Scaling **up**

ACHIEVING A BREAKTHROUGH IN ADULT LEARNING WITH TECHNOLOGY

23 May 2012

ufi charitable trust

Table of **Contents**

Scaling **up**

DIGITAL TECHNOLOGIES are altering the way we work, trade, buy things, play, communicate, arrange holidays, pay taxes and have a social life, but so far – despite subsidy and encouragement – have made a disappointing impact on how we learn in formal contexts. Yet we live in a fast changing and increasingly competitive world, one where new skills and insights are essential. The new wave of computing should be mobilised to radically improve teaching, learning and access in vocational education and training. This report discusses the issues and barriers that impede our progress, and identifies the next steps needed to ensure we make best use of our digital potential.

It is not good enough to argue that computers are just another tool to aid teachers and trainers in their work, like books, overhead projectors and TVs before them. Tools are indeed all that they are, but very special tools. They come in a dazzling variety of forms, from PCs and laptops to smart phones and tablets, set-top boxes and games consoles. They can be wherever you are, whenever you need them. They also have the most versatile multimedia capabilities of any devices yet encountered, with the ability to process media elements from text to still images, animations, audio and video, at increasingly high quality levels, and certainly far surpassing the educational capability of the printed word and conventional television. They are multi-purpose – a single device can be used for business, learning and fun. And unlike the learning tools of the past, learners own them (and frequently love them).

There is another characteristic of computers that sets them apart from all previous aids to learning. They can process at astonishing speed. This allows them to undertake tasks beyond the capabilities of humans: to process interactions from many learners simultaneously and in real-time; to simulate real-world events and processes in 3D; to learn from the interactions made by learners and to apply pedagogic rules instantly. When connected, as just about all computers are, through the Internet and other networks, the true potential for scaling up education and training can be seen vividly. Learners can connect with the 2.5 billion or more other Internet users around the world, to collaborate in learning everything from the most generic to the most niche subjects and skills. Connected learners also have access to huge amounts of potential learning content in a wide variety of media formats.

As a result, today's computers and the software they run are capable of supporting startling improvements in learning. They can deliver lively and engaging learning material; they can relieve the learning professional from the repetitive task of imparting information; they can reach many thousands of learners simultaneously; they can link learners in regional, national and international study groups; they can vastly increase choice of subject and mode of study; they can enable substantial reductions in travelling time and expense, not to mention CO_2 emissions.

In this report, we argue that it is essential that we realise the extraordinary potential of our new technologies to solve the problems in vocational learning. To do that, we need to identify the opportunities and also the barriers to progress: that is also our aim. We cannot carry on as we have always done before:

- to remain employable in a highly-competitive and fast-changing world, most adults

Scaling Up

Nine hundred million people now interact with each other on Facebook, maintaining relationships with friends, family and work colleagues across the world.

now need to retrain on a regular basis throughout their working lives;

- structural changes in the job market mean we have both surpluses and shortages of labour in different sectors;
- the current shortage of financial resources in education and training is placing greater pressures on budgets and on the time of teachers and trainers;
- and unemployment wastes potential, costs money and threatens civil unrest.

Above all, there is a growing expectation, from the young in particular, that computers will be used to transform their learning as they have already transformed their personal lives. This is not foolhardy and naïve. Computers can, and will, change everything in vocational learning, as they have done just in about every other walk of life. It's time to scale up our use of learning technologies. Education and training claim to be society's change agents. We, Ufi Charitable Trust, look forward to working with learning professionals to deliver lasting and radical change.

Executive summary

OUR PURPOSE

This report was commissioned by the Ufi Charitable Trust to investigate opportunities for and barriers to the application of digital technology to adult learning. Its aim is to identify priorities for the funding of research and development in digital learning. Our theme is 'scaling up', increasing the impact and spread of new ways to learn; our ambition is to help the Trust support a transformation in the UK's vocational education and training.

Landscape

Chapter 1 of our report discusses the major and enduring challenges facing our economy and society. Unemployment is high, reflecting not just the national economic climate, but continuing differences in regional prosperity and productivity. Major companies and government departments are aiming to reduce costs, often by substantial workforce reductions. Section 1.5 recognises that our vocational education system makes an important contribution to skills and social cohesion, but lacks innovation and is trapped within tight budgets and a turbulent policy environment. Young people often leave formal education with inadequate skills, and many older workers lack adequate literacy and numeracy (1.4). Lifelong learning is often trumpeted as the solution to these problems, yet evidence suggests that adults have little time to spend in formal learning.

But what we know of adult learning, and of the potential of new technologies, can move us away from despair. If providers can respect the values that adults seek in learning – a sense of control and autonomy, choosing a skill that matters, and the ability to make a contribution to society – the motivation will be there (1.6). New technologies can offer the choice and freedom that adults seek in their learning. It is already supplying what is needed in the informal arena, through social networking, in information seeking, using Internet searches, specialist sites and more general ones such as Wikipedia and YouTube, and in commercial transactions as online purchases grow. This extraordinary technology should be mobilised to meet our training and skills needs (1.7), but it isn't: the record, despite some outstanding pioneering work, has been disappointing.

Scaling Up

Forty-eight hours of video are uploaded to YouTube every minute. As the preferred source for how-to videos on just about any subject, it is the second most popular search engine in the world.

Findings from our study

Chapter 2 looks at the findings from our desk research and the online questionnaire. This delivered 142 responses, 36 in-depth interviews with researchers, business people, learning professionals and civil servants (2.1.1 on). We've included telling quotations from our sources throughout the report. Our respondents were clear that Ufi should support work that has the potential for large-scale delivery, and should encourage innovative delivery channels. The desk research led us to consider

Scaling Up

Wikipedia is the sixth most popular website in the world containing 19m articles in 270 languages. With 3.9m English-language articles, it is 50 times bigger than the Encyclopaedia Britannica.

international trends and shifts in technology and delivery. Having completed the information-gathering stage, we were able to identify opportunities and barriers under four main headings:

Capability building and advocacy (2.2)

Positive programmes have raised teacher skills, and many professionals make impressive use of digital resources. However, our research identifies clear and enduring skills gaps among teachers, trainers and other learning professionals. This gap is a major obstacle to a step change in vocational learning in the UK. Alongside this, there is widespread ignorance among decision-makers about the real potential of learning technologies.

New models for the organisation of learning (2.3)

The delivery models that underpin formal educational practice have not significantly altered in over three hundred years. We look at the current issues, and how they have often been produced by government requirements. Continuous, incremental improvements of these existing processes are unlikely to deliver the step change that we need. We review some innovative thinkers who argue we now have the opportunity to transform the learning process, rather than just automate it:

- Peer-supported and assessed learning allows for major improvements in scalability, reducing the reliance on teachers and trainers, at the same time providing benefits for learners themselves.
- 'Flipping the classroom', whereby the delivery of new learning material is accomplished online using media such as video, and then contact time with teachers and trainers is devoted to coaching and group activities that cannot be automated, again offers the promise of unprecedented scalability, as well as greater flexibility for learners (2.3.4).
- Separating learning from assessment (2.3.2) would allow learners to choose their own method of learning, safe in the knowledge that they have an equal opportunity to obtain a particular qualification.

Scaling Up

There were 1.2 billion mobile web users in the world at the end of 2011, increased from 870 million in 2010. 54% of all Europeans now own a mobile device capable of accessing the Internet.

Interaction and immersion (2.4)

Section 2.4.7 summarises our findings here. By making better use of the power of computers to deliver intelligent and adaptive learning simulations, games and virtual worlds, we could provide the following opportunities:

- Increasingly immersive, engaging and personalised learning experiences, counteracting the rather poor reputation of much current e-learning content.
- The ability for learners to practise cognitive, interpersonal and motor skills on their own or in groups, without the on-going support of learning professionals and without risk.
- Massive potential scalability, at very low cost per learner, for those projects which effectively address the skills required by large populations.

Learning infrastructure (2.5)

The major advances we are currently experiencing in technology provide many opportunities that can help us to overcome barriers and deliver a step change in vocational learning:

- The increasing availability of cloud services has the potential to dramatically reduce the cost of learning design, delivery and administration (2.5.2).
- The widespread ownership of highly-powerful smart phones and other mobile devices will provide an alternative and highly-accessible channel for learning and performance support content and other learning activities. Our questionnaire

respondents looked to greater exploitation of this mobile technology (2.5.3).

- E-book readers provide a low-cost and flexible way to distribute learning content, including open educational resources (2.5.3).

Priorities for funding

Chapter 3 looks at many different possible interventions. We assessed each one for its potential impact on learners, value for money, sustainability and scalability. And realistically, we asked how challenging it would be to make the proposed reform.

We organised our recommendations into three clusters:

1 Increase the capability of those involved in running the vocational learning system.

2 Exploit networks to bring together learners, learning content and learning professionals.

3 Harness computers to support individualised and differentiated learning.

We then identified a number of interventions that we believe could contribute to a step change in vocational learning. In each area we picked two as headlines:

Increase capability (3.2)

- Invite projects for the design, development and delivery of a large-scale, open, online course to develop the knowledge and skills of learning professionals.
- Invite projects to create analytical tools for use by organisations deciding on how to make large-scale changes to the design and organisation of their formal learning provision.

Exploit networks (3.3)

- Invite projects that support the development of peer assessment systems that enable learners to provide structured feedback and support to other students studying at the same or a lower level.
- Invite projects that champion the creation of curriculum content using the production, testing and updating methods that are central to the success of open source software.

Harness computers (3.4)

- Invite projects that support designers of simulations, games and virtual environments relevant to vocational learning, to take their projects through into development and implementation.
- Invite projects to make a 'mass' and wholly-online intervention focusing on Level 2 numeracy/mathematics learning by 16-19s and by older adults.

Alongside these six headline ideas, we describe a number of additional interventions that should also be seriously considered. Although we have consulted widely, there will undoubtedly be many good ideas that have not yet occurred to us, our interviewees and questionnaire respondents, and we look forward to receiving these.

The combination of these interventions will, we believe, over time, make a major contribution to a step change in vocational learning in the UK, through a 'scaling up' in the application and use of learning technologies.

Scaling Up

The Khan Academy, a library of over 3100 maths and other educational videos has been accessed over 150 million times.

Conclusion

We believe that the existing vocational education and training system could, in time, respond to the problems and opportunities we identify: but it is limited in resource,

and, weighed down by the baggage of past and current practice, in imagination. The opportunities are too great, and the needs too pressing to stand back and merely hope for change. Ufi cannot, by itself, bring about a transformed vocational learning, but it can certainly act as a catalyst for one – section 3.5 suggests how this might be effective. The time is right for action. Of course there are barriers and problems; but we have extraordinary opportunities to meet them with innovative solutions. We hope our report points the way.

Some **background**

About Ufi

This study has been commissioned by the Ufi Charitable Trust[1], a registered charity and company limited by guarantee, set up in 1998 by the Government to use new technology to transform the delivery of learning and skills. In 2011, the Trust announced the sale of Ufi Limited and the learndirect brand to private equity house LDC; the proceeds from the sale of Ufi Limited and the learndirect brand have created an endowment fund to support Ufi's mission, which is to take a central role encouraging the adoption of 21st century technologies to achieve a step change in adult learning and employability for all. The overall purpose of this study is to help Ufi decide how best to put these funds to work in order to achieve its mission. With the support of the Trustees, we have focused our effort on the intersection between employability, learning and technology. Our scope has been vocational learning in FE colleges, training institutions, workplaces and by learners independently; we have not focused attention on learning in schools or universities.

How the study was carried out

The study was carried out between January and May 2012 by Clive Shepherd, Dick Moore, Seb Schmoller and Adrian Perry[2]. We started with a period of desk research, looking at national and international sources. We designed and released an online questionnaire that asked people with an interest in the subject of the study to give us their views on the ways forward: we were delighted to receive 142 responses, from people in a wide range of roles and organisations. We also arranged and undertook in-depth interviews with recognised experts in digital learning, and in vocational education generally. We were keen to talk to employers, which are the end-users of skilled workers; and checked our conclusions with the Trustees of Ufi as the work progressed.

About this report

The report is organised in three main chapters. In Chapter 1 we survey the landscape. In Chapter 2 we examine four thematic aspects of the application of learning technologies and identify barriers to the increased use, and options for the deployment of learning technologies, and thus for interventions by Ufi. In Chapter 3 we present our principal recommendations for consideration for action by Ufi. The appendices provide supporting information including notes on methodology, results from the online questionnaire, and details of interviewees. We hope the report speaks for itself, but will be happy to respond to requests for information about our methodology and conclusions.

Scaling Up

The free, online Introduction to Artificial Intelligence course created by two Stanford University professors attracted 160,000 enrolments. Learners took part from every country in the world except North Korea.

1 The landscape

1.1 Context

Any report that aims to shape the skills of the population to better meet the needs of the economy should have a sense of context. In the UK at the moment, the context is one of austerity. This is not the place for an extended economic analysis, but these challenges cannot be ignored:

- Western economies are suffering the deepest, and most enduring, recession since the 1930s.
- Public expenditure cuts aimed to reduce the government's budget deficit are set to continue. Substantial reductions in the public sector payroll have occurred, yet the bulk of the cuts are still to come.
- Lack of skills is not just an economic or personal issue; it has social consequences. Most of those who took part in the 2011 riots had few or no qualifications.
- 60% of young people do not go on to higher education. Of these, half leave school with few if any qualifications.
- Between a quarter and a third of all young people reach the age of 19 either outside employment, education or training, or having followed courses which offer no route to higher levels of education or the prospect of meaningful employment.
- Youth unemployment has remained stubbornly resistant to policy intervention in the past, and is now at its highest since the 1970s.
- At least seven million people of working age (some say as many as 16 million), in and out of work, are very poorly or wholly unqualified.
- There are widespread and enduring regional variations in value added per person – with consequent disparities in income and employment.
- A globalised economy has enabled major businesses to take manufacturing and service functions off-shore.

Most of these challenges have been present for some time – even in times of economic growth and generous public spending settlements. We are now, however, faced with the need to confront them with fewer resources. Like other Western economies, the UK suffered a grave setback following the 2008/9 financial crash. The 'crunch' has been responsible for a loss of more than 10% of GDP. A full recovery if and when it happens, and many argue that it will not, will take several years: and will not restore that deadweight loss in output.

1.2 Austerity and employment

In the meantime, recession reduces government tax receipts and increases welfare spending, creating enormous pressure on public finances. The Coalition Government's deficit reduction measures have involved substantial real cuts to much of the public sector, including to state spending on the vocational training system. These cuts are planned to continue annually for the lifetime of the current

Government. They bear particularly heavily on those parts of the country (such as the North East) where public sector employment had previously softened the de-industrialisation of the 1980s and 1990s. In many areas of the country, for many categories of employment – there are wide role-based variations – the number of people seeking work far exceeds the number of vacancies. We need to be hesitant before suggesting training as the catch-all answer to this problem:

"People who would be hired like a shot if they lived in the south-east can't get jobs because they live somewhere else, where the economy is rubbish, and they can't afford to move to the south-east. But that's not about needing different sorts of skills training. That's about other blockages in the economy." [3] Alison Wolf

Improved opportunities in our regions can only be delivered by a coordinated approach – greater private investment, improved public infrastructure, raised standards in education and training. As things stand, there are wide and widening regional disparities in gross value added per person[4]:

Within an economy that is growing slowly, if at all, there are some brighter spots. The 'Internet economy', of which online learning businesses are themselves part, contributed £121bn to the overall UK economy in 2010[5], equivalent to 8.3 per cent of gross domestic product. This is expected to rise to 12.4 per cent of GDP by 2016. Some high technology businesses, such as those in the Oxford/Cambridge/Milton Keynes 'triangle', are thriving. Manufacturers who export, and can meet the needs of growing economies such as Brazil, China, or India, are succeeding. However, two thirds of all employment is in three large sectors: finance and business services; distribution, hotels and restaurants; education, health, and public administration. The immediate outlook for these sectors is not encouraging.

1.3 Small and medium-sized enterprises

About half of the UK's employment and business turnover is in micro, small and medium-sized enterprises, which can show the flexibility and innovation to survive the crisis. However, press reports suggest that access to finance is a severe constraint on growth. Their ability to access any training, let alone digitally-based content is also limited by pressures of time and cultural issues. A study carried out by Cedefop and the European commission[6] identified the key factors that characterise training needs within successful SMEs:

- Thinking of new forms and non-conventional forms of learning is important.
- Generic training is less relevant; the ability to contextualise training content is important.
- Anticipation of change should be a permanent concern.
- Adaptation requires a clear analysis of training needs and should be aligned with strategy.

The report identified blended, e-learning and social systems of learning as those most likely to be appropriate and adopted. It was clear that training and skills development are important indicators of success within SMEs, and are especially so during times of rapid change.

CASE

My New Business is a new web site developed by Business Link which provides start-ups with the core educational support they'll need to succeed in the first 18 months of trading. It has over 200 specially-commissioned videos and e-learning courses on a wide range of start-up topics, including business planning, finance, marketing and tax. The site represents one of the biggest government-backed online learning initiatives of the past ten years.

Thanks to e.learning age magazine for this case study

1.4 Young people, jobs and skills

As for the skills of the young people who will enter the labour market, the picture is mixed. University enrolments have risen in the past decade, and approximately 40% of all school leavers now go on to higher education. Yet of the majority that do not, about half leave school with no qualifications at NVQ Level 2 or above. More than 100,000 young people each year reach the age of 19 (that is, between a quarter and a third of all young people) either outside employment, education or training, or having followed courses that offer no route to higher levels of education or the prospect of skilled employment[7]. The CBI is not alone in being disturbed by this:

"…it is essential that schools and colleges ensure that young people enter the labour market with a strong grasp of basic skills. Employers do not expect everyone to arrive at their door 'job ready', but at the very least they want young people who are literate and numerate and who have good employability skills. Problem solving, team-working and time management skills are a necessary part of employment, and business will often consider these qualities to be as important as exam results and formal qualifications. Improving these skills was employers' top priority for the education system." [8] Richard Lambert

This sharply divided flow of people into the adult population has a cumulative effect: at least seven million people of working age (some say as many as 16 million), in and out of work, are very poorly or wholly unqualified at a time when it is estimated that half the new jobs require tertiary or upper secondary education. And this is not just a matter of formal qualifications, nor of those who have not studied at university:

"Over two thirds (68%) of employers are not satisfied with the business and customer awareness of school/college leavers, with 57% unhappy with their time management skills." [9]

We must not blame young people, or the education system, for job losses caused by a recession that was out of their control. The rising level of youth unemployment is the result of macro-economic factors, outstandingly mistakes of financial management and economic policy. But employer criticisms of the way young people leave the education system lacking employability skills predate the recession. What is more, in relation to international competitors, the performance of the UK pupils in key areas such as science and maths seems to have deteriorated over the last 25 years[10]. Economic recovery will be easier, and competitiveness enhanced, with a workforce stronger in skills and motivation.

1.5 Vocational education

The vocational education system, that is, provision organised in FE colleges, by employers, and by work-based learning providers, contributes very strongly to the social and economic fabric. Most 16-19 year-olds in full time education are in colleges, not schools: and many colleges and private trainers have strong links with employers and the labour market. Their major contribution is, of course, in vocational courses, but employment-focused work is not the only direction. Hackney College shows, "the proportion of NEET young people in Hackney has reduced from over 13 per cent in 2008 to 4.7 per cent in 2011/12"[11]. But this does not mean that the system functions smoothly or effectively overall. Alison Wolf argues that this is partly because of how funding flows to providers:

"In the last ten to twenty years, part of the problem has been that it's been a supply driven system, with providers signing contracts to deliver this or that amount of provision. Output-related funding systems of this kind are incredibly distorting. I don't think in Whitehall they begin to understand just how deep the distortion has been." Alison Wolf. [12]

The assertion that funding is biased to the supply-side is contentious. College Principals and private trainers pointed out to us that their budgets are strongly

driven by enrolments, and government funding is only available if clients, adults and young people, choose to join their provision and stay on to success. However, the funding system has been frequently changed, and has been criticised for its distance from employer needs and the labour market. And this is not the only problem. The (English) vocational education system sits within a very complicated and frequently-changed organisational and regulatory framework:

"… the period since the 1970s saw the inception of the Manpower Services Commission, its dissolution and the creation of Training and Enterprise Councils (TECs), the creation of the Further Education Funding Council (FEFC – taking control from the local authorities) and the amalgamation of FEFC and TEC into the Learning and Skills Council in 2001. The LSC underwent several high profile internal reorganisations (and was then) replaced by the Skills Funding Agency, the National Apprenticeship Service and the Young People's Learning Agency." [13]

"Time and again in recent years, England has experimented with unique and uniquely complex regulatory arrangements. None of our developed country peers operates with anything like our multiple, over-lapping agencies. The experiment has been a failure. Major changes are needed that will simplify the system, clarify decision-making and increase transparency, and which will replace a huge and ineffective regulatory system with a much smaller and more effective one concentrated on a number of key activities." [14]

This framework is shown in Appendix 3, which one insider described as 'like the wiring diagram of a power station'. Worse, policies are frequently changed, based on ideology or personal experience, and distanced from evidence. As Frank Coffield put it in his coruscating 2006 inaugural lecture at the Institute of Education:

"Charting the impact of government policy on practice has not been, however, a simple matter of recording linear, evolutionary, coherent or cumulative progress. …. Policies have not only evolved or been radically altered, as Secretaries of State and senior civil servants have come and gone, but some polices were abandoned, while others were from the start internally inconsistent or flatly contradicted existing policies … The mental image suggested by these structural arrangements is of three well-intentioned but dyspraxic and myopic elephants, who are constantly bumping into each other and standing on each other's feet instead of interweaving smoothly in one elegant dance." [15]

There is a further problem. There is huge diversity and fragmentation within the vocational education sector itself, with even the largest individual providers being small when compared with major employers. Especially with the current policy focus on increasing competition between providers, and on giving them greater autonomy and independence, there are inherent biases within the system against procuring at scale on a joint basis, a situation aggravated by the fact that many of the UK's e-learning suppliers are themselves also small.

The landscape will not become simpler. As a result, Ufi will need to shape recommendations that are relevant to, and allow it to operate alongside, several organisations with similar, related, overlapping, or complementary aims. These include the following:

- An enormous network of private and public providers, with literally millions of learners.
- Government organisations like the Department for Business Innovation and Skills, the Department of Work and Pensions, and the Prison Service, deploying billion pound budgets.
- Funders of innovation like Nominet Trust and Nesta.
- JISC, which describes itself as 'the UK's expert on information and digital technologies for education and research', and the JISC-funded services that it controls.[16]

- Major foundations with a focus on education like the Bill and Melinda Gates Foundation.
- Not-for profit organisations with an exclusive or strong focus on learning technology – typically charities or community interest companies. Examples include the Association for Learning Technology (ALT), the Charity Learning Consortium, the eLearning Network (eLN), and Towards Maturity.
- Organisations (some private, some public) that are key players (internationally or nationally) in the deployment of learning technologies. Examples include learndirect, major Internet businesses like Facebook and Google, learning providers or awarding bodies that make extensive use of learning technologies such as the Open University, OCR, City & Guilds, the Wikimedia Foundation, and the Mozilla Foundation[17].
- Organisations with remits that are particularly relevant to the aims of Ufi such as NIACE, the National Extension College, and the mainly DfE-funded National Centre for Excellence in the Teaching of Mathematics (NCETM).

This is a wide range of organisations and the degrees of overlap are varied and substantial. It creates a challenging backdrop against which Ufi must operate, and sponsor radical change in delivery and demand. Ufi will need to manage its relationships in a strategically astute way if it is not to waste effort and/or miss opportunities (or cause others to do either). But the agencies and organisations are just one aspect of the delivery system. We must also consider the technology context, and the users themselves – the adult learners. It is to these themes that our report now moves.

1.6 Adult learners and adult learning

Public debate about vocational education and skills often concentrates on young learners – apprentices and school leavers. But the vast majority of the labour force is made up of adults who are in jobs – or unemployed – now. If we are to use digital technologies to make a step change in skills, our solutions must reflect the particular needs of this population. They must take account of the fact that learning is only one small part of what adults have to contend with. Complex lives and pressures of work mean there is plenty to be getting on with without having to undertake formal study. It is no surprise that formal learning is much less central to the lives of adults than young people.

The proportion of time spent in formal learning is small, dropping from around 18% when of school age to a tiny percentage of waking hours when adult. There is also clear evidence that opportunities to take formal training later in life are linked to earlier educational attainment: it is those who already have high level qualifications who get the bulk of the chances to raise their skills and income. If we are to make an impact on this situation, increasing participation and raising skills, we must understand what can motivate the adult learner. We must particularly recognise the importance of informal learning, even though much of the research on learning is concentrated on formal learning.

Those who have studied this topic believe that, given the right approach, adults can be highly motivated to learn. The latest research on motivation[18] indicates that our strongest motivators are intrinsic:

"When it comes to motivation, there's a gap between what science knows and what business does. Our current business operating system – which is built around external, carrot-and-stick motivators –doesn't work and often does harm. We need an upgrade. And the science shows the way. This new approach has three essential elements: (1) Autonomy – the desire to direct our own lives; (2) Mastery –the urge to get better and better at something that matters; and (3) Purpose –the yearning to do what we do in the service of something larger than ourselves."

In *The Adult Learner*, Malcolm Knowles describes how, as a person matures, their:

- self-concept moves from being a dependent personality to a self-directed one;
- growing experience becomes an important resource for learning;
- time perspective shifts from one of postponed application of knowledge to the immediacy of the task at hand;
- motivation to learn comes from within.

Adult learning can and should build on these basic motivators. But, of course, adult llearners are not a homogeneous population, as Aaron Sloman[19] reminds us:

"Has anyone got a good understanding of how many types of adult there are? Different people can do different things. Different people are interested in different things. There are people who know what they want, and just need help doing it. There are people who have no idea what they can do and who could be inspired to want something new, which is currently way beyond anything they ever think about. We need to offer different options and resources to these different sorts of learners."

There are many areas in which technology can be applied to vocational learning, but perhaps the most pressing is adult numeracy and literacy. According to the BIS 2011 Skills for Life Survey[20], in England and Wales the number of adults with literacy at level 2 and above is 56% (up from 44.2% in 2003) and at level 1 and above 85.1% (2003 83.8%). The picture for numeracy is less encouraging. Those at level 2 and above are just 21.8% (down from 25.5% in 2003), with 50.8% at level 1 and above (2003 53.1%). These figures come to life when you consider that adults with skills below level 2 may not be able to compare products and services for the best buy, or work out a household budget.

Those with skills below Level 1 may not be able to read bus or train timetables or check the pay and deductions on a wage slip. This is not just a matter of the competencies needed in our personal lives:

"Employers frequently cite the need for (improved) reading, writing and maths skills in the workplace, and report a significant gap between the skills levels of employees and skills needs in the workplace … There is growing evidence that gaining literacy and numeracy skills in adulthood has a positive effect on earnings and employment"[21]

And, of particular significance to this study, the report tells us that:

"There has been relatively little funded work on the development of software and new e-learning techniques for adults in this field. Robust trials are required to clarify which are the effective practices in using technology for different groups of learners, and for different types of learning outcome."[22]

This is important. We believe that new learning technologies are particularly suited to providing adults with the autonomy which they crave, making it increasingly possible for them to learn what they want, when and where they want, and with whom they want, and with an emphasis on practical skills which can be applied to current real-world tasks.

1.7 Technology landscape

Our belief in the importance of digital solutions stems in part from the extraordinary technical advances in computing that are transforming social, academic and business life. The first programmable computer filled a room at Bletchley Park: we now have devices of similar or greater power in a runner's shoe.

Mobile devices herald the fifth major cycle of innovation in computing in the last fifty years – from mainframes to minicomputers to personal computers to laptops to mobile devices like phones and tablets. Each wave of innovation depended on improved connectivity, and we have now reached the point where communications

networks cover most of the globe. More and more physical objects have their own in-built computing capability and are becoming networked: by 2015 it is predicted that there will be 10 billion mobile devices, that is, an average of 1.3 devices for every person[23].

Open and free operating systems such as Linux and Google's Android co-exist with proprietary and commercial software and "tethered"[24] devices such as iPads.

Behind the scenes there are fundamental and pervasive shifts in how computing power is bought, sold, and distributed, so that users can now rent as much or as little computer power and storage as they need by the hour, day or week, at low cost, without the need for capital. This is referred to as 'cloud computing' and is transforming how technological capability is procured. The result is that start-ups can challenge long-established organisations in the development and provision of new digital services and products without the need for large capital investment.

"It's pretty clear that there's an architectural shift going on. These occur every 10 or 20 years. The previous architecture was a proprietary network with PCs attached to it. With this new architecture, you're always online, every device can see every application, and the applications are stored in the cloud." Eric Schmidt, then CEO of Google, 9 April 2007, interviewed in *Wired* magazine.[25]

There is concern that some sections of society are unconnected, through poverty, geography, lack of skills, or personal decision; they will miss out on the commercial and learning opportunities offered by the new digital world. This concern may be exaggerated, but should not be ignored, for while we live in a world in which financial transactions in Asia and crop sales in Africa are carried out using mobile phones, data from the Oxford Internet Institute[26] shows that, in the UK, only 31% of those with no qualifications use the Internet, compared with 80% of those with basic, further or higher qualifications. However, over 60% of those who are unqualified, and do not use the Internet, are 65 or older. Essentially, it is mainly older citizens who do not use the Internet.

Technology shifts of this size have economic and social consequences, for good or ill. Open data and open content are forcing changes in the now overlapping publishing and digital media industries. Some predict the death of the traditional newspaper, and local book shops are already under threat. Billions of people world-wide now find and use online content, make purchases via the Internet and use social networking services. Hundreds of millions play online games and simulations for hours per day. The new technologies are changing the nature of many jobs, putting at a premium the need for citizens and employees to be computationally- and data-aware. As Douglas Rushkoff asserts: "programme or be programmed"[27].

Educational organisations are not exempted from these changes, and need to rethink their way of working. There are the first signs of change, courses that run internationally, wider access to learning materials, college and university intranets and virtual learning environments. Useful initiatives have extended the use of IT in teaching and learning, like the JISC-funded, Creative Commons-licensed Hairdressing Training web site[28], and some innovative institutions, like the Open College of the Arts, or The Sheffield College's Online College, are based around digital solutions.

But in general, despite the best efforts of agencies like JISC and Becta[29], schools and colleges use forms of organisation and delivery that are recognisably the same as in the 1940s and 50s – classroom delivery, annual enrolment, standard courses, fixed terms and assessments. They must recognise that the Internet is now the first port of call for those looking to learn. For millions of informal learners and hobbyists, connecting to collaborative spaces on the Internet and researching tips and advice is a very natural activity but it is rarely incorporated well within formal learning. Worse yet, we often actively dissuade such activity, for example, by banning the use of mobile devices in class. This is an extraordinary waste of potential:

"At NEC we were always worried about the loneliness of the long distance learner, the isolation. However, they can be more in touch (through social media), than if they were at a local FE college." Ros Morpeth[30]

1.8 Conclusion

Let's take a moment to summarise where we have got to. Our economy and society face major and enduring challenges. Unemployment is high, reflecting not just a nationally austere economic climate, but continuing differences in regional prosperity and productivity. Major companies and government departments are aiming to reduce costs, often by substantial workforce reductions. Our vocational education system makes an important contribution to skills and social cohesion, but it lacks innovation and is trapped within tight budgets and a turbulent policy environment. Young people often leave formal education with inadequate skills, and many older workers lack adequate literacy and numeracy. Lifelong learning is often trumpeted as the solution to these problems, yet evidence suggests that adults have little time to spend in formal learning.

But what we know of adult learning, and of the potential of new technologies, can move us away from despair. If providers can respect the values that adults seek in learning – a sense of control and autonomy, choosing a skill that matters, and the ability to make a contribution to society – the motivation will be there. New technologies can offer the choice and freedom that adults seek in their learning. It is already supplying what is needed in the informal arena, through social networking, in information seeking, using Internet searches, specialist sites and more general ones such as Wikipedia and YouTube, and in commercial transactions as online purchases grow. It seems obvious that this extraordinary technology can be mobilised to meet our training and skills needs. But the fact is, it hasn't: the record, despite some outstanding pioneering work, has been disappointing.

The next section moves to considering the potential and the barriers. We report on our discussions with a wide range of interested parties as we look to see what is stopping the wider use of learning technologies, and suggest how we might build greater capacity to respond. We investigate how to find ways whereby the current system might transform its offer. This is important because this system has, after all, contact with the largest group of learners and maintains a grip on the bulk of the learning budget. We consider the issues that surround our learning infrastructure. But we also suggest investigating new models of learning, and new ways to build capacity.

2 Findings

2.1 Opportunities and barriers

In this chapter, we set out the major findings from our online questionnaire, in-depth interviews and desk research. In particular, we have tried to establish where there are significant opportunities for a step change in vocational learning in the UK and where there are barriers that get in the way.

Online questionnaire

In total, 142 people responded to our online questionnaire. Respondents were asked to comment on the impact that they believed different types of initiative would have on achieving a step change in learning and employability for adults. All the options that we presented were well-supported; however, the following were supported particularly strongly:

- Disseminating good or best practice.
- Strengthening the learning technologies practitioner and research fields overall.
- Influencing the Government to ensure that inspection, audit and funding regimes are supportive of (or are at least neutral towards) technology-supported learning.
- Supporting both larger and smaller scale trials of methods and approaches.

We asked respondents to indicate the extent to which they agreed with five assertions about how Ufi might target its resources. Two options were supported very strongly:

- **Concentrate on projects that are likely to act as catalysts for much larger-scale programmes** (3.91)[31]. This point in particular has had a major impact on our recommendations, not least because, though the funds available to Ufi are substantial, they are a drop in the ocean in comparison with the total amounts invested in vocational education and training. For Ufi to bring about a step change, it is therefore essential that an emphasis is put on interventions that can act as catalysts for much more significant large-scale action, that has an impact on tens of thousands of learners and more.
- **Focus on new and alternative channels for vocational education and training, rather than hoping only to have a major influence on the traditional channels** (3.82). This result may be considered surprising given that 48% of respondents indicated that they were working for a learning provider. It has influenced our recommendations to the extent that we have included several suggestions for interventions that challenge the *status quo* of learning provision.

We asked respondents to rate twelve developments in learning technologies that could provide significant opportunities for advancements in vocational education and training in the UK. There was **very strong** support for:

- capability building, to address the skills gap in the application of learning technologies;

- promoting the use of mobile technology.

There was also **strong** support for a number of other categories of intervention including:

- using technology to achieve process improvements;
- promoting learning in the cloud;
- exploring the potential for intelligent and adaptive tutorials;
- using technology for scenario-based learning, large scale simulations and multi-user games;
- encouraging learners freely to adopt any learning programme of their choice, formal or informal, in preparation for formal assessment;
- using technology to make apprenticeships more efficient.

Interestingly, there were no discernible differences in questionnaire findings on the basis of sector (public, private, voluntary/charitable), functional role, size of organisation or level[32].

In-depth interviews

We carried out 36 in-depth interviews with researchers, business people, learning professionals and civil servants[33] to discover what they saw as the potential of learning technologies in education and training, and what they saw as the barriers to uptake. These interviews helped us refine our thinking on both problems and solutions, pointing, for example, to the scope and need to tackle the adult numeracy problem (more so than literacy) with learning technologies playing a key role, and highlighting opportunities for interventions as well as some particular cautions. The remainder of this chapter is devoted to a fuller exploration of our findings.

We have organised our findings under four key themes:

1 **Capability-building and advocacy:** The need to develop the skills of learning professionals in general and learning technologists to take advantage of the opportunities afforded by new technologies. Also the need to increase awareness among decision-makers of what it is possible to achieve.

2 **New models for the organisation of learning:** The possibility to break-away from centuries-old educational practice and to take advantage of techniques such as peer support and assessment, 'flipping the classroom' and separating learning from assessment.

3 **Interaction and immersion:** The potential to exploit the power of computers to provide Increasingly immersive, engaging and personalised learning experiences.

4 **The learning infrastructure:** The opportunity afforded by major technological advancements, including cloud computing and the increased sophistication of mobile devices.

In each case, we explore in some detail the ideas and insights expressed by our interviewees and questionnaire respondents and then conclude with a summary of the major opportunities that exist for improvements to vocational learning and the major barriers to taking these further. These opportunities and barriers then serve as the basis for our recommendations as described in chapter 3.

2.2 Capability building and advocacy

A skills gap in learning technologies

Any teacher or trainer embarking on a new career in 1980 would have had a

relatively limited set of technologies available to them, predominantly extensions of the blackboard invented in the 18th Century and essentially ***teacher-led***: whiteboards, flip charts, overhead projectors, 35mm slide projectors, perhaps also early VCRs and TV. Whether the teacher or trainer was likely to be classroom-based – which was probably the case – they would have expected to learn how to use all these tools confidently.

In the 32 years since then the relentless march of computer technology, supported by ever-greater Internet connectivity, has led to an big increase in the range of available learning media, many ***learner-led***. These developments provide substantial opportunities for making learning more flexible, accessible and efficient. Unfortunately, at some point during this period, those responsible for the training of teachers and trainers decided that it was no longer necessary for learning professionals to be fully conversant with all the tools of their trade[34]. The application of learning technologies became a job for specialists, rather than a core competence. Inevitably, a skills gap has developed, leaving many learning professionals lacking in confidence with new technologies, a problem that is amplified by the fact that their students increasingly feel no such inadequacies.

Towards Maturity is a community interest company that provides tools that allow UK organisations to benchmark their experiences with learning technologies against their peers. In their 2011 survey, they asked what the major barriers were to the implementation of learning technologies. Top of the list, identified by 62% of 512 respondents, was 'lack of knowledge about its potential use and implementation', followed, at 61%, by 'lack of skills to implement and manage learning technologies'. These figures were nearly identical in the previous year. As a comparison, shortfalls in learner ICT skills were identified by only 30% of respondents.

Laura Overton, Chief Executive, Towards Maturity, comments "the willingness of learning professionals to try new things has probably tripled since 2008. But what has also been noticeable for us is people's confidence in trying new things, which appears to have halved in the same period – and I think one of the reasons is that technology's been changing so much."

The importance of capability building was emphasised in the results from the questionnaire conducted for this study. When asked to assess twelve possible opportunities for advancements in vocational education and training in the UK, capability building was ranked first by respondents from every sector –private, public and voluntary/charitable. The following comments by questionnaire respondents are typical:

"The very low level of staff ICT skills across the adult learning sector will make a move towards technology-supported learning difficult to implement." John Ellison, Leicester Adult Skills and Learning Service

"(What is needed is …) professional development for practitioners to build confidence and competence in using technology-based content and assessment tools." Denise Morgan, Wide Bay Institute of TAFE

"The greatest constraint is the lack of ICT skills among tutors and managers in learning providers. ICT competence should be compulsory in all levels of teacher training. The second issue I would highlight is insufficient understanding of new pedagogies enabled by digital technologies among leaders." Martin Sepion, JISC RSC London

What skills are missing?

If learning technologies are to be successfully applied, a wide variety of skills are required. Not every learning professional needs all these skills, as much depends on the sector in which they work, the responsibility they have for decision-making and their role in analysis, design, development and delivery. The list that follows illustrates the diversity of the skill-set[35]:

Underpinning knowledge:

- Know about computers and how they work.
- Know about the Internet and how it works.
- Know about the theory and practice of adult learning.
- Know about learning technologies.

Strategic skills:

- Analyse strengths, weaknesses, opportunities and threats with regard to the use of learning technologies in an organisation.
- Establish an overall strategy for the use of learning technologies.
- Determine skills gaps with regard to learning technologies and make plans to overcome these.
- Determine gaps in the technical infrastructure and make plans to overcome these.
- Analyse the sources of resistance among key stakeholders and make plans to overcome these.
- Develop a marketing plan to support the learning technology strategy and to maximise take-up.
- Evaluate the effectiveness and efficiency of the strategy.
- The top-level design of new curricula and programmes:
- Analyse the learning requirement, target audience characteristics and the practical constraints and opportunities.
- Select effective strategies and methods for each key stage / element in the intervention.
- Select learning media to efficiently deliver each of these methods (including learning technologies where appropriate).

Content creation skills:

- Project manage the process of content creation.
- Design digital learning content.
- Prepare the written and spoken elements of the content.
- Prepare interactions and test items.
- Source audio-visual assets.
- Use software tools to build content.
- Test and refine content.

Facilitation skills:

- Facilitate live online sessions using web conferencing tools or in virtual worlds.
- Set up and manage learning interventions in virtual learning environments (VLEs), learning management systems (LMSs) and other platforms.
- Design and facilitate individual and group online learning activities.
- Provide coaching and support online.
- Curate digital content.
- Employ technology effectively in the classroom.

Addressing the skills gap

The skills gap exists for both full-time learning technology specialists and the learning profession as a whole. Perhaps the most common full-time specialist role is that of learning content designer (what in the US is called an 'instructional designer'). Learning content designers work in bespoke e-learning development companies and in specialist teams in larger workplaces and universities. Although there is an important theoretical underpinning to this role, design skills take a long time to develop and novices benefit most from extended coaching and continuous exposure to different approaches and perspectives. Currently there are few, if any, courses that offer this kind of approach. Many employers believe that they can train designers in two days, which might go some way to explaining the poor quality of so much e-learning. Although there are more prolonged post-graduate courses available, these tend to focus on applications within the formal education system and on the facilitation of online distance learning, the first of which is not as relevant for workplace learning. The UK has a proud heritage in the design of interactive learning content stretching back some 30 years – perhaps only the USA can boast more expertise and experience in this sector. Yet, as demand increases for greater use of learning technologies, particularly in the workplace, there is an inadequate supply of new designers ready to meet the need.

There is a danger, however, in concentrating expertise in learning technologies in a relatively small band of specialists. The whole learning profession needs to be engaged with new technologies if they are to make sensible choices about methods and media, take advantage of opportunities for efficiencies, and protect their own long-term career security.

"If I was going to fix the situation with vocational learning, I would start with the skills of learning and development professionals," says Laura Overton. She'd look for new and innovative ways to build skills and confidence and for learning professionals themselves to experience new ways of doing things.

Increasing awareness of what's possible

All key stakeholders, from learning technologists to decision makers to learners themselves, can benefit enormously from a greater awareness of what it is possible to achieve with learning technologies. While some educational resources are open and easily accessible, the majority remain hidden to all but their immediate target populations. There are certainly signs that barriers are coming down:

- *eLearning Network*, a community for those interested in workplace e-learning, shares best practice through its conferences, webinars and blog.
- *Association for Learning Technology*, the members of which tend mainly to be based in education, disseminates best practice through its conference, journal and webinars, and runs a successful peer-based certification scheme for learning technologists.
- *e.learning age magazine*, which runs the annual E-Learning Awards, is now running webinars in which award winners can present their successful projects.
- *Towards Maturity* has published more than 100 case studies of successful e-learning projects.
- *Learning Technologies conference* and its associated online community, the Learning and Skills Group, runs a highly-successful webinar series aimed at spreading good practice.

All of these efforts are proving worthwhile, although hampered in many cases by lack of funding. One also gets the impression that these groups tend to 'preach to the converted' and that the majority of learning professionals and senior decision makers remain largely unaware of the potential benefits (and pitfalls when poorly

applied) of learning technologies. Charles Jennings of Duntroon Associates and former Chief Learning Officer for Thomson Reuters claims that "We just haven't been bold enough and shouted our successes from the rooftops." For Donald Taylor, Chairman, Learning and Performance Institute, the greatest thing preventing the truly pervasive impact of learning technology in the workplace is "organisational cultures which say, 'learning takes place in the classroom when you're being instructed like you were at school.' The greatest step-change we could have towards having learning technologies exploited properly is for managers, executives and learners to all understand that they can learn wherever they are, whenever, using a range of technological tools. And that it's a good thing."

Learners are also important stakeholders and they need to be convinced, as much as anyone, that learning with technology can be both productive and enjoyable. Gareth Davies, of FrogTrade Ltd, explains: "The issue will be getting people to engage with the learning technologies. Just because technology can and does make an impact, it doesn't naturally follow that people will rush to use it. In our experience, the system needs to be fun to use before anything else – if it isn't on a par with the computer games and systems they use at home, people don't engage with it."

And some learners will not have enjoyed their first encounters with e-learning. Lesley Price, from the eLearning Network, laments the fact that "in the workplace, many people have had bad experiences of e-learning where the content is essentially just 'paper behind glass' and was not interactive or engaging. This negative experience makes them reluctant to engage again."

Most of all, we need initiatives that reach out to senior decision-makers in language that they understand. So much of the conversation in learning technologies can be viewed as an echo chamber, in which everyone agrees with each other about how great it all is. If it really is great, it can be expressed in terms of real returns and efficiencies.

Charles Jennings explains that implementing any major transformation has to be both bottom up and top down. "You do some short, sharp proofs of concept and make sure that you get it right, but at the same time it's never going to fly unless you get senior, senior leaders enrolled." Don Taylor agrees: "The people who really have to be convinced are managers and executives. Because they're the people who decide what people do when they're at work. Consciousness-raising is where it's at. Priming demand."

Conclusions

There is a clearly-identified skills gap among teachers, trainers and other learning professionals. This gap is a major obstacle to a step change in vocational learning in the UK. We believe the opportunity is there to engage the learning professions as a whole with technology and obtain their wholehearted enthusiasm for change. As long as teachers and trainers believe they are not equipped to contribute to this change, they will more than likely be obstructive, rather like turkeys which are, understandably, reluctant to vote for Christmas.

A lack of capability is a major barrier to the application of learning technologies. Not only do the learning professions as a whole need to engage with technology, but those who are specialist learning technologists need to continue to develop their skills. Many of the recommendations that we make in this report require new ways of thinking and new specialisms – without the support of a highly skilled and motivated community of learning technologists, we will not be able to take advantage of the opportunities.

A lack of knowledge of what is possible is another major barrier. There are plenty of great examples of the use of learning technologies in FE, by private training providers and in the workplace. Decision makers need to be made aware of what is possible, not just in terms of efficiency savings, but in the potential for more effective

learning at an unprecedented scale.

We address these opportunities and barriers in our recommendations in chapter 3.

2.3 New models for the organisation of learning

A recurring theme arising from our interviews was that the delivery models that underpin formal educational practice have not significantly altered in over three hundred years. It has been observed that a university professor or school teacher from the 18th Century would recognise and feel comfortable with current educational practices. Where there have been innovations, these tend to have centred on efficiency gains:

"We are stuck in a mind set in terms of how we deliver training. Basically, we need to impart learning to the individual. And it's from us the expert to that individual. To date technology has been used just to automate that process. And I think that's really causing us some problems," says Laura Overton of Towards Maturity. She thinks that small successes in automating learning have "stopped us innovating, pushing the boundaries and taking risks in using technology to actually transform the learning process, rather than just automate it."

Technology has been used extensively to collect information to measure and compare institutions, courses and student performance. The Further Education and Skills sector in particular has been asked to provide complex returns that have changed annually. An example is the Individual Learning Record (ILR), a replacement and simplification for the Individual Student Record (ISR), which has 103 fields of student information. As a result, we have no shortage of data, league tables and statistics that detail the failure of the system to deliver much in the way productivity gains over the last 20 years. Indeed, there was a comment in our questionnaire that the data collection and funding systems themselves are a barrier against innovation.

Across the FE sector there has been a long-term downward pressure on the number of 'guided learning hours' that funders have been willing to support for any particular course. This has had some beneficial impact on the cost-effectiveness of the system, albeit at the expense of teachers working harder. But it has also tended to lock in traditional teaching and learning methods, mainly because the audit regime has required learning providers to prove that there has been face-to-face contact between learners and teachers equal to the number of guided learning hours that are funded.

Providers who have considered organising asynchronous provision (where learners and teachers are separated in time and space) have tended to be put off by the prospects of more intense audit scrutiny. And provision where the teaching is embodied in the technology (exemplified by the Khan Academy or Udacity) might well not be funded at all. For these reasons the FE system has tended to see TEL as an enhancing 'bolt-on' rather than a core method for providing courses.

A key question to be answered is, are there alternative educational processes that, if adopted ***en masse,*** are capable of improving the attainment levels of students? In *The 2 Sigma Problem: The search for Methods of Group Instruction as Effective as One-to-One Tutoring*[36] Bloom demonstrated that the average student's attainment level could be improved by two standard deviations against a control group that was taught using conventional instructional methods. Bloom achieved this step change using mastery learning[37] and one-to-one tutoring, observing that 90% of the study group achieved the same level in summative assessments as 20% of the control class.

Bloom realised that one-to-one tutoring would be prohibitively expensive for most societies. However, he conjectured that a combination of several altered variables when combined with process change could result in a similar performance improvement. He then identified and measured the importance of teaching

methods, instructional material and home or peer support.

New tools provide new ways of doing things; however, new tools in and of themselves are not enough. For a step change in effectiveness to occur, we need new delivery models that take advantage of the new affordances. Dylan Wiliam, Emeritus Professor of Educational Assessment at the Institute of Education, University of London, provides an example: "One of the things that technology can do which whole-class teaching can but rarely does achieve, is the engagement of the individual. With technology it's very easy to create that sense of engagement. Another powerful thing about technology is that it enables you to constrain the environment in ways that make people focus on the intended activity. So online environments can create a way of structuring the activities of the individual to make it more likely that they achieve the intended learning outcomes."

Education and training have so far been remarkably unchanged either by the 'powerful things' referred to by Dylan Wiliam, or by the computing-based 'architectural shift' that has changed fundamentally the way in which knowledge is created, mediated, accessed and acquired. Professor Sugata Mitra explains: "If we let Google into the classroom and the examination hall, the education system will have to change. Responsible teachers will show us the way. We don't have to MAKE the system change, but we can LET it change by itself."

Didactic exposition continues to be a common teaching or training method, despite the long-standing evidence that it is ineffective. Arnold Arons (1997)[38] points to the "unwelcome" truth that "much as we might dislike the implications, research is showing that didactic exposition of abstract ideas and lines of reasoning (however engaging and lucid we might try to make them) to passive listeners yields pathetically thin results in learning and understanding – except in the very small percentage of students who are specially gifted in the field."

But changes are afoot. Sebastian Thrun, talking about Salman Khan and the Khan Academy, explains that "what he (Salman Khan) is doing in the grand scheme of things is something that our (AI) class did as well, which is move away from the classroom setting, which has the dogma of a whole group of kids having to progress at the same pace and show in public what they know and don't know. He's moving into more of a tutor setting, where the teacher – in this case mediated by digital media – and the student interact one on one. And that same recipe applied to the AI class. We pushed a little bit further in that we also had a schedule, we had exams; so we had mechanisms to keep students engaged more than he did. But I think all these experiments lead us to an extremely promising direction for education, which I believe can really fundamentally alter the delivery of knowledge."

Interestingly, Thrun has stated that he will no longer lecture at Stanford and the President of Stanford himself claims that: "lecture halls are a thing of the past." He predicts the death of the lecture as university education moves online[39].

In this section we explore some major changes to the underlying models for the organisation of learning.

Peer-supported learning and peer-based assessment

Peer review has been central to ensuring the validity of research for several centuries. Wikipedia has been constructed though the efforts of large numbers of contributors reviewing and critiquing each other's work. The same is true for Open Source software, as Eric Raymond, author of the influential essay *The Cathedral and the Bazaar*[40], makes clear: "Open-source peer review is the only scalable method for achieving high reliability and quality."

In many respects the social Web, with its rating systems, opportunities to make comments and pose questions, is a huge, peer-review based content engine.

Bloom (see above) showed that peer support, when factored into the educational process in a systematic manner – as good teachers do – has the potential to

improve attainment. Bloom undertook his research in the early 1980s. At that time peer support could only have been feasibly provided within a coterie of peers at a single institution or at a single geographic location, perhaps in the way that Eric Mazur has proven works so very well as a central adjunct to large group teaching: "It's the middle of a class period and two hundred students aren't listening to the instructor. Instead, they're engaged in over fifty simultaneous conversations with their neighbours. This probably sounds like a disaster to many teachers. But it's actually a rousing success: the students are discussing a question which challenges them to think about the material and justify their reasoning to their classmates." [41]

Developments in ICT since Bloom's earlier work have altered what is possible: questionnaire respondents believe that peer-supported learning could have a substantial potential impact[42], and a number of web-based tools are available to support large scale implementations of peer-based learning[43].

We learned during the study of structured schemes that use a combination of blind peer review[44] and competence frameworks[45]. In these schemes, using an online system, learners submit evidence of learning to fellow students one or two grades above them, who then review their work. The role of the teacher is to direct learning, moderate quality and provide guidance and support. This process removes the constraint of a single teacher, through whom all course work has to pass for marking and review.

The approach has its critics, most of who point to the fact that the individual most likely to benefit would be the student undertaking the review work. According to Dylan Wiliam, Emeritus Professor of Educational Assessment at the Institute of Education, University of London: "I have a real problem with the authority of the marking. So I think that when students begin to do peer-assessment it is very important that students blind-mark other students' work. The major beneficiary is the student that does the marking."

There are others who think the approach has merit for those whose work is reviewed also recognise the likely educational value to the reviewers. Dan Buckley, until recently, Director of Research and Development at Cambridge Education: "I think they (the reviewers) gain most benefits to be honest, because of the need to reflect on their learning. For adults the model provides the possibility of coaching skills." [46] Dave Pratt, Professor of Mathematics Education at the Institute of Education, agrees: "Because of the reflection that you have to do in order to teach the subject, you suddenly realise a lot more about the subject than you did before. I imagine that having to mark other people's work in this sort of way would force them (the reviewers) to reflect on the subject in ways that they probably hadn't done before. In fact, according to Piaget, reflection is the key to learning. So in that respect, marking other people's work may be quite powerful."

But, as Dan points out, all learners perform the role of both learner and reviewer in such a scheme. The point was made that, in order to review or explain an idea to someone else, the person doing the explaining had to marshal their arguments and review their knowledge. Several interviewees separately commented that the best way to learn something is to have to teach it. Gareth Dent, CEO, Open College of the Arts, is one: "I could see how that could work to help level-two and level-three students understand precisely what they have gained in terms of critical skills."

Alongside this, peer learning encourages critical thinking, improves learner motivation and contributes to the acquisition of team-working skills.

Peer-based learning and support are also at the heart of the successful and large or very large scale open courses such as:

- the "massive online open courses" (MOOCs) developed by Stephen Downes and others[47];
- the unprecedentedly-large *Introduction to Artificial Intelligence* course organised by Stanford's Sebastian Thrun and Google's Peter Norvig[48].

In the case of the latter, over 2000 students helped translate the course materials into several languages other than English; also, three complementary and overlapping, large, peer-based support networks sprang up, organised by students, in one case using the Open Source Question and Answer system[49], which uses AI techniques to reward and validate (with a system of badges) users and to rank and structure their contributions.

Separating learning and assessment

Questionnaire respondents strongly supported the idea that the separation of learning and assessment, under which learners can freely adopt any learning programme of their choice, formal or informal, in preparation for formal assessment, is a development that could provide significant opportunities for advancements in vocational education and training in the UK.[50]

But there were reservations, if only by implication. Teresa Mullin of KM Training Ltd told us: "My research[51] shows that many vocational learners still require a 'facilitator' to decode the learning they are being exposed to through e-learning. Therefore the extent to which e-learning systems, however, brilliant, can be used will always be limited, particularly at NVQ level 3 and below."

Whilst these kinds of reservations are important, we believe that the underlying idea of separating learning and assessment should be investigated.

An important point to note here is that it would be the *mode of learning* rather than the *qualifications obtained* that would change. This would answer a point made to us by Gareth Davies, of FrogTrade Ltd, who said "The first issue is finding a way of creating credibility for any learning done, particularly with employers".

Sue Pember, BIS Director of Further Education and Skills Investment, expands on this when she states that: "Progress and use of on online assessment has slowed, which is a shame as it has many benefits for learners. The reason for its lack of use is that the general population is worried about the rigour of such a form of assessment. This is an understandable concern and those developing online assessment need to rise to the challenge to make sure online assessment is compatible to other forms of assessment. This is an area where the Ufi Trust could take a lead and start to put more emphasis on the benefits, especially if they wanted to put some of their resources behind it."

We discussed this idea with Mark Dawe, Chief Executive of OCR. He drew a clear distinction between different categories of adult learner – essentially those who have higher levels of self-esteem and self-motivation, whom he contrasted with those who lack confidence, skill, and motivation. In the case of the latter (and typically those who have failed in or been failed by the education system fall into this category), Mark argued, there is usually a need for formal course provisin.

"Scale is a crucial issue as there have been countless small-scale projects and innovations that are not sustainable and do not scale." Ian Chowcat, Sero Consulting Limited

But, for the former category, there may be scope to devise provision in which learners are lightly supported (the term that arose in our conversation was 'chivvied') through a loosely-structured series of learning activities, with a conventional, formal examination provided at the end of the process.

An example of a situation in which this approach might be appropriate is if an under-qualified social care worker needs to get GCSE Mathematics or English in order to go on a nursing course. He or she might sign up for a technology-enabled, supported, self-study option under which the learner (or the State, or a prospective employer) might pay for the 'chivvying' and the accreditation costs, which would be lower than the costs of a conventional taught course. Learners of this kind are likely to be quite thinly spread geographically: the role of technology would be to help them find each other, form cohorts, access resources, and book to be assessed at a big enough scale to ensure viability.

On the face of it, this kind of initiative would benefit from being run in close collaboration with an awarding body.

Learning can be thought of as a spectrum, with an individual, self-organised learner at one end, teaching themselves something personal using freely-available resources on the Internet, through to a group of people getting together, deciding on a formal qualification that they wish to pursue, and finding a teacher to teach them, with or without a face-to-face component. The key consideration here, at either end of the spectrum, is that demand for and orchestration of the learning has a strong 'bottom-up', self-organised component.

Delivering personalised learning

The key features of personalised learning can be loosely defined as: the ability to provide rapid formative assessment, learning material tailored to meet the needs of the individual, and tutoring delivered in a context that reinforces its relevance to the learner.

In our study, innovators in the field reflected on the need to personalise content and delivery mechanisms. Ben Betts, Managing Director of HT2 describes how "there's this perception that we've got to get as much information across to the learner as is humanly possible and they'll remember it all and it will be brilliant. We just seem to have overlooked everything we know about memory and how people learn". We have to move beyond the 'banking' of knowledge. Personalised learning based on your own knowledge, your own capability, your own standing, is being enabled by technology and adaptive learning.

CASE

Dixons has been using technology in learning for the last five years. This fast-moving retailer works with over 10,000 different products, with new ones constantly being added. So, building and maintaining a knowledge base for their staff is a key strand of their strategy to continually improve the customer experience.

Boyd Glover, Head of Learning at Dixons Retail, commented that: "Prior to introducing learning technologies, the organisation relied heavily on a catalogue of classroom courses, but these were costly and time consuming. What we needed was a learning offering that didn't just deliver more for less but could also be more aligned to support individuals on-the-job."

Dixons averages 15 million page hits to their online learning environment every four weeks, with 35% of staff accessing learning at home and via their own devices. Statutory compliance has improved, saving £500,000 in year 1, with a 25% improvement in customer service metrics.

A recent pilot to encourage staff to use video to share their knowledge with their peers has improved results even further increasing the average retail laptop sale by 30%.

Thanks to Towards Maturity CIC for this case study.

Steve Creasy, Head of Project Delivery at Pearson, describes how delivery systems also need to change: "It is of vital importance that we develop resources and methodologies that allow ALL learners to access their learning and development in the most appropriate way, time and place."

It is clear that key suppliers in vocational learning recognise the potential of technology to make a difference. Innovators are experimenting with delivery models that are challenging orthodoxy and re-engineering traditional educational processes.

The 'flip' model

In conventional teaching, class time us used to present and discuss information

with students, who then undertake practical exercises with this information as homework. With the 'flip' model, students acquire new information, using digital learning materials, as homework, and then precious class-time is used for what was previously done as homework: tackling difficult problems, working in groups, researching, collaborating, crafting and creating.

The flip model is not, of course, at all new – blended and distance learning programmes have been using this model for over a century. The critical innovation is the ability to monitor the learner's progress and then provide summary data in a timely manner to the tutor (and the learner!).

The Khan Academy[52] has created numerous short video tutorials on mathematics and other subjects, allowing students to progress at their own pace, with practice exercises before and after each video. As of April 2012, the Academy hosted 3100 videos and with over 150 million tutorials reviewed.

Breaking down a mathematics curriculum into a series of short videos is of itself innovative, but when combined with the ability to monitor a student's progress – thus allowing tutors to identify where the barriers have occurred – we can see an example of (learning) management by exception.

When delivered at scale, such systems allow the use of statistical methods to improve the effectiveness of the course material. We would be foolish if we believed that the model expounded by the Khan Academy on its own will transform our educational systems, and those interviewed in the study suggested improvements, such as the addition of diagnostic tools to provide a 'front-end' to the process.

At the heart of the flip model is a process change, breaking the requirement for a cohort to progress in a linear fashion through a curriculum guided by an expert. The model supports personalised learning, supported by tutor intervention, and provides data than can be analysed in the pursuit of process improvements.

Conclusions

The delivery models that underpin formal education have not significantly altered in over three hundred years. Continuous, incremental improvements to these existing processes are unlikely to deliver the step change that we need. We have opportunities to transform the learning process, rather than just automate it:

- **Peer-supported and assessed learning** allows for major improvements in scalability, reducing the reliance on teachers and trainers, at the same time providing benefits for learners themselves.
- **Flipping the classroom**, whereby the delivery of new learning material is accomplished online using media such as video, and then contact time with teachers and trainers is devoted to coaching and group activities that can not be automated, offers the promise of scalability, as well as greater flexibility for learners.
- **Separating learning and assessment** allows learners to choose their own method of learning, safe in the knowledge that they have an equal opportunity to obtain a particular qualification.

2.4 Interaction and immersion

Why we are under-exploiting the power of computers

Computers have for some time been capable of delivering a high-quality media experience, bringing together text, images, animation, audio, video and interaction in a way that is beyond the capability of traditional media.. Through Internet resources such as YouTube and Wikipedia, not to mention hundreds of thousands of more specialist sites, learners can develop their knowledge of just about any topic imaginable, on desktop PCs, tablets, games consoles and smart phones.

The vast majority of this information is passive: it requires no interaction. While it is

perfectly possible for someone to learn without any structured form of interaction, by taking notes, reflecting with colleagues or practising alone, the outcomes are likely to be uncertain and limited by the learner's degree of metacognitive skill – the extent to which they have learned how to learn. Structured interaction is desirable when the learner's goal is to develop knowledge and understanding, but may well be critical when the need is to develop a new skill.

There's only one way to develop a skill and that is through practice, ideally spaced over time and supported by specific, timely and relevant feedback. Historically this support has been provided in real-time, by teachers, coaches and instructors, whose time and attention was typically severely limited. In the ideal world, learners would have the opportunity to practise as many times as is necessary to develop their confidence in the new skill, in a safe environment (where there is no financial, physical or psychological risk), and with individual attention. For the majority of learners, who cannot afford a personal coach or tutor, this is simply not feasible.

Strangely, in the fields of education and training, the predominant role to which the computer is assigned is as substitute for a lecturer, presenter or textbook. However, what really differentiates a computer from previous technologies, such as TVs, tape and disc players, is, as the name implies, its capacity to compute. This capacity, as predicted by Moore's Law, is growing exponentially. The processing power of a computer is hardly exploited in the vast majority of e-learning materials, in which interaction is often limited to simple multiple-choice questions and navigation between pages. These activities use such an infinitesimal proportion of a computer's processing power as to be almost un-measurable. Yet, as any game player will attest, the potential to engage, to challenge, to immerse and to personalise through application of processing power is enormous. This power can be used to help learners to develop valuable skills when human support is in short supply or is unobtainable through cost or distance.

"For me it's really simple to define good online learning content – it's something that gets as close to what learners need to do in the real world as possible. It simulates a real situation and then gets people to learn what to do in that context. You get past this idea of 'Here's the theory. Let's cross our fingers you can do it for real.'"
Rob Hubbard, Chair, eLearning Network

Simulations

According to Wikipedia, 'a simulation is an imitation of some real thing, state of affairs, or process'. A simulation sits somewhere between the observation of expert performance and trying out those skills for yourself on the job. It enables learners to experiment, make mistakes, experience successes, obtain feedback, reflect and hypothesise. To be effective, simulations need to approximate the situation in which the skill must be applied for real. This requires a degree of physical fidelity (the simulation looks and feels like the real thing) and functional fidelity (it behaves like the real thing). Fidelity comes at a cost (many millions of pounds if you're talking flight simulators or similar, many hundreds of thousands if you're looking to enact a critical incident with multiple players in a virtual world) but cost has, of course, to be balanced against risk.

Computer-based simulations can be used to develop just about every type of vocational skill:

- *Cognitive skills* (problem-solving, analysis, decision-making, calculating, articulating in words, etc.): Examples include the use of simple animated models to allow learners to experiment with mathematical and scientific principles, or business games, that allow individuals or teams to play the role of entrepreneur or business manager. The emphasis here is on functional fidelity – the accurate modelling of real-world processes.
- *Motor skills* (typing, driving, lifting heavy objects, trade and craft skills, etc.): In this case, physical fidelity is also required, which typically requires the creation of special input devices, as developed for the plumbing and electrical courses delivered by Train4TradeSkills or, for full flight simulators, complex control panels and hydraulics.
- *Interpersonal skills* (selling, serving customers, negotiating, providing feedback, etc.): Simulations in this case require some degree of physical fidelity, particularly in the way in which the people with which the learner is interacting are represented.

This can be achieved by simple still images, but more effectively through video or 3D characters. Functional fidelity can be accomplished, with careful design, through conditional branching. The problem comes in assessing and providing feedback on the learner's responses. This is easy enough when interaction takes place by making choices from a list; but much harder if the requirement is to assess what they actually say.

There is nothing new about the idea of using computer-based simulations to aid learning. The potential has been recognised as long as we have had affordable computers, and some excellent examples have existed in all three domains – cognitive, motor and interpersonal – for decades. In some sectors, such as aviation, defence and oil and gas[53], simulations are major business. So why is such an obvious opportunity being overlooked in mainstream vocational education? Here are some possible explanations:

Simulations are complex to develop. While there are undoubtedly many learning professionals with the subject matter expertise to help scheme out a simulation with a high degree of functional fidelity, these people do not necessarily have access to the required software engineering and/or media development skills.

Simulations are costly to develop. While many forms of learning content can be created inexpensively, the same cannot be said for simulations. There is a strong argument for pooling resources centrally to build resources which all can use.

There is limited awareness of what is possible. Although learners certainly know what is achievable, because in many cases they play games every day on their smart phones, games consoles or tablets, learning materials have a much more conservative heritage.

CASE

Train4TradeSkills' award-winning virtual reality system provides electricians, plumbers, carpenters and gas engineers with repeated, safe practice of essential skills. Myra Smallman, a head teacher at Train4Tradeskills, said: "It's just like flight simulation. It allows the student to make their mistakes before they make their way into the big wide world. The beauty is you can be working away just as you would if you were on site but there is no danger of causing a problem for yourself or a customer – this really is the way forward." The system has reduced material costs by £10,000 per class of 30 and cut workshop training time by 30%. One student commented: "It's an easy way to learn. It's more interactive. The concept is pretty amazing."

Thanks to Towards Maturity CIC for this case study

In the view of Conrad Wolfram, Strategic and International Director, Wolfram Research, "The author is setting up a landscape. In the past it was like there was a kind of a railway line laid out through the landscape and they're chugging along and they might take a branch line at some place and go down it. What I'm interested in is giving the learner a four wheel drive and letting them drive wherever they like over this landscape."

Games

A game is an activity with a goal and rules, in which the learner competes against others, real or imaginary, or aims to better their own, previous attainments. A game can involve simulation (such as a business game) and it can use 3D (as with most console games, particularly of the action variety) but neither simulation nor an immersive 3D environment is a necessary ingredient.

According to US motivational guru, Anne Bruce, people who have fun at work

are not only doing their job, they are doing it at a higher level. And what goes for work goes for learning too. “When learning isn’t fun, it’s not learning,” says Roger Schank, author of Virtual Learning[54]: “Listening to endless lectures and memorising countless facts and figures aren’t fun activities. What’s fun is doing.”

CASE

The InterCaz game, developed by Caspian Learning for Interplay Energy, allows students to practise combustion safety scenarios with almost unlimited variability. It delivers certification-quality learning for highly-complex tasks in a tightly regulated area, with successful completion helping home safety engineers to retain their professional licence.

Users start the immersive, 3D, online game outside one of a series of test houses equipped with a set of inspection tools. They take measurements, test appliances and set up sensor tests, logging their results, actions and notes on a virtual clipboard. Fifty different variables can be randomly configured or tailored to the student

Thanks to e.learning age magazine for this case study

Rob Hubbard, Chair of the eLearning Network, explains: “If you need someone to learn something, they need to go over it multiple times. They need to practice it, they need to reflect upon it, think about what they were doing and improve their performance. It’s only through that repetition that people will become truly effective. Incorporating game mechanics – for example some kind of reward or recognition – into learning is a way to encourage people to do that.”

Many readers will agree that the most enjoyable, and the most effective, learning experiences that we’ve had have been when we’ve been able to get stuck into something practical – a project, a case study, a chance to try things out for ourselves. But, according to learning games advocate Marc Prensky[55], effectiveness – let alone fun – is not always the primary driver for trainers: ‘The problem with most companies’ use of learning technologies, from the learner’s point of view, is that they are used today primarily to make things easier for the trainer. Most of what exists so far in terms of web and other technology used for learning is so elementary or old-fashioned in its learning approaches that, apart from remote delivery, it adds little to learning and often subtracts from it.’

Simulations and games, when they’re well-designed, provide the opportunity for repetitive practice. One of the most popular learning games in the early 1980s was a typing tutor fashioned on Space Invaders. As menacing hordes of invaders attacked in the form of letters of the alphabet, your task was to type them out of the sky. The letters came quicker and in tougher combinations, and so your typing improved.

Gamification introduces game mechanics into learning materials that are not primarily designed for entertainment. These mechanics include the use of badges, levels of achievement, leader boards and progress bars. A classic example is KhanAcademy, the online maths education site, which uses extensive gamified elements to keep students engaged and encouraged to complete courses.

For Ben Betts, Managing Director of HT2, “It’s about the art of nudging people into the actions that you think are going to take them further. And games can be quite good at that, at encouraging people to take little actions or do little things that perhaps they wouldn’t have done before. It’s also about knowing how good you are and where you sit in the world and I think games can be used to deliver that sort of information in a in a non-threatening way.”

Motivation is a key element in bringing about vocational learning and any game player can attest to the remarkable motivational capacity of well-designed games.

There is evidence of gamification being introduced into online learning content, but there is still much more to be achieved. There are barriers:

- Learning professionals who were not brought up playing video games may be unaware of the potential of gamification.
- There may be some resistance to the word 'game', which implies a lack of seriousness about the activity. Even the term 'serious game' was not palatable enough for the eLearning
- Guild in the USA, which after much deliberation decided to adopt the term 'immersive learning simulation'.
- Games, as evidenced in the entertainment world, have very high production values, which many learning professionals may regard as unobtainable on limited budgets. Having said that, game mechanics in no way depend on high production values. As Mark Prensky points out: "Eye candy counts a lot less than gameplay in making this stuff effective. Graphics can and should scale – from black and white diagrams to a lifelike 3D animation, based on budget and learning need. The world is littered with beautiful, failed projects, both learning tools and games, yet the graphics-poor Gameboy has sold 100 million+ units."
- As with simulations, there is little awareness of what is possible, or of the tools and techniques needed to incorporate game mechanics into learning materials.

Games have the potential to impact on the problem of adult numeracy, as Vanessa Pittard, Trustee of ALT, and past Director of e-Strategy for Becta, explains: "I think I would invest in the development of some gaming technologies for learning maths, probably at level two. That is to say games-based learning systems that are thoroughly engaging and not trivial competitive games; they should stimulate much deeper learning through real challenges and simulations and help develop a really good understanding of maths concepts. But it would probably cost more than five million."

Virtual worlds

A virtual world is a three-dimensional graphical environment which a learner can navigate in real-time. Unlike a 3D animated cartoon, such as Toy Story, which is pre-rendered into a linear format, virtual worlds go where the user wants to go. Real-time 3D graphics make major demands on computer processing power but modern computers are more than up to the task.

Until relatively recently, it was inconceivable to imagine real-time 3D graphics to play a major role in vocational learning materials, because it took a great deal of technical expertise both to model the characters, objects and environments in 3D and then to develop the software which would render these in real-time and allow users to interact with them. Only the video games industry and those with the resources to develop high-end simulators (such as the aviation and defence sectors) could justify this sort of investment.

While modelling is still a major undertaking, if there was to be greater co-operation and sharing then this barrier could be overcome. Where the greatest progress has been made is in the development of tools, such as UK-based Caspian Learning's *Thinking Worlds*, which dramatically reduce the time it takes to author 3D learning applications.

Three-dimensional graphics are not necessarily 50% more useful than their 2D counterparts but they are certainly more realistic and immersive. Possibilities for 3D graphics in vocational learning include the following:

- Collaborative role-plays that allow learners to interact online in realistic environments such as retail stores and offices. These role-plays are more authentic than any conduced in a classroom. The fact that learners interact through an on-screen

avatar rather than in-person also allows them to participate with less inhibition.

- Simulations that require individual learners to interact with virtual 3D characters. An example would be the British military's use of 3D graphics to have soldiers rehearse their interactions with Afghan civilians.
- Environments which a learner can explore to familiarise themselves in advance with an environment in which they will be required to work, such as n oil rig or power plant.

As yet we have seen little widespread evidence of the use of virtual worlds in training, even though real-time 3D graphics have been used on a widespread basis in games now for 20 years. As with simulations and games, the obstacles appear to be a lack of awareness of the possibilities, expertise and capacity.

Intelligent systems

Our use of the Internet and computers is shaped increasingly by smart software. Take video games, which now adapt their game play in response to a player's actions, or spam filters which work with far greater accuracy than only a few years ago, or speech-recognition and machine-translation systems, whose accuracy can astound. Big strides are beginning to be made, for example:

- Marking software has been developed that is capable of producing scores similar to those given by human markers of written assignments;
- Companies such as Grockit and Knewton, which have developed adaptive learning systems, are gaining large followings of users, as well as substantial investment.

Meanwhile the educational and training establishments are waking up to the potential of 'learning analytics'. Respondents to our questionnaire thought that 'intelligent and adaptive tutorials' and 'personalisation through mass data' will have substantial potential impact.

A particular barrier to successfully creating software that helps learners develop their conceptual understanding is the great difficulty in building a solid proficiency model or map of a knowledge domain. For example, a well-funded team of expert researchers at Carnegie Mellon University developed an effective tutoring system (now called the Cognitive Tutor[56]) for a relatively small proportion of the US equivalent of the Year 10 algebra curriculum. Dylan Wiliam, Emeritus Professor of Educational Assessment at the Institute of Education, University of London, explains: "The Cognitive Tutor has been very well researched and it's very effective. It's probably better than 90% of teachers that are teaching this part of the curriculum. But one of the reasons it is so effective is that its focus is on such a very constrained domain. And it still took the Carnegie Mellon team 20 years to work out what are the knowledge structures that are involved in this domain." In short, whilst the computer science behind the tutoring system is robust and getting even more so, the proficiency models of learners' cognition are neither well developed nor easy to create.

In contrast, adaptive systems that use smart software to help learners navigate better on their learning journeys (sometimes in combination with social tools that support peer interaction) offer a different promise, as companies like Grockit and Knewton are showing. An analogy for this is satellite navigation: to make a complicated and unfamiliar journey by car or on foot, many people now rely on their sat nav. Adaptive systems can provide learners with something of an equivalent, that knows who they are, what they already know, what they've done previously, how their answers compare with those of others, and what they might need to do next. If a learner goes off-track, the system suggests how to get back on course. Learning is more complicated than navigation and even sat navs can get drivers or walkers into difficulties; but the underlying principles and the direction of development are increasingly clear.

Conclusions

By making better use of the power of computers to deliver intelligent and adaptive learning simulations, games and virtual worlds, we provide the following opportunities:

- **Increasingly immersive, engaging and personalised learning experiences**, counteracting the rather poor reputation of much current e-learning content.
- **The ability for learners to practise cognitive, interpersonal and motor skills on their own or in groups**, without the on-going support of learning professionals and without risk.
- **Massive potential scalability, at very low cost per learner**, for those projects that effectively address the skills required by large populations.

We have identified the following principle barriers to taking up these opportunities:

- **A limited awareness** among decision makers of what is possible.
- **Limited expertise among learning professionals**, requiring them to work alongside technical and creative specialists to whom they may not normally have access.
- **The relative complexity and cost of development** may act as a deterrent for smaller teams.

We address these opportunities and barriers in our recommendations in chapter 3.

2.5 Learning infrastructure

The technology landscape

We are in the middle of a technology step change similar in scale and nature to the introduction of the PC in the late 70's early 80's. This is as a result of four major trends:

- The exponential improvement in processing power. Moore's Law[57] has resulted in an annual 60% increase in processing power since 1965 when first stated by Gordon Moore.
- The widespread mass adoption of mobile and smart phone technology combined with third generation packet switched networks (3G).
- The shift from physical servers to virtual servers, where multiple virtual servers coexist on a single physical computer.
- The development of standard software components[58] that can be automatically combined thereby creating complex work-flows at a low unit cost.

When taken together, these four trends are transforming the technology landscape and are as profound as the introduction of personal computing was in the 80's. As is often the case during such shifts, new players such as Amazon and Google are entering the market with innovative service offers constructed from highly-automated business services, and are charged according to use, billable on a monthly basis. Such services are usually referred to as 'cloud' computing and are transforming how organisations purchase and consume IT services.

Moving to the cloud

Cloud computing has been described in many ways, most often as Infrastructure as a Service (IaaS) or Software as a Service (SaaS). At its heart is a business model that removes the need for an organisation to own the underlying capital equipment or software licences and allows them to rent infrastructure or software services by

> **"What we are looking for is ways in which we can get students to engage – engage with the course materials, their tutor and essentially with each other. Cloud services have helped us to do this by moving the focus from building and maintaining infrastructure to creatively combining services to enhance the student experience. I feel we are still just scratching the surface."**
> **Gareth Dent CEO of the Open College of the Arts on the use of cloud services in education**

the hour, month or year without the need for complex contracts.

Organisations no longer need to own or manage their own infrastructure. Cloud computing has taken outsourcing to the point at which all major office productivity tools, that would typically cost organisations around £1,500 per year per user when delivered as a managed service, are now available at £30 per year, and often free to educational and non-profit organisations. Because of the automation and scale, such services are typically more reliable. It is not hard to see why whole school districts, universities and companies are migrating their ICT systems into the cloud.

The move to the cloud underpins services such as Facebook, Twitter, Google + and YouTube, which are used by hundreds of millions every day. The users of these services don't care where their data is stored or the operating system the services run on. An innovative services such as Pearson's Open Class[59], currently in beta, is offering a learner management system capable of being rolled out across a nation, or region, completely hosted in the cloud and accessible from within the institution or from home at no cost.

In our interviews, we heard from small educational organisations that have moved their systems to the cloud with some success.

Collaboration is at the centre of these new cloud-delivered services. The ability for individuals to contribute to a document while physically dispersed is transforming business processes and has the potential to do the same for educational delivery.

The promise of mobile devices

The Morgan Stanley report written at the end of 2009 estimated that there would be 10bn+ mobile devices capable of connecting to the Internet by 2015. The report's definition of mobile device was wide and included devices such as e-readers, car electronics and home game systems as well as smart phones and tablets. If this estimate is correct, the number of mobile devices will be an order of magnitude larger than the number of desktop computers in use.

> **"A lot of our learners, although they live in difficult circumstances, have smart phones, and we're very keen to start using the technology that they're using."**
> **Viv Drake, Lifelong Learning, Skills and Communities Sheffield City Council**

The combination of smart phones with social networks has reached such a penetration that to not be connected would be considered a form of social exclusion by many.
While smart phones are not a complete replacement for a laptop or PC connected to the Internet, their very portability extends a user's sphere of connectivity out of the classroom or workplace into the world. This portability, combined with new functionality, opens up new possibilities:

- Translation software enables us to understand material in a different language and when combined with voice recognition and speech synthesis software provides an embryonic translator.
- Searching for and playing video content that demonstrates a technique or skill.
- The use of GPS capability to provide context-sensitive information about your destination.
- Reading e-books and sharing annotations with others.
- Using software such as Google Goggles to analyse an image and obtain additional information.

These are astonishing and unprecedented capabilities. When combined with access to the Internet and the ability to make and receive calls, we have with a smart phone the equivalent of a digital Swiss Army knife. Projects such as the recently-demonstrated prototype augmented reality glasses from Google[60], suggest that we have only just begun to explore these possibilities. Already, we are completely accustomed to reading manuals, watching 'how-to' videos and accessing data while undertaking any sort of task and this alone has the potential to transform instruction.

Mobile devices have huge potential for vocational learning that is powerful, personal and portable, for use on-site and on-the-job. First we have to get mobile devices into the workplace, as Graeme Arnott, Training Officer at SECTT, attests: "I work in the vocational sector (adults training to be electricians). Many companies have banned mobile phones from work sites. They do not see them as a valuable learning tool. I think that until these employers operate in a culture of e/m-learning, this will be a serious constraint." The opportunities to integrate mobile devices within our vocational learning systems would seem obvious, and yet many of our institutions and training providers require that learners switch off their mobile devices when engaging in learning.

A library in your pocket

E-readers, such as Amazon's Kindle, are increasingly popular as consumer devices but have much impact on education. With a capacity to hold thousands of books, as well as provide annotation functionality, these devices would seem an obvious choice to distribute the total reading material for a course.

Issues of legibility, particularly in bright light, have largely been overcome with the advent of electronic paper displays that have high contrast and low power consumption[61]. These are early days but the trend is clear for anyone travelling on public transport – digital books are for many now the norm.

E-readers, when combined with open educational resources, have the potential to reduce the distribution and production costs of educational material by a factor of 10. Course texts created digitally and electronically-distributed can be printed on demand for a fraction of the cost of traditional text books.[62] They can be annotated, are searchable and can contain hyperlinks to volatile data hosted on the Internet.

Open Educational Resources, Open Access Journals, and digital libraries such as Project Gutenberg hold entire libraries of books that are out of copyright and often out of print, making them freely available, yet these are as yet little used in vocational learning. Said Michael S Hart, the late founder of Project Gutenberg: "One thing about e-books that most people haven't thought much about is that they are the very first thing that we're all able to have as much as we want of other than air."

"Freed of the constraints of traditional factories, additive manufacturing allows designers to produce things that were previously considered far too complex to make economically." The Economist April 2012

Tools commonly used to manage the construction and version control of software in open source projects could be used to compile and distribute text books. FLOSS Manuals[63] is an example of a service that uses collaboration tools and open control processes to allow a group of authors to develop, maintain and publish manuals and instructional material. We can envisage a step change that could revolutionise the distribution of educational texts constructed along similar lines. Such systems can provide educational resources at a fraction of the cost of a current textbook and in a manner that would allow every student to have a digital copy for free and a printed copy of their own at a marginal cost.

We are already beginning to see action to take advantage of these opportunities. The legislature in Washington Sate has declared that the status quo – $130m a year for expensive, paper-only textbooks that are, on average, 7-11 years out of date – is unacceptable. Policy makers instead decided their one million+ elementary students deserved better and they have acted to require the Superintendent of Public Instruction to support their schools in learning about and adopting existing open educational resources aligned with their curricular standard.[64]

3D digital printing

3D digital printing[65] is receiving considerable public and business interest. The ability to publish 'physical' objects has the potential to revolutionise manufacturing with concepts such as 'mass bespoke' becoming feasible. 3D printers, if incorporated into a mathematics curriculum, would provide relevance as well as contextualisation for students who struggle with abstraction. Such devices have the potential to

create a renaissance curriculum, requiring students to include material science, material culture, maths and design in the creation of an object. Initiatives such as the Fablab centre in Manchester[66] that allow SMEs and entrepreneurs to create prototypes for a fraction of the cost of traditional pattern making will drive innovation. Additive manufacturing, that is, manufacturing based on digital printing, looks set to transform many areas of traditional manufacturing. What's more, it can take place, potentially, in a back bedroom.

People, process and technology

From the above, it is absolutely clear that technological innovation continues apace and offers new and potentially more effective ways to deliver vocational education and training. However, it is clear that having new capabilities alone will not deliver change. If we are to incorporate such innovations within educational practice, we need robust processes that are inclusive, and teachers and learners who are familiar with their operation.

In our study, we heard many examples of technology-supported learning projects that failed to gain adoption or were unsustainable. For technological innovation to be effective, we need to overcome barriers to access and ensure that learning professionals and learners alike are sufficiently skilled to exploit the opportunity.

Conclusion

The major advances we are currently experiencing in technology provide many opportunities that can help us to overcome barriers and deliver a step change in vocational learning:

- **The increasing availability of cloud services** has the potential to dramatically reduce the cost of learning design, delivery and administration.
- **The widespread ownership of highly-powerful smart phones and other mobile devices**, will provide an alternative and highly-accessible channel for learning and performance support content and other learning activities.
- **E-book readers** provide a low-cost and flexible way to distribute learning content, including open educational resources.

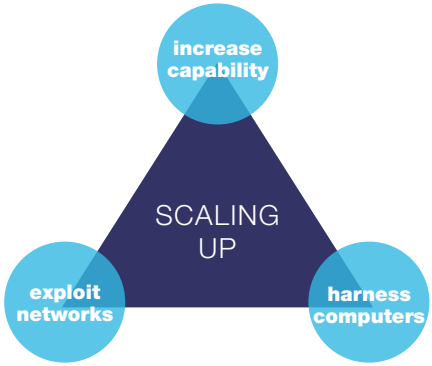
We address these opportunities and barriers in our recommendations in chapter 3.

3 Priorities for funding

3.1 Removing barriers and harnessing opportunities

These are our recommendations for action. We assessed each intervention based on how we judged it against the following criteria:

- **Potential** – Would an informed outsider consider there to have been a step change?
- **Value for money** – What is the unit cost per successful intervention when running at peak?
- **Sustainability** – What extent would the change effected by the intervention be self-sustaining?
- **Scalability** – What extent could the activities be scaled to have a beneficial impact on large numbers of learners?
- **Challenge** – How challenging would it be to make the intervention?



Our recommendations fall into three clusters:

1 **Increase capability** of those involved in running the vocational learning system

2 **Exploit networks** to bring together learners, learning content and learning professionals

3 **Harness computers** to support individualised and differentiated learning

The combination of these three will, we believe, contribute to a step change in vocational learning: through a 'scaling up' in the application and use of learning technologies.

Within each of these clusters we have identified two headline interventions that we believe could contribute to a step change in vocational learning. Alongside these, we describe a number of additional interventions that should be seriously considered for future attention.

Note that many of the ideas that we present here are inter-related. The programme of work going forward should therefore take account of any inter-dependencies.

3.2 Increase capability

The opportunity is there to engage the learning professions as a whole with technology and to obtain their wholehearted enthusiasm for change. Without a major increase in capability across the learning professions, and among learning technologists in particular, progress will be much slower than it needs to be.

At the same time, we know that there is a widespread lack of awareness of just what is possible with learning technologies.

Within this cluster of recommendations, we endeavour to overcome these barriers.

Large-scale online course for learning professionals

Invite projects for the design, development and delivery of a large-scale, open, online course to develop the knowledge and skills of learning professionals. This project would serve a number of purposes:

- Make a contribution towards addressing the current skills gap.
- Showcase the potential of courses for very large audiences.
- Test the use of new knowledge collection engines (such as OSQA – the Open Source Question and Answer system) to support learners throughout the course and to build a bank of useful knowledge on learning technologies.

To secure an audience in the thousands, the course would most likely need to be free of charge, although it could be that some fee is charged for those who require formal accreditation. We assume that minimal individual tutoring will be required and that successful completion can be successfully determined by peer-review and/or computer-gradable assessments.

Assuming the course was a success, it could be repeated at much reduced cost and extended to cover additional, more specialist aspects of learning technologies.

Engines such as OSQA use gamification to promote individuals who contribute good questions and answers. They may be considered as a hybrid between social networking systems and traditional bulletin boards. Useful content is elevated by the system and its creators recognised within the community. They harness the power of crowd sourcing and when applied to a body of knowledge can rapidly become highly-visible repositories of expertise.

Analytical tools that put learning first, technology second

Invite a project to create an initial set of analytical tools modelled on those developed by the National Centre for Academic Transformation (NCAT)[67] for use by organisations deciding on how to make large-scale changes to the design and organisation of their formal learning provision.

Key amongst these should be a decision-support tool that would help its users come to reasoned, evidence-based decisions as to whether a particular learning challenge is susceptible to one or more technology-based learning interventions, especially in vocational learning, and, if yes, what categories of intervention should be considered.

- Provided the tools are well designed and that there is an adequate level of uptake, then this intervention can help ensure that effort and funds are concentrated on the right kinds of problem.
- The costs of developing the tools (probably in Excel format) will be low in comparison to the savings and/or increases in effectiveness that should result from their use.
- Tools of this kind will need to be kept up-to-date and be developed iteratively to take account of practice. Ideally they should be hosted on a curated web-site, which permits rating by and other kinds of feedback from users, as well as the submission, by users, of new tools.
- The tools themselves will not scale in a conventional sense, but to the extent that they encourage organisations to implement changes that are themselves scalable they will contribute to Ufi's overall endeavour to 'scale things up'.

Other suggestions

Advocacy with senior leaders
Partner with organisations that are capable of raising awareness of the potential

for learning technologies among senior business and education leaders, and government. Many interviewees have made the point that it will be difficult to see major leaps forward in the application of learning technologies until senior leaders become more aware of the potential benefits to be gained, and the steps necessary to realise those benefits.

Above all, this audience needs to be made aware of successful examples of the application of learning technologies, in particular where technology has enabled substantial savings in terms of time, cost or CO2 emissions, or has contributed to improved accessibility to learning.

Competency frameworks, career paths and curricula
Partner with professional bodies, industry associations and awarding bodies to develop competency frameworks, career paths and curricula for learning and development generalists who wish to build their technology skills, as well as for learning technology specialists looking to progress in their careers.

The goal here is to provide a common and widely-accepted framework to support and provide focus for a wide range of formal and non-formal interventions aimed at addressing the current learning technologies skills gap.

Short, accredited online courses for learning professionals
Invite projects for the creation of a suite of short, accredited online courses, which show learning professionals how to apply different applications of technology to adult learning. To influence the vocational sector, teachers, trainers and lecturers must be given CPD opportunities that do more than simply explain options. They must experience these techniques for themselves.

These courses could cover applications such as the design of adaptive learning content, the design and moderation of large-scale, open, online courses, blended learning, 'flipping the classroom', mobile learning or the use of virtual classrooms. In each case they could make use of the approaches and technologies with which they are concerned.

A significant increase in the number of learning professionals that can implement and use technology in learning must be achieved. This intervention should produce a measurable upswing in this number.

Ensure that Ufi focuses some of its efforts on the Internet economy
The 'Internet economy' contributed £121bn to the overall UK economy in 2010, equivalent to 8.3 per cent of GDP. This is expected to rise to 12.4 per cent of GDP by 2016. The number of companies based in the Tech City area of Shoreditch, East London, increased from about 200 to 700 in the last 2 years.[68] Learning technologies have a role to play in high-growth start-up businesses, because entrepreneurs and their staff need to access learning and development, and because online learning businesses are a part of the Internet economy itself.

If there is to be a step change in the uptake and application of learning technologies, then this will surely involve high-growth start-ups (whether not-for-profit, as in the case of Khan Academy, or profit-making, as in the case of Udacity or Coursera). Ufi should focus some of its activities on the Internet economy, for example by supporting the development of e-learning clusters and by helping entrepreneurs and venture capitalists better understand the learning technology field.

3.3 Exploit networks

Computer networks have the potential to bring together learners, learning content and learning professionals on an unprecedented scale, with fantastic responsiveness and flexibility. In this cluster of recommendations, we look at ways in which we can take advantage of these opportunities to support vocational learning in the UK.

Peer assessment systems

Invite projects that support the development of peer assessment systems that, when aligned with an appropriate competency framework, enable learners to provide structured feedback and support to other students studying at the same or a lower level.

Such systems (examples include Peerwise[69], Peermark[70], and Aropa[71]) harness the potential of peer review and support to provide rapid formative assessment to the student submitting the work, while also requiring the peer reviewer to reflect on their own learning.

Important characteristics of such approaches include:

- Scope to manage the process and the underpinning software systems at scale across across multiple organisations – large and small – including employers, work-based learning providers, and colleges.
- Reduction in routine marking workload for teachers and trainers, who are instead able to focus on helping students to gain mastery of a subject or skill.
- In a vocational context, reduce the costs of moderation and assessment, while helping learners to develop mentoring and coaching skills.
- Students are required to reflect on their own and others' learning and express views about both. They thereby gain important communication skills outside the subject of their course as well as a deeper and more fluent understanding relating to the course itself.
- In the context of crafts and trades the approach can engender 'commitment to the craft/trade', characterised by older, more skilled workers 'bringing through' those at an earlier stage in their development.

Development of curriculum content using open source approaches to production

Invite projects that champion the creation of curriculum content using the production, testing and updating methods that are central to the success of open source software.

In the world of open source software, distributed teams – typically volunteers – are organised in a coordinated way on a range of activities including deciding on road-maps, producing and testing code, writing documentation, finding and fixing bugs. A proportion of the software produced this way is exceptionally successful. Examples include the operating system Linux, the browser Firefox, the web server Apache, and the learning environment Moodle. Each is run under a different organisational model: so there is no one way to do things right.

Curriculum content includes (but is not restricted to) learning materials, course designs, activities, assessment questions, text book content, and educational software and systems. All of these:

- are (or can be) digital, with close-to-zero distribution costs;
- require (or should require) iterative improvement;
- are used by widely dispersed individuals working for and in different organisations;
- are (or should be) regularly, systematically and rapidly updated;
- should be produced, like software, for use at scale, on a 'make once, use many times' basis.

On the face of it, therefore, open source production models, coupled with modern approaches to print production and e-book distribution (when relevant) should be applicable to the development and supply of curriculum content. But the practical

issues of applying such models are not currently well understood. The Trust should fund at least one project that tests and champions an open source production approach to the curriculum content for one or more major areas of vocational learning. The intended output from such a project would be better curriculum content and a solid, properly documented understanding of different approaches and their critical success factors.

Other suggestions

Crowd-sourcing diagnostic mathematics questions from teachers
Invite projects to crowd-source from teachers a user-rateable set of diagnostic questions to act as a 'front end' to the mathematics section of existing online resources, especially those published by the Khan Academy. This idea arises from a discussion by the project team with Dylan Wiliam, who sees diagnostic questioning as a cornerstone of effective learning and teaching of mathematics.

Experienced and expert maths teachers are capable of devising excellent and effective diagnostic questions, and widespread use of a good set of diagnostic questions would improve learners' and teachers' understanding of where learners' difficulties (in mathematics) lie. Suitably organised on the Web, diagnostic questions could be rated by teachers and serve as a main component of a 'front end' to content about different aspects of mathematics. Even if the creation of a 'front end' to the Khan Academy itself proves impracticable, teachers could use the diagnostic questions in their day-to-day work in any case.

Once a core of effective diagnostic questions exists, the longer term costs of adding new ones would be relatively low, especially if a community of users was developed to support the site. There is no practical limit to the number of users of such a system and if successful, it would contribute to a general improvement in the quality of formative feedback, something known to be crucial to improving the effectiveness of teaching and learning.

Free resources intervention in vocational learning
Invite proposals for a carefully-designed and managed project that would explore the scope to use scalable learning by recruiting a reasonably large cohort to obtain a vocationally relevant qualification.

Such an intervention would use a curated set of freely-available support resources, with pre-organised access to social media-based tools and systems that harness the kinds of peer-support referred to elsewhere in this study. Assessment of learners' motivation and suitability to take part in such a programme would form part of a standard pre-course assessment process, thereby reducing (for learners) the risk of failure.

Important outputs would be assessments of the costs, benefits, problems and possibilities of this type of learning, together with design and implementation guidelines focused on the scaling up of this learning approach.

3.4 Harness computers

The power and capability of computers, from desktops to tablets, has increased exponentially, yet we have so far made limited use of this potential for learning. In this cluster of recommendations, we look at ways in which we can take advantage of the power of computers to solve problems in vocational learning in the UK.

Development of simulations, games and virtual environments

Invite projects that support designers of simulations, games and virtual environments relevant to vocational learning, to take their projects through into development and implementation.

- Flight simulators have been used for decades to teach complex skills. It could be time for a similar approach in the training of other vocational skills.

- Projects need to address large populations and identified skills gaps. Video alone, through YouTube, has already provided lots of 'how to' tutorials; simulations could do a lot more.
- It is important that psychological fidelity takes precedence over physical fidelity in such simulations, projects that address actual transferable skills and not just look and feel.
- An important aspect of simulation is that completion itself can be seen as assessed performance.
- Illustrating best practice and allowing learners to practise best practice is what good learning simulations achieve.

Although difficult to design, develop and deliver, content of this nature is massively scalable. Some care would have to be taken to ensure that, whatever projects are chosen, do not unfairly distort existing markets.

Online intervention focusing on numeracy/mathematics

Invite projects to make a 'mass' and wholly-online intervention focusing on Level 2 numeracy by 16-19s and by older adults:

- The Khan Academy and Sebastian Thrun's Udacity each provide or use online resources that support mathematics or computer science. In the case of Udacity, a systematic and effective method for structuring online courses using short video clips and frequent quiz/task-based, machine-marked interactions has been invented that goes some way to creating, for learners, the sense of receiving one-to-one instruction.
- A similar approach deserves to be trialled properly at a lower academic level, with a focus on the acquisition of the kind of vocational mathematical capability – 'techno-mathematical literacy' – that adults need, and which the educational system is fails to provide.[72]
- The project would need to take account of the 'Crowd-sourcing diagnostic mathematics questions from teachers' proposal in Section 3.3.

If this model proves successful, the effect on the nation's numeracy problem could be great, as could be the impact on the efficiency of the system as a whole as the process is scaled up. (In the case of Udacity, Thrun estimates – for Udacity's very high volume non-accredited courses – that the average cost per student per course is $1[73]. The marginal cost per learner per course under this kind of model is therefore close to zero.)

Other suggestions

Adaptive learning
There is a need to provide challenging, non-linear, adaptive environments, in which learners can test their understanding and consolidate and improve this through practice, at their own pace, when and where they choose.

The Trust should invite projects that investigate the application of adaptive learning to the acquisition of better functional numeracy or English. Once successfully built, the tool/courseware would require limited maintenance and could exist successfully within the open source software ecosystem. If available as an 'app' for mobile phones, there would be very good scope for widespread uptake and use.

Technology-supported, problem-based learning
The Trust should support curriculum developments that have problem-based learning as their focus. The proliferation of how-to videos and guides across the Internet suggests that there is no shortage of appetite for goal-focused instruction. Embedding formal instructional content within such courses or activities has the

potential to re-engage learners that have eschewed formal learning, and would be particularly suitable for adults.

Employers state that they have a need for entry-level employees that have capability and soft skills. Such a delivery model provides the opportunity for learners to gain these skills while learning. The Cedefop report mentioned in 1.3 reinforces the applicability of this approach within small and medium-sized enterprises. Activity-based accreditation has much in common with the apprenticeship model. The challenge and risk will be assuring the quality of the educational content and that skills are transferable.

Cloud-based education systems
The Trust should positively discriminate in favour of projects that exploit cloud-based infrastructure or components. Cloud-based services have scalability at their core. Easy access from devices such as smart phones and tablets embeds learning inside learners' own devices. Cloud-based tools have collaboration at their heart and allow learners to work with peers both inside their organisations and around the world.

By reducing the need for organisations to own or maintain expensive IT equipment and software, a significant barrier to the adoption of technology assisted learning is removed. Institutions have been struggling to use and deploy e-portfolios and other vocational support services for the past twenty years. Low cost and secure cloud-based services are entirely appropriate for cash-starved institutions that want to deliver technology solutions at low cost.

3.5 Moving forward

Although we have consulted widely, there will undoubtedly be many good ideas that have not yet occurred to us, our interviewees and questionnaire respondents, and Ufi will continue to encourage learning technologists and others interested in this field to add to the list.

We have paid special attention to ideas that we believe will act as catalysts for projects on a greater scale. Not all of these will be successful, but their chances of success can be improved by putting in place processes that have been proven to work elsewhere.

Jim Farmer, Instructional Media + Magic, Inc:

"In my experience catalysts are not sustainable. They tend to disappear and fail to meet their objectives. One of the requirements of the Mellon Foundation was that a project had to be committed to sustainability, have specific quantitative measures of achievement (typically number of users), and an understanding no additional funding would be provided. This worked well in the sense the Mellon projects; uPortal, Sakai, and Kuali did meet their goals and became sustainable within the predicted time frame, with typically two or three years of growing user base. This applies to JISC projects as well, especially the VRE series which continued to be used after JISC funding was discontinued. The best record, however, is the ESUP Portail project in France. Projects have all been completed on time and within budget. The focus on user base has continued. There is evidence their projects have both increased productivity and provided students with a better learning environment. Reviewing their work may be useful."

As we hope will have been abundantly clear from the body of this report, the time is right for action. Not only do we have a plethora of problems to address, we have the good fortune to be presented with exciting opportunities to provide solutions. No doubt the existing vocational education and training system will in its own time respond to these problems and opportunities, but at its own pace, weighed down by the baggage of past and current practice. Ufi cannot, by itself, bring about a step change in vocational learning, but it can act as a catalyst for one.

Appendix 1 Questionnaire **analysis**

Response to the questionnaire

The questionnaire was conducted online.

332 people clicked on the link to the questionnaire.

194 started the questionnaire.

171 asked to be sent a copy of the project report.

155 provided their name and email address and responded to the compulsory "about you" questions 2 to 10.

142 users responded to the questions on favoured types of initiative and constraints on the mass-adoption of technology-supported learning. In the analysis that follows, we deem these **142** to be the questionnaire population.

132 fully completed the questionnaire.

Over 100 narrative responses were provided to the three questions inviting comments. Some of these were substantial and carefully considered, which is perhaps unusual for a questionnaire of this kind.

Interestingly, some 97 respondents asked to be kept in touch with developments with Ufi and 61 stated that their organisation might wish to collaborate with Ufi in the future.

About the respondents

Amongst questionnaire respondents there was a considerable interest in the study.

Respondents were based overwhelmingly in the UK.

Respondents with an organisational affiliation (91%) were evenly spread across organisations of different sizes.

Respondents with an organisational affiliation (90%) were evenly split between the private and public sectors, with a much smaller proportion defining themselves as working in the voluntary or charitable sector.

Respondents self-categorised their organisation as follows, with 48% working for a learning provider, and 24% working for a supplier of content, infrastructure, or services. 9% reported working for a research organisation.

Respondents self-categorised their role as follows, with 39% describing themselves as practitioners, and 27.5% as senior managers, 18% as managers, and 10% as researchers.

Respondents self assessed their expertise on a five-point Likert scale. Overall they were somewhat *less expert* in 'Employability' (3.32 – 44% expert or highly expert) and 'Vocational education' (3.31 – 47% expert or highly expert), and rather *more expert* in 'Technology-supported learning and its organisation' (4.13), 'Adult learning' (3.95), 'Being an online learner' (3.74), and 'Online/e-assessment' (3.64).

Favoured types of initiative

Using a five-point Likert scale, respondents commented on the impact that they believed different types of initiative would have on achieving a step change in learning and employability for all adults in the UK. All the options presented were well-supported. The following were supported particularly strongly:

- Disseminating good or best practice (4.02)
- Strengthening the learning technologies practitioner and research fields overall (3.93)
- Influencing the Government to ensure that inspection, audit and funding regimes are supportive of (or are at least neutral towards) technology supported learning (3.90)
- Supporting larger scale trials of methods and approaches (3.88)
- Supporting smaller scale trials of methods and approaches (3.85)

Rather less strongly supported were:

- Identifying good or best practice (3.69)
- Commissioning research and/or development (3.49)

Constraints on the mass adoption of technology-supported learning

This question probed respondents' assessment of various constraints on the mass adoption of technology-supported learning.

Of the options offered, 'Technology supported learning is perceived to be more difficult than traditional learning' was judged to be the *least* significant as a constraint (2.98), followed by 'There is a shortage of suitable technology-based learning content' (3.12).

'The quality of content, process or assessment is inadequate' was judged to be the *most* important constraint (3.60), followed by 'Technology-supported learning is perceived to lack a sufficiently social component' (3.37), 'Access to appropriate technology and connectivity' (3.30) and 'Qualifications obtained using technology-supported learning do not have sufficient validity with employers' (3.23).

It should be noted here that in no case – with the possible exception of 'The quality of content, process or assessment is inadequate' (3.6) – was the average score sufficient to justify the particular constraint being regarded as of major importance.

The targeting of resources

We asked respondents to indicate the extent to which they agreed with five assertions about how Ufi might target its resources. There was support amongst our respondents for all of them, with two options supported *very strongly*:

- Ufi should concentrate on projects that are likely to act as catalysts for much larger-scale programmes (3.91).
- Ufi should focus on new and alternative channels for vocational education and training, rather than hoping only to have a major influence on the traditional channels (3.82).

Notwithstanding the support for projects that act as catalysts for much larger-scale programmes, support for Ufi to concentrate on initiatives and/or interventions that directly or indirectly affect very large learner numbers, i.e. 10,000 – 1,000,000, or which are capable of scaling up to affect large numbers of learners was relatively weakly supported (3.29).

The somewhat lower level of support for Ufi to focus on initiatives that support vocational education and training at entry levels 1 and 2, and NVQ levels 1-4 (3.22), is consistent with the point noted earlier concerning respondents' relative lack of expertise in terms of employability (3.32) and vocational education (3.31).

Opportunities for advancements in vocational education and training

We asked respondents to use a five-point Likert scale to rate twelve developments in learning technologies that could provide significant opportunities for advancements in vocational education and training in the UK.

There was *very strong* support for:

- Capability building: Addressing the skills gap in the application of learning technologies (4.21);
- Mobile technology: Using smart phones, e-readers and tablets not only to reduce dependency on printed textbooks but to support all sorts of individual and collaborative learning (4.19).

There was *strong* support for:

- Using technology to achieve improvements to processes: Reducing costs and/or improving quality through a better application of technology to learning and/or to administration (3.99);
- Learning in the cloud: Using the cloud to reduce the cost of technology infrastructure and provide opportunities for massive scalability (3.98);
- Intelligent and adaptive tutorials: More intelligent and adaptive tutoring systems that provide a more personalised user experience (3.93);
- The contextualisation of learning: Using technology to provide context through scenario-based learning, large scale simulations and multi-user games (3.89);
- The separation of learning and assessment: Learners can freely adopt any learning programme of their choice, formal or informal, in preparation for formal assessment (3.80);
- Using technology to make apprenticeships more efficient: Increasing scalability through a better application of technology to learning and/or to administration (3.79).

The remaining options were also supported, albeit *less strongly*:

- Peer-supported learning and assessment: Highly-scalable programmes with a minimal reliance on formal tuition. Peers provide each other with support throughout the learning process and can also act as assessors against strict competencies (3.65);
- Encouraging entrepreneurship: Using business games and simulations, as well as sites that support new ventures through micro finance coupled with learning opportunities/materials (3.57);
- "Gamification": Using game dynamics to engage the learner and maintain motivation (3.54);
- Personalisation through mass data: Massively-scalable learning programmes generate large volumes of student data that can be exploited to provide more intelligent and personalised programmes (3.52).

Appendix 2 Names and roles of **interviewees**

We would like to thank the very large number of people who have contributed to this report. In particular, those listed below who participated in interviews or contributed comments to our questionnaire. Those marked with an * were interviewed specifically for this report. Many of the people listed are associated with several organisations; in each case we have selected the one that seems most relevant in this context.

Graeme Arnott, Training Officer at Scottish Electrical Charitable Training Trust (SECTT)

Martin Baker*, CEO, Charity Learning Consortium

Ray Barnes*, Chair of Ufi Trust and former Chief Administrative Officer of Visa International

Ben Betts*, Managing director, HT2

Sal Brinton*, Ufi Trustee and a working Liberal Democrat peer in the House of Lords

Dan Buckley*, until recently, Director of Research, Cambridge Education

Ian Chowcat, Head of Learning Innovation, Sero Consulting Ltd

Donald Clark*, Ufi Trustee, board member of Cogbooks, LearningPool and previously founding CEO Epic Group plc

Alastair Clark*, Development ICT and Learning, NIACE

Steve Creasy, Head of Project Delivery at Pearson

Bryn Davies*, Ufi Trustee, and Principal of Ystrad Mynach College, Wales

Gareth Davies, Managing Director, FrogTrade Ltd

Mark Dawe*, Chief Executive, OCR

Gareth Dent*, Chief Executive, Open College of the Arts

Kirstie Donnelly*, City and Guilds

Viv Drake*, Lifelong Learning, Skills and Communities, Sheffield City Council

Gavin Dykes*, Fellow, Education Impact

Stuart Edwards*, Deputy Director, Department for Business, Innovation and Skills

John Ellison, Leicester Adult Skills and Learning Service

Jim Farmer, Owner and Technical Advisor, Instructional Media + Magic, Inc, USA

David Frost*, Ufi Trustee, Chairman of the Studio Schools Trust, and past Director General of the British Chambers of Commerce

Rob Hubbard*, Chair, eLearning Network

David Jennings*, Director, DJ Alchemi Ltd

Charles Jennings*, Managing Director, Duntroon Associates, and former Chief Learning Officer for Thomson Reuters

Sarah Jones*, CEO learndirect

Heather MacDonald, Principal, The Sheffield College

Brian Mawdsley, Engineer and designer

Bobbie McClelland*, Deputy Director, Department for Business, Innovation and Skills

Sugata Mitra*, Professor of Educational Technology, School of Education, Communication and Language Sciences, Newcastle University and visiting professor, MIT Media Lab, USA

Denise Morgan, Manager, Teaching and Learning Innovation, Wide Bay Institute of Training and Further Education Australia

Ros Morpeth*, Chief Executive, National Extension College

Teresa Mullin, Director, KM Training Ltd

Laura Overton*, Chief Executive, Towards Maturity

Susan Pember*, Director of Further Education and Skills Investment, Department for Business, Innovation and Skills

Vanessa Pittard*, Trustee of the Association for Learning Technology (ALT) and past Director of E-strategy at Becta

Dave Pratt*, Professor of Mathematics Education at the Institute of Education

Lesley Price, Board member, eLearning Network

Martin Sepion, JISC Regional Support Centre, London

Aaron Sloman*, Honorary Professor of Artificial Intelligence and Cognitive Science, University of Birmingham

Donald Taylor*, Chairman, Learning and Performance Institute

Josie Taylor*, Professor of Learning Technologies, and Director of the Institute of Educational Technology, Open University

Sebastian Thrun*, Research Professor at Stanford University, Google Fellow, and Vice President and a co-founder of Udacity

John Weston*, Retiring Chair of Ufi's Trustees, and past Chief Executive of BAE Systems

Steve Wheeler, Associate Professor in Learning Technology, School of Education Plymouth University

Dylan Wiliam*, Emeritus Professor of Educational Assessment at the Institute of Education, University of London

Jane Williams*, Ufi Trustee, previously Principal of City of Wolverhampton College, a Director in DfES, and an Executive Director of Becta

Peter Williams*, Editor, e.learning age magazine

Tom Wilson*, Retiring Ufi Trustee and Director of unionlearn – the TUC's learning and skills organisation

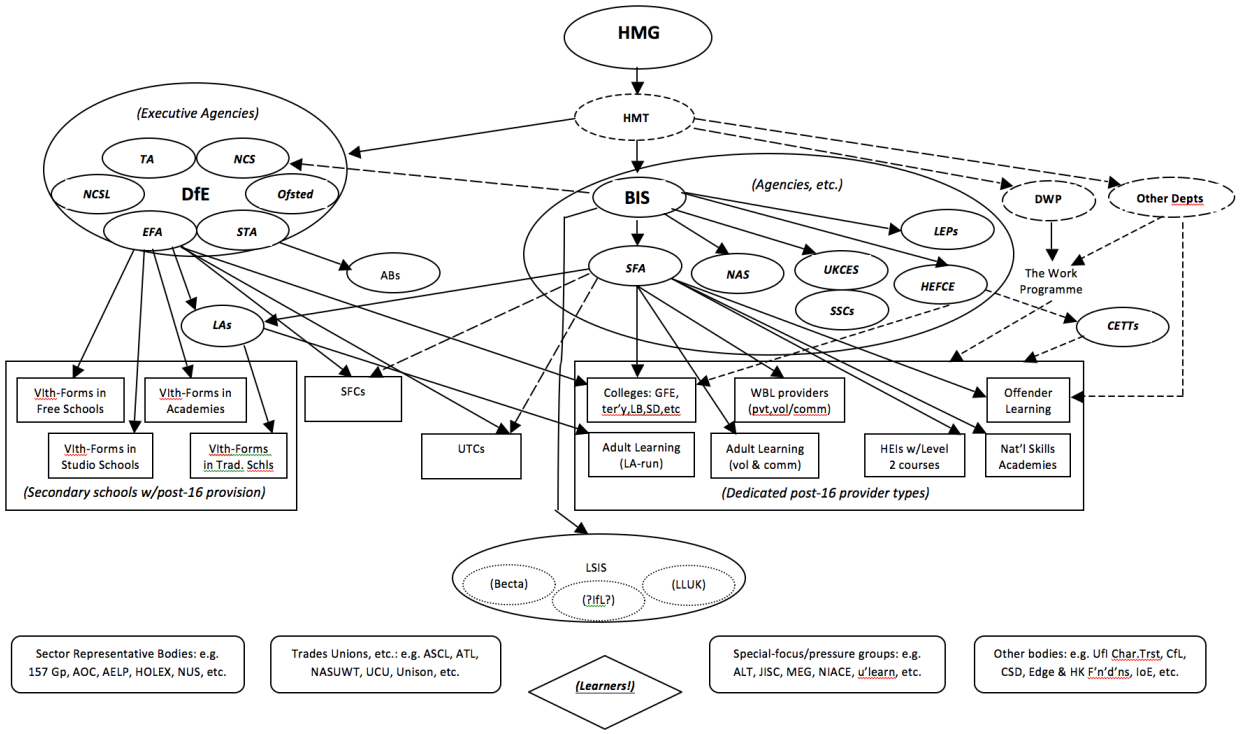
Alison Wolf*, Sir Roy Griffiths Professor of Public Sector Management, Kings College London

Conrad Wolfram*, Strategic and International Director, Wolfram Research

Rob Wye*, CEO, Learning and Skills Improvement Service (LSIS)

Appendix 3 The post-16 learning and skills sector 2012

A simplified 'structural overview map'



Key to graphical styles:

Oval text boxes: government bodies of all kinds and at all levels – including agencies, services, etc. (see also fonts)

Rectangular text boxes: provider organisations

Rounded oblong text boxes: other types of organisations

Solid lines: full/formal links (e.g., reporting, responsibility, funding, etc.)

Dashed lines: partial/informal links, and/or non-educational bodies linked to education and training

Dotted lines: past bodies/functions, recently 'absorbed'

Bold font: government departments, etc.

Bold italic font: agencies, NDPBs, etc.

Key to abbreviated labels:

ABs: awarding bodies

ASCL: Association of School and College Leaders

AELP: Association of Employment and Learning Providers

ALT: Association for Learning Technology

AOC: Association of Colleges

ATL: Association of Teachers and Lecturers

BIS: Department of Business, Innovation and Skills

CETTs: Centres for Excellence in Teacher Training

CfL: Campaign for Learning

CSD: (City & Guilds) Centre for Skills Development

DfE: Department for Education

DWP: Department of Work and Pensions

EFA: Education Funding Agency (formerly YPLA)

GFE: general further education (colleges)

HEFCE: Higher Education Funding Council for England

HK F'n'd'n: Helena Kennedy Foundation

HMG: HM Government

HMT: HM Treasury

HOLEX: national network of local adult learning providers

IfL: Institute for Learning

IoE: University of London Institute of Education Centre for Post-14 Research and Innovation

JISC: Joint Information Systems Committee

LAs: local authorities

LB: land-based (colleges)

LEPs: local enterprise partnerships

LLUK: Lifelong Learning UK

MEG: Mixed Economy Group

NAS: National Apprenticeships Service

NASUWT: National Association of Schoolmasters Union of Women Teachers

NCS: National Careers Service

NCSL: National College for School Leadership

NDPBs: non-departmental public bodies

NIACE: National Institute for Adult and Continuing Education

NSA: National Skills Academies

NUS: National Union of Students

SDI: specialist designated (institutions/colleges)

SFA: Skills Funding Agency

SFCs: sixth-form colleges

SSCs: sector skills councils

STA: Standards and Testing Agency

Ter'y: tertiary (colleges)

TA: Teaching Agency

Ufi: University for Industry

u'learn: unionlearn

UCU: University & Colleges Union

UKCES: UK Commission for Employment and Skills

UTCs: University Technical Colleges

Appendix 4 About the **authors**

Clive Shepherd

Clive established his interest in interactive media while Director, Training and Creative Services for American Express in Europe, Middle East and Africa. He went on to co-found Epic, one of the UK's major producers of custom e-learning, where he won many industry awards and assisted in taking the company public in 1995. Since 1997 he has operated as a consultant for UK and international public, private and third sector organisations. He was recognised for his Outstanding Contribution to the Training Industry at the World of Learning Conference in 2004 and for four years was Chair of the eLearning Network. Clive is a Director of Onlignment Ltd, which provides expertise in online communication. Clive is a prolific blogger and speaker. His books include The New Learning Architect and The Blended Learning Cookbook.

Seb Schmoller

Seb spent 20 years teaching and developing courses for workplace trade union representatives, becoming involved in online learning through the TUC in the late 1980s. Between 1996 and 2002, Seb led the Sheffield College's ground-breaking work in online learning, including having responsibility for the award-winning Learning to Teach On-Line (LeTTOL) and GCSE English Online courses. Seb stood down as Chief Executive of the Association for Learning Technology (ALT) in May, having led ALT since 2003 in a half-time role that he has combined with independent consulting. Seb is Vice-Chair of Governors of The Sheffield College, a non-academic reviewer member of the ESRC Peer-Review College, and a member of the Advisory Board of the £12m ESRC/EPSRC Technology-Enhanced Learning programme.

Dick Moore

Dick has 30 years' experience working as an educational technologist. He was a member of the Walsall Educational Development Centre's microelectronics team in the 1980s, developing software schools. Thereafter Dick worked in FE as Director of Technology and/or head of management information at three of the UK's largest colleges. After a spell in Los Angeles as CTO at an Internet start-up, Dick worked between 2000 to 2010 as CTO and Director of Technology for learndirect. Dick is a Trustee of the Association for Learning Technology and chair of their publications committee. Dick now runs an independent consultancy, MooreAnswers Ltd, working mainly in the education and not-for-profit sectors and writes an occasional blog at www.toolsandtaxonomy.com

Adrian Perry, OBE

Adrian Perry is a respected consultant in education leadership and management, who has worked for national and regional agencies as well as individual organisations. He is Senior Visiting Fellow at the University of Sheffield Faculty of Education. Before his present career, Adrian worked as a successful college Principal for 15 years, and a board member of local TECs and LSCs. He chaired the South London Learning Partnership, and was a Steering Group member for the BSA Review of Family Learning. He holds an honorary doctorate from University of London South Bank, and was award an OBE in 2003.

Endnotes

1 Ufi is registered charity number 1081028. For the purposes of this report, the Ufi Charitable Trust will be referred to simply as Ufi.

2 There are brief biographies of the authors in Appendix 4.

3 Alison Wolf, whom we interviewed on 10/3/2012, is Sir Roy Griffiths Professor of Public Sector Management at King's College London

4 Adapted from the Economist, 14/4/2012 – http://www.webcitation.org/66zAN4Mes – last accessed 26/4/2012

5 Financial Times, 28/3/2012 – http://www.ft.com/cms/s/2/24b995ea-00b4-11e1-8590-00144feabdc0.html#axzz1tb2HhJ9n (registration required) – last accessed 30/4/2012.

6 Guide for training in SME's 2009 http://www.cedefop.europa.eu/EN/news/4047.aspx last accessed 29/4/2012

7 Review of Vocational Education – The Wolf Report – http://www.webcitation.org/66rmZSyqV – last accessed 12/4/2012

8 Richard Lambert, Director General if the CBI, quoted in The Daily Telegraph, 17 May 2010. http://www.webcitation.org/67ILVmZE8 – last accessed 29/4/2012.

9 "Ready to grow: business priorities for education and skills," – http://www.webcitation.org/67IN69Urc – last accessed 29/4/2012. "Shackled by the skills crunch" by the Institute of Directors' Martin Harris, makes similar points. See http://www.webcitation.org/67IM8m7OO – last accessed 29/4/2012.

10 There is plenty of debate about the overall meaning of the UK's slippage in the OECD's Programme for International Student Assessment (PISA). But it is widely accepted that the UK's relative position in mathematics, literacy and science has deteriorated considerably over the last 25 years.

11 "After the riots – the final report of the Riots Communities and Victims Panel" – http://www.webcitation.org/67INfW1CC – last accessed 29/4/2012

12 Alison Wolf, whom we interviewed on 10/3/2012, is Sir Roy Griffiths Professor of Public Sector Management at King's College London

13 Instinct or Reason: How education policy is made and how we might make it better, p21 – http://www.webcitation.org/67INtFRL4 – last accessed 29/4/2012

14 Review of Vocational Education – The Wolf Report – http://www.webcitation.org/66rmZSyqV – last accessed 12/4/2012

15 Running ever faster down the wrong road: an alternative future for Education and Skill http://www.webcitation.org/66qglydW4. Cynics might argue that what Coffield described as "the pelting torrent of official documents which have flooded the sector since 1997" has in part resulted from the ways in which email and text processing enable the faster and more voluminous production and updating of policy.

16 JISC is currently in the process of being simplified and reshaped as part of a wide-ranging review. This review is slated to have been completed by Autumn 2012. See http://www.webcitation.org/6737XHf3O – last accessed 19/4/2012.

17 We include the Mozilla Foundation because of its important on 'badges', though these are not discussed in the report. See http://openbadges.org/en-US/about.html – last accessed 19/4/2012.

18 Drive: The Surprising Truth About What Motivates Us (Riverhead, 2011), Daniel L Pink

19 Aaron Sloman is Honorary Professor of Artificial Intelligence and Cognitive Science at the University of Birmingham

20 BIS Research Paper Number 57, December 2011, http://www.webcitation.org/66zQXxsjx

21 BIS Research Paper Number 57, December 2011, http://www.webcitation.org/66zQXxsjx

22 BIS Research Paper Number 57, December 2011, http://www.webcitation.org/66zQXxsjx

23 Mobile Internet Report. Morgan Stanley- http://www.webcitation.org/670j01chN last accessed 18/4/2012

24 The Future of the Internet. Jonathan Zittrain- http://www.webcitation.org/670imRvBB last accessed 18/4/2012

25 Interview with Eric Schmidt, CEO of Google http://www.webcitation.org/67MEe0uKX last accessed 01/4/2012

26 Dutton, W.H. and Blank, G. (2011) Next Generation Users: The Internet in Britain 2011. Oxford Internet Institute, University of Oxford – http://tinyurl.com/6yj8adm – last accessed 3/5/2012

27 Programme or be programmed , Dogulas Rushkoff- http://www.webcitation.org/670iZEIME last accessed 20/4/2012

28 Hairdressing Training – http://www.webcitation.org/67SP0myIW – last accessed 6/5/2012

29 In the five years prior to its abolition in early 2011, Becta sought to encourage the use of learning technologies in vocational learning. Here, for example, is a report from Becta: 'E-portfolios for apprentices: A guide for provides and employers' – http://tinyurl.com/bukweha – last accessed 6/5/2012. Reports of this kind remain relevant to Ufi's current endeavours.

30 Interview with Ros Morpeth, CEO at the National Extension College.

31 We report here and below the average scores from the "Likert scales" that we used in the questionnaire. A score of 5 would indicate complete agreement with the question posed. A score of 0 complete disagreement.

32 For a more detailed analysis of our findings from the questionnaire, see Appendix 1.

33 There is a full list in Appendix 2.

34 A study by ALT in 2010/2011 – http://www.webcitation.org/67SYtMs5X – (last accessed 6 May 2012) showed that the training FE teachers receive has failed to equip them to properly to use learning technologies in their work.

35 Source: E-learning Skills Matrix, developed by SkillsJourney, 2009.

36 Education Researcher, Vol 13, No. 6. (Jun. – Jul., 1984) http://www.webcitation.org/672gYmKur

37 Wikipedia artical on Mastery learning referencing Bloom's work http://en.wikipedia.org/wiki/Mastery_learning

38 Arons, A.B. 1997. Teaching Introductory Physics, p. 362. Wiley

39 Stanford University's president predicts the death of the lecture hall, IEEE Soectrum, http://bit.ly/IPvEGV

40 The Cathedral and the Bazaar is an essay by Eric S Raymond O'Reilly ISBN 1-56592-724-9

41 Eric Mazur's Harvard University web site http://www.webcitation.org/672eDYSCw] – last accessed 19/4/2012

42 Likert score 3.65

43 Examples include Aropa, a web-based system designed to support peer review activities in large, undergraduate classes – http://www.webcitation.org/67GqjldmH, Peerwise, a service developed at Auckland University that challenges students to write assessment questions and challenge each other with them – http://www.webcitation.org/67Gr39lyx .

44 Blind peer review, when either the reviewer or the originator of a work does not know the identity of the other in the reviewing process. http://en.wikipedia.org/wiki/Peer_review last accessed 14/4/2012

45 http://en.wikipedia.org/wiki/Competency_framework last accessed 14/4/2012

46 Interviewed 20/2/2012

47 How to organise a MOOC – Slideshare presentation by Stephen Downes, 10/9/2011 – http://www.slideshare.net/Downes/how-to-organize-a-mooc last accessed 19/4/2012

48 What can we learn from Stanford University's free online computer science courses? by Seb Schmoller, ALT Online Newsletter, November 2011 – http://www.webcitation.org/672i7WRt8 – last accessed 19/4/2012

49 http://www.osqa.net/ – last accessed 19/4/2012. http://meta.osqa.net/ – last accessed 19/4/2012 – shows OSQA in active use within the OSQA community.

50 Likert scale average score 3.80

51 Cutting Edge or Cut loose? Apprentices' experiences of workplace e-learning, LSIS, RDF 2011

52 The Khan Academy http://www.khanacademy.org/

53 According to John Rowley, CEO of Atlas Knowledge, a leading global supplier of oil and gas industry training, "In the long term we feel sure that simulations of all types will become mainstream, especially with better tools making it easier to develop simulations for learning. After all, we are working in a market were the estimated spend on virtual reality training and simulation in the oil and gas industry was £2.2 billion in 2011."

54 Virtual learning by Roger Schank, published by McGraw-Hill, 1997.

55 Digital game-based learning by Marc Prensky, published by McGraw-Hill, 2001.

56 http://www.webcitation.org/67I6wzplJ – last accessed 29/4/2012

57 The prediction by Gorden Moore in 1965 that the number of transistors on a chip that could economically be produced would double every two years. Moore's Law has at least held good in the succeeding 47 years.

58 A standard (software) component can be used to perform a function and linked to other components via a robust and well defined interface.

59 Pearson's Open Class http://www.joinopenclass.com/open/home/what

60 Google Project Glass Unveiled http://goo.gl/7pkNi

61 Eink a technology that performs well in sunlight and has low power consumption http://www.eink.com/

62 Cable greens evidence to the senate states that the cost of a text book could be reduced to $4 from ~$40 http://goo.gl/pp5DP a unit cost that allows students to keep the books and use study skills such as highlighting and annotation.

63 http://en.flossmanuals.net/ is an organisation that develops manuals and educational material about open source software.

64 OER K-12 Bill Passes in U.S. Washington State, March 1st, 2012 http://creativecommons.org/tag/cable-green.

65 3D digital printing is the ability to manufacture items by laying down successive layers of material,((additive manufacturing), as opposed to traditional manufacturing where objects are constructed using traditional machining technques (subtractive manufacturing)

66 Fablab is a fully kitted fabrication workshop, which gives everyone in the community from small children through to entrepreneurs and businesses, the capability to turn their ideas and concepts into reality http://www.fablabmanchester.org/ last accessed 01/5/2012

67 http://thencat.org/ – last accessed 20/4/2012

68 Financial Times, 28/3/2012 – http://www.ft.com/cms/s/2/24b995ea-00b4-11e1-8590-00144feabdc0.html#axzz1tb2HhJ9n (registration required) – last accessed 30/4/2012.

69 http://www.webcitation.org/67LvNIOS8 – last accessed 2/5/2012

70 http://www.webcitation.org/67LvSiku2 – last accessed 2/5/2012

71 http://www.webcitation.org/67LvZ6Qam – last accessed 2/5/2012

72 For a full treatment of this issue see Improving Mathematics at Work – The Need for Techno-Mathematical Literacies, by Celia Hoyles, Richard Noss, Phillip Kent and Arthur Bakker (2010)

73 Thrun discusses the costs of provision towards the end of this middle section of this 1/5/2012 interview, between 13.30 and 23.52 – http://tinyurl.com/d9x8224 – last accessed 2/5/2012