suggests some ways forward:

To capture the voices of teachers and trainers;	- by using digital tools for recording and sharing teachers' best ideas, validated by their students' feedback.
To understand what contributes to learners' ownership and enjoyment of their learning;	- by promoting and experimenting with the use of digital technologies that make students active learners, supported with the tools of ownership of their own learning, such as e-portfolios, self-assessment, peer learning, simulation models for experimenting, user generated content tools for creativity.
To put teachers at the heart of the system, supported as dual professionals.	- by harnessing the existing online tools and resources available to create an *online professional academy* for FE, and so develop the professional community knowledge of learning technology.
To develop the needs of trainers in industry;	- by making the same online development community available across industry as well as the education sector.
To promote closer connections between teaching and work	- by using online environments to link college-based course work with authentic practice in the workplace.

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