

Modelling benefits-oriented costs for technology enhanced learning

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Abstract

The introduction of technology enhanced learning (TEL) methods changes the deployment of the most important resource in the education system: teachers' and learners' time. New technology promises greater personalization and greater productivity, but without careful modeling of the effects on the use of staff time, TEL methods can easily increase cost without commensurate benefit. The paper examines different approaches to comparing the teaching time costs of TEL with traditional methods, concluding that within-institution cost-benefit modeling yields the most accurate way of understanding how teachers can use the technology to achieve the level of productivity that makes personalisation affordable. The analysis is used to generate a set of requirements for a prospective, rather than retrospective cost-benefit model. It begins with planning decisions focused on realizing the benefits of TEL, and uses these to derive the likely critical costs, hence the reversal implied by a 'benefits-oriented cost model'. One of its principal advantages is that it enables innovators to plan and understand the relationship between the expected learning benefits and the likely teaching costs.

Keywords: cost-benefit analysis; cost modeling; benefits-oriented cost model; e-learning; ICT in education; innovation in higher education; technology-enhanced learning

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Introduction

Technology enhanced learning is expected to make a radical difference to education, specifically, the quality and effectiveness of the learning experience. It is also expected that one of its key contributions will be to make 'personalised learning' a reality (DfES, 2003; Leadbetter, 2004). However, none of this will happen simply through the introduction and availability of learning technologies and resources. For all that ICT is meant to be a disruptive technology, education is a very robust and powerful system that is not easily disrupted. If

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radical change is to happen, and make a sustained improvement to the education system, then to some degree at least this change has to be planned and managed.

This was part of the motivation behind the recent development of a cross-sector e-learning strategy in the Department for Education and Skills (DfES, 2005)ⁱ. The intention was to clarify a strategic plan for the future use of TEL, and why it is important for education. The four overarching objectives – personalized learning, inclusion, flexible learning opportunities, and productive time – defined the values of the education system and its challenge to the technology. If e-learning is to be worth having, it must achieve worthwhile changes that cannot be achieved without it.

An e-learning strategy, whether at institutional or national level, is the means by which we all manage the change that new technology promises, without it managing us. The UK's Department for Education and Skills (DfES) developed its system-wide e-learning strategy because it recognizes the holistic nature of a national education system, all sectors of which need to respond to the opportunities offered by new technology. These concerns are not confined to the UK. In 2004 then Secretary of State for Education, Charles Clarke, inaugurated an annual international seminar on the topic, now attended by ministers of education and officials from over 60 countriesⁱⁱ.

The DfES strategy acknowledges the immensely difficult task of changing a culture in which the drivers of curriculum and assessment requirements, stakeholder demands, career rewards, and funding models, are all geared to old technologies. In the end, teachers and learners will be behaving differently if digital technologies are to be exploited fully in service of education. So a strategy is needed to set out how that is to be achieved in a largely devolved, but well-established traditional education system.

The point of this paper is to examine what these changes will mean for the deployment of the most important resource in the education system: teachers' and learners' time. It focuses on the first and fourth overarching objectives of the e-learning strategy, personalization and productivity, seeking to understand how we can use the technology to achieve the level of productivity that makes personalisation affordable.

Defining the problem

Costing studies for HE usually show that digital technologies cost more than traditional methods, and yet e-learning continues to grow in universities (Guri-Rosenblit, 2005).

Managing this change requires a good understanding of the costs and benefits in a long-term sustainable system that uses new technology well. However, modelling the costs and benefits of education is challenging enough for traditional teaching methods. The literature offers little help for academics who need to model the costs and benefits of the more complex process of educational change using new technology. This is a critical problem, because unless academics are able to understand the relationship between the benefits and costs of this new approach to teaching, it will be impossible to realize the potential of new technology.

The first section begins by examining existing approaches to cost modeling and measures of benefits. A critique of existing approaches generates a list of requirements for a different approach. The principal idea is to get beyond retrospective analysis of costs and benefits, and move instead to an approach that focuses on prospective planning for the internal relation between critical benefits and their related costs.

Current approaches to costing technology innovation

The costs of introducing new technology have been studied more extensively in higher education than in other sectors of education, as institutions attempting to innovate with new technology want cost information to inform investment. Evaluation studies are used to motivate the intention to innovate, but these focus on benefits. Costing studies have set out to establish, retrospectively, either the comparative costs of new technology versus old technology courses (e.g. Garrett and Maclean, 2004), or the range of costs for specific technologies, either across institutions, (e.g. Perraton 2002, OBHE 2003, OECD-CERI 2005), or within institutions (e.g. Bates 2005, Nicol and Coen 2003), each attempting to offer a definitive analysis of the cost of this type of innovation. There are some difficulties with each of these approaches.

Cross-institution approaches

Comparative costs of online courses as against campus-taught courses, for example, show little consistency in pricing across institutions. In a survey of 25 universities' MBA courses,

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Garrett and Maclean found that while some charge almost *double* the campus-based fee for an online course, others charge around *half* the fee for the campus-based version. Fees might be thought to bear some relation to costs, but the authors conclude that the costs of online learning are not well understood, and this is reflected in their “significant under or over-estimation of cost, leading to inaccurate cost-based pricing” (Garrett & MacLean, 2004). A university that does not realistically cost online teaching is likely to generate a radically different cost structure for its online courses from one that does.

Estimates of the comparative costs of different teaching technologies for distance learning suffer from similar diversity, again because they are costed in different ways. Perraton argues that while the costs of a particular method depend on local circumstances, which makes standard pricing impossible, between-method comparative costs can be generalised across institutions (Perraton, Creed et al., 2002). However, his study produces very different cost analyses from those of Bates, who did a within-institution analysis (Bates, 2005). Neither study comments on discrepancies of this kind, though both refer to Hülsmann as a common source (Hülsmann, 2000).

Other studies throw some light on the sources of discrepancy. An OECD/CERI in-depth survey of online learning in a small but representative sample of universities worldwide offers a detailed perspective on the larger surveys run by the Observatory of Borderless Higher Education (OECD-CERI, 2005). Most of the universities consulted see cost reduction potential in online learning, while being unable as yet to demonstrate it. The greatest confidence was evident in the universities with the best-developed online presence, suggesting that while the initial experience is of higher cost, universities learn how to manage, and begin to bring about a lower cost model. There is no well-established baseline cost for comparison, as the report finds that universities have as much difficulty in evaluating the costs of traditional education. However, it draws the helpful conclusion that the factors that help to bring down costs in the more mature institutions are:

- substitution, rather than duplication of online services,
- greater re-use and sharing of e-learning resources,
- increased peer learning, and

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more standardised production of materials

- all features of a more mature and better-managed system.

Rumble points out a further difficulty for transferring cost analyses across institutions. Placing a money value on the activities and resources being used in teaching is unreliable because the relevant parameters have to be related to the budgets and accounts of the institution, which may structure its finances differently from another institution (Rumble, 2001).

Within-institution approaches

By contrast with the cross-institutional surveys, Bates has done an extensive within-institution analysis of the costs of several technologies across different sizes of student population, taking into account both production and delivery costs. He demonstrates well the enormous effect on cost-per-hour of the different combinations of fixed and variable costs needed for each technology (Bates, 2005). The importance of including economies of scale in the analysis is also argued by the US-based Bridge project on costing methods (Jewett, 2002), (Jones & Matthews, 2002).

These conclusions tell us very little, however. It is obvious that a materials-based self-study medium will benefit from economies of scale, for the simple reason that fixed production costs can be spread over larger numbers of students, each of whom attracts a fixed fee. It is not a very surprising result. The critical issue is to assess the variable costs of the additional staff time for personalization each student requires, e.g. for personal support and assessment of their work. It is important to reveal the assumptions made on this, because the labour-intensive nature of student support diminishes economies of scale achieved in other areas. Corporate training studies have reported economies of scale derived from new technology, but they are often related to the reduction of the kinds of expenses never incurred in higher education, such as flights and hotels (Guri-Rosenblit, 2005). It takes much more care to achieve economies of scale in HE without reducing quality.

An institution-based analysis should be able to take scale into account, and case studies such as Bates' analysis for the University of British Columbia, where production costs are genuinely comparable, is valuable because it tells us something about the relative costs for that context. However, it may not be easily transferred to other contexts. The 'other things'

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that are considered as 'being equal' are never sufficiently explicit to afford reliable deductions. Trying to assign a particular cost to the production of a teaching resource in any medium begs too many questions of teaching quality, production values, expected self-study time, complexity, below-the-line costs, etc. These may be part of the 'understood' background within a particular institutional context, but become figural if the case study method is used as the basis for a different institutional case.

This is acknowledged in a UK-based approach to cost-benefit, which also focused on the institution-level analysis (Nicol & Coen, 2003). The method proposes beginning with the identification of benefits, and then calculating the total annualized costs of these. There are two problems here. The approach does not offer any help with how 'total costs' are to be derived, and the benefits identified, though they can often be measured (e.g. recruitment rates), cannot be uniquely associated with the options being compared. However, the approach is not designed to deliver accurate costing, as the authors stress, but to encourage an institutional debate about costs.

A more robust approach to institutional costing was taken in the most elaborate costing study to date, the US-based Pew Foundation's Program on Course Redesign. The explicit aim of the Program was to use technology in the design of courses in order to reduce costs, improve quality and enhance access. It therefore took seriously the business of defining costs accurately. Thirty institution-based projects were funded each year, from 1999 to 2001, to redesign their pedagogical approaches to achieve more efficient learning. Twenty of the thirty reported cost reductions, mainly through the adoption of course management systems, automated assessment, online tutorials and shared resources. The benefits of ICT were expressed in terms of

- higher grades,
- better performance on tests of content knowledge and understanding,
- reduced drop-out, failure and withdrawal rates, and
- significant movement from passive to active, learner-centred pedagogy

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These are all retrospective measures, but the change in pedagogy and the drive to reduce costs, were planned in from the start, as they have to be if they are to be achieved (C. Twigg, 2002).

The important innovation of the Pew Program was to focus on planning for both cost reduction and greater value to the learner, right from the start of the innovation. This enabled it to achieve and demonstrate the cost-effectiveness of introducing technology in ways that other projects have never managed. Given its relative success, a study was commissioned to assess its transferability to the UK, and the report from the Observatory for Borderless Higher Education contains a wealth of information and sources of technology costing methodologies (OBHE, 2003). The report observes that there has been very little engagement with the findings of the Program in the US, no critique, no adoption, and only occasional description can be found in the literature. Perhaps the model itself does not transfer easily, but the Program has shown that cost-effectiveness can be achieved in the form of both cost reduction and benefits to students, IF there is careful planning from the start. The Pew Program therefore stands as a valuable guide for any institution that sets out to optimise its use of technology, and demonstrates that there are several different and successful institutional models of this type (C. A. Twigg, 2003) .

Comparative costing of old and new teaching methods has proven difficult, therefore, both across and within institutions. We cannot generalize across institutions because local conditions are so different, and we cannot compare old and new methods within institutions because there is no established baseline for the comparative costing of old and new teaching methods. Although the UK has made an advance on costing teaching in general terms with the TRAC 'transparent approach to costing' methodology (HEFCE, 2005), it does not address the costs of different types of teaching method. We can therefore only expect to provide an approach that each institution can interpret and adapt to ensure it has an accurate representation of its own comparative costs of innovation.

Relating benefits to costs

Costing studies have not explicitly linked the sought-after benefits of new technology to their related costs. Assessing the comparative benefits of different teaching methods has

presented difficult methodological problems for educators throughout the history of educational innovation. The common finding is of 'no significant difference', although it is more likely to mean that we have failed to demonstrate the differences that exist, rather than the literal meaning that these two different ways of learning are identical for learners. It may also mean that the innovation has not yet reached maturity – it takes time to learn how to design a new teaching method, and a comparative evaluation too early in its practice will undermine the chances of optimising it. Educational innovations do persist, for a variety of reasons other than clear short-term evidence of benefit, and then have the opportunity to improve over time and demonstrate their worth. By then the requirement for evidence has passed, and we still have no baseline for comparison with further innovation, other than the macro-level evidence from the assessment system, too crude to help with the scale at which most innovation takes place.

Inevitably, most costing studies have focused mainly on the difficulty of costing, avoiding the difficulty of measuring benefit. However, an adequate cost-benefit analysis should bring the two together at the detailed level of the nature of the innovation. Ehrmann makes the argument that rather than engage in the doomed attempt to measure benefits directly, we should use proxy measures instead, and cost the activities that lead to pedagogical benefit (Ehrmann, 2002). The analysis should relate the sources of the benefits of an innovation – the activities that teachers and learners engage in – to the costs of those activities for both teachers and learners.

The principal cost parameters for comparing teaching methods

What do we conclude? We need to identify the common ground that can be established across educational costing studies. If the models do not transfer easily we should at least be able to identify the most important parameters to include in a costing model capable of determining the benefits of digital technologies for learning.

Existing studies together provide a comprehensive range of parameters ((Bates, 2005), (Perraton, Creed et al., 2002), (Rumble, 2001), (Steinberg, 2004), (C. Twigg, 2002)). The contrasting approaches of this selection of the studies discussed here is evident from Table 1.

For each one the terminology they use is set against similar parameters identified by the other researchers, as far as possible.

Table 1: Contrasting approaches to costing parameters for comparing traditional and technology-based teaching

Bates	Perraton	Rumble	Steinberg	Twigg
Planning and management	Set-up		Change management	
Course development	Running (fixed)	Creating	Design	Instructional preparation
		Acquiring	Rights costs	
Tutors	Running (variable)	Pedagogic support	Student support	Instructional delivery
		Administrative support	Student administration	
Administration / overheads		Institutional management		
Course maintenance				
Materials	Production	Producing		
	Reproduction			
Delivery and operations	Distribution	Delivering	Delivery	
	Reception			
			Quality control	
			Evaluation	Evaluation
			Staff development	Staff development
Technical support			Staff support	

Costing parameters are selected for different reasons, depending on the purpose of the study. While the cost to students of receiving online study is important for Perraton, for example, it is less important for Twigg, as the Pew programme was run within institutions providing on-campus access for students. While all the studies include some aspect of pedagogic design the actual costs gathered differ. For example, Twigg assumed the materials being used were already available, whereas others build in total design and development costs as well as production. The selection of cost parameters must be clearly related to the

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purpose of the study, and the assumptions made about other costs clearly stated, for the analysis to be properly interpreted. Table 1 defines a superordinate set of costing parameters for TEL, that can be used in any campus, online, or blended learning context, and from which a particular costing exercise may select, as long as omissions are made explicit as the assumptions being made.

The approach to costing will also differ according to the level at which decisions are being made. At institutional level the flexibility offered by TEL is critical, because it enables students to enroll and study who otherwise could not do so. Case studies of investment at this level can show the value to the institution or department of deploying this feature of TEL (Bartolic-Zlomislic & Bates, 1999). But 'flexibility' concerns the mode of study. In this paper the focus is mode of learning, and how we make 'personalised learning' affordable. Decisions about teaching and learning are the domain of academics and the benefit-cost analysis entailed should be devolved to them.

To sum up, academic staff wishing to deploy new technology for a department or course in a cost effective way will find several limitations in existing approaches to costing:

There is no consistency in costing new technology methods across institutions in terms of costs measured

There is no consistency in the parameters to be used for comparing the costs of new technology with the costs of traditional methods, within an institution

There is no critical literature: studies that produce conflicting findings do not comment on these discrepancies

Costing models identify parameters to be costed, but give little help in estimating or measuring these for a particular institution, department, or course

There is no agreement on how best to identify and compare benefits of new technology against traditional methods

However, all the researchers in the field are agreed on the importance of understanding the costs and benefits of technology innovation, and on the difficulty of doing it. The model proposed here is an attempt to build further on the common ground that already established.

Modelling the real costs and pedagogic benefits of TEL innovation

Expenditure on technology enhanced learning is increasing every year, mainly because it is expected to benefit both an institution and its learners, and because in many cases it is experienced as being beneficial. So it will continue to expand. TEL is becoming gradually more mainstream as institutions improve their ICT infrastructure and personal access becomes more widespread. That may be good, but without a reasonable control of the costs there is the prospect that this expenditure will consume a disproportionate amount of the limited funding available to education without commensurate value. We have the telling example of the way the commercial sector has managed the introduction of new technology:

Little evidence of the benefits of IT to the US economy except in a few special technical areas (Landauer, 1995)

You can see the computer age everywhere but in the productivity statistics (Robert Solow, quoted in (Madrick, 1998)

Public services cannot afford the low productivity for ICT that the private sector coped with. Given that the expansion and embedding of e-learning is now inevitable, it must be planned carefully to ensure that learners are indeed benefiting from the innovation, and costs are at least understood and controllable. But for that to be possible, academics, teachers and managers need better tools than they have at present. Studies of the costing of technology demonstrate the high costs to education, and argue strongly for better planning by university managers (Schmidlein & Taylor, 2000), but do not show how to link the new costs to the expected benefits. Without understanding the relationship between the two, any planning will fail to deliver on the benefits. When costing is taken seriously, it becomes possible to develop an accurate business plan, and thereby set an appropriate fee (Bates, 2005).

This paper proposes a modelling tool to help innovators construct a plan for improved learning benefits, and controlled teaching costs. It is not an attempt to model all the benefits of TEL, nor all the costs of a course or module, such as the institutional overheads, the equipment and travel costs for staff and students, etc. It focuses only on the costs linked to staff and student time, and the benefits linked to the types of learning and teaching, not

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benefits such as flexible study times, reach to off-campus students etc. This analysis is about the nature of the learning process itself.

The requirements of a cost-benefit model can be derived both from the limitations of the current approaches, and from the needs of the innovators who might be using it.

The cost-benefit modelling tool should have the following characteristics therefore. It should:

Define benefit parameters that can differentiate between old and new methods

The focus should always begin with the expected benefits. The first question put by the UK Government's Treasury, in its advice on appraisal of an innovation, is about the benefit - "Can new technology offer a better way to achieve our objective?" - not the cost (HMT). However, a focus on learning benefit is not a feature of most costing studies. The benefit is taken either as understood, or as given by the nature of the change being costed, such as the move to online. A cost-benefit model should begin instead by representing the benefits to learners in terms of the key educational objectives: the degree of personalisation they can expect, and the quality of the learning experience planned. And it is essential to select for comparison the benefits that are primarily derivable from the innovation in question, and do not result from general institutional activities.

Define the cost parameters that can be associated with comparative benefits

The nature of the benefits will have a major impact on the costs, and may even need to be curtailed to make them affordable. An understanding of the detailed relationship between costs and benefits is essential if we are to make the best use of available resource. So a critical requirement of a cost-benefit model is that it make that relationship clear and explicit.

Focus on the major cost driver of staff time

The cost of switching from traditional to TEL methods, will not necessarily involve significant equipment costs in a well-equipped institution already making extensive use of ICT systems. It can be treated almost as a given, alongside buildings and telephones, with the attendant depreciation and replacement costs over the years.

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Institutions with an understanding of overheads will already know their cost per staff member. The more significant cost driver in the switch to TEL is that teachers, support staff and students spend their time differently. This difference in practice is also responsible for the added benefit of the innovation, so this should be the focus. “Can we use available resource better?” is the second question put by the Treasury in its advice on appraisal of innovation (HMT). The Pew Program, for example, showed that both cost reductions and learning benefits rested on how teachers used their time.

Represent value to the learner in terms of use of their time

None of the existing models include a parameter for student time, and yet this will be particularly important as post-school learners find their time constrained by the need to be in paid employment. Even at school level, learners will be aware of many competing demands on their time, and will want their classroom and personal study time to be used efficiently. Again, the way learners spend their time, traditionally and with the innovation, is an aspect of personalization, and should be represented in terms of both its cost and its benefit.

Support the local exploration of the cost-benefit relationship

The costing models in the literature have had almost no impact on practice in educational institutions planning e-learning innovation. They do not achieve consistency, they do not fit local practice, and they require considerable effort on the part of users and innovators to work out costs typically unavailable to them, given the recondite nature of teaching costs traditionally. A more user-friendly model would represent costs in terms of learner, teacher and support staff time for a meaningful period of study time – e.g. a course module, a school week, etc. It should be straightforward for users to find the data needed for input, and the model should be customisable to fit with local practice, and adaptable in the light of experience.

Represent technology-specific benefits

It is important that the model should include as far as possible all the advantages that new technology can confer in terms of relevant costs and benefits. A key advantage, for example, is that interactive, creative and communicative forms of new technology

offer personalization, and these more active forms of learning should be represented. Another advantage is that digital resources can be adapted and reused in different contexts. This simple fact would be complex to model in its entirety, but should be representable in some way to ensure that such an advantage can be brought into the plans. A further key advantage is scalability – the same resources can reach much larger numbers of students. If the model can demonstrate the advantages of scale and reuse, then it will also motivate the exploitation of these important benefits of using new technology.

Represent benefits in terms of improvements in learning

The most important benefits, ultimately, are the learning outcomes, the improvements in understanding and skills implicit in the learning objectives. A summative evaluation will test whether they have been achieved, but for planning purposes the model must represent the means by which these outcomes are to be achieved, i.e. time spent on different teaching methods. The current policy objective in the UK is personalization for learners of all types, across all subjects and stages of education (DfES, 2003; Leadbetter, 2004). The model should therefore represent improvements in learning in terms of proxy parameters measuring the degree of personalisation offered.

These are the minimal requirements for a workable cost-benefits model for educational change. Its key characteristic is that it aims to model, prospectively, the relation between the critical benefits (learning experiences) and the critical costs (time). A model of this type is more accurately described, therefore, as a 'benefits-oriented cost model'.

This approach would answer the question: what combinations of innovative and traditional methods yield the kind of personalisation that is both beneficial and affordable? The NATFHE survey of changes in lecturers' workload due to online learning showed that while its positive features were *the enhancement of the student experience* and the ability to cater for *a more diverse range of student needs*, the principal disadvantages related to *workload* and *lack of support* (NATFHE, 2003). The approach advocated here would represent all these factors.

A prototype 'benefits-oriented cost model' for educational change

A model is proposed here that takes account of the requirements above, and attempts to provide a usable design and planning tool for academics and teachers who wish to make the shift to innovative teaching in a way that generates clear improvements in terms of benefits to learners, and more productive use of time. It is built within a standard spreadsheet tool, as a familiar environment. The requirements derived above are represented within the tool in the following ways.

Define benefit parameters that can differentiate between old and new methods

These are defined in terms of the types of learning activity afforded by the teaching media used. Five types of learning activity are defined: attending, investigating, discussing, practising, articulating, each of which can be linked to some, but not all types of teaching medium. For example, a large group lecture affords 'attending', whereas a tutorial affords more 'discussing' than 'attending', and a print-based study guide should involve the students in both 'attending' and some 'practising'. The same kind of analysis can be done for new media, e.g. interactive computer-marked assignments (ICMAs) provide a good environment for 'practising' because the learner is given immediate feedback on their performance. Digital tools (e.g. spreadsheets, data analysis, CAD, etc.) similarly give the opportunity to practise, but they also capture what the learner does, or creates, or builds, offering a kind of 'articulating' opportunity as does the traditional essay. Computer-mediated communication (CMC) gives a much better opportunity for discussion than the face-to-face tutorial, because learners have equal time, whereas the tutor occupies a privileged position in most tutorials, and takes a high proportion of the speaking time. The digital 'audio-graphic' environment, which, like the tutorial, is synchronous and tutor-led, behaves much more like the tutorial than CMC, from the point of view of how learners spend their time. Learner time spent on each medium can therefore be estimated as an expected distribution between the different types of learning they encounter. Table 2 shows how 4 hours-worth of study time spent on each of these different media might be expected to distribute learner time differently across the five broad types of learning activity.

Table 2: Differential distribution of type of learning activity across different teaching media, those in italics being computer-based

Learning activities	Large group	Print	Tutorial	<i>ICMA</i>	<i>Tools</i>	<i>CMC</i>	<i>AudioGr</i>
Attending	4	3	3				3
Investigating							
Discussing			1			4	1
Practising		1		4	3		
Articulating					1		
Total	4	4	4	4	4	4	4

By representing the learner’s experience of different media in this way, it becomes possible to demonstrate the value of the more active forms of learning offered by digital technologies, thereby providing a comparative description of a better quality learning experience. The naming of learning activities can be changed by the user, and the distribution of time is also entirely in the hands of the user, but should be allocated according to their own understanding of the expected learning experience provided by each medium.

Define the cost parameters that can be associated with comparative benefits

For each teaching medium it is possible to define the staff time required to prepare, produce and present that teaching. This is calculated in terms of academic time for preparation, production time for design and development, and academic time for presentation. Different methods vary greatly. For example, a face-to-face tutorial requires some advance preparation, no production, and the same presentation time for staff as study time for students, whereas an asynchronous online conference requires little preparation, some technical production time to set up and run the conferencing environment, and significant presentation time if the academic is an attentive member of the conference. Table 3 shows an extract of the default data in the model for a group of students, each of whom spends one hour on either a tutorial or an online conference, whereas the academic spends either half an hour preparing for the tutorial and an hour presenting it, or half an hour reading, contributing to, and maintaining the conference. For a conferencing system embedded in the IT infrastructure, there is still

some production time needed to design and test the conferencing format, discussion groups, moderators, navigation mechanisms, etc. These differential estimates are built into the model to calculate staffing costs, and are related directly to the type of learning experience being provided. Staff time calculations are based on the fixed costs (of preparation and production), and the variable costs (of presentation). The latter will also be linked to different staff-student ratios (see Table 5). Again, users may change the default data to their preferred estimates.

Table 3: Staff hours needed to prepare and present one hour of learning/study time

	Tutorial	CMC
Academic preparation	0.50	0.00
Professional production	0.00	1.00
Academic presentation	1.00	0.50

Focus on the major cost driver of staff time

The only costs represented in this model are staff time, but they include time for planning, design, development, production and support. They do not include time spent on overall curriculum planning and design, as this is common to old and new versions of a course or study period. Costs of equipment and infrastructure are not included, because these are also used across a range of courses, and are amortised over years of use. By estimating staff costs per hour in terms of average salary it is also possible to calculate the break-even fee for the teaching time elements for a course. This can be particularly important if student numbers are being increased with the introduction of new media, as the model calculates the effects of both fixed and variable costs.

Represent value to the learner in terms of use of their time

Table 4 shows how the model represents value to the learner. Design 1 offers a simple design for a 10-hour period of study, consisting of just two teaching methods: 5 hours of lectures and 5 hours for learners to spend producing a tutor-marked assignment, e.g. an essay based on the lectures. The boxes show the types of learning activity that

may be afforded through each medium. For Design 1 the final column gives the resulting distribution of learners' time across the five learning activities. It assumes that learners spend their time primarily 'attending' during the lecture, but that the essay requires some 'practising' of the skills of the subject as well as doing the work for 'articulating' their own point of view.

Table 4: Student time to be spent on learning activities for each teaching medium

Design 1		Teaching methods			
Learning activities	Lecture	TMA	Tools	ICMA	Hours
Attending	5				5
Investigating					0
Discussing					0
Practising		2			2
Articulating		3			3
Total learner time	5	5	0	0	10

Design 2		Teaching methods			
Learning activities	Lecture	TMA	Tools	ICMA	Hours
Attending	1				1
Investigating					0
Discussing					0
Practising		1	3	1	5
Articulating		2	1	1	4
Total learner time	1	3	4	2	10

Design 2 offers a wider range of teaching methods. The majority of the time on lectures is shifted to use of computer-based tools, and the time spent on an essay is reduced in favour of interactive computer-marked assignments, which provide more practice and formative feedback. Comparing the final columns, showing the resulting distribution of learners' time across learning activities, the second design has reduced the amount of relatively inactive 'attending', to improve the proportion of active learning and formative feedback. In this way, expected benefits can be designed into the new course plans.

Support the local exploration of benefits-oriented costs

The staff time estimates built into the model as default values are based on a survey of academics at a distance teaching university. However, the estimates from practising academics responding to the survey varied by orders of magnitude in terms of, for example, how long it takes to prepare a one hour lecture. There is little point in attempting to define how long it takes an academic to prepare a lecture, and such estimates would be even more inappropriate for innovative methods. The time estimates built into the model must therefore be seen strictly as default values, which are editable to fit local conditions. This adaptability of the model also makes it possible for academics and course designers to change their own estimates of how long to allow for design, production and presentation. Suppose they estimate 3 hours per study hour to design an audio-graphics session, run the model, and discover that this creates a high cost. They could then change the estimate to 2 hours per study hour. The model is acting not as a description of current activity, in this case, but as a planning tool to clarify constraints – ‘*for this course to be viable we have to find ways of spending less time on design*’, or ‘*we accept the high cost because we are building in learning time for the first run, and will reduce the cost of preparation in the second run*’. The articulated plan gives academics more control over the introduction of the innovation – they may decide to scale down the amount of change to a course to make it more manageable, or the analysis may give them what they need to argue for increased resource to develop the innovation.

Represent technology-specific benefits

The more active forms of learning afforded by digital technologies provide the key benefit to learners. But there are two further benefits to represent: *reusability*, and *economies of scale*. Reusability can be represented by reducing the staff hours needed to prepare and produce materials, for each method. Reuse does not reduce production time to zero, as the materials must be discovered, selected, evaluated, and modified, but the time is certainly considerably less than the time to design and produce from scratch. Estimates can be useful in demonstrating the difference reuse makes to the viability of a course.

Economies of scale are represented in terms of amortised fixed production costs, and the variable 'presentation' costs. For most technology-based methods, while production time may sometimes be higher, this is a *fixed cost*, independent of student numbers. So they achieve economies of scale for large student numbers, for example, with a shift from classroom laboratories to interactive simulations. In this case, the presentation time, with no lab supervision, also reduces dramatically, so there is considerable saving. Marking assignments is a wholly *variable cost*, and computer-marked assignments will reduce these costs to zero, while increasing production time. For large numbers this again achieves considerable economies of scale.

Finally, the presentation costs for technology-based methods can be lower because group sizes for computer-mediated conferencing (CMC) can be larger than for face-to-face: there is much more peer-to-peer interaction among learners online, reducing the role of the academic, though not to zero: the contribution, and simple presence of the academic is extremely important. The optimal group size for an online synchronous 'Audio-graphic' tutorial will be as low as a face-to-face tutorial, because synchronous discussion is serial and time-bound.

Table 5 shows how the model could be used to test the effect on staff time shifting 18 hours worth of learning time from old methods (tutorial, workshop, marked assignment) to their equivalent in new methods (CMC, computer-based tools, computer-marked assignment). Table 6, using the same shifts in methods, but with larger student numbers, shows how the model behaves in terms of economies of scale. For the purpose of illustration, this comparison looks at the extreme case of converting all the old technology methods in Design 1 to the equivalent new technology methods in Design 2. The mix of academic and support staff is assumed as the same for both. Tutorial time is converted to online CMC; workshop time shifts entirely to interactive tools, such as simulations and role-play games; tutor-marked assignments (TMAs) become interactive computer-marked assignments (ICMAs). Normally the shift would be to a blend of methods, but this extreme case helps to demonstrate the contrast in the behaviour of the different types of method.

Table 5: Staff hours needed to prepare and present the study hours defined for each method.

Design 1	Teaching methods						Total hours
	Tutorial	W/S	TMA	CMC	Tools	ICMA	
Study hours	10	3	5	0	0	0	18
Preparation	5	12	10				27
Production	0	24	0				24
Presentation	20	3	5				28
Total staff time	25	39	15	0	0	0	79

Design 2	Teaching methods						Total hours
	Tutorial	TMA	W/S	CMC	Tools	ICMA	
Study hours	0	0	0	10	5	3	18
Preparation				0	30	9	39
Production				10	50	15	75
Presentation				5	0	0	5
Total staff time	0	0	0	15	80	24	119

Table 5 is for a cohort of 15 students, with group sizes for tutorials set as 10, workshops as 20, CMC as 30. Staff hours per student can then be calculated as 5.3 (79/15) for Design 1 and 7.9 (119/15) for Design

Taking the calculation of staff time for tutorials in Design 1 as an example: the model assumes that it takes half an hour to prepare a 1 hour tutorial, no production time is needed, and it takes 1 hour to present a 1 hour tutorial. As tutor-group size is set to 10, the 15 students need 2 tutors. The total staff time for 10 hours' worth of tutorial for this group is therefore calculated as 25 hours. If the user puts in different estimates for presentation and production, or changes the maximum group size, of course the totals would be different.

Table 5 shows that for such low student numbers, TEL in Design 2 costs more in terms of staff hours per student. The shift to new technology cannot confer the advantages of economies of scale, only the benefits of greater flexibility of learning time, and more active learning opportunities with the new methods.

By contrast, Table 6 shows how a shift to the same technology-based methods scales up to a larger cohort of 100 students, and achieves a lower per-student cost in terms of staff time. The traditional methods also improve their cost-effectiveness through amortisation of preparation and production time over larger numbers, but they lose on the higher cost of presentation time. Making the same assumptions about group size for tutorials (10), for example, requires $1 \times (\text{no. of students} / \text{group size})$, i.e. $1 \times 100/10 = 10$ hours for each tutorial hour planned, which is a huge 100 hours of presentation time from staff for the 10 hours of tutorials. CMC has a larger group size (30), and lower proportion of presentation time: for a 1 hour tutorial the academic is present for 1 hour, whereas for 1 hour's worth of learner time allocated to CMC the academic is assumed to be 'present' for half an hour, as students interact with each other far more. So CMC requires $.5 \times (\text{no. of students} / \text{group size})$, i.e. $.5 \times 100/30 = .5 \times 4 = 2$ hours for each CMC hour planned. It therefore delivers a comparable learning experience for a third of the time for a face-to-face tutorial.

Table 6: Staff hours needed to prepare and present the study hours defined for each method.

Design 1	Teaching methods						Total hours
	Tutorial	W/S	TMA	CMC	Tools	ICMA	
Study hours	10	3	5	0	0	0	18
Preparation	5	12	10				27
Production	0	24	0				24
Presentation	100	15	33				148
Total staff time	105	51	43	0	0	0	199

Design 2	Teaching methods						Total hours
	Tutorial	TMA	W/S	CMC	Tools	ICMA	
Study hours	0	0	0	10	5	3	18
Preparation				0	30	9	39
Production				10	50	15	75
Presentation				20	0	0	20
Total staff time	0	0	0	30	80	24	134

Table 6 shows data for 100 students, with group sizes for tutorials set as 10, workshops as 20, CMC as 30. Staff hours per student are 2 (199/100) for Design 1, and 1.3 (134/100) for Design 2.

Both old and new methods benefit from economies of scale. Even for the traditional methods higher student numbers achieve greater efficiency and much lower per-student cost in terms of staff time. The implications of this are discussed further in the concluding section.

On this basis we can see how the model allows planning to differentiate between the different kinds of benefits conferred by new technology, and also to plan properly for use of technology where low student numbers make it uneconomic.

Represent benefits in terms of improvements in learning

A prospective planning model does not represent learning outcomes, but it can represent intended improvements in learning in terms of proxy parameters, i.e. measures of the degree of personalisation offered. In the current version this can be done in terms of the staff-student ratios used for the size of each type of group, and by shifting to more personalized forms of learning such as the use of online 'tools' (e.g. simulations, games, creative programs, discussion environments, etc., all of which offer more active learning, more practice with immediate formative feedback, more learner interaction, and more learner creativity), computer-marked assignments (which give some level of formative feedback), or more active learning, as discussed above. Thus an expectation of improvements in learning can be planned in, being verified independently, once the innovation is running.

The model proposed here therefore takes account of all the requirements specified in the previous section. By implementing it in a familiar and widely available spreadsheet environment, it provides an accessible and user-friendly design and planning tool for academics and teachers who wish to make the shift to innovative teaching. The most important contribution it makes is to formalise the planning of improvements in learning. This can no longer be left to chance, as new technology becomes mainstream, student numbers keep increasing, and staff and student time become ever more precious commodities. This is

the concern that lies at the heart of the productivity objective – to use staff and student time as well as possible, as the only way of achieving both higher volume and higher quality.

The value of modelling tools

A modeling tool of the kind described here does not necessarily represent the system as it is – how well that is done is entirely in the hands of the user. The default data are average values derived from studies in one institution, but local implementations vary so widely that averages become meaningless. This is why it is unrealistic to expect that we can describe general cost-benefits across different educational contexts. But the model does capture the form of the analysis that has to be done to give an adequate representation of the relation between costs in terms of staff and student time, and benefits in terms of personalization and quality of active learning experience.

The model is best used, therefore, as a planning tool. It can help to:

- clarify thinking about the purpose of a technology-enhanced learning innovation

- identify the key parameters that confer learning benefits

- compare old, new, and blended methods

- model alternative plans

- support an iterative approach to designing a plan against the cost it generates

- capture the planning in a form that can be communicated and revised

- define the staff resource needed to realise a plan

- assess the per student cost of the teaching time for a course

This makes it possible for an academic or teacher using the model to understand how to deliver personalised learning in a way that is affordable.

An adaptable and locally customizable modeling tool of this kind also the virtue that it brings control of costs and benefits close to the academic designing a new course or period of study.

Unlike the costing studies discussed at the beginning of the paper, it does not attempt to ascertain costs as if they could be independent of a particular context and set of local conditions. These are best understood locally. Therefore, costing studies should be

undertaken, planned, tested and validated locally, and related to benefits. This is a 'prospective' approach to planning for quality teaching and learning, and their related costs, rather than the more usual 'retrospective' approach, as in the contrasting forms of QA (Ellis & Moore, 2006).

It also supports experimentation. Once a plan has been drafted using the model, it can be redesigned to generate a more acceptable bottom line, with different assumptions, or different starting conditions. It becomes more likely that innovators will plan in the features discovered in mature e-learning institutions – substitution of new methods for old rather than duplication, greater re-use and sharing of e-learning resources, increased peer learning, and more standardised production of materials, where appropriate (OECD-CERI, 2005). The advantage is that it becomes clearer, through this process, to assess what it takes to create an acceptable bottom line. In addition, once the plan has been carried through, the model stands as a comparison with what actually happened. Returning to it to compare initial assumptions with how long it actually took to develop an hour's worth of an interactive assignment will help innovators both to understand their current costs, and to plan more effectively in future.

Concluding points

Costing studies for new technologies have given little help to innovators and managers because they have tried to give a definitive and generalized answer to the question of whether they are cost-effective. Especially with an innovation that we are still discovering how to optimize, which changes the infrastructure requirements from physical to digital, and which dramatically changes the way in which staff spend their time, it is not feasible to determine a definitive answer. But given the cost of new technology, the value we expect from it, and the extensive planning it requires, it is essential that innovators should be able to get a better grip on the relationship between the expected benefits and the likely costs.

The analysis here has shown that current approaches to costing methodologies will not help with either costing the innovation, demonstrating its value, or supporting planning. The argument generated seven key requirements for a modeling tool to help innovators, teachers and managers. The solution offered focuses on the heart of the innovation, namely the way teachers and learners spend their time, and therefore captures the core costing parameters

Modelling benefits-oriented costs for TEL

for preparation, production and presentation, as defined within Table 1. It is the quality of the teaching that confers the main benefits for learners, and therefore it makes sense to represent these first in our attempts to capture a cost-benefit model – turning it round, to become a ‘benefits-oriented cost model’. The other important benefits of digital technology are to provide flexibility of provision, wider access to material etc. but these improve the opportunity to study, rather than the quality of the learning experience per se, and need a different kind of costing analysis.

Finally, for this benefits-oriented cost model to be optimized, the results of each use should be shareable across the teaching community. As for any theoretical description of the world, it must be challenged in the light of application to practice. There are many further complexities that could be built into this simple initial model. It would be valuable, therefore, to develop a community of users who can then develop and improve the model with use. An online community of practise, where innovators share their planning models, is a further benefit of new technology, as it provides a highly efficient way of enabling a community of practice to improve its tools. The modeling tool described here is therefore available for copy, reuse and further developmentⁱⁱⁱ. Making such a tool available to innovators and managers should support local improvements in understanding benefits and related costs of the technology, and within a community of practice could lead to a better general understanding of how to optimize the innovations in personalised learning that digital technologies make possible.

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ⁱ The author was responsible for the consultation and development of the strategy, as Head of the E-Learning Strategy Unit at the DfES from 2002-5.

ⁱⁱ Ministerial Moving Young Minds seminar, see www.eife-l.org/news/releases/epBETT2006.

ⁱⁱⁱ Further research and development is taking place as part of the JISC Design for Learning Programme, within the project 'User-oriented planner for learning analysis and design', see <http://www.wle.org.uk/d4/>.

Both the original version of the model, which generated the Tables in this paper, and the current version of the model are available to download as Excel spreadsheets.