Information Technology-based Teaching and Learning in Higher Education: a view of the economic issues

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ABSTRACT The past twenty years have seen significant expansion of United Kingdom higher education, so that the present system is one of mass access. Approximately one-third of the 18-21 age cohort now proceeds to higher education, and almost half of all enrolled students are aged twenty-one or over. Adjustment to the new order has occurred during periods of financial stringency (measured by units of resource per student), and rapid developments in communications and information technology, which are believed to offer efficiency gains to the sector. A series of national and locally-funded development initiatives has encouraged exploration of alternative teaching and learning delivery strategies, based on these technologies. To date, uptake of IT-assisted teaching and learning resources has been limited. Measures designed to establish the true development and adoption costs and related benefits (both economic and educational) from this approach to teaching and learning are equally restricted. This paper outlines some of the basic economic principles relating to resource allocation decisions in IT-assisted teaching and learning. The methodology of Cost-Benefit Analysis (CBA) is discussed, as are the major conceptual and practical difficulties of accurate assessment of costs and benefits in this context.

Introduction: the challenges posed for teaching and learning

Higher education (HE) in the United Kingdom (UK) has undergone massive expansion over the past twenty years. Until the 1970s, the proportion of the school-leaving population progressing to courses in higher education was less than one in fifteen. During the 1980s and 1990s, this proportion increased significantly, so that in 1996-97 approximately one in three of the population aged 18-21 was pursuing a course in HE, either through full-time
or part-time study. Additionally, the National Committee of Inquiry into Higher Education (Dearing, 1997) highlighted the large and increasing numbers of adults aged twenty-one and over who have opted for study in HE during the past decade. These mature students represented almost half of all higher education students in 1995-96 (HESA, 1997), with 42% of the total aged over twenty-five. This changed demographic profile may alter significantly in the near future in the light of proposed changes in the way that higher education is to be financed. Indications early in 1998 suggest that the number of mature applicants to higher education had fallen by approximately 16% over 1997, compared to a fall overall of some 4.2% (The Times Higher Education Supplement (THES), 13 February 1998). Suggested reasons for this reduction include the introduction of fees and removal of grants, as well as demographic factors, and the past success of universities in recruiting mature students.

Over this twenty-year period total public funding for higher education has increased in real terms by 45%, although the unit of funding per student has declined in real terms by 40%. Dearing suggests that a number of universities have responded to these increased pressures on finance by under-investment in physical space and other infrastructural investment. Some institutions have indicated that current teaching practice and existing systems for student assessment and support can barely cope with the increased throughput of student numbers. Others have alleged that increasing the proportion of the population admitted to study in HE, together with alternative entry and progression routes and increasingly diverse qualification goals, might affect the overall quality of teaching and learning. All of these factors are likely to be significantly affected by current proposals both to alter the funding arrangements for higher education and the increased attention being paid to the need to inculcate a lifelong learning ethos among the population, as a potential contributor to individual employment prospects, as well as to national economic performance.

One consequence of the recent changes has been increased demands on lecturer and support staff time. This, coupled with increased pressure on academic staff to engage in scholarly activities other than teaching and research – additional administrative duties related to increased student numbers, consultancy, organisation of short, fee-earning courses – has, in some institutions, squeezed the amount of conventional teaching contact time available. A number of institutions have conducted internal analyses of current working practices, and given thought to alternative course delivery methods. Examples of alternative teaching and learning models and indicative implications for cost of development and course delivery are outlined in Appendix Two of the Dearing Report (Dearing, 1997).
System Response

One suggested solution to these issues is that UK higher education radically alter the way in which teaching and learning is delivered and assessed. In particular, with the rapid growth in power and functionality of modern computing and networking systems, the sector has been encouraged, both at the national level, and by locally-driven initiatives, to embrace IT-supported teaching and learning strategies.

With the launch of the Computers in Teaching Initiative (CTI) in 1989 by the then Universities' Funding Council (UFC), UK higher education was sent a clear signal of public sector funding agencies' view of the importance of information technology-supported teaching and learning in all aspects of higher education. An initial twenty (later increased to twenty-four) discipline-based CTI Centres were located in universities around the UK, to advise and support academics in the use of computers in teaching. Additionally, a Central Support Service (CTISS) was located at Oxford University, to coordinate provision of information, advice and training for academics on the resources available in their disciplines, and on how to adopt IT materials in their own teaching. Later phases of this programme focused on awareness-raising within the academic community of the potential and availability of computer-based learning materials. Subsequently, UFC launched the first phase of the Teaching and Learning Technology Programme (TLTP) in February 1992, when universities were invited to submit bids to the £7.5 million per annum initiative (UFC, 1992). The invitation indicated that, ‘the aim of the programme is to make teaching and learning more productive and efficient by harnessing modern technology’.

In response, UFC funded forty-three projects from the 160 submissions received, at a total cost of £22.5 million over three years. A second phase of TLTP was launched in April 1993 by the UK funding bodies (successors to UFC), with similar aims to Phase One, providing total funding for a further thirty-three projects at a cost of £11.25 million over three years. The projects selected for public sector funding include around a quarter located in single institutions, with a focus on changing the institutional ethos through fuller integration of learning technology into the teaching and learning strategies of the university. The remainder are focused on courseware development in a wide range of academic disciplines, involving consortia ranging in size from two to fifty institutions. In addition to the external funds committed to IT-supported teaching and learning developments, host institutions have contributed directly and indirectly to these initiatives. The consensus on total funding, both national and local, committed to the first two phases of TLTP is around £75 million (TLTP, 1995; TLTP, 1996).
In July 1997 a third phase of TLTP was outlined, with funding from HEFCE (Higher Education Funding Council for England) and DENI (Department of Education Northern Ireland) of £3.5 million per annum for three years. The emphasis in Phase Three is strongly on implementing in mainstream teaching those courseware materials and IT-supported learning practices already developed, and on evaluating the outcomes associated with their implementation and wide-scale use within universities.

Quite apart from national initiatives, many universities have developed local solutions to perceived teaching and learning delivery requirements, making extensive use of modern communications and information technology (CIT). The Dearing Report estimates annual expenditure on CIT in HE institutions to be approximately 10% of the total HE budget – between £800 million and £1 billion (Dearing, 1997). Not all of this expenditure is for direct IT-assisted teaching and learning development and adoption, but a significant proportion may be assumed to be used in this way.

In addition, the Joint Information Systems Committee (JISC) is charged with the responsibility for stimulating and enabling the cost-effective exploitation of information systems, and to provide a high-quality national network infrastructure for UK higher education and research communities. JISC provides or manages a wide range of other programmes for supporting scholarly activity, including an Electronic Libraries Programme (eLib), stemming from the Libraries' Review Group 1993 Report (Follett, 1993), under which £15 million has been committed to sixty projects over the period 1995-1998. The JISC Technology Applications Programme (JTAP) is designed to investigate the impact of technologies on higher education and develop applications in support of JISC’s overall strategy. JTAP has supported fifty-three projects in its first phase, including visualisation, virtual and remote environments, cluster computing, networks, and collaborative and distance working. Phase Two projects include use of IT in support of institutional management, and development of a specification for affordable computers for students (including Network Computers). JISC and a consultancy firm have developed a set of Guidelines for Developing an Information Strategy in Higher Education Institutions (HEIs) through 1995-96 and a pilot project was launched in six HEIs in June 1996. This initiative correlates with the view expressed in Dearing that institutions develop effective communications and information strategies, including management development programmes in which senior managers acquire deep understanding of CIT (Dearing, 1997, Chapter 13, especially Recommendations 41 and 42). Similar recommendations were indicated in Boucher et al (1997).

Given the large sums involved in all of the above initiatives, together with the significant emphasis given to the importance of CIT in the Dearing Report (Dearing, 1997) it is fundamentally important to give due
consideration to the costs associated with widespread adoption of IT-supported teaching and learning, and wider aspects of CIT and related technologies in the choice of delivery strategies, in relation to the benefits expected from so doing. Indeed, such was the importance attributed to CIT in the Dearing Report, that one complete chapter was devoted to its potential for benefiting higher education. References to the supposed efficacy of IT-supported teaching and learning appear throughout the Report. A single example will give the flavour:

...the innovative exploitation of Communications and Information Technology (C&IT) holds out much promise for improving the quality, flexibility and effectiveness of higher education. The potential benefits will extend to, and affect the practice of, learning and teaching and research. (...) There is scope to reduce costs in the future and the potential is great, but implementation requires investment in terms of time, thought and resources in the short term. (Dearing, 1997, para.13.1; emphasis added)

In the context of the large amounts of time and comparatively large sums of money devoted to IT-assisted teaching and learning initiatives over almost a decade, it is disappointing that a national committee of inquiry into the current locus and future direction of higher education has so little to say on the extent to which such teaching and learning activities have already impacted upon the sector, and even less to add by way of quantitative assessment of the efficacy or otherwise of adopting these learning methods. Dearing (1997) focused on two key issues for the future of higher education:

x extending access, particularly to under-represented socioeconomic groups;
x proposing a mechanism for generating sufficient financial resources to ensure the continuing quality and accessibility of mass higher education.

However, when the financial implications of the proposed mechanism are unravelled, it is apparent that the funding problems outlined above are unlikely to be ameliorated in either the short or longer term. Barr & Crawford (1997), in their evidence to the House of Commons Select Committee on Education and Employment, indicate that the current arrangements for classification of student loans impact adversely on the quantum of finance available to fund higher education. Loans are currently classified as a component of grants in the public accounts, rather than recognising that a significant proportion will be repaid (in due time). According to their analysis, the current funding shortfall in universities will be exacerbated by the Government responses to the Dearing proposals, because:

x they produce no more resources for students or universities;
x they put access at risk;
x they create inequities in other ways;
they cannot be implemented within the proposed time-frame. Reports in the educational press indicate that applications to many UK HEIs are markedly down compared with the same date in 1996 (THES, 17 October 1997; THES, 13 February 1998). This might be seen as early indicative evidence of the occurrence of Barr’s second prediction. The consequences for HEIs of the first prediction are that even greater pressure is put on university finances. Statements in Dearing that CIT can provide significant cost savings in delivering high-quality teaching and learning need to be examined to assess the extent of such savings and/or quality enhancements.

In July 1996 HEFCE commissioned a short research study into the processes and issues associated with information technology-assisted teaching and learning (ITATL) in higher education. The results (Boucher et al., 1997) indicated that the original HEFCE commissioning document was correct in asserting that the potential of IT-based methods in support of teaching and learning has yet to be fully realised, and that evidence in favour of the original productivity and efficiency objectives of TLTP (UFC, 1992) was sparse. The commissioning document included the comment:

In the present context of financial stringency and greatly increased numbers of students entering HE, the maintenance of quality in the face of reduced units of resource is something to which technology assisted teaching might contribute. Although development and innovation in the use of IT in teaching and learning is accelerating – with realisable potential yet to be achieved – the extent to which the above broad objectives are being met is still uncertain. Furthermore, much of the evidence which supports the use of technology assisted teaching and learning is either diffuse or anecdotal. (HEFCE, 1996)

The outturn of the research programme largely confirmed this view, particularly in respect of the extent to which enthusiasm for large-scale adoption of IT-assisted teaching and learning methods was driven more by acts of faith and hope than by substantiated and well-documented experiment. In particular, hard quantitative evidence on the costs and benefits of IT to institutions and the higher education sector was extremely difficult to obtain. In this respect, there are similarities between higher education and a number of commercial organisations (Willcocks, 1994; Parker, 1996; Willcocks, 1996), where information systems investments have rarely yielded the productivity benefits and cost-reductions claimed in advance of the investment.

**Review of Existing Economic Literature on IT-supported Teaching and Learning**

Scott (1997) examined the extent to which current analyses of IT-assisted teaching and learning take account of the costs and benefits of undertaking the development. Overall he concludes that much of the existing literature
(which is both relatively scarce and tending toward the normative rather than the substantive), fails to measure adequately the true costs of IT-assisted teaching and learning and is possibly even less successful at capturing the benefits. In general, the costs of development of courseware, managing the development effort and providing stable, well-documented resources for easy adoption into higher education courses are predominantly loaded at the beginning of any IT development project. The benefits, where these can be identified, tend to be educational (Hawkridge, 1992) and long-term, and the methodology for assessing improvements in student learning (measures of effectiveness) is not universally recognised in the education research community (Boucher et al, 1997). The benefits, which are largely intangible, include (CTISS, 1992):

- improved overall student motivation;
- improved quality of learning experience, and a shift from passive to active learning;
- change in institutional culture, especially with respect to an ability to exploit technology;
- improvement in transferable skills (e.g. independent study or IT skills);
- improved quality of teaching;
- improved teaching materials quality;
- more flexible student access to learning materials, both on-site and (via telecommunications) off-site.

Additional benefits may arise as a result of using computer-based simulations to allow learning which might otherwise be too dangerous, too costly, destructive or unethical, or which if performed in real-time would not yield measurable output. In all such cases the economies of scope permitted by adopting appropriate IT-assisted teaching and learning materials allow for learning which might otherwise be impossible. Evidently, in such cases there is an opportunity for identifying significant benefits from adopting new technologies. More generally, however, a framework for analysing the true costs and benefits of IT-assisted teaching and learning must take account of a range of cost and benefit categories which pose differing and often challenging measurement problems.

Economic Fundamentals

In the past universities have been largely publicly funded. With only minor exceptions, those seeking to enter higher education in the UK have relied upon the public sector to provide payment of tuition fees and a means-tested maintenance award. Governments of various complexions have reiterated the critical importance of an effective post-secondary education sector to ensuring the productivity growth necessary for the UK to perform effectively in increasingly competitive global markets (National Advisory Council for Education and Training Targets, 1993; Department of Trade and Industry,
The tightened financial constraints in higher education and increased rates of student throughput referred to above, require public sector funds to be allocated as efficiently as possible within HE. In achieving this allocative efficiency, a widely accepted methodology is that of Cost-Benefit Analysis (CBA).

CBA is an analytical procedure whose objective is estimation and evaluation of the net benefits associated with alternatives for achieving defined public goals (Prest & Turvey, 1965). The literature on CBA is vast, and the range of public projects to which the analysis has been applied includes assessment of new bridges, underground transportation systems, new hospitals, schools, hydroelectric schemes, etc. Despite the apparent diversity of projects to which it is applied, the methodology is relatively robust to the scale and complexity of the project, and firmly rooted in sound economic theory. The method follows a logical two-step paradigm:

- stipulation of one or several criteria by which to judge economic states;
- analyses of these states according to the defined criteria.

The decision to undertake some public investment projects (of which decisions to initiate programmes such as CTI, TLTP, eLib and internally-funded IT-assisted teaching and learning programmes are examples) leads to an altered economic state. The objective of CBA is to assess whether the altered state is an improvement or not. Whether the alteration is an 'improvement' depends on individuals' perceptions of how their own welfare is affected by the decision, and incorporates their preferences into the evaluation of economic states, as a social phenomenon. Four potential candidates for the criterion can be considered:

- unanimity;
- pareto superiority;
- majority rule;
- potential Pareto superiority (Kaldor-Hicks criterion).

In the case of the unanimity criterion, economic state one is deemed socially superior to state two if each member of society individually judges one to be superior to two. This criterion is, in most real-life assessments, unhelpful. There is virtually no substantive policy issue on which the whole population agrees unanimously. For Pareto superiority (Pareto, 1896), economic state one is judged socially superior to economic state two if at least one person judges the former superior to the latter, and no one judges otherwise. Although theoretically unassailable as a decision criterion, in practice this rule is inapplicable, because preferences on either side of the boundary will undoubtedly exist. The majority rule, where state one is judged socially superior to state two if the majority judge it to be so, is undoubtedly democratic, but this criterion is not adopted in practice. The most compelling reason for non-adopting is the massive informational requirements for the whole population to make well-informed judgments.
Evidence from opinions expressed on the large number of issues arising during the course of a year (or a Parliament) should be sufficient to demonstrate the potential flaw in the majority-voting criterion. This leaves the potential Pareto superiority criterion. Economic state one is judged to be socially superior to state two if those who gain by the choice of the former over the latter could compensate those who lose, so that, if the compensation were paid, no one would be worse off than in state one (Hicks, 1939; Kaldor, 1939).

The potential Pareto superiority condition is not universally accepted as the only way of measuring whether overall welfare is increased by undertaking an investment, but it forms the basis for most CBA undertaken in public sector investment appraisals. At the outset of any analysis of public sector resource allocation, the objectives or goals need clear articulation. In many public sector project appraisals the defined objectives are financial; achieving a specified outcome within a given budget, or at minimum cost.

Equally commonly, and reflecting the grounding of CBA in welfare economics, social objectives will be included, such as maximisation of social welfare, or achieving an improvement in social or environmental conditions, for a given expenditure. Defined public goals which impact on higher education are identified in Government policy statements on access to higher education, the development of a Learning Society and related performance targets for education and training. Aspects of these goals are also addressed in the Dearing Report, but objective quantification is not straightforward, and will necessarily involve making or imposing subjective value judgments on key variables. Discussion of these points is beyond the scope of the current paper.

The fact that CBA seeks to identify net benefits indicates that it is ideally used as a comparative procedure; that is, it compares the relationship between costs and benefits of a state arising from a defined investment activity, with that of the status quo ante. To place this in context:

Cost-benefit analysis is a way of setting out the factors which need to be taken into account in making certain economic choices. Most of the choices to which it has been applied involve investment projects and decisions — whether or not a particular project is worthwhile, which is the best of several alternative projects, or when to undertake a particular project. (Prest & Turvey, 1965)

A key issue surrounding the finance of IT-assisted teaching and learning in higher education is the relationship between the costs and the benefits of adopting this method of delivering and supporting teaching and learning. Case studies undertaken in the ITATL project sought information from institutions on these perceived costs and benefits. Limited amounts of quantitative information were gathered, and much of that obtained was of variable quality. This seriously constrained attempts to model the relationships among costs and benefits, and made it difficult to identify the
most important parameters, or to construct fully operational models concerned with the effectiveness of financial decisions taken in developing IT-assisted teaching and learning courseware and the adoption of this approach to the selected course within institutions.

CBA is an appraisal method for assessing the relative desirability and financial aspects of a proposed investment activity and all of the perceived benefits reckoned to flow from the investment project, prior to undertaking the investment. In doing so, it is intended to operate as a decision-support tool, by screening out inappropriate or socially and economically sub-optimal investment projects from a potential set of investment opportunities.

One of the alternatives comprising this set is the option of continuing to provide teaching and learning according to present practice. In order to evaluate whether investment in IT-assisted teaching and learning methods provides net benefits to institutions, it is necessary to have information on the current costs and benefits associated with these (conventional) course delivery methods. Typically, academic staff design and produce their teaching materials using whatever tools are most appropriate to their needs and levels of expertise. For some, lecture notes and other teaching materials may be hand-written, or word processed by secretarial staff. For others, use of word processors and/or presentation and graphics packages means that production of IT-enhanced resources may be undertaken directly. In yet other cases academics may create their own computer-based learning resources, using spreadsheets, databases, simulation packages, and similar applications. In virtually all cases, however, little direct recording of the time taken to undertake such preparation means that no firm basis exists for assessing the present cost of course delivery, and there is, therefore, little notion of the benefits which are derived therefrom. Evidently, clear private benefits accrue to the individual academic, in keeping intellectual capital and other skills-based human capital updated. Private benefits accrue to students who successfully complete their courses. Wider social benefits may apply to society. These are discussed further below.

CBA sometimes comes in for criticism in that it seeks to attribute monetary values to the costs and benefits associated with the investment activity. This criticism is often at its most severe when CBA is used to establish decision criteria for allocating scarce resources in medical contexts. Obtaining accounting information or internal estimates of the costs associated with externally funded courseware development projects should not, in principle, be too difficult, nor should it be controversial. However, establishing the true opportunity costs and benefits is not as straightforward as might be thought. It is commonplace for activity or project costs to be measured according to accounting principles, where the focus of attention is on the receipts and disbursements of funds associated with a defined area of activity. Measurement in this way typically leads to two potential errors: x failure to attribute the real cost of using scarce resources, and
a failure to account correctly for capital (Begg et al, 1994). Measuring or imputing monetary values for the benefits which arise from undertaking the development and implementation of courseware in teaching and learning contexts is often more problematical. As Scott (1997) points out, both the literature on costs and benefits of IT-assisted teaching and learning, and the data relating to these are currently limited.

Identification and Classification of Costs and Benefits

Although CBA provides a theoretically coherent framework of analysis for deciding on committing public funds, the technique needs to be modified in the context of the IT-assisted teaching and learning analysis. In this case, the challenge is to assess ex post the cost-effectiveness of modifying the delivery mode of a course of study using IT-assisted teaching and learning. Identifying these costs and benefits needs to be undertaken carefully, to avoid the possibility of double-counting. This issue applies more commonly to benefits than to costs but, because the procedure seeks to measure the incremental change effected by the decision to undertake the investment, sunk costs need to be excluded from the analysis. This has clear implications for the analysis of the development cycle for IT-assisted teaching and learning.

Both costs and benefits may be classified in a number of ways, providing varying degrees of illumination and/or usefulness. An obvious classification is that benefits are seen as positive effects arising from the investment, whereas costs are negative. More revealingly, benefits are additions to the real product of an economy, whereas costs are a diminution of the real product. When seen in this light, it is clear that CBA seeks to establish the extent of the opportunity costs related to the activity.

Opportunity cost (strictly, marginal opportunity cost) of a specific resource measures the cost incurred by failing to use the resource in its best alternative use. For example, the cost of a hectare of land for building a house will depend on whatever alternative uses the land has. If it is prime arable land, expect the price to be high; if it is marginal scrub land, the price will be correspondingly lower. If the land has good industrial potential, or if others perceive it to be a choice residential location, then expect the price to be higher still.

In adopting the IT-assisted teaching and learning approach, a range of key costs need to be considered:

- courseware development costs;
- incremental capital and recurrent equipment costs;
- (marginal) costs associated with provision of appropriate resources;
- infrastructural costs (costs of cabling, trunking, building reorganisations, etc.);
- maintenance (of equipment, software and other materials);
user support costs (technical support, training, etc.);
- costs of adoption (including dislocation costs);
- access costs (both on-site and off-site);
- security costs associated with IT resource centres;
- replacement costs (hardware and infrastructure);
- institutional overheads (space, heating, lighting, administrative support, etc.);
- spillover costs;
- other costs (not elsewhere specified).

Spillover costs, otherwise known as external effects or externalities, are costs and benefits which accrue to agents other than those originally involved in the decision to undertake an investment project. For example, many would argue that successful participation in education has benefits that the direct recipients are not able directly to perceive. University education, in particular, normally provides graduates with opportunities for higher lifetime earnings streams than are achievable without acquiring the necessary qualification. Medicine, law and engineering are just a few instances where possession of the appropriate qualification is tantamount to a 'licence to practise'. Taxpayers will benefit if university education increases the future money incomes, and hence the tax payments, of students. Additional benefits may be conferred if graduates contribute to national political, cultural and economic life in ways which are valued by society.

Much of the discussion surrounding the range of initiatives to develop IT-assisted teaching and learning makes little distinction between the cost categories above. Furthermore, discussion of alternative costing models associated with different scales of operation and adoption of varied course delivery techniques, in Dearing (Dearing, 1997, Appendix 2), shows little precision in the specific cost concept in question. Some confusion arises there among measures of total cost, average total cost, average variable cost and marginal cost. Analysis of the context of the discussion indicates that the cost measure under consideration is the average total cost of course delivery, and the objective for the university decision-maker is to search for the minimum of this quantity. Regardless of whether the costs and benefits are quantifiable or not, it can be unequivocally stated that the scale of operation which minimises the Average Course Delivery Cost is an incorrect criterion. Why should this be so? It is because no account is taken of the associated benefits. Figure 1 shows that the correct criterion is to operate the course at a scale where the marginal delivery cost is equal to the marginal benefit from undertaking delivery in this manner.

The upper part of Figure 1 shows a typical Total Cost curve relating project cost to scale of operation. The intercept on the vertical axis is the Fixed Cost of operation (overhead, etc.). Over some ranges of operation it may be expected that economies of scale apply, so that as scale of operation increases, Total Cost typically increases as the Total Variable Cost increases,
but at a relatively modest rate. Beyond a certain point, however, decreasing returns begin to set in and diseconomies of scale appear (reflected in the increasing gradient of the Total Cost curve).
The Total Benefit curve is superimposed on the diagram, and is drawn under the assumption that Total Benefits will increase as the scale of operation increases, but at a diminishing rate. It is clear that there are two scales of operation where the Total Cost and Total Benefit are equal. More interesting, however, is the tangent OA, indicating the minimum point of the Total Cost curve, which occurs at the scale of operation given by X.

In the lower part of the diagram, on the same scale, are representations of the corresponding Marginal Cost and Marginal Benefit curves, together with the Average Total Cost. The Marginal Cost Curve intersects with the Marginal Benefit curve at X*, which is precisely the point where the vertical distance between the Total Cost and Total Benefit is greatest (upper diagram). From this simple representation it is clear that maximum Net Benefit occurs when the Marginal Cost = Marginal Benefit, and not where the Average Total Cost of operation is a minimum.

Although cost of equipment, maintenance and replacement costs are, in principle, relatively easily identified, HEIs have not generally recorded cost data in a form which provides accurate operational figures on infrastructure and access costs, nor any of the less tangible cost concepts listed earlier. It appears that the costs associated with use of equipment, and access to IT facilities are deemed to be approximately zero to those making use of the IT facilities. The significant quantities of time allocated by academic and technical staff to IT-assisted teaching and learning development within institutions are similarly allocated a zero or minute cost value. Evidently, if the true costs of undertaking IT-assisted teaching and learning development and adoption are not recorded, there is the possibility that the quantities of courseware developed, and the scale of operation of IT-assisted teaching and learning-based programmes may function at non-optimal levels.

Identifying the benefits associated with development and implementation of IT-assisted teaching and learning is even more problematical than costs. The conventional measure of benefits – termed efficiency gains in the TLTP proposals (UFC, 1992) – such as time saved through adoption of changed teaching and learning practices, has not been widely available to date. In practice, where some time savings have been achieved, course teams have often made use of the additional time by teaching additional concepts, addressing topics in greater breadth and depth, or providing reinforcement learning. In such cases, far from
IT-assisted teaching and learning being adopted as a substitute for face-to-face lecturer contact, as commonly feared at its introduction, the revised modus operandi is often adopted as a complement to conventional practice. Evidently, there is a quality dimension to such methods of working, but few attempts to measure such quality-enhancement procedures have yet been undertaken.

The benefits accruing to institutions may be categorised in a number of ways. Internal benefits accrue directly or indirectly to the institution or department concerned. In a private investment project, the benefits would be the additional revenue earned by a business as a direct result of undertaking the project. For social investment such as funding the development of IT-assisted teaching and learning approaches, the internal benefits would be those increases in value produced directly by undertaking the activity, such as:

- increased quality of course materials;
- increased consistency of ‘look and feel’ of teaching materials;
- increased quality of students’ learning resulting from the new approach;
- increased academic staff expertise in instructional design;
- increased staff expertise in human-computer interface design;
- increased staff project management skills;
- increased utilisation of existing capital stock of IT equipment, network infrastructure and software;
- increased proportion of students gaining higher graded qualifications.

Evidently, many of these are difficult to quantify and may be of limited direct significance to the overriding objectives of university decision-makers. Furthermore, there may be secondary benefits which accrue to a wider constituency. These include:

- increased cross-institutional working in developing teaching materials;
- increased quality and consistency resulting from such collaboration;
- increased capability of graduates, which may have long-run benefits for the performance of the UK economy.

All of these potential benefits need to be quantified and evaluated. At the current state of knowledge the UK HE sector is not well placed to do so.

Additionally, projects may generate external effects which are somewhat more complex to analyse. External effects transcend the project boundaries, and may confer uninvited benefits and/or costs on others. In the case of benefits, these outsiders pay nothing; in the case of costs, they are not compensated. These externalities include both pecuniary and technological externalities (Scitovsky, 1954). Pecuniary externalities apply to the financial effects of the project on others, experienced through a price change for inputs to the process or outputs from it. If, for example, it could be established that the quality of learning improved as a result of adopting IT-assisted teaching and learning rather than conventional teaching and learning methods, and as a result employers recognised this by paying a
premium for such graduates, then a clear pecuniary externality exists. Some universities might seek to charge differential tuition fees based on such arguments. Establishing a suitable measurement yardstick would be tricky. Furthermore, such externalities have implications for income distribution and consequently should be excluded from a rigorous CBA. Technological externalities, on the other hand, should be included. If it could be established that adoption of IT-assisted teaching and learning methods really does confer large time-savings for institutions in delivering courses, then the value of such time-saving can, in principle, be computed and incorporated in the analysis. Little clear evidence exists to date in favour of this hypothesis.

The CBA should seek to include intangible benefits in the analysis, although to do so can present considerable operational difficulty. These are effects in which there is no market, or in which there is reason to suppose that existing markets do not value an effect completely (Dasgupta & Pearce, 1972). Existence of intangibles and public goods (such as education) requires the conventional CBA to be modified to a cost-effectiveness analysis (CEA). The methodology is identical to CBA, but the benefits are not valued in the same terms as costs. In such cases the objective may not be cited in purely financial terms, but include statements of aspiration, social concerns, etc. Equality of opportunity for example is an intangible benefit which cannot be quantified. CEA would seek to compare alternative policies and strategies for achieving this goal.

The ITATL research attempted to impute values of educational, institutional and sectoral costs incurred and benefits achieved, including those classified as intangibles. It is essential to establish a valuation for the resources committed to any investment project, because to do otherwise is to risk allocating these scarce resources sub-optimally. Correct investment decisions will only be made if the prices used by the decision-maker are an accurate reflection of the true social value of the inputs, at the social optimum distribution of such resources. Such prices provide high-quality signals of the true costs of using scarce resources, and are termed ‘shadow prices’. Where markets operate in an unfettered manner, the resource costs can be clearly signalled. Where markets do not operate efficiently or do not operate at all, as in the provision of higher education courses, it is necessary to infer how individuals value resources by observing their behaviour, or by eliciting their responses to direct resource-related questions. From the behaviour of decision-makers in IT-assisted teaching and learning development projects, it appears that the subjective valuation of some resources (existing IT equipment, student time, development effort, etc.) was close to zero. A correct economic interpretation of this phenomenon is the implicit assumption, therefore, that these resources are in excess supply at an optimum allocation of resources. This does not square with the common observation that higher education is resource constrained. Additional measurement difficulties arise in attempting to value IT-assisted teaching
and learning development projects in terms of enhanced professional and organisational development, increases in quality of teaching materials and courses, and greater institutional visibility or academic kudos.

CBA in Operation

Considering all measured and imputed values for the relevant perceived costs and benefits, CBA assesses the relative effectiveness of the project. The most theoretically acceptable method is to sum the discounted values of the costs and benefits, and to inspect the resulting numerical value, the Net Present Value (NPV), which is defined as:

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} + \sum_{t=1}^{n} \frac{B_t}{(1+r)^t}$$

Figure 2. Calculation of Net Present Value.

Because funds committed to investments and the benefits expected to flow from these arise at different points in time, allowance needs to be made for these timing differences in adding together costs and benefits over the project lifetime. Conventionally this is undertaken by discounting the monetary values of the costs and benefits at an appropriate discount rate. Investment appraisal techniques such as CBA select those projects for which this discounted sum is greater than zero, and does not select those for which the discounted sum is zero or negative. Alternative decision rules, such as calculation of a project’s internal rate of return (IRR) are sometimes suggested, as is the Benefit:Cost Ratio. Both of these methods are considered inferior to the NPV criterion.
In assessing the processes of IT-assisted teaching and learning development and adoption, additional complexities may apply. CBA assumes that all costs are known with certainty, as are all of the benefits. It also assumes that the lifetime of the project is known with certainty, and that the discount rate does not change during the lifetime of the project. All of the foregoing parameters and variables may be adjusted to undertake plausible assessments of the degree of robustness of the project under differing conditions. Varying the test discount rate allows for assessment of the sensitivity of the resultant NPV to the chosen rate. Spreadsheets allow for comprehensive sensitivity analyses, including varying the discount rate for different periods within the project lifetime. Generalised sensitivity analysis allows for variation in a number of decision variables simultaneously, at the expense of computational complexity (Sassone & Schaffer, 1978).

By assigning probabilities to the likely monetary values of outcomes of the project, the probability distributions of costs and benefits can be assessed for varying degrees of risk. The conventional risk measure is the variance (or standard deviation) of the probability distribution of expected outcomes (Wilkes, 1974; Wilkes, 1977; Samuels & Wilkes, 1980). Further complications arise where a series of investment projects is not independent, as in the TLTP developments, and especially when capital to fund projects is rationed. Discussion of these issues is beyond the scope of this article; the topics are fully treated in the standard finance literature (Lorie & Savage, 1955; Prest & Turvey, 1965; Robicheck & Myers, 1966; Myers, 1968; Hillier, 1969; Mao, 1970; Fama & Miller, 1972; Wilkes, 1974; Wilkes, 1977; Levy & Sarnat, 1978; Samuels & Wilkes, 1980; Brealey & Myers, 1984; Chan, 1984; Francis, 1986; Higson, 1986; Brigham & Gapenski, 1987; Due, 1989; Blake, 1990; Lee, 1993; Lumby, 1994).

A major consideration in the literature on CBA is choice of the discount rate. For profit-seeking organisations, the appropriate discount rate is the opportunity cost of capital facing the organisation (Copeland & Weston, 1992). This will vary over the trade cycle according to prevailing demand conditions in the economy, to reflect the trading position of the organisation and the degrees of risk which the project is perceived to possess. Market views of the likely future growth and profitability of the firm will determine the rate at which an organisation may borrow funds. As the discount rate changes, so too does the NPV of the project. As the rate increases, the discount factor (the term \((1 + r)^{-i}\)) becomes smaller, so that the costs and benefits are given less weighting in the summation of the cash flows expected. Therefore, as the discount rate is increased, the NPV of the project falls. Similarly, as the period for which the project is expected to
deliver benefits increases, the NPV calculation gives less and less weight to those costs and benefits which appear further in the future. In the case of the IT-assisted teaching and learning projects, this raises a potential problem. Expected lifetime of these projects is short: between three and five years, but with the costs front-end loaded and the benefits delayed, so that timing of costs and benefits is critical.

In the business sector, because the discount rate is set to represent the opportunity cost of the capital tied up in the investment, a project needs to generate a return at least as great as that which could be earned elsewhere in the capital market. Furthermore, businesses are required to pay tax depending on the size of the annual profit. When tax is taken into account, the discount rate which firms apply to investment appraisals should be significantly above the prevailing market rate of interest. Since high discount rates favour projects which provide returns (benefits) early in the project lifetime, and penalise those with longer-run benefits, business typically focuses on projects which provide returns in the short to medium term.

By contrast, in the public sector, the Treasury has conventionally specified a discount rate which seeks to capture the social opportunity cost of capital. For most public sector CBA, a rate of 6% is considered appropriate, often because public sector projects are expected to produce benefits over long time periods. Clearly, this is the case in assessing decisions related to building new hospitals, bridges and similar projects. Whether this represents a realistic discount rate is dependent upon the prevailing rate of inflation and on the perceived riskiness of the project to be undertaken. Adjustments need to be made to the discount rate to allow for inflation (by subtracting the rate of inflation from the nominal rate), or to adjust for differing degrees of risk, by adding a risk-premium. More sophisticated risk analyses may be conducted by assigning probabilities to the cash inflows and outflows associated with the project, and conducting the NPV calculations taking account of the expected values of these quantities and their variances, as noted earlier.

It was common under previous administrations to apply a ‘market test’ as a means of assessing whether a public sector project which consumed resources was worthwhile or not. In undertaking an IT-assisted teaching and learning development, decision-makers are assessing whether to undertake the activity, in the expectation that the successful delivery of the project will produce a revised means of delivering teaching and learning services. This activity is deemed worthwhile if the monetary values of the benefits obtained from the IT-assisted teaching and learning activities exceed the monetary values of the costs incurred in undertaking the project. This simple statement is true, however, if and only if the prices used to value the resources associated with the project are the correct shadow prices. If market prices are equal to the shadow prices, then CBA is redundant; if
market prices are not equal to shadow prices, financial appraisal gives an incorrect result.

Further refinement allows analysis of related and contingent investment projects, and for those undertaken under conditions of capital rationing. Even these adjustments are subject to criticism on theoretical grounds, the discussion of which is beyond the scope of this paper.

Conclusion

This article has sought to highlight some of the economic issues relating to the development of new methods of undertaking teaching and learning in UK higher education, through adoption of IT-assisted teaching and learning approaches. The basic methodology of CBA has been outlined, and problems in the measurement of the opportunity costs and perceived benefits from these new delivery methods examined. Discussion of the cost concepts and associated benefits has highlighted the present difficulty in assessing the extent to which past and present initiatives have succeeded in delivering the efficiency gains and quality enhancements expected when the projects were initiated. A major challenge for the sector is to develop appropriate methodologies to identify and quantify the benefits claimed for IT-assisted teaching and learning over conventional teaching and learning methods, and to impute monetary values to the educational, institutional and social benefits achieved. Similarly, more effective cost measures need to be developed as part of the institutions’ decision-making armoury. Evidence from a limited set of case-studies (Boucher et al, 1997) indicated that efficiency gains and gains in effectiveness of teaching and learning can be identified in only a limited number of instances to date. The definitions of efficiency and effectiveness are as defined by Eilon (1984):

\[
\text{Efficiency} = \frac{\text{Actual Output}}{\text{Planned Output}} \\
\text{Effectiveness} = \frac{\text{Actual Output}}{\text{Potential Output}}
\]

Further work is required on developing indicators of effectiveness in the use of IT-supported teaching and learning efforts. Work on refining the processes of economic decision-making in UK HE is also required. A problem facing the ITATL research project was the general absence, within the case studies considered, of clearly articulated measures of output to be associated with the IT-assisted teaching and learning projects undertaken. In general, development teams were content to take the existence of a set of IT-based resources as the output from their efforts, but had not attempted any measure of the incremental effects on the costs of teaching and learning, nor of the incremental benefits accruing either at departmental, institutional or sectoral level. The view was that the production of IT-assisted teaching and learning materials was a ‘good thing’ in its own right. More comprehensive assessment of the efficacy of undertaking such development was generally lacking.
The academic community has yet to agree on a method of measuring the effectiveness of IT-assisted teaching and learning-related interventions into the teaching and learning process. It is hoped that the ITATL research will encourage development of wider analysis of the educational effectiveness of such interventions, from which imputed monetary and educational evaluations may be discovered.

Analysis of national and locally-funded IT development initiative project case studies has suggested that a proportion of the IT development activities had been funded as path-breaking developments, with funding committed in the nature of pump-priming, and the expectation (at least from the developers’ perspective) that the initial development would be treated as a prototype. The major benefits are expected to occur when the initial materials were developed for larger-scale adoption within the institution, more widely across the HE sector, over a longer time-scale and with the additional opportunity arising from possible commercial exploitation. Analysis of the cost-effectiveness of IT-assisted teaching and learning was considered over a five-year horizon, on the assumption that the intellectual content of teaching and learning materials in higher education is expected to have a shelf-life of between three and five years. Although the standard CBA approach to assessing cost effectiveness has some merits in being simple to understand and providing general guidance, Parker et al (1988) indicate that CBA can fail to reflect fully the dynamic characteristics of investment activities.

The process of adopting IT-assisted teaching and learning in higher education is tantamount to a Business Process Re-engineering (BPR) effort. The literature on BPR indicates that the most successful transformations achieved using this approach involve close dialogue between external agents of change and decision-makers within organisations, to explore the key variables in the processes, to identify the strategic change(s) required, and to develop appropriate mental and operational models. This is best followed by extensive debate and development of operational (formal) models to represent the process and its strategic components (Morecroft & Sterman, 1994). A critically important aspect of this set of activities is the development of ‘ownership’ of the shared model by all key actors. Lane (1994) indicates that the process of modelling alone can provide powerful learning insights for decision-makers.

A major strategic challenge facing institutions is the massively increased access to higher education over the past decade, with declining units of resource, coupled with the rapid growth and adoption of new IT solutions at all levels of society. One consequence of these changes is the recognition that students entering higher education may have heightened IT skills compared with previous cohorts, together with heightened expectations that higher education will provide access to a range of IT solutions in support of teaching and learning. For institutions, one difficulty
has been to identify and support academic staff who are willing and able to adopt IT-assisted methods in their own teaching and to disseminate these changes of practice more widely across the sector. The challenge for institutions is to manage the tension between the momentum for change and the inertia of current practice. Equally difficult is the task of assessing accurately the costs and related benefits of undertaking these changes. Where change is largely incremental it is possible for management to adapt their past experience reasonably readily and to apply modifications of current and past managerial expertise in managing change effectively. Where change is fundamental, and largely discontinuous, as is the case in the widespread encouragement for the sector to adopt IT-assisted teaching and learning approaches, past relationships cannot be assumed to apply in the future. This will necessitate a quantum change in organisational thinking, where the core processes of universities are significantly altered. Research in this area is presently in progress.

Acknowledgements

I am grateful to two anonymous referees for helpful comments. Any remaining errors or inaccuracies are the sole responsibility of the author.

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